SECTION 500.00 – STANDARD METHODS & PRACTICES

IDAHO STANDARD PRACTICE (IR),
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SECTION 510.00 - AGGREGATES

IT-13-17 Measuring Mortar-Making Properties of Fine Aggregate Idaho
IT-15-04 Degradation
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SECTION 520.00 - BITUMINOUS MATERIALS

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IR-128-17 Sampling Concrete for Chloride Analysis

IT-131-17 Total Chloride Content of Hardened Concrete by Gran Plot Method

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SECTION 540.00 - PAINT

IR-7-04Inspecting/Sampling Paint and Curing Compound

IT-121-98 Determining Total Solids-Latex Percent

SECTION 550.00 - SOILS

IT-8-17 Resistance R-Value and Expansion Pressure of Compacted Soils and Aggregates

IR-62-17 Taking Undisturbed Soil Samples for Laboratory Consolidation, Shear and Permeability Tests

SECTION 560.00 - MISCELLANEOUS

IR-12-17 Calibrating Torque-Wrenches, Tightening and Testing Bolt Tensions

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IR-87-17 Pavement Straightedge Procedures

IT-120-17 Determining Volume of Liquids in Horizontal or Vertical Storage Tanks
Please do not forget to check Section 275 for TEST Methods Modifications

SECTION 570.00 – WAQTC / IDAHO FIELD OPERATING PROCEDURES

SECTION 570.01 - AGGREGATE

1. AASHTO T 2 (16) Sampling of Aggregates
2. AASHTO R 76 (16) Reducing Samples of Aggregates to Testing Size
3. AASHTO T 255 (14) Total Evaporable Moisture Content of Aggregate by Drying
4. AASHTO T 27 (17) & AASHTO T 11 (17) Sieve Analysis of Fine and Coarse Aggregates & Materials Finer Than 75 µm (No. 200) Sieve in Mineral Aggregates by Washing
5. AASHTO T 335 (17) Determining the Percentage of Fracture in Coarse Aggregate
6. AASHTO T 176 (17) Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test

SECTION 570.02 – ASPHALT I & II

1. AASHTO T 168 (10) Sampling Bituminous Paving Mixtures
2. AASHTO R 47 (12) Reducing Samples of Hot Mix Asphalt (HMA) to Testing Size
3. AASHTO T 329 (16) Moisture Content of Hot Mix Asphalt (HMA) by Oven Method
4. AASHTO T 308 (17) Determining the Asphalt Binder Content of Hot Mix Asphalt (HMA) by the Ignition Method
5. AASHTO T 30 (17) Mechanical Analysis of Extracted Aggregate
6. AASHTO T 209 (16) Theoretical Maximum Specific Gravity and Density of Hot Mix Asphalt Paving Mixtures
7. AASHTO T 166 (16) Bulk Specific Gravity of Compacted Hot Mix Asphalt using Saturated Surface-Dry Specimens
8. AASHTO R 66 (16) Sampling Asphalt Materials
9. AASHTO T 312 (16) Asphalt Mixture Specimens by Means of the Superpave Gyratory Compactor
10. WAQTC TM 13 (13) Volumetric Properties of Hot Mix Asphalt
11. AASHTO R 67 (15) Sampling Hot Mix Asphalt (HMA) After Compaction (Obtaining Cores) SEE AASHTO TEST MANUALS
SECTION 570.03 – CONCRETE
1. WAQTC TM 2 (14) Sampling Freshly Mixed Concrete
2. AASHTO T 309 (15) Temperature of Freshly Mixed Portland Cement Concrete
3. AASHTO T 119 (16) Slump of Hydraulic Cement Concrete
4. AASHTO T 121 (17) Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
5. AASHTO T 152 (17) Air Content of Freshly Mixed Concrete by the Pressure Method
6. AASHTO T 23 (17) Method of Making and Curing Concrete Test Specimens in the Field

SECTION 570.04 – EMBANKMENT AND BASE
1. AASHTO T 255 (16) Total Evaporable Moisture Content of Aggregate by Drying &
AASHTO T 265 (16) Laboratory Determination of Moisture Content of Soils
2. AASHTO T 99 (17) Moisture-Density Relations of Soils Using a 2.5-kg (5.5-lb) Rammer and 305-mm (12-in.) Drop &
AASHTO T 180 (17) Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and 457-mm (18-in.) Drop
3. AASHTO R 75 (16) Developing a Family of Curves
4. AASHTO T 85 (16) Specific Gravity and Absorption of Coarse Aggregate

SECTION 570.05 – IN-PLACE DENSITY
5. AASHTO T 355 (16) In-Place Density of Hot Mix Asphalt using the Nuclear Moisture-Density Gauge.
6. AASHTO T 310 (13) In-Place Density and Moisture Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
7. AASHTO T 255 (16) Total Evaporable Moisture Content of Aggregate by Drying &
AASHTO T 265 (16) Laboratory Determination of Moisture Content of Soils
8. AASHTO T 272 (16) One-Point Method for Determining Maximum Dry Density and Optimum Moisture
9. FOP CURVES(16) Use of AKDOT & PF ATM-212, ITD T-74, WSDOT TM 606, or WFLHD Humphreys Curves
SECTION 580.00 – IDAHO Field Operating Procedures

1. **ASTM D4791** Flat and Elongated Particles in Coarse Aggregate

2. **AASHTO T 304** Uncompacted Void Content Of Fine Aggregate

3. **AASHTO T 343** Density of In-Place Hot Mix Asphalt (HMA) Pavement by Electronic Surface Contact Devices

4. **AASHTO R 64** Standard Practice for Field Sampling and Fabrication of 50-mm (2-in) Cube Specimens using Grout (Non-Shrink) or Mortar

5. **AASHTO T 359** Pavement Thickness by Magnetic Pulse Induction
SECTION 590.00 – IDAHO TRANSPORTATION DEPARTMENT (ITD) SAMPLER / TESTER QUALIFICATION PROGRAM (STQP)

590.10 Individual Test Method Qualifications.

590.10.01 Non-ITD Personnel.
Idaho Standard Practice for

Investigation of Aggregate and Borrow Deposits

IDAHO Designation: IR-142-06

1. SCOPE

1.1. This method sets forth the accepted procedures to be used in investigating sources of sand, gravel and rock for aggregates, borrow, and granular borrow for use in highway construction. It also includes accepted procedures for sampling, testing, and source plan development.

1.2. This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. REFERENCE DOCUMENTS

2.1. Idaho Standards

- ITD Standard Specifications for Highway Construction.
- ITD Materials Manual, Section 270.00, Materials Sources.
- Idaho Code, Sections 54-2081 and 54-2802.

2.2. AASHTO Standards

- T 2, Sampling of Aggregates, Appendix X2

2.3. ASTM Standards


3. TERMINOLOGY

3.1. For the purpose of this test method, the term "Contractor" shall be defined as any individual(s) or company interested in investigating a materials source with the intent of meeting Idaho Transportation Department specifications.

4. GENERAL

4.1. The Contractor shall comply with the provisions of ITD Standard Specifications, including requirements necessary prior to beginning any work or investigation with equipment within any source. Reference ITD Materials Manual, Section 300.13, Aggregate Materials Sources.
5. **INVESTIGATION AND SAMPLING**

5.1. Materials source investigation and sampling shall include the following:

5.2. Sand and gravel deposits shall be investigated by excavating test pits located 150 ft. to 200 ft. on centers. The test pits shall be selected to form an effective grid over the entire area to be investigated. The test pits shall represent the materials present to the full depth intended to be mined. In lieu of test pits, large diameter drilling may be acceptable if the drilling method collects a representative sample and is submitted for pre-approval by the District Materials Engineer.

5.2.1. If the sand/gravel deposit has an exposed face, the Contractor may elect to replace the first row of test pits by sampling from the face. Sample locations shall be selected forming a grid pattern over the exposed face, and extending into the face to undisturbed material, to represent the area investigated. A minimum of three sample locations shall be selected along any exposed face. Any source sampled at the face will require, in addition, a minimum of one row of test pits at a maximum of 150 ft. from the face. The test pits and samples shall represent the materials present to the full depth intended to be mined.

5.3. Rock deposits shall be investigated using core drilling equipment. Drill holes shall be spaced no more than 200 ft. on center to form an effective grid covering the entire area investigated. Drill holes shall be deep enough to represent the full depth of the excavation.

5.3.1. Bulk samples may be taken from blasted areas in lieu of core drilling. The samples may be collected from the blasted rock pile if the blasted materials accurately represent the entire area investigated and the full depth of the excavation. Additional sampling and testing of the quarry face or core drilling shall be required if additional material is required beyond the materials represented by the blasting. Samples from blasted rock piles shall not be used to characterize the materials more than 200 feet beyond the blasted rock face.

5.3.2. If the rock quarry has an exposed face, the Contractor may elect to replace the first row of rock cores by sampling from the face. Sample locations shall be selected forming a grid pattern over the exposed face and extending into the face to represent the area investigated. A minimum of three sample locations shall be selected along any exposed face. Any source sampled at the face will require a minimum of one row of rock cores at a maximum of 200 ft. from the face. The rock cores shall represent the intended materials present to the full depth intended to be mined.

5.4. For project-specific sources consisting of either sand/gravel deposits or rock deposits, sample location spacing shall be adjusted to form an effective grid over the area to be worked. A minimum of three samples shall be taken. The grid shall represent the intended depth of excavation, as well as the area to be worked, to produce the required quantities. Samples from an exposed face shall meet the requirements of Paragraph 4.1 or 4.2.

5.5. The investigator shall keep an accurate, detailed record of each sample, test pit, and boring location and detailed descriptions of all materials present in the proposed source. The detailed descriptions shall include but not limited to; geologic descriptions, scaled boring logs, and 4 inch by 5 inch minimum size color photographs of the materials, cores, and samples in the moist condition. Detailed descriptions of the source materials shall be made by direct, hands-on observations. Material descriptions taken from or referenced from published or non-published documents will not be accepted in lieu of a materials source investigation in accordance with this procedure but may be used to supplement the investigation. Descriptions of bedrock materials shall be provided by a qualified Professional Geologist. Clear copies of the original records shall be provided to the Engineer for source approval.

5.6. All investigations shall be performed under the direction of or by a qualified Professional Engineer or Professional Geologist licensed in the state of Idaho. All sample locations shall be selected by the
Professional Engineer or Professional Geologist and shall be in accordance with the current version of AASHTO T 2, Sampling of Aggregates, Appendix X2; and ASTM D 420 Standard Guide to Site Characterization for Engineering, Design, and Construction Purposes.

5.6.1. For the purpose of this test method, direct supervision shall include the Professional Engineer or Professional Geologist having intimate knowledge of the source so as to be able to determine the sample locations and sampling methods as well as sufficient knowledge of the site to meet the descriptive requirements herein.

5.7. Sampling shall be performed under the direct supervision of a qualified Professional Engineer or Professional Geologist licensed in the state of Idaho. Sampling procedures shall be performed in accordance with the current version of AASHTO T 2, Sampling of Aggregates, Appendix X2; and ASTM D 420-98, Standard Guide to Site Characterization for Engineering, Design, and Construction Purposes. Though the actual sample size may vary due to the gradation of the materials being sampled, the minimum sample size shall be 100 lbs. and shall be representative of the aggregate being mined. Multiple samples may be required to accurately represent the distribution of materials in the source. Each sample shall represent one test. The entire sample shall be crushed, blended and split into appropriate portions for the tests required.

6. TESTING

6.1. Required test data for aggregate sources shall conform to Standard Specifications Section 703 – Aggregates, and ITD Contract Specifications.


6.2. The laboratory used to perform the tests shall be qualified under the Idaho Transportation Department’s Lab Qualification Program or be AASHTO accredited. All individuals that perform laboratory tests for source approval shall be qualified by the Registered Engineer in charge of the laboratory.

6.3. Copies of all test results shall be furnished by the independent laboratory to the Engineer. Copies of all test results shall be furnished by the independent laboratory to the Engineer.

7. MATERIALS SOURCE PLAN

7.1. A Materials Source Plan shall be prepared and submitted to the Engineer. At a minimum, the plan shall contain the following:

7.2. A vicinity sketch in enough detail that the source can be located.

7.3. A legal description of the source.

7.4. A sketch of the source depicting the boundary dimensions and drawn to scale.

7.5. A north arrow.

7.6. The test pits, sample locations, borings, active or working faces shall be depicted on the sketch relative to their location in the source.

7.7. The area to be worked shall be delineated with test pits, sample locations, and borings representing the material shown.
8. QUALIFIED AGGREGATE MATERIAL SUPPLIERS

8.1. Upon completion of the requirements outlined in this test method, the Contractor's source may be included on the Idaho Transportation Department (ITD) list of Qualified Aggregate Materials Suppliers as defined in the ITD Quality Assurance Manual (Section 265.00, Qualified Aggregate Materials Suppliers).
Idaho Standard Method of Test for

Measuring Mortar-Making Properties of Fine Aggregate

IDAHO Designation: IT-13-17

1. SCOPE

1.1. This method provides a means of determining whether a natural, unproven fine aggregate meets the minimum strength requirements for mortar making properties in concrete by comparing the compressive strength to the compressive strength of Ottawa Sand, the standard.

1.2. This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. REFERENCE DOCUMENTS

2.1. AASHTO Standards

- M 152, Flow Table for Use in Tests of Hydraulic Cement
- T 22, Compressive Strength of Cylindrical Concrete Specimens
- T 71, Effect of Organic Impurities in Fine Aggregate on Strength of Mortar
- T 84, Specific Gravity and Absorption of Fine Aggregate
- T 106, Compressive Strength of Hydraulic Cement Mortar (Using 50-mm or 2-in. Cube Specimens)

2.2. ASTM Standards

- C778, Standard Specification for Standard Sand

3. APPARATUS

3.1. Flow Table (drop table), flow mold, caliper, and

3.2. 1” x 5/8” hard rubber tamper as described in AASHTO T 106

3.3. Cylinder molds, 2”x4”, either plastic single use, or brass, (waxed to a glass plate).

3.4. Mixing bowl and spoon. Small trowel and scoop.

3.5. Tamping rod, (3/8” diameter x 8”) with spherically rounded ends.

3.6. Balance, capable of reading to the nearest gram.

3.7. Capping compound and fixture for 2” diameter specimens.
3.8. Compression testing machine with proper sized spherical test head.
3.9. Moist Closet and lime saturated water bath

### 4. TEMPERATURE AND HUMIDITY

4.1. The temperature of the mixing water, the Moist Closet, and the storage tank water shall be maintained at 73.4 ±3 ° F (23.0 ±1.7 ° C).
4.2. The relative humidity of the Moist Closet shall not fall below 95%
4.3. During mixing and molding of test specimens, the laboratory shall be maintained at 50% or greater relative humidity.

### 5. SAMPLE PREPARATION

5.1. **Natural Sand Mortar** - (AASHTO T 84) this mortar shall be made using a representative sample of natural sand from the unproven source (3,000 to 5,000 grams).

5.1.1. The sand is moistened to a point past SSD, then covered and kept moist for a minimum of 15 hours to allow the sand to reach total saturation.

5.1.2. Dry the sand to an SSD condition per AASHTO T 84, being careful not to segregate material while constantly mixing.

5.1.3. Weigh 2,500.0 grams, being careful to get a representative sample. Cover this sample to keep it in an SSD condition until needed.

5.1.4. Cement: Weigh 700.0 grams of Portland cement, either Type I & II or Type III.

5.1.5. Water: Measure 420.0 ml of conditioned water.

**Note 1** — Conditioned water is distilled water at 73.4 ±3 ° F (23.0 ±1.7 ° C).

5.2. **Ottawa Sand Mortar** – This mortar is the standard of comparison.

5.2.1. Blend natural Ottawa sands, combined weight 2,500.0 grams. Combine 1,225.0 grams of graded sand, and 1,275.0 grams of 20-30 sand, both conforming to ASTM C778, and thoroughly blend.

5.2.2. Cement: Weigh 700.0 grams of Portland cement, either Type I & II or Type III.

5.2.3. Water: Measure 420.0 ml of conditioned water.

**Note 2** — All tests shall be run using the same cement Type, Manufacturer, and Lot. The amounts of water and cement used in this method are never varied. All of the water and cement must be used to maintain a consistent W/C ratio (0.60) between all samples. The amount of sand added to the mixture is varied to get the proper flow.

5.3. If brass molds are to be used, apply a light coating of release agent or light oil to molds. This will allow for removal of specimens without damage.

5.4. Start with a *damp bowl* and add 420.0 ml of conditioned water.

5.5. Add 700.0 grams of cement and let it absorb for 1 minute.
5.6. Stir by hand into a smooth paste.

5.7. Add the sand while stirring continuously until the desired consistency of the mix has been reached. Note: Normally, the mix will achieve the required consistency before all of the sand (2,500 grams) is used.

5.8. Stir the mixture vigorously for 30 seconds, and then perform a flow test.

6. **FLOW TEST**

6.1. Fill the cone in two layers, 20 blows per layer with the hard rubber tamping tool. The mixture should overfill the cone at this point.

6.2. Cut the excess mortar off using the edge of a trowel creating a plane surface.

6.3. Carefully lift the cone off the mixture leaving the molded specimen on the table. The entire process to this point should be performed in one minute.

6.4. At exactly one minute, start flow table and drop 10 times. The mortar shall be proportioned to produce a consistency of 95-105 in 10 drops of the flow table.

**Note 3** — Allowance for flow trial – One free trial may be performed, but only if mix is too wet and the only ingredient that may be added is sand, to stiffen the mix. Then remix (5.7), and perform flow again starting with (6.1).

6.5. After flow measurement, immediately place the mortar back in the bowl and remix vigorously for 15 seconds.

6.6. Fill cylinder molds (brass or plastic) in three layers, each layer receiving 25 blows using the tamping rod with spherical end. Make two sets of 3 cylinders, (6 total). One set for 3 days and one set for 7 days if Type III cement is used, or one set for 7 days and one set for 28 days if Type I and II cement is used.

6.7. Cut off the mortar to a plane surface, flush with the top of the mold, by drawing the straight edge of a trowel with a sawing motion across the top of the mold.

6.8. Place the cylinders in the Moist Closet for curing.

7. **CURING SPECIMENS**

7.1. After 20 to 24 hours of curing in the Moist Closet, the specimens shall be removed from the molds, marked for identification, and immediately placed in a temperature controlled, lime saturated water bath for final curing.

7.2. Cylinders shall remain in the water bath to cure for a period of 3 days and 7 days, or 7 days and 28 days, depending on the cement type used. They will be removed from the water bath in sufficient time to perform the capping procedure and allow for curing of capping compound prior to testing. Testing shall be performed within ±1 hour for 3 day tests, ±2 hours for 7 day tests, and ±20 hours for 28 day tests, from the time of molding.

8. **CAPPING SPECIMENS**

8.1. Cylinders shall be capped before testing in such a manner that the ends will be plane and at right angles to the axis of the cylinder. While cylinders are in the capping process, they shall be maintained in a moistened condition by covering with wet towels. Any conventional capping material may be used.
9. TESTING SPECIMENS

9.1. Cylinders shall be tested for compressive strength at 3 days and 7 days, or 7 days and 28 days after molding. Testing age of cylinders depends on cement Type used to make test specimens.

9.2. If more than one specimen is removed from the storage water for testing, these specimens shall be covered with a wet towel to keep specimens in a moistened condition until time of testing.

9.3. Before placing the test cylinders in the compression test machine, they shall be wiped to a surface dry condition and have any loose sand and/or debris removed from the bearing test surfaces.

9.4. Place the cylinder carefully in the test machine centering it on the upper bearing block. Check the spherical head (upper) for freedom of movement prior to the beginning of each test. A constant load shall be applied without interruption until failure, at a rate of 20 psi to 50 psi per second, (standard loading rate for cylindrical specimens, AASHTO T 22). No adjustment shall be made in the controls of the testing machine while a specimen is yielding rapidly just prior to failure.

10. ACCEPTANCE

10.1. Acceptance is based on a comparative strength between the two mortars. The natural sand mortar must be at least 90% of the strength that is achieved by the standard sand mortar.
Idaho Standard Method of Test for
Idaho Degradation

IDAHO Designation: IT-15-04

1. **SCOPE**

1.1. This test method is intended as a quantitative measure of the resistance of a graded aggregate to production of fines by abrasion in the presence of water. The test provides a means by which it is possible to evaluate how the aggregate may perform in the road.

1.2. *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. **APPARATUS**

2.1. *Idaho Degradation Machine.* The Idaho Degradation Machine is equipped with an electric motor with gear reduction. The machine shall maintain a substantially uniform speed of 30 to 33 rpm. Metal cans equipped with spring tension handles to securely hold one-gallon (3.8 liter) jars in place are so positioned that the jars rotate end over end. Diameter of the metal cans shall be such that the jars are a snug fit, but can be inserted and removed without binding. The cans shall be deep enough so that the straight portion of the jar is completely within the can.

2.2. *Containers.* Wide mouth one-gallon (3.8 liter) jars with lids. The lids are fitted with solid 1/8 in. (3 mm) thick rubber gaskets.

2.3. *Sieves.* A set of U.S. Standard, 8 in. (200) mm diameter sieves 3/4 in. (19 mm) through No. 200 (0.075mm). These sieves shall meet AASHTO M 92 specifications.

2.4. *Sand Equivalent apparatus* as described in AASHTO T 176.

2.5. Scoop, brush and rust proof drying container approximately 18 in. x 12 in. x 2 in. (460 mm x 300 mm x 50 mm) deep.

2.6. *Drying Oven -* 140°F (60º C) maximum.

2.7. Balance with a 2,000 g capacity sensitive to 0.1 g.

3. **PREPARATION OF SAMPLE**

3.1. Sample makeup (Oven-dry at 140°F (60º C) max.)

3.1.1. The sample for testing with 1/2 in (12.5 mm) or larger size aggregate shall have the following gradation:

- 16.7% passing the 3/4 in. (19 mm) and retained on the 1/2 in (12.5 mm) 183 g.
- 16.6% passing the 1/2 in. (12.5 mm) and retained on the 3/8 in (9.5 mm) 183 g.
- 16.7% passing the 3/8 in. (9.5 mm) and retained on the No. 4 (4.75 mm) 184 g.
- 50% passing the No. 4 (4.75 mm) 550 g.

Total 1100 g.
3.1.2. The sample for testing with 3/8" (9.5 mm) size aggregate shall have the following gradation:

- 25% passing the 1/2" (12.5 mm) and retained on the 3/8 in. (9.5 mm) 275 g.
- 25% passing the 3/8 in. (9.5 mm) and retained on the No. 4 (4.75 mm) 275 g.
- 50% passing the No. 4 (4.75 mm) 550 g.
Total 1100 g.

3.1.3. The sample for testing with No. 4 (4.75 mm) size aggregate shall have the following gradation:

- 50% passing the 3/8 in. (9.5 mm) and retained on the No. 4 (4.75 mm) 550 g.
- 50% passing the No. 4 (4.75 mm) 550 g.
Total 1100 g.

3.2. Combine oven dried original and crushed portions representative of the gradation of the material as intended for use. For material coarser than the No. 4 (4.75 mm) sieve, thoroughly mix original and crushed portions and weigh out exactly the specified amount. Obtain the specified amount of No. 4 (4.75 mm) materials by the method of quartering or by the use of a sample splitter as described in AASHTO R 76.

3.3. **Note 1** — The coarse portion of the sample shall be hand shaken to refusal on each specified sieve size before make-up. Hand shaking shall continue until not more than 1% by weight of the residue passes any sieve during one minute.

4. **PROCEDURE**

4.1. Place the prepared oven dried material (maximum temperature 140°F (60º C) in a wide mouth jar and enough water to cover the aggregate to a depth of approximately 1/2 in. (13mm)

4.2. Allow the sample to soak at least 16 hours.

4.3. If necessary, after the soaking period adjust the water in the jar so the aggregate is barely covered.

4.4. Place lid with rubber gasket on jar and seal tightly. Fit the jar into the Idaho Degradation Machine making certain that the spring tension handle is securely holding the jar.

4.5. Start the Idaho Degradation Machine and allow the jar to make 1,850 revolutions. The tumbling action of the aggregate as the jar rotates end over end produces the degradation.

4.6. At the end of the test period empty the contents of the jar over a No. 4 (4.75 mm) sieve placed over a container to catch all the No. 4 (4.75 mm) material and water.

4.7. Wash out the jar using as little water as possible. Wash the plus No. 4 (4.75 mm) material until all the fines sticking to the aggregate are washed into the minus No. 4 (4.75 mm) portion of the sample. Place the container with the minus No. 4 (4.75 mm) portion in the oven for drying.

4.8. Oven dry the plus No. 4 (4.75 mm) material and then shake to refusal over the appropriate coarse sieves. If any material passes the No. 4 (4.75 mm) sieve, it is to be added to the minus No. 4 (4.75 mm) portion.

4.9. Stir the minus No. 4 (4.75 mm) portion occasionally and remove from oven when a cast point is reached. A cast point is defined as the point when a portion tightly squeezed in the palm of the hand will form a cast which will bear very careful handling without breaking.

4.10. When the cast point is reached, run sand equivalent on the minus No. 4 (4.75 mm) material according to AASHTO T 176.

4.11. Retain the material from the sand equivalent test and return it to the minus portion.
4.12. Wash entire minus No. 4 (4.75 mm) portion over No. 200 (0.075 mm), dry and sieve as described in AASHTO T 11.

4.13. Compute the total gradation based on initial oven dry weight of 1100 g. This becomes the gradation after degradation.

**Note 2**—Weights should be recorded to the nearest gram.

5. **REPORT**

5.1. The before-test gradation and sand equivalent together with the after-test gradation and sand equivalent are reported. The amount of degradation in indicated by the difference in test values.

**Note 3**—If the before-test gradation of material passing the No. 4 (4.75 mm) sieve is measured by sieve analysis of a representative sample for which the % Passing No. 4 (4.75 mm) is 50%, the before test percentages for No. 4 (4.75 mm) and finer sieve from the analysis are recorded directly in the "BEFORE TEST" column on Form ITD-895. Otherwise, all before test percentages for No. 4 (4.75 mm) and finer sieves must be multiplied by an adjustment factor before recording on the form. The adjustment factor is 50 divided by the percentage of material passing No. 4 (4.75 mm) in the representative before-test gradation sample. For example, if the No. 4 (4.75 mm) and finer before-test percentages are determined on a sample consisting of 100% minus No. 4 (4.75 mm) material, the adjustment factor is 50/100 = .050. Similarly, if the sample for determining before-test gradation has 40% minus 4.75 mm, the adjustment factor for No. 4 (4.75 mm) and finer sieves is 50/40 = 1.25.

5.2. The test results shall be reported on Form ITD-802.

6. **PRECAUTIONS**

6.1. Avoid baking sample during drying period prior to sand equivalent test.

6.2. Be sure to return all of the material from the sand equivalent test back into the minus No. 4 (4.75 mm) portion.
Idaho Standard Method of Test for

Evaluating Cleanness of Cover Coat Material

IDAHO Designation: IT-72-17

1. SCOPE

1.1. The cleanness test indicates the relative amount, fineness and character of clay-like materials present in aggregate as coatings or otherwise.

1.2. This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. REFERENCE DOCUMENTS

2.1 AASHTO Standards

- M 92, Wire Cloth Sieves for Testing Purposes
- M 231, Weighing Devices Used in the Testing of Materials
- T 176, Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test.
- R 76, Reducing Field Samples of Aggregates to Testing Size.

2.2 Other Standards

- California Test 227 – Method of Test for Evaluating Cleanness of Coarse Aggregate.

3. APPARATUS

3.1 Balance – Capacity sufficient for the sample mass, accurate to 0.1 percent of the sample mass or readable to 0.1g. Meets the requirements of AASHTO M 231.

3.2 Sample Splitter – Meets the requirements of AASHTO R 76.

3.3 Graduate assembly – Consists of:

3.3.1 funnel large enough to hold 8 inch brass wire sieves at the large end and necked down to approximately 2 in. diameter at the other end,

3.3.2 No. 8 (2.36mm) & No. 200 (0.75mm) 8 inch brass wire sieves, Meeting the requirements of AASHTO M 92.

3.3.3 500 ml graduate cylinder.

3.4 Washing vessel (as described in Figure 1) or wide-mouth 3.8 L jar with lid and rubber gasket.

3.5 Mechanical shaker – Uses oscillation or orbital action capable of securely holding the washing vessel.

3.6 Sand equivalent (SE) cylinder – Conforming to AASHTO T 176 with rubber stopper.

3.7 Graduate cylinders – 10 ml and 500 ml.
3.8. Sand equivalent (SE) solution (Stock) Conforming to AASHTO T 176

3.9. Syringe or spray attachment.

3.10. Potable water, i.e., tap water or bottled water at approximately the same temperature as the stock solution, but not at a higher temperature than the maximum temperature allowed by AASHTO T 176.

4. **SAMPLE PREPARATION**

4.1. Obtain a sample of cover coat material (CCM) in accordance with the FOP for AASHTO T 2 and reduce to 1000 ±50 grams in accordance with the FOP for AASHTO R 76.

4.2. **Note 1** — Sample shall be placed in a sealed container, such as concrete cylinder mold, to prevent loss of moisture. Sample shall be run in condition of placement on roadway i.e. moist. Sample shall not be allowed to dry.

4.3. Using a 10 ml graduate cylinder, obtain 7 ml of SE solution.

4.4. Pour the 7 ml of SE solution into the SE cylinder.

4.5. Assemble the graduate assembly (#8 (2.36mm) sieve, #200 (0.75mm) sieve, funnel, 500 ml graduate cylinder).

5. **PROCEDURE**

5.1. Place the 1000 ±50 gram CCM sample in the washing vessel or wide-mouth jar. Spread the material evenly across the bottom of the vessel or jar. Add only enough water to cover the aggregate.

5.2. Allow the sample to soak for one minute from the introduction of wash water into the vessel or jar.

5.3. Agitate the sample by either mechanical or hand method.

5.4. **Mechanical Method.**

5.4.1. Seal and secure the wash vessel in the mechanical shaker.

5.4.2. Agitate the vessel for two (2) minutes, without using the hammer if the shaker has one.
5.5. **Hand Method.**

5.5.1. Seal the jar with lid and rubber gasket.

5.5.2. Hold the jar vertical with both hands either by the sides or by the top and bottom. Agitate the sample in the vessel, creating an arm motion that causes the jar to describe a circle with at least a 6 in. (150 mm) radius. See the sketch showing the path of the jar during the agitation period. Use of a countertop with a 6 in (150 mm) radius drawn on the surface will help in this operation.
Figure 2—Path of Jar During Agitation Period

Note 2 — The jar itself does not turn on its vertical axis. The jar's vertical axis describes a circle with a 6 in. (150 mm) radius as near as possible.

Note 3 — Side F always faces the operator.

5.5.3. Continue this agitation at the rate of three (3) complete rotations per second for one minute.

6. **MEASURE FOR CLEANNESS**

6.1. Remove the lid from the vessel or jar. Continue agitating the vessel by hand to keep the fine contents in suspension. Pour all contents over the graduate assembly.

6.2. Wash out the vessel or jar over the graduate assembly using the syringe or spray attachment until the graduate cylinder is filled to 500 ml. mark.

6.3. Remove the sieves and funnel portion for the graduate assembly from the 500 ml graduate cylinder. Bring the solids into suspension by capping the cylinder with the palm of the hand and turning the cylinder upside down then right side up, 10 times, through an 180° arc as rapidly as possible.

6.4. Immediately pour the thoroughly mixed liquid into the SE cylinder until the 15 inch mark is reached. Cap the SE cylinder with a rubber stopper.

6.5. Mix the contents of the SE cylinder by alternately turning the cylinder upside down and right side up, allowing the air bubble to completely traverse the length of the cylinder. Repeat this cycle 10 times. A cycle is from right side up to upside down to right side up.

6.6. On a worktable that is not subject to vibrations allow the SE cylinder and contents to stand undisturbed for 20 minutes ± 15 seconds.

6.7. After 20 minutes, read and record to the nearest 0.1 inch the height of the column of sediment.

7. **CALCULATIONS**

7.1. Compute the cleanness value to the nearest whole number.

\[ CCCC = \frac{3.214 - (0.214 \times HH)}{3.214 + (0.786 \times HH)} \times 100 \]

Where:

CV = Cleanness Value

H = Height of Sediment in inches.
QUALIFICATION CHECKLIST
CLEANNESS VALUE – IDAHO T 72
Record the symbols “P” for passing or “F” for failing on each step of the checklist.

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. The sample was maintained moist in sealed container.</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>2. The sample is equal to 1000 ±50 grams.</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>3. There is 7 ml of SE solution in SE tube.</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>4. The graduate assembly including sieves, funnel and 500 ml graduate cylinder is properly put together.</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>5. CCM sample was placed in washing vessel or jar and water was added just covering the aggregate.</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td><strong>Mechanical Method</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. The vessel was secure in the shaker.</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>7. Agitation was started after one (1) minute.</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>8. The vessel was agitated for two minutes.</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td><strong>Hand Method</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Agitation was started after one (1) minute.</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>10. The vessel was properly rotated with 150mm radius.</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>11. Vessel was agitated 3 complete rotations per second.</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>12. Vessel was agitated for one (1) full minute.</td>
<td>12</td>
<td></td>
</tr>
<tr>
<td><strong>Measure for Cleanness</strong></td>
<td>13</td>
<td>14</td>
</tr>
<tr>
<td>13. All contents of vessel or jar were washed over sieves into the 500 ml graduate cylinder.</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>14. Cylinder was rapidly turned upside down at 180°, ten (10) times.</td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>15. Mixture was poured into SE cylinder to 15 inch mark.</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>16. SE Cylinder was rotated at least ten (10) complete cycles. Bubble traveled full length of tube.</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>17. Cylinder was allowed to stand 20 minutes on work table free from vibrations.</td>
<td>17</td>
<td></td>
</tr>
<tr>
<td>18. The sediment reading was to the nearest 0.1 inch.</td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>19. Calculations were accurate to the nearest whole number.</td>
<td>19</td>
<td></td>
</tr>
</tbody>
</table>

Comments: First Attempt: Pass [ ] Fail [ ] Second Attempt: Pass [ ] Fail [ ]

Testing Technician’s Name: _____________________________ WAQTC #: __________________ Date: ____________

Examiner’s Name: ___________________________ Signature _____________________________
Idaho Standard Method of Test for

**Vibratory Spring-Load Compaction for Coarse Granular Material**

**Idaho IT-74-98**

Idaho IT-74 is identical to WSDOT Test Method No. 606, "Method of Test for Compaction Control of Granular Materials," with the following exceptions.

A. Delete 1.1b and replace as follows: When Idaho IT-74 is specified as an alternative to AASHTO T 99 or AASHTO T 180, Idaho IT-74 should be used if the material has more than about 10% retained on the 3/4 in. (19 mm) screen.

B. Use of the WSDOT forms included in Test Method No. 606 is optional. ITD forms may be substituted.
WSDOT Test Method T 606
Method of Test for Compaction Control of Granular Materials

1. Scope

a. This test method is used to establish the theoretical maximum density of granular materials and non-granular materials with more than 30% by weight of the original specimen is retained on the No. 4 Sieve or more than 30% by weight of the original specimen is retained on the ¾” sieve.

b. There are three separate tests in this method which present a method for establishing the proper theoretical maximum density values to be used for controlling the compaction of granular materials. These tests account for variations of the maximum obtainable density of a given material for a given compactive effort, due to fluctuations in gradation.

c. By splitting the material on the U.S. No. 4 (4.75 mm) sieve and determining the specific gravity, the compacted density, and the loose density of each of the two fractions, a curve of theoretical maximum density versus percent passing the U.S. No. 4 (4.75 mm) sieve can be plotted. These curve values will correlate closely with the densities obtained in the field; using modern compaction equipment.

d. Table 1 identifies the Test, Method or Procedure to use in performing T 606. The table is divided into the Fraction of the split (Fine or Coarse) and the material type of that Fraction.

<table>
<thead>
<tr>
<th>Test Method Selection Table</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fine Material</strong></td>
</tr>
<tr>
<td>Soil Type</td>
</tr>
<tr>
<td>Sandy, Non Plastic, Permeable</td>
</tr>
<tr>
<td>Silt, Some Plasticity, Low Permeability</td>
</tr>
<tr>
<td>Sandy Silt, Some Plasticity, Permeable</td>
</tr>
<tr>
<td><strong>Coarse Material</strong></td>
</tr>
<tr>
<td>No more than 15% by weight of original aggregate specimen exceeds ¾” (19 mm)</td>
</tr>
<tr>
<td>15% or more by weight of original aggregate specimen is greater than ¾” (19 mm), but does not exceed 3 in. (76 mm)</td>
</tr>
</tbody>
</table>

Table 1

e. The test methods are applicable either to specifications requiring compacting to a given percentage of theoretical maximum density, or to specifications requiring compaction to a given compaction ratio.
f. Use of these test methods eliminates the danger of applying the wrong “Standard” to compaction control of gravelly soils.

g. Native soils within the contract limits to be used for embankment construction and/or backfill material do not require the sampling by a qualified tester. For material that requires gradation testing such as but not limited to manufactured aggregates and Gravel Borrow, a qualified tester shall be required for sampling.

1.1 Scope

Test No. 1
(Fine Fraction-100 Percent Passing U.S. No. 4 (4.75 mm) Sieve)

a. This test was developed for the sandy, non-plastic, highly permeable soils which normally occur as the fine fraction of granular base course and surfacing materials.

b. When the fine fraction is primarily a soil having some plasticity and low permeability, AASHTO T 99 (Standard Proctor Test) may be used. With borderline soils, both tests should be applied and the one yielding the highest density value should be used.

1.2 Apparatus

a. Vibratory, Spring Load Compactor — Specifications for vibratory spring load compactor can be obtained from the State Materials Lab.

b. Mold — Molds can be fabricated from standard cold drawn-seamless piles or tubes. The dimensions for the small mold are; height 8 in (± 0.002 in), ID 6 in (± 0.002 in). The wall thickness of the mold shall be no less than ¼ in. The mold has a bottom plate which attaches to the mold and is slightly larger than the outer diameter of the mold. The small button at the center of the small mold follower is a measuring point. The height of this button should be adjusted so the machine follower does not bear on it during compaction.

c. Mold Piston — A piston which has a bottom face diameter of 5 ⅞ in (150 mm) OD and an overall height of 2 in. The top of the piston shall have a 2 ¼ in ID.

d. Height-Measuring Device — A scale with an accuracy of 0.01 in (0.25 mm).

e. Tamping Hammer — As specified in AASHTO T 99, Section 2.21.

f. Sieve — U.S. No. 4 (4.75 mm) sieve.

g. Oven — Capable of maintaining a temperature of 230° ± 5°F (110 ± 5° C) for drying moisture specimens.

h. Balance — A balance having a capacity of 100 lbs (45 kg) and a minimum accuracy of 0.1 lbs (50 g).

i. Tamping Rod — ⅝ in (16 mm) spherical end.
1.3 Procedure

a. Oven-dry the total original sample at a temperature not to exceed 140°F (60°C).

b. Obtain tare weight of mold and bottom plate, record weight (mass) to the nearest 0.01 lb (5 g) or less if using a balance that is more accurate than 0.1 lbs.

c. Sieve the entire specimen over a No. 4 (4.75 mm) sieve to separate the fine and coarse material. Retain the coarse material for the second half of the procedure (T 606 Test 2).

d. Split the No. 4 minus material in accordance with WSDOT FOP for AASHTO R76 to obtain a representative specimen of approximately 13 lbs (6 kg). (This mass can be adjusted after the first compaction run to yield a final compacted specimen approximately 6 in (150 mm) high.)

e. Estimate the optimum moisture for the material. Calculate the mass of water required for optimum moisture and add water to specimen.

Weight of Water

Equation: \( Wt. \text{ of water} = (\text{decimal percent water})(\text{mass dry sample}) \)

f. Mix the specimen until the water and dry material are thoroughly and completely mixed.

g. Place the specimen in the mold in three layers. Rod each layer 25 times and tamp with 25 blows of the tamping hammer. The blows of the hammer should produce a 12 in (305 mm) free fall provided severe displacement of the specimen does not occur. In such cases, adjust the blow strength to produce maximum compaction. The surface of the top layer should be finished as level as possible.

h. Place the piston on top of the specimen in the mold, and mount the mold on the jack in the compactor. Elevate mold with the jack until the load-spring retainer seats on top of the piston. Apply initial seating load of about 100 lbs (45 kg) on the specimen.

i. Start the compactor hammers and, at the same time, gradually increase the spring load on the specimen to 2,000 lbs (908 kg) by elevating the jack in accordance with Table 2.

j. Check the mold for specimen saturation. The specimen is considered saturated when, free water (a drop or two of water) shows at the base of the mold. If water is not present at the base of the mold within the first 1½ minutes stop the test, remove the specimen from the mold and repeat 1.3 e-j. The specimen can be reused for subsequent water contents providing it is not a fragile material.

k. Caution: Most materials will yield the highest density at the moisture content described above. Some materials may continue to gain density on increasing the moisture above that specified; however, severe washing-out of the fines will occur, which will alter the character of the sample and void the test results.
1. If moisture is observed at the base of the mold continue applying loads at the following rates:

<table>
<thead>
<tr>
<th>Load in lbs (kg)</th>
<th>Time in Minutes</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 to 500 lbs (45 to 227)</td>
<td>1</td>
</tr>
<tr>
<td>500 lbs to 1,000 lbs (227 to 454)</td>
<td>1/2</td>
</tr>
<tr>
<td>1,000 lbs to 2,000 lbs (454 to 908)</td>
<td>1/2</td>
</tr>
</tbody>
</table>

*Table 2: Rate of Load Application*

m. After reaching 2,000 lbs (908 kg), stop the hammers, release the jack, and return to zero pressure.

n. Repeat step h. four additional times; remove the mold from the compactor.

o. Measure and record the height of the compacted specimen to the nearest 0.01 in (.25 mm) and calculate the volume (see Section 1.4)

p. Remove the specimen from the mold, weigh it, and record its mass (weight) to the nearest 0.01 lbs (5 g), and calculate the wet density.

q. Vertically slice through the center of the specimen, take a representative specimen (at least 1.1 lbs (500 g)) of the materials from one of the cut faces (using the entire specimen is acceptable), weigh immediately, and dry in accordance with AASHTO T 255 to determine the moisture content, and record the results. Calculate and record the dry density.

r. Repeat steps d. through m. at higher or lower moisture contents, on fresh specimen if needed, to obtain the theoretical maximum density value for the material, three tests are usually sufficient.

1.4 Calculations

a. The formula for calculating the volume and dry and wet densities are as follows:

\[
V = \frac{1 - H_2}{1728} (B \cdot H_1)
\]

Where:
V= Volume, ft³
H₁= Inside height of the mold, in
H₂= Height from top of the specimen to the top of the mold, in
B = Inside bottom area of the mold, in²

Wet Density (pcf) = \frac{\text{Wet Weight}}{(\text{Wet Volume})}

Dry Density (pcf) = \frac{\text{Dry Weight}}{1 + \left(\frac{\text{Wet Volume}}{\text{Dry Volume}}\right) \cdot \text{MC}}

*Note: See AASHTO T 255-00 “Total Moisture Content of Aggregate by Drying,” for moisture content calculations.*
Test No. 2
(Coarse Fraction-100 Percent Retained on the U.S. No. 4 (4.75 mm) Sieve)

2.1 Scope

a. This test is used when there is 100 percent retained on the U.S. No. 4 (4.75 mm) sieve. There are two separate procedures based on the maximum size of the aggregate being tested. Procedure 1 is used when no more than 15% by weight of the original specimen of the coarse aggregate exceeds ¾ in (19 mm). Procedure 2 is used when 15% or more by weight of the original specimen of the aggregate is greater than ¾ in (19 mm), but does not exceed 3 in (76 mm). If there is any aggregate greater than 3 in (76 mm), it has to be removed before proceeding with the test.

Procedure 1
(Aggregate Size: No. 4 to ¾ in (19 mm))

2.2 Equipment

a. The apparatus for this test is the same as that used in Test No. 1

2.3 Procedure

a. From the coarse split obtained in Test No. 1, Section 1.3(C), separate a representative specimen of 10 to 11 lbs (4.5 to 5 kg) and weigh to 0.01 lbs (5 g), or less if using a balance that is more accurate than 0.1 lbs.

b. Dampen the specimen to 2½% moisture and place it in a 0.1 ft³ (0.0028 m³) mold, in three lifts. Tamp each lift lightly to consolidate the material to achieve a level surface. Omit rodding. Avoid loss of the material during placement.

c. Place the piston on top of the specimen in the mold, and mount the mold on the jack in the compactor. Elevate mold with the jack until the load-spring retainer seats on top of the piston. Apply initial seating load of about 100 lbs (45 kg) on the sample.

d. Start the compactor hammers and, at the same time, gradually increase the spring load on the sample to 2,000 lbs (908 kg) by elevating the jack in accordance with the Table 2.

e. Follow procedure described in Test No. 1 Section 1.3 m through 1.3 r.

f. Using the original dry weight value, calculate the dry density in lb/ft³ (kg/m³). Use the formula for dry density described in Test No.1, Section 1.4.
2.4 Equipment

**Procedure 2**
*(Aggregate Size: No. 4 to 3 in (76 mm))*

a. ½ ft³ (0.014 m³) standard aggregate measure.

b. A metal piston having a diameter ⅛ in (3 mm) less than the inside diameter of the ½ ft³ (0.014 m³) measure.

2.5 Procedure

a. From the coarse fraction in Test No. 1, Section 1.3c., separate a representative specimen of 45 lbs (20 kg) and weigh to 0.1 lb. (50 g), or less if using a balance that is more accurate than 0.1 lbs.

b. Split the specimen into five representative and approximately equal parts.

c. Place the specimen in the mold in five separate lifts after each lift is placed in the mold, position the piston on the specimen, mount the mold in the compactor, and compact as described in Table 2, Section 1.3h. Spacers between the load spring and piston must be used to adjust the elevation of the mold to the height of the lift being compacted.

d. After the final lift is compacted, remove the mold from the compactor, determine the height of the compacted specimen, and calculate the volume (see Test No. 1, Section 1.4(a)).

e. Calculate the dry density in lbs/ft³ (kg/m³) (see Test No. 1, Section 1.4(a)).

---

Test No. 3
Specific Gravity Determination for Theoretical Maximum Density Test

3.1 Equipment

a. Pycnometer calibrated at the test temperature having a capacity of at least 1 quart (100 ml).

b. One vacuum pump or aspirator (pressure not to exceed 100 mm mercury).

c. One balance accurate to 0.1 g.

3.2 Material

a. Fine fraction U.S. No. 4 (4.75 mm) minus 1.1 lbs (500 g) minimum.

b. Coarse fraction U.S. No. 4 (4.75 mm) plus 2.2 lbs (1,000 g) minimum.
3.3 Procedure

a. Place dry material, either fine or coarse fraction, in pycnometer, add water. Put pycnometer jar top in place and connect to vacuum apparatus. Apply vacuum for at a minimum of 20 minutes until air is removed from specimen. Slight agitation of the jar every 2 to 5 minutes will aid the de-airing process. If the material boils too vigorously, reduce the vacuum. Remove vacuum apparatus, fill pycnometer with water, dry outside of jar carefully and weigh. Water temperature during test should be maintained as close to 68° ± 1° F (20° ± 0.5° C) as possible.

Calculate Specific Gravity as follows:

\[
\text{SP. GR.} = \frac{MM}{MM + b - c}
\]

Where:

a = Weight of dry material, grams
b = Weight of pycnometer + water, grams
c = Weight of pycnometer + material + water, grams

3.4 Reports

a. All test results are recorded on the theoretical maximum density work sheet.

b. Use the appropriate computer program to determine the theoretical maximum density.
Idaho Standard Method of Test for

Disintigration of Quarry Aggregates (Ethylene Glycol)

IDAHO Designation: IT-116-13

1. SCOPE

1.1. This method outlines the preparation and test procedure for measuring the presence of deleterious clay in quarry aggregates.

1.2. This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. REFERENCE DOCUMENTS

2.1. AASHTO Standards
   ■ M 231, Weighing Devices Used in the Testing of Materials

2.2. ASTM Standards
   ■ E11, Woven wire Test Sieve Cloth and Test Sieves

2.3. Other Standards
   ■ Standard Specifications, Subsection 703.01

3. APPARATUS

3.1. Oven 60 ± 2°C

3.2. Balance —A balance conforming to the requirements of M 231, Class G2.

3.3. Sieves conforming to ASTM E11 Specifications.

3.4. Technical Grade Ethylene Glycol

4. PROCEDURE

4.1. Wash and dry enough material passing the 12.5 mm and retained on the 9.5 mm sieve to provide 500 grams of material when shaken to refusal.

4.2. Immerse in technical grade ethylene glycol for a period of 15 days.

4.3. Decant and dry the aggregate. Shake to refusal over a 9.5 mm sieve and calculate the percent retained.
Idaho Standard Method of Test for

Specific Gravity and Absorption of Fine Aggregate Using Automatic Vacuum Sealing (CoreLok) Method

IDAHO Designation: IT-144-08

1. **SCOPE**

1.1. This standard covers the determination of specific gravity and absorption of fine aggregates.

1.2. The values are stated in SI units and are regarded as the standard units.

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

2. **REFERENCE DOCUMENTS**

2.1. AASHTO Standards

- M 231, Weighing Devices Used in the Testing of Materials
- T 2, Standard Practice for Sampling of Aggregates
- T 19, Standard Test Method for Bulk Density (Unit Weight) and Voids in Aggregate
- T 255, Total Evaporable Moisture Content of Aggregate by Drying
- R 76, Reducing Samples of Aggregate to Testing Size

2.2. ASTM Standards

- E1547, Standard Terminology Relating to Industrial and Specialty Chemicals

2.3. OTHER Standards

- CoreLok Operational Instructions (InstroTek, Inc.)

3. **TERMINOLOGY**

3.1. *Absorption*—the increase in the mass of aggregate due to water in the pores of the material, but not including water adhering to the outside surface of the particles, expressed as a percentage of the dry mass. The aggregate is considered “dry” when it has been maintained at a temperature of 110 ± 5°C for sufficient time to remove all uncombined water.
3.2. **Specific gravity**—the ratio of the mass (or weight in air) of a unit volume of a material to the mass of the same volume of water at stated temperatures. Values are dimensionless.

3.3. **Apparent specific gravity**—the ratio of the weight in air of a unit volume of the impermeable portion of aggregate at a stated temperature to the weight in air of an equal volume of gas-free distilled water at a stated temperature.

3.4. **Bulk specific gravity**—the ratio of the weight in air of a unit volume of aggregate (including the permeable and impermeable voids in the particles, but not including the voids between particles) at a stated temperature to the weight in air of an equal volume of gas-free distilled water at a stated temperature.

3.5. **Bulk specific gravity (SSD)**—the ratio of the mass in air of a unit volume of aggregate, including the mass of water within the voids filled to the extent achieved by vacuum saturating (but not including the voids between particles) at a stated temperature, compared to the weight in air of an equal volume of gas-free distilled water at a stated temperature.

4. **SUMMARY OF METHOD**

4.1. Sufficient fine aggregate sample is dried to constant mass and representative dry fine aggregate samples of the same material are selected for testing. One sample is sealed in a vacuum chamber inside a plastic bag and opened under water for rapid saturation of the aggregate. The dry mass and submerged mass of the sample is used for calculation of apparent specific gravity. Other samples of the same aggregate are tested in a known volume metal pycnometer. The known mass of the pycnometer with water, mass of the dry aggregate, and mass of the dry aggregate and pycnometer filled with water is averaged and used for calculation of bulk specific gravity oven dry (OD.) The results from the samples tested are used to calculate absorption, and bulk specific gravity saturated-surface-dry (SSD).

5. **APPARATUS**

5.1. **Balance**—A balance that conforms to AASHTO M 231. The balance shall be sensitive, readable and accurate to 0.1% of the test sample mass. The balance shall be equipped with suitable apparatus for suspending the sample in water.

5.2. **Water Bath**—A large container that will allow for completely submerging the sample in water while suspended, equipped with an overflow outlet for maintaining a constant water level. Temperature controls may be used to maintain the water temperature at 25 ± 1° C (77 ± 2°F).

   **Note 1** — It is preferable to keep the water temperature constant by using a temperature controlled heater. Also, to reduce the chance for the bag to touch the sides of the water tank, it is preferable to elevate the water tank to a level at which the sample can be placed on the weighing mechanism while the operator is standing up (waist height), and the placement of the sample and the bag in the water tank can easily be inspected.

5.3. Sample holder for water displacement of the sample, having no sharp edges.

5.4. **Vacuum Chamber**—with a pump capable of evacuating a sealed and enclosed chamber to a pressure of 6 mm Hg, when at sea level. The device shall automatically seal the plastic bag and exhaust air back into the chamber in a controlled manner to ensure proper conformance of the plastic to the specimen. The air exhaust and vacuum operation time shall be set at the factory so that the chamber is brought to atmospheric pressure in 80 to 125 seconds, after the completion of the vacuum operations.
5.5. **A Vacuum Measurement Gauge**, independent of the vacuum sealing device, that could be placed directly inside the chamber to verify vacuum performance and the chamber door sealing condition of the unit. The gauge shall be capable of reading down to 3 mm Hg and readable to ± 1 mm Hg. The gauge shall be NIST traceable.

5.6. **Plastic Bags**, used with the vacuum device, shall have a minimum opening of 235 mm (9.25 in.) and maximum opening of 260 mm (10.25 in.). The bags shall be of plastic material, shall be puncture resistant, and shall be impermeable to water. The bags shall have a minimum thickness of 0.127mm (0.005 in.). The manufacturer shall provide the apparent specific gravity for the bags.

5.7. **Metal pycnometer and lid**, with 137 ± 0.13 mm (5.375 ± 0.005 in.) inside diameter (ID) and 89 ± 0.41 mm (3.5 ± 0.016 in.) height, for testing fine aggregates. The pycnometer shall be machined to be smooth on all surfaces. The inside of the lid shall be machined at a 5° angle to create an inverted conical surface.

5.8. **Pycnometer clamping device** to hold and secure the lid on the metal pycnometer from lifting during fine aggregate tests. The device shall be provided with a level indicator.

5.9. **Syringe** with a needle no larger in diameter than 3 mm (0.125 in.)

5.10. Thermometer or other temperature device with range to 40ºC (100ºF) accurate to ±1º.

5.11. **Isopropyl alcohol** – Technical Grade.

5.12. **Accessories**— A bag cutting knife or scissors, spray bottle for the isopropyl alcohol, a bucket large enough to allow the pycnometer to be fully submerged in water, water containers to dispense water into pycnometer during testing, small paint brush and 25 mm (1 in.) wide aluminum spatula.

6. **VERIFICATION**

6.1. System Verification: The vacuum settings of the vacuum chamber shall be verified once every 12 months and after major repairs and after each shipment or relocation.

6.1.1. Place the gauge inside the vacuum chamber and record the setting, while the vacuum unit is operating. The gauge should indicate a pressure of 6 mm Hg or less. The unit shall not be used if the gauge reading is above 6 mm Hg.

**Note 2**— In line vacuum gauges, while capable of indicating vacuum performance of the pump, are not suitable for use in enclosed vacuum chambers and cannot accurately measure vacuum levels.

6.2. Calibration of Pycnometer:

6.2.1. Prior to testing, condition the pycnometer to 25 ± 1°C (77 ± 2°F) by placing it inside a bucket of water that is maintained at 25 ± 1°C (77 ± 2°F). Place the pycnometer clamping device on a level surface. Use a level indicator or the provided level to level the device.

**Note 3** – The clamping device must be protected from hot or cold ambient laboratory temperatures that are more or less than 25 ± 1°C (77 ± 2°F).

6.2.2. Remove the pycnometer from the water bucket and dry it with a towel. Place the pycnometer in the device and push it back until it makes contact with the stops.
6.2.3. Fill the pycnometer with 25 ± 1°C (77 ± 2°F) water to approximately 10 mm (0.375 in.) from the top. Using the alcohol spray bottle, spray the surface of the water to remove bubbles.

6.2.4. Gently place the lid on the pycnometer and close the clamps on the device.

6.2.5. Using a syringe filled with 25 ± 1°C (77 ± 2°F) water, slowly fill the pycnometer through the large fill hole on the lid post. Make sure the syringe tip is far enough in the pycnometer to be below the water level. Gentle application in this step prevents formation of air bubbles inside the pycnometer.

6.2.6. Fill the pycnometer until water comes out of the 3 mm (1/8-in.) hole on the surface of the lid.

6.2.7. Wipe any remaining water from the top of the lid with a towel.

6.2.8. Place the entire device with the pycnometer on the scale and record the mass. Record the mass to 0.1 in the top portion of the Aggregate Worksheet. (See Appendix 1)

6.2.9. Clean the pycnometer and repeat steps 6.2.1 to 6.2.8 two more times and average the calibration masses obtained in 6.2.8.

6.2.10. If the range for the 3 calibration masses is larger than 0.5 grams, then the test is not being run correctly. Check to see if the device is level. Make certain the water injection with the syringe is done below the pycnometer water surface and is applied gently. Check the water temperature. Check the pycnometer temperature. Repeat the above procedure until you have three masses that are within a 0.5 gram range.

6.2.11. The pycnometer must be re-calibrated daily prior to testing.

7. SAMPLING

7.1. Sampling shall be performed in accordance with AASHTO T 2.

7.2. Samples shall be dried to constant mass in accordance with AASHTO T 255.

7.3. Samples shall be reduced in accordance with AASHTO R 76 to a mass as close as possible to the required testing size by the addition or removal of material.

8. PROCEDURES

8.1. Equipment Preparation

Note 4 – Make certain water temperature used for this test remains at 25 ± 1°C (77 ± 2°F).

8.1.1. Prior to testing, condition the pycnometer to 25 ± 1°C (77 ± 2°F) by placing it inside a bucket of water that is maintained at 25 ± 1°C (77 ± 2°F).

8.1.2. Remove the pycnometer from the water bucket and dry thoroughly with a towel.

8.1.3. Place the pycnometer clamping device on a level surface. Use a level indicator or the provided level to level the device.

8.1.4. Place the empty pycnometer in the pycnometer clamping device and push it back until it makes contact with the stops.

8.2. Determine Bulk Specific Gravity
8.2.1. Oven dry to constant mass according to AASHTO T 255, enough fine aggregate to obtain three 500 gram samples and one 1000 gram sample, reduced according to AASHTO R 76.

8.2.2. Allow the sample to cool to 25 ± 1°C (77 ± 2°F).

8.2.3. Determine the mass of a 500 ± 1 gram dry sample, Trial 1, that is at 25 ± 1°C (77 ± 2°F) and record to 0.1 on the Aggregate Worksheet.

8.2.4. Steps 8.2.5 to 8.2.13 shall be completed in less than 2 minutes.

8.2.5. Place approximately 500 ml of 25 ± 1°C (77 ± 2°F) water in the pycnometer (halfway full).

8.2.6. Slowly and evenly pour the sample into the pycnometer. Make certain aggregate is not lost in the process of filling the pycnometer. Use a brush if necessary to sweep any remaining fines into the pycnometer. If any aggregate is lost during the process of filling the pycnometer, start the test over.

8.2.7. Use a metal spatula and push it to the bottom of the pycnometer against the inside circumference. Slowly and gently drag the spatula to the center of the pycnometer, removing the spatula after reaching the center. Repeat this procedure in eight equal increments until the entire circumference is covered. If necessary, use a squeeze water bottle to rinse any sample residue off the spatula into the pycnometer.

8.2.8. Fill the pycnometer with 25 ± 1°C (77 ± 2°F) water to approximately 10 mm (0.375 in.) of the pycnometer rim. It is important the water level be kept at or below the 10 mm line to avoid spills during lid placement.

8.2.9. Use the spray bottle filled with isopropyl alcohol to spray the top of the water to remove air bubbles.

8.2.10. Gently place the lid on the pycnometer and lock the clamping device. Using the syringe, slowly fill the pycnometer through the center hole on top of the lid post. Make sure the syringe tip is far enough in the pycnometer to be below the water level. Gentle application in this step will prevent formation of air bubbles inside the pycnometer.

8.2.11. Fill the pycnometer until water comes out of the 3 mm (1/8-in.) hole on the surface of the lid.

8.2.12. Wipe any remaining water from around the 3 mm (1/8-in.) hole with a towel.

**Note 5** – Do not wipe water from the rim of the pycnometer if it seeps between the lid and the pycnometer. Allow this water to remain.

8.2.13. Determine the mass of the sample, the pycnometer and the device. Record the mass to 0.1 in B of the Aggregate Worksheet.

8.2.14. Discard the sample and prepare the equipment according to step 8.1.1 to 8.1.4.

8.2.15. Repeat steps 8.2.3 to 8.2.13 for another 500 ± 1 gram sample, Trial 2.

8.2.15.1. The difference in the mass of Trial 1 and Trial 2 recorded in B must be 1.0 gram or less. If the difference is greater than 1.0, then repeat steps 8.2.14 and 8.2.15 using another 500 ± 1 gram dry sample.

8.2.16. Calculate the average mass for the two trials that are within 1 gram; record to 0.1 on Aggregate Worksheet.
8.2.17. Record the average weight of the pycnometer from section 6.2.9 on Aggregate Worksheet.

8.3. Determine Apparent Specific Gravity

8.3.1. Set the vacuum device according to manufacturer’s recommendation.

8.3.2. Tare the immersed weighing basket in the water bath.

8.3.3. Use a small plastic bag and inspect the bag to make sure there are no holes, stress points or side seal discontinuities in the bag. If any of the above conditions are noticed, use another bag.

8.3.4. Determine the mass of the bag and record to 0.1 on Aggregate Worksheet.

**Note 6**—Always handle the bag with care to avoid creating weak points and punctures.

8.3.5. Determine the mass of a 1000 ± 1 gram sample of oven dry aggregate and record 0.1 at E on Aggregate Worksheet.

8.3.6. Place the sample in the bag. Support the bottom of the bag on a smooth tabletop when pouring the aggregate to protect against punctures and impact points.

8.3.7. Place the bag containing the sample inside the vacuum chamber.

8.3.8. Grab the two sides of the bag and spread the sample flat by gently shaking the bag side to side. Do not press down or spread the sample from outside the bag. Pressing down on the sample from outside the bag will cause the bag to puncture and will negatively impact the results. Lightly spray mist aggregates with high minus 75-μm (No. 200) sieve material to hold down dust prior to sealing.

8.3.9. Place the open end of the bag over the seal bar and close the chamber door. The unit will draw a vacuum and seal the bag, before the chamber door opens.

8.3.10. Gently remove the sample from the chamber and immediately (within 5 seconds) submerge the sample in the water bath equipped with a balance for water displacement analysis.

**Note 7** - It is extremely important the bag be removed from the vacuum chamber and immediately placed in the water bath. Leaving the bag in the vacuum chamber or on a bench top after sealing can cause air to slowly enter the bag and can result in low apparent specific gravity results.

8.3.11. Completely submerge the bag at least 2-inches below the surface of the water during cutting.

8.3.12. Make a small cut across the top edge of the immersed bag approximately 25 to 50 mm (1 to 2 in.).

8.3.13. Hold the immersed bag open at the cut for approximately 45 seconds allowing the water to freely flow into the bag. Allow any small residual air bubbles to escape. Do not shake or squeeze the sample, as these actions will cause the fines to escape from the bag.

8.3.14. After water has filled in, make another cut on the opposite side of the immersed bag approximately 25 to 50 mm (1 to 2 in.). Squeeze any residual air bubbles on top portion of the bag through the openings by running your fingers across the top of the bag. Do not completely remove any portion from the bag nor allow any portion of the bag to reach the surface of the water. Keep the sample and bag at least 2-inches below the surface of the water at all times.
8.3.15. Place the bag containing the sample in the immersed weighing basket to obtain the underwater mass. Allow water to freely flow into the bag. Make certain the bag or the sample are not touching the bottom, the sides, or floating out of the water bath.

8.3.16. Allow the sample to stay in the water bath for a minimum of fifteen (15) minutes but not more than 20 minutes.

8.3.17. Record the submerged mass on the Aggregate Worksheet and wait one minute. If after this time the mass increases by more than one-gram, wait an additional five minutes. Record the mass and continue this process until the mass stops increasing.

9. **CALCULATIONS**

9.1. Test result calculations for percent absorption, apparent specific gravity and bulk specific gravity will be obtained from the software supplied by the manufacturer. Use the data from the Aggregate Worksheet. The software will provide a report of the test results.

9.2. The final test result will be determined from an average of two laboratory specimens.
### Weight of pycnometer and clamping device filled with water.

<table>
<thead>
<tr>
<th>Sample Number or Label</th>
<th>Trial Number</th>
<th>A Dry Sample Mass (500 g)</th>
<th>B Mass of pycnometer with sample and water (g)</th>
<th>C Plastic Bag Mass (g)</th>
<th>D Mass of two rubber sheets (g)</th>
<th>E Dry Sample Mass (1000 g)</th>
<th>F Mass of Sealed sample opened under water</th>
</tr>
</thead>
<tbody>
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* Trial 3 is only necessary if the mass in B for the first 2 trials is larger than 1.0 grams.
PERFORMANCE EXAM CHECKLIST

SPECIFIC GRAVITY AND ABSORPTION OF FINE AGGREGATE USING AUTOMATIC VACUUM SEALING (CORELOK) METHOD
IDAHO IT-144-08

Record ‘P’ For Passing “F” for failing each step of the checklist.

<table>
<thead>
<tr>
<th>Verification Element</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Pycnometer and lid placed inside a bucket of water at 25 ± 1C (77 ± 2F)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Pycnometer and lid removed from water dried well and placed on clamping device until it makes contact with stops?</td>
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<tr>
<td>3. Pycnometer filled with 25 ± 1C (77 ± 2F) water to 10mm (3/8”) of top, sprayed with Isopropyl alcohol to remove air?</td>
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<tr>
<td>4. Lid gently placed on Pycnometer and clamped?</td>
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<tr>
<td>5. A syringe filled with 25 ± 1C (77 ± 2F) inserted in top of lid and gently added until water is expelled through the 3mm (1/8”) hole?</td>
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<tr>
<td>6. Water wiped from lid, device water and pycnometer weighed and recorded to</td>
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<tr>
<td>7. Procedure repeated two additional times (no greater than 0.5g difference) recorded to work sheet and averaged?</td>
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</table>

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Trial 1</th>
<th>Trial 2</th>
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<tbody>
<tr>
<td>8. Representative samples obtained per FOP for AASHTO T 2?</td>
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<td>9. Reduced per FOP for AASHTO R 76?</td>
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<td>10. Dried per FOP for AASHTO T 255?</td>
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<tr>
<td>11. Samples cooled to 25 ±1C (77 ± 2F)?</td>
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<tr>
<td>12. Three samples obtained @ 500g ±1g and one @ 1000g ±1g?</td>
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<tr>
<td>13. Pycnometer and lid removed from water, dried and pycnometer placed on clamping device until it makes contact with stops?</td>
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<tr>
<td>14. Water added to pycnometer (at 25 ± 1C, 77 ± 2F) to approximately half full?</td>
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<tr>
<td>Procedure Element</td>
<td>Trial 1</td>
<td>Trial 2</td>
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<tr>
<td>15. Sample at 500 g ± 1g slowly added to pycnometer?</td>
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<tr>
<td>16. Metal spatula inserted against side of pycnometer and slowly pushed to center removed, repeated in eight equal increments?</td>
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<tr>
<td>17. Water added at 25 ± 1C (77 ± 2F) to within 10mm (3/8&quot;) of rim?</td>
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<tr>
<td>18. Sprayed with isopropyl alcohol to remove air?</td>
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<tr>
<td>19. Lid gently placed on pycnometer with 3mm (1/8&quot;) hole to the front and clamped?</td>
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<tr>
<td>20. Syringe filled with 25 ± 1C (77 ± 2F) water inserted in top of lid and water slowly added until it is expelled through 3mm (1/8&quot;) hole?</td>
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<tr>
<td>21. Excess water wiped from lid?</td>
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<tr>
<td>22. Clamping device, pycnometer and sample mass recorded to 0.1 g?</td>
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<tr>
<td>23. Clamping device, pycnometer and sample mass determined no more than 2 minutes from time sample was submerged?</td>
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<tr>
<td>24. Second 500g ±1 g sample tested and mass recorded?</td>
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<tr>
<td>25. If recorded mass of first and second sample greater than 1 g, was a third 500 g ± 1 g sample tested?</td>
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<tr>
<td>26. Vacuum device set at manufacture’s recommended setting?</td>
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<tr>
<td>27. Small plastic bag inspected and mass determined to 0.1 g and recorded?</td>
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<tr>
<td>28. 1000 g ±1 g sample mass determined and recorded?</td>
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<tr>
<td>29. 1000 g ±1 g sample placed in the bag, supported by a smooth surface to prevent punctures?</td>
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<tr>
<td>30. Sample placed in vacuum device and spread flat by grasping both sides of bag and gently shaking?</td>
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<tr>
<td>31. Open end of bag placed over seal bar and closed?</td>
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<tr>
<td>32. Sample removed from vacuum chamber when door opens and submerged in 25 ± 1C (77 ± 2F) water bath within 5 seconds?</td>
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<tr>
<td>33. Bag maintained at a minimum depth of two inches?</td>
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<tr>
<td>34. A small cut made at corner of bag approximately 25 to 50mm (1&quot; to 2&quot;)?</td>
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<tr>
<td>35. Submerged bag held open until water flows freely into bag (approximately 45 seconds)</td>
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<tr>
<td>Procedure Element</td>
<td>Trial 1</td>
<td>Trial 2</td>
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<td>---------------------------------------------------------------------------------</td>
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<tr>
<td>36. A second cut approximately 25 to 50mm (1” to 2”) made to opposite side of bag?</td>
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<tr>
<td>37. Residual air removed from bag by running fingers across top of submerged bag?</td>
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<tr>
<td>38. Bag placed in weighing basket and water allowed to flow freely into bag?</td>
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<tr>
<td>39. Sample mass determined and recorded after 15 minutes but not more than 20 minutes and recorded to 0.1g?</td>
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<tr>
<td>40. Test data entered into manufacture’s software to obtain test results?</td>
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</tbody>
</table>

**COMMENTS:**  
First Attempt: Pass ☐ Fail ☐  
Second Attempt: Pass ☐ Fail ☐

Examiner Signature: ___________________________  
Sampler / Tester Qualification # ____________

Examiner Signature: ___________________________  
Sampler / Tester Qualification # ____________
SECTION 520.00 - BITUMINOUS MATERIALS

IT-61-08  Sampling and Viscosity Testing Emulsified Asphalt Binders in the Field

IR-63-13  Design of Seal Coats and Single Surface Treatments by the McLeod Method

IT-99-17  Detection of Anti-Stripping Additive in Asphalt

IR-125-16  Acceptance Test Strip for Hot Mix Asphalt (HMA)

IT-137-17  Effectiveness of Anti-Strip Agents After Hot Storage in Asphalt Binder Using Bottle and Sand

IT-146-16  Determination Of Reclaimed Asphalt Pavement (Rap) Aggregate Bulk (Dry) Specific Gravity (G₉₁)
Idaho Standard Practice for

Design of Seal Coats and Single Surface Treatments by the McLeod Method

Idaho IR-63-13

1. Scope

In the late 1960’s Norman McLeod (1969) presented the following design method which was later adapted by the Asphalt Institute (1979, 1983) and the Asphalt Emulsion Manufacturers Association (1981). In this method, the aggregate application rate depends on the aggregate gradation, shape, and specific gravity. The binder application rate depends on the aggregate gradation, absorption and shape, traffic volume, existing pavement condition, and the residual asphalt content of the binder. It should be noted that this method was developed primarily for use with emulsion binders and has not been verified in Idaho.

The McLeod method is based on two basic principles:

1. The application rate of a given aggregate should be determined such that the resulting seal coat will be one-stone thick. This amount of aggregate will remain constant, regardless of the binder type or pavement condition.

2. The voids in the aggregate layer need to be 70 percent filled with asphalt for good performance on pavements with moderate levels of traffic.

2. Design Procedure Components

2.1 Median Particle Size. The Median Particle Size (M) is determined from the aggregate gradation chart. It is the theoretical sieve size through which 50 percent of the material passes. The following sieve sizes should be used:

<table>
<thead>
<tr>
<th>Sieve Sizes</th>
</tr>
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<tbody>
<tr>
<td>1 inch</td>
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<tr>
<td>¾ inch</td>
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<tr>
<td>½ inch</td>
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<td>Inch</td>
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<td>¼ inch</td>
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<td>No. 4</td>
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<td>No. 8</td>
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</tbody>
</table>
### 2.2 Flakiness Index

The flakiness index (F) is a measure of the percent, by weight, of flat particles. It is determined by testing a sample of the aggregate particles for their ability to fit through a slotted plate (Idaho IR-64-09).

### 2.3 Average Least Dimension

The Average Least Dimension, or ALD (H), is determined from the Median Particle Size and the Flakiness Index. It is a reduction of the Median Particle Size after accounting for flat particles. It represents the expected seal coat thickness in the wheel paths where traffic forces the aggregate particles to lie on their fattest side. The ALD is calculated as follows:

\[
H = \frac{M}{1.139285 + (0.011506)FI}
\]

Where:
- \(H\) = Average Least Dimension, inches
- \(M\) = Median Particle Size, inches
- \(FI\) = Flakiness Index, percent

### 2.4 Loose Unit Weight of the Cover Aggregate

The dry loose unit weight (W) is determined according to AASHTO T-19 and is needed to calculate the voids in the aggregate in a loose condition. The loose unit weight is used to calculate the air voids expected between the stones after initial rolling. It depends on the gradation, shape, and specific gravity of the aggregate.

### 2.5 Voids in the Loose Aggregate

The voids in the loose aggregate (V) approximate the voids present when the stones are dropped from the spreader onto the pavement. Generally, this value will be near 50 percent for one size of aggregate, less for graded aggregate. After initial rolling, the voids are assumed to be reduced to 30 percent and will reach a low of about 20 percent after sufficient traffic has oriented the stones on their fattest side. However, if there is very little traffic, the voids will remain 30 percent, and the seal will require more binder to ensure good aggregate retention. The following equation is used to calculate the voids in the loose aggregate:

\[
V = 1 - \frac{W}{(62.4G)}
\]

Where:
- \(V\) = Voids in the loose aggregate, in percent expressed as a decimal
- \(W\) = Loose unit weight of the cover aggregate, lbs/ft³
- \(G\) = Bulk specific gravity of the aggregate (AASHTO T 19).
2.6 Aggregate Absorption. Most aggregates absorb some of the binder applied to the roadway. The design procedure should be able to correct for this condition to ensure enough binder will remain on the pavement surface. McLeod suggests an absorption correction factor, \( A \) or 0.02 gal/SY if the aggregate absorption is around 2 percent (as determined from AASHTO T-84). In the Minnesota Seal Coat Handbook, it is recommended that a correction factor of 2 percent be used if the absorption is 1.5 percent or higher.

2.7 Traffic Volume. The traffic volume, in terms of vehicles per day, plays a role in determining the amount of asphalt binder needed to sufficiently embed the aggregate. Typically, the higher the traffic volume, the lower the binder application rate. At first glance, this may not seem correct. However, remember that traffic forces the aggregate particles to lie on their flattest side. If a roadway had no traffic, the particles would be lying in the same orientation as when they were first rolled during construction. As a result, they would stand taller and need more asphalt binder to achieve the ultimate 70 percent embedment. With enough traffic, the aggregate particles will be laying as flat as possible causing the seal coat to be as thin as possible. If this is not taken into account, the wheelpaths will likely bleed. The McLeod procedure uses Table 63-1 to estimate the required embedment, based on the number of vehicles per day on the roadway.

<table>
<thead>
<tr>
<th>Traffic Factor*</th>
<th>Traffic – Vehicles per day</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Under 100</td>
</tr>
<tr>
<td>0.85</td>
<td>0.75</td>
</tr>
</tbody>
</table>

*The percentage, expressed as a decimal, of the ultimate 20 percent void space in the aggregate to be filled with asphalt.

Note: The factors above do not make allowance for absorption by the road surface or by absorptive aggregate.

2.8 Traffic Whip-Off. The McLeod method also recognizes that some of the aggregate will get thrown to the side of the roadway by passing vehicles as the seal coat is curing. This loss is related to the speed and number of vehicles on the new seal coat. To account for this, a traffic whip-off factor (\( E \)) is included in the aggregate design equation. A reasonable value is to assume 5 percent for low volume, residential type and 10 percent for higher speed roadways. The traffic whip-off factor is shown in Table 63-2.

<table>
<thead>
<tr>
<th>Percentage Waste Allowed for Traffic Whip-Off and Handling</th>
<th>Wastage Factor, ( E )</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.01</td>
</tr>
<tr>
<td>2</td>
<td>1.02</td>
</tr>
<tr>
<td>3</td>
<td>1.03</td>
</tr>
<tr>
<td>4</td>
<td>1.04</td>
</tr>
</tbody>
</table>
### 2.9 Existing Pavement Condition

The condition of the existing pavement plays a major role in the amount of binder required to obtain proper embedment. A new smooth pavement with low air voids will not absorb much of the binder applied to it. Conversely, a dry porous and pocked pavement surface can absorb much of the applied binder. Failure to recognize when to increase or decrease binder application rate to account for the pavement condition can lead to excessive stone loss or bleeding. The McLeod method uses the descriptions and factors in Table 63-3 to add or reduce the amount of binder to apply in the field.

<table>
<thead>
<tr>
<th>Existing Pavement Texture</th>
<th>Correction, S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Black, flushed asphalt surface</td>
<td>-0.01 to 0.06</td>
</tr>
<tr>
<td>Smooth, nonporous surface</td>
<td>0.00</td>
</tr>
<tr>
<td>Slightly porous, oxidized surface</td>
<td>+ 0.03</td>
</tr>
<tr>
<td>Slightly pocked, porous, oxidized surface</td>
<td>+ 0.06</td>
</tr>
<tr>
<td>Badly pocked, porous, oxidized surface</td>
<td>+0.09</td>
</tr>
</tbody>
</table>

These surface conditions may vary throughout the project, and adjustments should be made accordingly.

### 3. McLeod Seal Coat Design Equations

The following equations are used to determine the aggregate and binder application rates. While the results may need adjustment in the field, especially the binder application rate, they have been shown to provide a close approximation of the correct material quantities.

#### 3.1 Aggregate Design Equation

The aggregate application rate is determined from the following equation:

**Equation 63-3**  
\[ C = 46.8 \times (1 - 0.4V) \text{ HGE} \]
Where:
C = Aggregate application rate, lbs/SY
V = Voids in the loose aggregate, in percent expressed as a decimal (Eq. 63-2)
H = Average least dimension, inches
G = Bulk specific gravity of the aggregate
E = Wastage factor for traffic whip-off (Table 63-2)

3.2 Binder Design Equation. The binder application rate is determined as follows:

\[ B = \frac{(2.244HTV + S + A)}{R} \]

Where:
B = Binder application rate, gal/SY
H = Average least dimension, inches
T = Traffic Correction Factor (based on vehicles per day, Table 63-1)
V = Voids in loose aggregate, percent expressed as decimal (Eq. 63-2)
S = Surface condition factor, gal/SY (based on existing surface, Table 63-3)
A = Aggregate absorption factor, gal/SY
R = Percent residual asphalt in the emulsion expressed as a decimal. Check with supplier to determine percent residual asphalt content of emulsion. For asphalt cement, R = 1.
Idaho Standard Practice for

Acceptance Test Strip for Hot Mix Asphalt (HMA) Pavement

IDAHO Designation: IR-125-16

1. SCOPE

1.1. This Standard Practice is used to:

1.1.1. obtain density gauge readings to establish density gauge correlation factors (State and Contractor)

1.1.2. obtain cores for determining the density gauge correlation factors

1.1.3. obtain loose mix samples for test strip acceptance testing (Contractor)

1.1.4. obtain cold feed aggregate samples for test strip acceptance testing (Contractor)

1.1.5. confirm the HMA can be compacted to the minimum of 92.0% but not in excess of 96.0% density

1.1.6. develop a roller pattern to achieve the specified density

1.2. This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. REFERENCE DOCUMENTS

2.1. AASHTO Standards

- FOP for T 168, Sampling Bituminous Paving Mixtures
- FOP for T 2, Sampling Aggregates
- FOP for T 343, Density of In-Place Hot Mix Asphalt (HMA) Pavement by Electronic Surface Contact Devices, Method C
- FOP for T 355, In-Place Density of Asphalt Mixtures by Nuclear Methods
- FOP for R 67, Sampling Asphalt Mixtures After Compaction (Obtaining Cores)

2.2. Standard Specifications, Subsection 405.03-A.

3. SUMMARY OF THE PRACTICE

3.1. This practice describes the testing and analysis needed to develop an Acceptance Test Strip to allow the Contractor to verify the mixture properties of the approved Job Mix Formula; establish density gauge correlation factors; develop a roller pattern that achieves the specified field density.
4. **APPARATUS**

4.1. **Sampling Device.**— As specified in FOP for AASHTO T 168.

4.2. **Density Gauge.**— With accessory equipment as specified in FOP for AASHTO T 355 or FOP for AASHTO T 343.

4.3. **Coring Equipment**— With accessories as specified in FOP for AASHTO R 67 for collecting six-inch diameter pavement cores.

4.4. **Measuring Device**— Approved measuring device capable of measuring test strip length.

5. **TERMINOLOGY**

5.1. **Acceptance Test Strip**— One or more Test Sections, the total length not less than 1,000 feet or more than 2500 feet. The Acceptance Test Strip shall be constructed to the same placement width and thickness as the course it represents. (Figure 1)

5.2. **Test Section**— a minimum of 500 feet (continuous) in length within the Acceptance Test Strip, constructed with a single asphalt binder content. A separate Test Section is required for each asphalt binder content used in the Acceptance Test Strip. (Figure 1)

5.3. **Roller Pass Density**— an uncorrected density reading determined using a density gauge in backscatter mode following a roller pass. The Roller Pass Density shall consist of one one-minute count with the density gauge placed parallel to the direction of travel. Filler material is not required and a core correlation will not be applied to these density readings.

5.4. **Maximum Roller Pass Density**— the uncorrected density reading following the roller pass which adds no more than 1/2 pound per cubic foot (8 kg/m³) to the previous density value. This shall be accomplished during the intermediate rolling. Sufficient roller passes shall be made to determine that a "false" break or leveling-off point is not used for the Maximum Roller Pass Density.

5.5. **Test Site Density**— the uncorrected density reading taken on the compacted pavement after finish rolling is complete at a Test Site for correlation to cores. It is obtained by using the test procedure specified in FOP for AASHTO T 355 or FOP for AASHTO T 343, without applying a gauge correlation factor. Filler material shall be applied as required in procedure before taking Test Site Density readings.

5.6. **Roller Pass**— the passing of the roller over an area (roller width) one time.

5.7. **Roller Coverage**— the rolling of the entire width of the pavement one time, including roller overlap.

5.7.1. **Breakdown Rolling**— constitutes the first roller coverage.

5.7.2. **Intermediate Rolling**— constitutes all rolling after the breakdown rolling and prior to the mix reaching the minimum temperature specified by the contract for such rolling.

5.7.3. **Finish Rolling**— constitutes the roller coverage, after intermediate rolling, required to bring the mix into a smooth, tight, hard surface without the presence of fatigue or cold-brittle cracking.

5.8. **Roller Pattern**— the number of roller passes necessary to achieve the specified density.
5.9.  *Stratified Random Sampling of HMA* — method used to ensure the specimens for the sample are obtained from throughout the Test Section, and are not concentrated in one portion of the Test Section. All sample locations will be determined by the Engineer using a random sampling system.

5.10. *Off Site JMF Verification* — off-project site location selected by the Contractor to verify aggregate and mixture parameter testing for contract requirements at a location and time agreed upon by the Engineer.

5.11. *Density Gauge Correlation Section for Off Site JMF Verification* — the first one-thousand feet of the first day’s paving used to determine the properties and density gauge correlation when an Off Site JMF Verification location is used. (Figure 2)

### 6. PROCEDURE

6.1. An Acceptance Test Strip shall be constructed after a uniform asphalt mix is being produced. The Acceptance Test Strip may be constructed using one or more Test Sections. The asphalt binder content of each Test Section must meet all specification requirements.

6.2. The Contractor shall obtain cold feed aggregate samples in accordance with the Specifications. Sampling will be determined by the Engineer using a random sampling system.

6.3. The Contractor shall obtain three loose mix samples from each Test Section in accordance with the specifications. Each Test Section will be divided into 3 segments of equal length and a loose mix sample will be obtained randomly from each segment by the contractor for acceptance testing. Exclude the first and last 30 feet of each section when selecting sample locations. (See Figure 1)

6.4. Each test section will be divided into 5 segments of equal length and test sites for cores and density reading will be obtained randomly from each segment. A minimum of five cores will be required to correlate the density gauges for a test strip. (See FOP for AASHTO T 355 or FOP for AASHTO T 343).

6.5. Standardize the density gauge. Refer to FOP for AASHTO T 355 or FOP for AASHTO T 343.

6.6. The Contractor shall compact each Test Section and record Roller Pass Densities in at least one location within each Test Section but no less than two per Test Strip. When density gauge readings indicate the Maximum Roller Pass Density has been achieved in a Test Section, compaction shall proceed in turn to each of the remaining Test Sections, if applicable, in the Acceptance Test Strip.

6.7. The Contractor shall record the temperature of the pavement following each roller pass on ITD Form ITD 891 to monitor the drop in mix temperature as rolling progresses in at least one location within each Test Section. Temperature readings shall be taken at the mid-point of the depth of pavement being tested.

6.8. Upon completion of all Test Sections in the Acceptance Test Strip, Test Site Densities (Subsection 5.5) shall be taken for each gauge to be used on the project for Quality Control or Acceptance Testing to determine a correlation factor according to FOP for AASHTO T 355 or FOP for AASHTO T 343. Form ITD-820 will be used by the Contractor and ITD project personnel to record the Test Site Densities for each gauge at each Test Site in each Test Section.

6.8.1. A correlation factor is valid only for the particular gauge, gauge thickness settings, gauge mode setting and at the probe depth used in the correlation procedure. Multiple gauges may be correlated from the same series of cores if done at the same time. (See FOP for AASHTO T 355 or FOP for AASHTO T 343)
6.8.2. Additional core correlation factors may be required to adjust for changes in the HMA pavement.

6.8.3. Re-correlation of the gauges is necessary on each lift of pavement.

6.9. After the pavement has cooled sufficiently to avoid deformation during coring, the Contractor shall obtain one core at each Test Site in accordance with FOP for AASHTO R 67. Pavement cores shall meet the criteria under the Correlation section of AASHTO T 355 or FOP for AASHTO T 343.

6.10. Off-Site JMF Verification. The Contractor, at no cost to the State, may elect to perform off-site Job Mix Formula Verification testing for contract requirements at a location and time agreed upon by the Engineer. Off-Site JMF Verification must occur within 14 calendar days prior to the anticipated start of production paving.

6.10.1. The Off-Site JMF Verification Section will verify aggregate and mixture parameters only (Subsection 6.1-6.3). All other properties will be determined during a Density Gauge Correlation Section placed on the prepared surface of the project.

6.10.2. The Density Gauge Correlation Section shall follow the procedure outlined in Subsection 6.8 to 6.9 and Figure 2. Break-over patterns, density gauge correlation factors, density acceptance of the placement, and Contractor’s workmanship will be verified during the Density Gauge Correlation Section. The Density Gauge Correlation Section shall be the first 1000 feet of the first day’s production.

6.10.3. The Maximum Theoretical Specific Gravity, $G_{max}$ used in the density determination will be determined from the State’s two Verification Tests on the first day’s paving plus one additional random sample.

6.10.4. The Contractor may continue production paving after completing the Density Gauge Correlation Section. The first day’s production paving is the first lot and subject to statistical analysis. Pavement placed in the Density Gauge Correlation Section may be tested for volumetric properties.

6.10.5. Materials from Department controlled sources cannot be used for Off-Site JMF Verification. The Off-Site JMF Verification location shall be accessible to ITD personnel at all times. If other than ITD property is used, written permission from the property owner shall be given for ITD employees to observe the work.

7. REPORT

7.1. The Contractor shall record the location, the number of roller passes, the corresponding Roller Pass Density reading, and pavement temperature following each roller pass in at least one location in each Test Section. This information shall be recorded on Form ITD-891 (Figure 2).

7.2. The Contractor shall plot Roller Pass Density readings and temperatures vs. roller passes on Form ITD-891 concurrently with the rolling. A copy of each completed Form ITD-891 shall be furnished to the Engineer upon completion of finishrolling.

7.2.1. From the cores, the Engineer will determine the density gauge correlation factors for each State gauge and core densities, percent compaction for each Test Section. Laboratory core test results will be provided to the Contractor prior to the startup of production paving for correlation of Contractor gauges. Density gauge correlation data shall be recorded on Form ITD-820 for each gauge.
<table>
<thead>
<tr>
<th>L'</th>
<th>X</th>
<th>N*</th>
<th>*</th>
<th>M</th>
<th>□</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Section Length (see 4.1 &amp; 4.2)</td>
<td>Number of Roller Passes (see 4.7)</td>
<td>Location of Density Gauge reading (test site) (see 5 Procedure)</td>
<td>Location of Core (see 5 Procedure)</td>
<td>Mix sample location (see 5 Procedure)</td>
<td>Avoid taking samples in these areas.</td>
</tr>
</tbody>
</table>

![Acceptance Test Strip](image)

Take mix samples at three stratified random locations. Take one core sample from random test sites selected in each of five stratified segments of the Acceptance Test Strip. The Contractor shall obtain three mix samples and five core samples. Exclude the first and last 30' sections from the generation of the stratified sections.

**Figure 1: Acceptance Test Strip.**

<table>
<thead>
<tr>
<th>X</th>
<th>N*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of roller passes (See 4.7)</td>
<td>Location of Core and Density Reading (Test Site) (See 5.10)</td>
</tr>
</tbody>
</table>

![Density Gauge Correlation Section](image)

The Contractor shall obtain one core sample from random test sites selected in each of five stratified segments of the Density Gauge Correlation Section.

**Figure 2: Density Gauge Correlation Section.**
# Plant Mix Pavement Test Strip Density Worksheet

<table>
<thead>
<tr>
<th>Key Number</th>
<th>Project Number and Name</th>
<th>Acceptance Test Strip Number</th>
<th>Date</th>
<th>District Number</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Contract Item Number</th>
<th>Contract Item</th>
<th>Aggregate Source Number</th>
<th>Depth</th>
<th>Width</th>
<th>Course</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Gage Make</th>
<th>Model</th>
<th>Serial Number</th>
<th>Maximum Theoretical Density</th>
<th>lb/ft³ from mix design at test section intended asphalt content</th>
<th>%</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Location</th>
<th>Offset</th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>Uncorrected Wet Density lb/ft³</td>
<td>Mix Temp °F</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
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<td>5</td>
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<td>6</td>
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<tr>
<td>9</td>
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<tr>
<td>10</td>
<td></td>
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<td></td>
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</tbody>
</table>

## Remarks

<table>
<thead>
<tr>
<th>Tester's Name</th>
<th>WAQTC No.</th>
<th>ITD Inspector's Name</th>
</tr>
</thead>
</table>

Distribution: White (Original) – Tester  Pink/Yellow (2 copies) – Engineer

Page _____ of _____
Idaho Standard Method of Test for

Sampling and Viscosity Testing of Emulsified Asphalt Binders in the Field

IDAHO Designation: IT-61-08

1. SCOPE

1.1. This method covers field sampling and field testing of emulsified asphalt binders used for seal coats. Testing is performed using the Saybolt Furol Viscometer.

1.2. This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. REFERENCE DOCUMENTS

2.1. AASHTO Standards

- R 66, Sampling Bituminous Materials
- T 72, Saybolt Viscosity
- T 59, Testing Emulsified Asphalts (“Consistency” – “Viscosity”, Sections 34-38)

3. APPARATUS

3.1. Saybolt Furol Viscometer with Bath, conforming to the requirements of T 72 with an oil or water bath capable of maintaining the required testing temperature.

3.2. Receiving Flask - see Figure# 1

3.3. Sieve – No. 20 (850 μm) sieve or a 20-mesh strainer of wire cloth framed or unframed.

3.4. Thermometers – ASTM No. 19°F or 19°C for tests at 122°F (50°C) conforming to the requirements of ASTM No. E1.

3.5. Thief Sampling Device – Capable of obtaining a sample from mid-depth of tanker/ tank.

3.6. Timer – Capable of measuring to the nearest 0.1 second.

3.7. Sample Can - 1-quart (1 liter) small-mouth


3.9. Sample bottle - 8 fl. oz. (265 mL) plastic dairy bottle

3.10. Sample bottle Stopper- with an opening to insert a dial thermometer through it and sized to fit the opening in the dairy bottle
Figure 1: Receiving Flask
Figure 2: Thief Sampling Device (Dip Method Device)
4. **SAMPLING**

4.1. The emulsified asphalt binder sample may be obtained by either of two methods. These methods are covered in R 66 but will also be covered here. They are; the “Valve method” and “Thief Method.” Samples shall be obtained before any material is unloaded.

**Note 1**— A safe means of sampling shall be provided by the contractor / supplier. With the “Thief method” proper fall protection must be provided.

4.1.1. Valve Method: A recommended design for the valve is shown in R 66.

4.1.1.1. In order to clear the line, draw and discard 4 L (1 gal) of emulsified Asphalt using a valve located in the center of the tank.

4.1.1.2. After clearing the line, immediately draw the emulsified Asphalt sample into a largemouthed 1 L (1 quart) plastic jar.

4.1.2. Thief Method (Dip Method): This method shall only be used when a truck tanker or distributor does not have a valve available to obtain the sample.

4.1.2.1. Attach the 1 L (1 quart) can at the bottom of the Thief device (see figure #2). Stopper the can with a #7 or #7-1/2 rubber stopper. The stopper shall have a way to remove it from the can once the can has been submerged on the thief device.

**Note 2**— Before sampling, a careful observation of the material shall be made to detect the presence of foam or free water on top of the load. Care should be taken to immerse sampling device deep enough to pass through any foam or free water that may exist on top of material.

4.1.2.2. Lower the attached stoppered 1 L (1 quart) can to mid-depth of the tanker/tank.

4.1.2.3. Pull the stopper from the can. Allow the can to fill.

4.1.2.4. Withdraw the Thief device along with the sample and sample can from the tanker/tank.

4.2. Immediately transfer approximately 204 mL (6 to 7 oz.) of emulsified asphalt into a 265 mL (8 fl. oz) plastic dairy bottle. Seal the container securely to eliminate the chance of evaporation of water in the sample with a rubber stopper having a small dial thermometer through its center.

**Note 3**— It is recommended that while the sample is cooling for testing clean the thief device and can stopper.

5. **TESTING**

5.1. Preheat the Sabolt Furol Viscometer bath to testing temperature 50 ± 0.05°C (122 ± 0.9°F).

5.2. Insure that the brass viscometer tube is clean and dry and that the cork inserted into the bottom of the tube.

5.3. Cool the emulsified asphalt sample to 51.7 ± 0.3°C (125 ± 0.5°F).

**Note 4**— The bottom of the sealed plastic bottle containing the emulsified asphalt sample may be immersed into a cold-water bath to cool it more quickly. Insure that thermometer is not touching the bottom of the bottle.
5.4. Once cooled, immediately pour the emulsified asphalt through a No. 20 (850 mm) sieve and into the brass viscometer tube until the sample is above the overflow rim.

5.5. Stir the emulsified asphalt sample in the brass viscometer tube at 60 RPM with a thermometer until it is at a temperature of 50°C ± 0.3°C (122°F ± 0.5°F). Avoid bubble formation while stirring. Once the test temperature is attained, withdraw the thermometer.

5.6. Place the tip of a suction pipette into the viscometer tube gallery. The gallery is the area where the overflow is contained. Quickly remove the excess emulsified asphalt from the gallery until the level in the gallery is below the overflow rim. Remove the pipette without touching the overflow rim.

5.7. Immediately cover the top of the viscometer tube.

5.8. Place the receiving flask in the proper position under the viscometer tube. Proper placement will insure that the sample will roll down the inside lip of the receiving flask.

5.9. Remove the cork from the viscometer tube and immediately start the timer.

5.10. Stop the timer when the emulsified asphalt meniscus bottom reaches the graduation mark.

5.11. Clean the viscometer tube, screen, cork, thermometer, and receiving flask.

5.12. If the initial tanker/tank sample fails to meet specified limits, a second sample will be obtained using the “Thief Method.” When the test results on the second sample also fail to meet specifications the tanker/tank will be rejected.

6. **REPORT**

6.1. Record the results to the nearest 1 second.

6.2. Results shall be reported on an ITD-1045, Sample Data Sheet Emulsified Asphalt and Cutbacks.
## QUALIFICATION CHECKLIST
### FIELD VISCOSITY – IDAHO IT 61

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

**Procedure Element**

**Sampling**

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Sample taken using a valve:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Minimum of 4 L (1 gal) allowed to flow before sample taken?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Sample taken in clean 1 L (1 quart) wide mouth jar?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Sample taken with Thief device.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Sample can immersed approximately to middle of tanker?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Rubber stopper removed from can and sample taken from the middle of the tanker / tank?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. A portion of the sample transferred to a one (1) half pint plastic bottle and sealed with a stopper having a thermometer in the center?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Equipment**

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. Temperature of the viscometer bath at 50ºC (122ºF)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Viscosity tube clean and dry and cork installed?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Testing**

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>6. Sample cooled to 51.7 ±0.3°C (125 ±0.5°F)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Sample poured through a #20 sieve prior to entering the brass viscosity tube?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Enough sample poured into the tube to allow overflow into gallery?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Thermometer placed into tube and sample stirred slowly until testing temperature reached?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Thermometer withdrawn and excess in the overflow gallery siphoned out using a pipette without touching overflow rim?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Emulsified asphalt sample in viscometer immediately covered?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Cork pulled allowing the sample roll down the inside lip of the receiving flask?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Timer immediately started when cork is pulled?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. Timer stopped when bottom of sample meniscus reaches graduation mark?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. Test results reported to nearest 1 second on ITD-1045 form?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**First Attempt:** Pass ☐ Fail ☐ **Second Attempt:** Pass ☐ Fail ☐

Comments: ________________________________________________________________

Participant Name ___________________________ Exam Date _______ WAQTC# _________

Examiner’s Name: __________________________ Signature _________________________

WAQTC #: ______________
Idaho Standard Method of Test for

Detection of Anti-Stripping Additive in Asphalt Binder

IDAHO Designation: IT-99-17

1. SCOPE

1.1. This method covers field procedures for verifying the presence of amine based anti-stripping additives in asphalt binder. This test is qualitative only and does not indicate percentage of anti-strip.

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

2. SUMMARY AND SIGNIFICANCE OF METHOD

2.1. A small amount of asphalt is heated in a solution of Isopropyl Alcohol. The decanted alcohol is tested with an indicator solution of Bromophenol Blue. A visual color change indicates the presence of amine based anti-stripping additives.

3. REFERENCE DOCUMENTS


4. APPARATUS

4.1. Hotplate

4.2. 50 ml Repipet fitted for a 4L Bottle, or a 50 ml Graduated Cylinder

4.3. Glass beakers of approximately 50 ml capacity and disposable aluminum cups of approximately 120 ml capacity.

4.4. Glass stirring rods or new disposable wooden stirring sticks approximately 6 inches long

5. REAGENTS AND SOLUTIONS

5.1. Reagent Grade Isopropyl Alcohol (minimum 99.7% water free.)

Warning - Isopropyl Alcohol is a flammable solvent and should not be used around any open flame.

USE THE ISOPROPYL ALCOHOL DIRECTLY FROM ITS ORIGINAL BOTTLE.

5.2. Bromophenol Blue, Certified ACS Grade
5.3. The bromophenol blue indicator shall be prepared to a concentration of 0.2% (wt/vol) in reagent grade isopropyl alcohol. The indicator, a flammable solution, should be a clear, orange color and not more than two years old. The indicator solution can be obtained from the Central Laboratory.

6. **SAMPLES**

6.1. The asphalt binder test sample should be taken in accordance with the sampling methods described in AASHTO R 66. Allow the sample to soak for one minute from the introduction of wash water into the vessel or jar.

7. **PREPARATION OF TEST SAMPLE**

7.1. Heat the sample of asphalt binder with care to prevent local overheating until it has become sufficiently fluid to pour. Occasionally stir the sample to aid in heating and assure uniformity. Maximum temperature should not exceed 325°F.

**Note 1:** Keep any water source or steam away from the testing area, water/water vapor will alter the test results.

8. **PROCEDURE**

8.1. **Control Blank**

8.1.1. Add 40 ml of Reagent Grade Isopropyl Alcohol into a 50 ml glass beaker or a 120 ml aluminum cup.

8.1.2. Warm the beaker and alcohol control blank on a hotplate until small boiling bubbles appear.

8.1.3. Remove beaker and alcohol from the hot plate and add 5 drops of the Bromophenol Blue Indicator solution and stir with a glass rod or wooden stick. A definite yellow color should appear. In some cases, additional drops may need to be added to achieve the yellow color. The same number of additional drops added to achieve the yellow color in the control blank must be added to the test sample to normalize the visual standard comparison.

8.1.4. A Control Blank color other than yellow indicates a contaminated blank. First verify that the alcohol is not contaminated by testing the alcohol again in different cleaned glassware. If contamination of the alcohol is verified obtain new alcohol. Provided the alcohol is acceptable, clean all testing equipment with the verified Isopropyl Alcohol again prior to testing. Replace alcohol and clean equipment as necessary until the control blank is successfully established.

8.2. **Test Sample**

8.2.1. Place approximately 1 g of well mixed asphalt binder to be tested into a 120 ml aluminum cup.

8.2.2. Add 40 ml of Reagent Grade Isopropyl Alcohol to the beaker or cup.

**Note 2—** 1 g of asphalt binder is about the size of a quarter and can be placed in the container with a glass rod or a wooden stick.

8.2.3. Warm the test sample, stirring occasionally, until the liquid portion becomes approximately the same shade of yellow as the Control Blank. Do not allow the sample to become too dark since this will interfere with the color interpretation.

8.2.4. Immediately pour the liquid portion of the mixture into a clean 50 ml glass beaker and add the same number of drops of Bromophenol Blue Indicator as was added to the Control Blank and stir.
8.2.5. Allow the sample to develop for 5 minutes before determining the color. The presence of an amine based anti-stripping additive is verified when the test solution turns green to blue and will be reported as “Positive”. Any other color shall be reported as “Negative”.

8.2.6. A negative IT-99 test result can be validated for sufficient anti-strip presence using IT-137 “Effectiveness of Anti-Strip Agents After Hot Storage In Asphalt Binder – Using Bottle and Sand” (excluding the 96 hr cure time). Validation testing for acceptance will be performed at the Central Laboratory.

8.2.7. Properly discard the liquid (alcohol and indicator) used for the Control Blank and the test sample.

9. REPORT

9.1. Report green to blue color as positive; report any other color as negative.
QUALIFICATIONCHECKLIST

DETECTIONOFANTI-STRIPADDITIVEINASPHALT-IDAHOIT-99

Record the symbols "P" for passing or "F" for failing on each step of the checklist.

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>General</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. All containers and or stir sticks were clean and chemical solutions were fresh.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Detection test by Color Method only</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. A control blank was performed.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. 40ml of Reagent Isopropyl Alcohol or equivalent was used.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. The asphalt mixture was heated on a hotplate.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Heating of sample was stopped before mixture became too dark.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. The same amount of Bromophenol Blue Indicator was added to both mixtures.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Test results were accurately interpreted and recorded on the proper ITD form. (Blue color as positive; report any other color change as negative).</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comments: First Attempt: Pass [ ] Fail [ ] Second Attempt: Pass [ ] Fail [ ]

Testing Technician's Name: __________________________ WAQTC # : _______ Date: _______

Examiner's Name: __________________________ Signature __________________________
Idaho Standard Method of Test for

Effectiveness of Anti-Strip Agents After Hot Storage in Asphalt Binder Using Bottle and Sand

IDAHO Designation: IT-137-17

1. SCOPE

1.1. This procedure provides results for anti-strip agent effectiveness in asphalt binder after hot storage.

1.2. This method is applicable on asphalt binders that become liquid at temperatures above 100°F.

1.3. This method is for acceptance of amine based anti-strip additives.

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

2. SUMMARY AND SIGNIFICANCE OF METHOD

2.1. This test will confirm the presence of anti-strip agents to withstand hot storage without conducting the immersion compression testing. The test results from this method and the IT-99 test method will confirm the effective presence of anti-strip additive in received and stored asphaltic binders.

2.2. Approval will be based on a concentration of 0.5 % (wt/wt) anti-strip to asphalt binder.

3. REFERENCE DOCUMENTS

3.1. AASHTO Standards

- M 231, Weighing Devices Used in the Testing of Materials

3.2. ASTM Standards

- C778, Standard Specification for Standard Sand
- D1193, Standard Specification for Reagent Water

3.3. Idaho Test Methods

- IT-99, Detection of Anti-Stripping Additive in Asphalt Binder

3.4. Standard Specifications for Highway Construction

- Subsection 702.04.
4. **REAGENTS AND MATERIALS**


4.2. *Distilled Water*—ASTM D1193, Type I.

4.3. *Toluene*—Technical Grade

4.4. Asphalt binder

4.5. Anti-strip Additive

5. **APPARATUS**

5.1. Oven capable of maintaining a temperature of 325°F ± 5°F

5.2. A new one quart metal can, dimension: L= 4.625” W= 2.375” H= 7.25” with opening of 1.75”. There shall be a tightly fitting screw top lid with an air hole 0.25” in diameter punched in it.

5.3. White Paper towels

5.4. Spatula, glass stir rod, new disposable wooden stick or other utensil for mixing purposes

5.5. Plastic bottles with snap top cap, approximately 2 oz. (60 ml) capacity (Polystyrene containers: 15 dram, I.D. 32 mm X H 64 mm)

5.6. Tinfoil cup of approximately 4 fl. oz. (115 ml) capacity

5.7. Balance conforming to AASHTO M 231 Class G 2.

6. **PROCEDURE**

6.1. Heat the sample of asphalt binder until it has become sufficiently fluid to pour. Take care to prevent local overheating. Occasionally stir the binder to aid heat transfer and assure uniformity. The maximum temperature shall not exceed 330°F.

6.2. Heat the anti-strip additive, do not exceed 100°F or manufacturers recommended temperature and mix thoroughly.

6.3. Place 796 ± 1.0 g of asphalt binder into the one-quart metal can container.

6.4. Add 4 ± 0.1 g of anti-strip additive and mix thoroughly.

6.5. Place the lid (with air hole) tightly on the container and place the sample in a preconditioned oven at 325 ± 5°F for 96 hours.

6.6. Remove the sample from the oven and stir.

6.7. Pour 25 ± 1.0 g of the binder and additive mixture into the 4 oz. tin container. Allow the liquid to cool to below 140°F but still remaining mixable.

6.8. Carefully add 4.5 ± 0.1 g of toluene and mix thoroughly.

**Note 1**—Polymerized asphalts may require additional toluene to thin the mixture.
**Warning**— Be sure that the asphalt binder has cooled to less than 140°F before the toluene is added. The solvent will still vaporize rapidly at this temperature, so this step should be performed under ventilation. No open flames or smoking can be permitted near the mixing operation.

6.9. Place 20 ± 1 g of Ottawa sand in the 2 oz. (60 ml) plastic bottle.

6.10. Add distilled water sufficient to cover the sand to a depth of approximately 1/2 inch above the surface of the sand in the bottle.

**Note 2**— Approximately 16 ml if using the 15 dram container

6.11. Add 1 ± 0.2 g of the asphalt/toluene mix liquid by dripping it from a spatula onto the surface of the water in the bottle.

6.12. Attach the top cap on the bottle and shake vigorously for 15 seconds.

6.13. Remove the top cap and pour off excess water and solvent.

**Note 3**— The water solvent mixture contains toluene which is a hazardous waste.

6.14. Gently tap the asphaltic wet sand onto a white paper towel, spread into a thin layer (not in a cone-shaped mound), and visually inspect the coating of the sand.

**Note 4**— Validation testing for acceptance of anti-strip when a field test result for IT-99 is Negative- The sample that was negative for IT-99 shall be heated until the material is pourable. Then follow the procedures from 6.6 through 6.14.

7. REPORT

7.1. Anti-stripping additive is effective after hot storage provided the wet sand and asphalt mixture combine into a homogeneous well-coated mixture having a uniform asphaltic color. Report the test results as "Positive." See Figure 1.

7.2. Anti-stripping additive is not effective after hot storage provided the wet sand and asphalt mixture is not homogeneous and well coated, globules of asphalt are apparent, and the mass is distinctly non-uniform in appearance. Report the test result as "Negative." See Figure 2.
Figure 1: Passing test result.

Figure 2: Negative test result.
Idaho Standard Method of Test for

DETERMINATION OF RECLAIMED ASPHALT PAVEMENT (RAP) AGGREGATE BULK (DRY) SPECIFIC GRAVITY (G_{sb})

IDAHO Designation: IT-146-16

1. SCOPE

1.1. This method covers the procedure for determining the Bulk (Dry) Aggregate Specific Gravity, (G_{sb}) of a Recycled Asphalt Pavement, (RAP) aggregate from Maximum Theoretical Specific Gravity (G_{mm}) tests of the RAP. An Effective Specific Gravity of Aggregate, (G_{se}) is calculated and used to determine the G_{sb} of the RAP after adjusting the G_{se} for asphalt absorption.

1.2. This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. REFERENCE DOCUMENTS

2.1 AASHTO Standards

- M 231, Weighing Devices Used in the Testing of Materials
- R 76, Reducing Samples of Aggregate to Testing Size
- T 2, Sampling Aggregates
- T 85, Specific Gravity and Absorption of Coarse Aggregate
- T 209, Theoretical Maximum Specific Gravity (G_{mm}) and Density of Hot Mix Asphalt (HMA)
- T 308, Determining the Asphalt Binder Content of Hot Mix Asphalt (HMA) by the Ignition Method

2.2 Idaho Standards

- IT-144, Specific Gravity and Absorption of Fine Aggregate Using Automatic Vacuum Sealing (CoreLok) Method

2.3 Other Documents:


2.4. Standard Specifications, Subsection 720.07.
3. SUMMARY OF METHOD

3.1. A representative RAP sample is prepared prior to testing by reheating and remixing the reclaimed material. Determine binder content and gradation, per FOP for AASHTO T 308, and apply the chemical extraction/ignition furnace correlation factor to the result. Perform a minimum of two maximum theoretical specific gravity (G_{mm}) tests so that an effective specific gravity (G_{se}) can be calculated. Use the calculated \( G_{se} \) value and the assumed asphalt binder absorption of the RAP to determine the bulk (dry) specific gravity (G_{sb}) of the RAP.

4. APPARATUS

4.1. *Drying Oven.* Oven of sufficient capacity for containing the sample and capable of maintaining a temperature of 230 ± 9°F.

4.2. *Balance.* Of sufficient capacity and conform to the requirements of M 231, Class G2.

4.3. *Sample Pans.* Large, flat and capable of holding 20,000 grams of RAP material.

4.4. *Chopping Utensil* – Blade trowel or other utensil used to separate the large conglomerations of a RAP sample into a loose-flowing condition.

4.5. *Vacuum Setup* – Associated with T 209

5. SAMPLING

5.1. Sample the RAP stockpile, in its final usable form, by obtaining a minimum of six representative locations from the RAP stockpile. Obtain 22 lb (10,000 grams) of RAP from each location. Thoroughly blend all the samples and reduce per R 76 to produce a 20,000-gram sample.

Note 1—NCHRP Report 673 includes a recommended RAP Sampling Plan in Chapter 9.

6. PREPARATION OF SAMPLE

6.1. Place the entire 20,000-gram sample into a large flat pan(s).

6.1.1. Place sample into a preheated oven at 230 ± 9°F. and heat for 30 to 45 minutes.

6.1.2. Remove the sample from the oven and begin breaking up the larger conglomerations of RAP with the chopping utensil.

6.1.3. Blend the heated RAP by mixing the freshly chopped material with the fines in the pan, as the material begins to soften.

6.1.4. Return the RAP into the oven and continue heating for another 15 - 20 minutes.

6.1.5. Remove the RAP from the oven and repeat the chopping of the conglomerations and blending of the fines until the RAP sample is homogeneous and conglomerations of fine aggregate complies with T 209.

6.1.6. Thoroughly blend the loose RAP sample and reduce to testing size per R 76. Testing sizes are stated in Section 7.
7. **PROCEDURE**

7.1. **Percent Asphalt Binder, $P_b$ using Chemical Extraction/Ignition Furnace Correlation Factor:**

7.1.1. Determine the $P_b$ of two dried RAP increments according to T 308. Calculate the uncorrected asphalt content of the two increments and if the difference exceeds 0.2 perform another pair of T 308 tests. Throw out the high and low values, and average the two remaining results.

7.1.2. Compare the average uncorrected asphalt binder content with the Contractor’s average uncorrected binder content value from Form ITD 1044 or Mix Design. If the algebraic difference exceeds 0.33 request new samples from the Contractor and repeat steps 5.1 through 7.1, otherwise accept the Contractor’s asphalt binder correlation factor (from the average of 6 chemical and 6 ignition furnace tests).

7.1.3. Calculate the RAP asphalt binder content using the average uncorrected T 308 results from step 7.1.1 and apply the Contractor furnished asphalt binder correlation.

7.1.4. Record the $P_b$ and the aggregate gradation.

7.2. **Maximum Specific Gravity determination, $G_{mm}$:**

7.2.1. Split out a minimum of three increments of the prepared RAP sample according to the mass requirements of T 209.

7.2.2. Dry the sample to a constant mass in an oven at 230 ±9° F. While drying, chop and break up the sample as you would with a standard $G_{mm}$ sample. Record as “dry RAP mass”.

7.2.3. Place the sample in 295° ± 5° F. oven for one hour.

7.2.4. Add 2 percent virgin asphalt binder (for example PG 64-28 or PG 58-28) at 295° ± 5° F. based on the “dry RAP mass” from step 7.2.2, to the RAP and thoroughly mix at 295° ± 5° F. to ensure uniform coating of all particles.

**Note 1**—In some instances, more than 2% additional virgin binder may be required to ensure complete coating.

7.2.5. Determine the $G_{mm}$ of two of the prepared RAP samples according to T 209 and keep the remaining sample(s) in reserve.

7.2.6. Calculate the individual $G_{mm}$ values. The average result will be used in the calculation provided the individual results do not vary by more than 0.010. If the individual results vary more than 0.010, repeat steps in 7.2., discard the high and low values and average the remaining individual results provided they do not vary more than 0.010. If remaining individual results vary more than 0.010 repeat steps in 7.2. until individual results compare within 0.010.

7.2.7. Estimate the asphalt binder absorption of the RAP, $P_{ba}$ from the water absorption of virgin aggregates used in the project.

8. **CALCULATIONS**

8.1. Calculate the “adjusted $P_b$” of the RAP to account for the addition of the 2 percent virgin asphalt binder as follows:

8.1.1. Calculate “mass of RAP Asphalt Cement (AC)”. 

---

Idaho Standards

Section 520

1/16

Idaho IT-146
8.1.1. Mass of RAP AC = Dry RAP mass \times P_b

8.1.2. Calculate “mass of virgin AC added”

8.1.2.1. Mass of virgin AC added = 0.02 \times \text{Dry RAP mass}

8.1.3. Determine “New RAP mass”:

8.1.3.1. New RAP mass = \text{Dry RAP mass} + \text{Mass of virgin AC added}

8.1.4. Calculate “Adjusted \(P_b\)”:

\[\frac{\text{Mass of RAP AC}}{\text{New RAP mass}} \times 100\]

8.2. Assume the Specific Gravity of Binder, \(G_b\). Use 1.040.

8.3. Calculate the effective specific gravity \((G_{se})\) of the RAP:

\[G_{se} = \frac{(100 - \frac{\text{Mass of virgin AC added}}{\text{New RAP mass}}) \times 100 - \text{Adjusted } P_b}{G_{me}}\]

8.4. Estimate or assume the asphalt binder absorption of the RAP, \(P_{ba}\)

8.4.1. Asphalt absorption of RAP is assumed to be two-thirds of the water absorption of virgin aggregates used in the project.

8.4.2. Determine the water absorption values by T 85 and Idaho IT-144 and calculate the total water absorption for the virgin aggregate by proportionately combining the coarse and fine absorption by the percent of each aggregate.

8.4.3. Calculate \(P_{ba}\):

\[P_{ba} = \frac{\text{virgin aggregate water absorption}}{2} \times 0.667\]

8.5. Calculate the stone bulk gravity \((G_{sb})\) of the RAP:

\[G_{sb} = \frac{G_{me} \times P_{ba}}{100 + G_{me} \times P_{ba}}\]

9. **EXAMPLE**

9.1. Example with 2\% virgin asphalt binder added:

9.1.1. \text{Dry RAP mass} = 3,000 \text{ g}

9.1.2. \(P_b\) (\% AC) in RAP = 4.9\%

9.2. Determine “mass of RAP AC”:

9.2.1. Mass of RAP AC = \text{Dry RAP mass} \times P_b

\[= 3,000 \times 4.9\% = 147 \text{ grams}\]
9.3. Add 2 percent virgin AC:

9.3.1. Determine “mass of virgin AC added”:
Mass of virgin AC added = 0.02 x Dry RAP mass
= 0.02 x 3,000 grams
= 60 grams

9.3.2. Determine “New RAP mass”
New RAP mass = Dry RAP mass + Mass of virgin AC added
= 3,000 + 60
= 3,060 grams

9.4. Calculate “Adjusted P_b”:
\[
P_{b,\text{adj}} = \frac{MMMAAA00000 RAPP AAAA + MMMAAA0000o VViiiiiiiiii AAAA}{NAAAANRRAPP MMMAAA} \times 100
\]
\[
= \frac{147 iiiiii ggl + 60 iiiiii ggl}{3,060 iiiiii ggl} \times 100
\]
= 6.8%

9.5. Calculate G_se:
\[
G_{se}(R MMM) = \frac{(100 - P_{b,\text{adj}})}{100 - P_{b,\text{adj}} + 1.040}
\]

Adjusted P_b = 6.8%
Rice Test, G_{mm} = 2.455
\[
G_{se}(RRRRR) = \frac{(100 - 6.8)}{2.455 - 1.040}
\]
\[
= \frac{93.2}{(40.73 - 6.54)}
\]
= 2.726

9.6. Calculate P_{ba} from water absorption of the virgin aggregate:
Water Absorption = 1.2%
\[
P_{ba} = 1.2 \times 0.667
\]
= 0.80% asphalt absorption

9.7. Calculate RAP G_{ab}:
\[
G_{se}(R RRRR) = \frac{PP_{ab} G_{se}(RRRRR)}{100 \times G_{se}(RRRRR) + 1}
\]

G_{se}(RAP) = 2.726
P_{ba} = 0.80%
G_b = 1.040
\[
G_{se}(RRRRR) = \frac{2.726}{0.80 \times 2.726 + 1}
\]
\[
G_{se}(RRRRR) = 2.670
\]
Idaho Standard Practice for

Sampling Concrete for Chloride Analysis

IDAHO Designation: IR-128-17

1. SCOPE

1.1. This procedure explains methods to be used in sampling concrete for chloride analysis.

1.2. Follow the general guidelines in the Bridge Deck Evaluation and Test Procedure Guideline Manual and AASHTO T 260. Specific and special guidelines are described below.

1.3. *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. REFERENCE DOCUMENTS

2.1. AASHTO Standards

   - T 260, Sampling and Testing for Chloride Ion in Concrete and Concrete Raw Materials

3. GENERAL SAMPLING INFORMATION

3.1. Lay out the test area to be sampled for a minimum of one sample location per 1,000 square feet (100 square meters) and a minimum of three sample locations per deck. Samples should be taken at points of probable high concentration, i.e., curb lines and lower side of super-elevated decks. Samples should not be taken at points where delamination or spalling has occurred since corrosion is obvious at these locations. Spalling or delamination can be located by performing a chain drag evaluation of a bridge deck, which can be valuable if the deck is bare or has a single seal coat. A seal coat of plant mix may give inaccurate information from a chain drag evaluation since the asphalt attenuates the sounds.

3.2. The best way to identify chloride sample depths and locations is to refer to the bridge plans for descriptions of the rebar location and depth, span size, and number of spans. A pachometer can also be used to locate the rebar depths and locations.

4. SAMPLING PROCEDURES AND GUIDELINES

4.1. For sampling, a rotary hammer is recommended with a 1 inch by 12 inches (25 mm by 300 mm) carbide-tipped bit and various thin wall electrical conduit depth sleeves. Also needed for sampling are a sampling spoon or spatula, 20-dram plastic vials or other sample containers, nylon bristle brushes, paper towels, and 2-Propanol (Isopropyl alcohol). In addition, some means of a "blowout" bulb, a portable air compressor, or other device is needed to clean out the holes after each test depth has been drilled and sampled.
Illustration A: Electrical conduit pipe cut for use as depth sleeves; 2-Propanol and a nylon brush are used to clean between samples.

Illustration B: Portable Air Compressor for Cleaning Between Samples.
4.1.1. Samples are usually taken at three separate depths predetermined according to the depth of the rebar in the bridge deck. In addition, a sample taken at or just below the rebar can be informative for severe chloride penetration. The samples are taken at approximately even increments of 1/2 inch (15 mm). See Table 1 below.

<table>
<thead>
<tr>
<th>ENGLISH MEASUREMENT</th>
<th>METRIC MEASUREMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>From</td>
<td>To</td>
</tr>
<tr>
<td>1/4 inch</td>
<td>3/4 inch</td>
</tr>
<tr>
<td>3/4 inch</td>
<td>1 1/4 inch</td>
</tr>
<tr>
<td>1 1/4 inch</td>
<td>1 3/4 inch</td>
</tr>
<tr>
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Note—Millimeters (mm) are the metric sample depths and are based upon approximations of the English measurements.

4.2. Using the rotary hammer, scar the surface approximately 1/4 inch (6 mm) deep. This assures that the samples will be taken below the surface dirt and other possible sources of erroneously high salt content. Drill three holes within a 6-inch (150 mm) diameter to obtain enough sample from each sampling depth. See Illustration E below.
Illustration D: Rotary hammer for sampling concrete for chloride testing. Hammer with depth sleeve set 2 1/4 inches (65 mm) sample depth.

Illustration E: Illustration is not drawn to scale. Suggested sampling area for one chloride sample location. Large circle diameter 6 inches (150 mm). Drill hole diameter 1 inch (25 mm).
4.2.1. Blow out the hole and the surrounding area using an air compressor, blowout bulb, or some other means that is suitable. **Do not use alcohol to clean out the sample holes.** Clean sampling tools: rotary hammer drill bit, depth sleeve, spoon, etc., using a nylon brush, paper towels, and 2-Propanol (Isopropyl alcohol) between samples to assure no contamination between samples. The rotary hammer drill bit and depth sleeves must be completely dry before proceeding with the next sample.

4.2.2. Place the first depth sleeve on the drill bit and drill in the three established holes with the rotary hammer. See Illustration F below.

![Illustration F](image)

**Illustration F:** Rotary hammer with depth sleeve in place. Ready to drill sample. Clean drill bit, depth sleeve, and sampling spoon between sample depths with 2-Propanol.

4.2.3. Drill until the depth sleeve seats itself on the concrete surface. Pull out the drill bit and, using a sampling spoon, carefully gather the pulverized sample out of the three drilled holes. Collect the pulverized sample material carefully and completely. Approximately 15 grams (or a 20-gram vial 3/4 full) is needed for each sample depth. Label the sample container for location and depth. The resulting pulverized concrete represents the first sample depth. See Illustration G below.

4.2.4. Clean the sampling tools: Drill bit, depth sleeves, spoons, etc., using a nylon brush, paper towels, and 2-Propanol (Isopropyl alcohol) to assure no contamination between samples. Rotary hammer and depth indicators must be completely dry before proceeding with the next sample. Blow out the hole and the surrounding area using an air compressor, blowout bulb, or some other suitable means using air.

4.2.5. Place the next sleeve guide on the rotary hammer for the next sampling depth. Drill and pulverize the concrete until the depth sleeve again seats itself on the concrete.

4.3. Continue with steps 4.2.3 through 4.2.5 until all desired sample depths have been drilled and sampled.
4.4. Identify the sampling locations on the ITD-404 Standard Computation Sheet or ITD-2680 Standard Computation Sheet-Large or use a created map drawn to scale. Please include with the samples the completed ITD-1044 forms for the samples, identifying specific holes and depths, and a copy of the Bridge Deck Survey Map or created map with information about the areas of delamination.

Illustration G: An example of a pulverized chloride sample.

4.5. The test hole may be patched with suitable patching material such as Set-45 or mortar (a combination of cement and clean sand) if appropriate.
Idaho Standard Practice for

Field Sampling of Hydraulic Cement and Fly Ash

IDAHO Designation: IR-143-17

1. SCOPE

1.1. This method covers obtaining the required field samples of hydraulic cement and fly ash from bulk shipments by means of the ITD in-line sampler.

1.2. This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. APPARATUS

2.1. In-line sampler with couplers fitting a 4” line

2.2. 5” coupler adaptor

2.3. In-line sample container

2.4. Two 4” to 5” hose adaptors (1 female, 1 male)

2.5. Rubber mallet

2.6. 4” pipe brush

2.7. ½” pipe brush

2.8. Manual for assembly and cleaning of in-line sampler

Note 1—Refer to the Manual for details on assembly.

2.9. Pelican 1650 transport & storage case.

3. PROCEDURE

3.1. After the trailer has discharged for 5 to 10 minutes, have the truck depressurize and connect the sampler to the discharge tube on the trailer of the bulk truck and secure with the Kam-Loc levers.

3.1.1. Connect the rubber hose / line which feeds cement into the silo or bins to the sampler and secure with Kam-Loc levers.

3.1.2. Strike Kam-Loc levers with rubber hammer until connectors are secure.

Note 2—The ring on the lever must be toward the outside in order to open the lever.
3.2. Have the truck re-pressurize and continue to discharge for a minimum of 15 minutes.

3.3. Allow the truck to depressurize.

3.4. Remove sampler after the line has been depressurized.

3.5. Remove container portion of the sampler and pour sample into a suitable sample container.

3.6. Properly label sample container with a permanent marker and complete the ITD-1044 Sample Data form with a copy of the mill analysis certification attached.

3.7. The sampler must be thoroughly cleaned after each sample is taken by following the directions in the sampler manual.
Idaho Standard Method of Test for

Acid Soluble Chloride Content of Hardened Concrete by Gran Plot Method

IDAHO Designation: IT-131-17

1. SCOPE

1.1. This method describes the laboratory analysis of chloride ion in hardened concrete.

1.2. This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. REFERENCE DOCUMENTS

2.1. AASHTO Standards

- M231, Weighing Devices Used in the Testing of Materials
- T 260, Sampling and Testing for Chloride Ion in Concrete and Concrete Raw Materials

3. SUMMARY OF METHOD

3.1. Test according to T 260 "Sampling and Testing for Chloride Ion in Concrete and Concrete Raw Materials" using Procedure A for acid-soluble chloride ions and Method II: Gran Plot method for analysis.

3.2. A standard solution containing 1 milliliter of known concentration of chloride ion (1000 ppm) and a blank of distilled water are also tested for percent recovery and to obtain a high degree of precision.

4. APPARATUS

4.1. Equipment for Chemical Testing.

4.1.1. Chloride ion or silver/sulfide ion selective electrode and manufacturer-recommended filling solutions.

Note 1—Suggested electrodes are the Orion 96-17 or Orion 94-6 used with Orion 90-02 or equivalent.

4.1.2. A millivoltmeter compatible with the ion electrode.

Note 2—Suggested millivoltmeter is the Orion Model 901A Specific Ion meter or equivalent.

4.1.3. Magnetic stirrer and teflon stirring bars.
4.1.4. A 25 ml buret with 0.1 ml graduations.

4.1.5. Analytical Balance complying with M 231, Class A.


4.1.7. Hot plate, 250°C to 400°C heating surface temperature.

4.1.8. Glassware 150 and 250 ml beakers, filter funnels, stirring rods, watch glasses, dropper, Guth wash bottles.

4.1.9. Sieve, U.S. Standard No. 50 (0.300 mm).

4.1.10. Whatman No. 40 and No. 41 filter papers (or equivalent).

Note 3—If equivalent filter papers are used, they should be checked to confirm they do not contain chloride that will contaminate the sample.

5. **REAGENTS**

5.1. Reagents for Chemical Testing.

5.1.1. Concentrated HNO₃ (specific gravity 1.42).

5.1.2. Sodium chloride, NaCl, reagent grade (primary standard).

5.1.3. Standard 0.01 normality NaCl solution. Dry reagent grade NaCl in an oven at 105°C. Cool, in a desiccator, weigh out approximately 0.5844 to the nearest 0.0001 gram, dissolve in distilled H₂O, and transfer to a 1 liter volumetric flask. Make up to the mark with distilled H₂O and mix. Calculate the exact normality as follows:

\[
N_{NaCl} = 0.0100 \left( \frac{W_{NaCl}}{0.5844} \right)
\]

where:

- \( W_{NaCl} \) = actual weight of NaCl
- \( N_{NaCl} \) = normality of NaCl solution

5.1.4. Standard 0.01 Normality AgNO₃. Weigh 1.7 grams of reagent AgNO₃, transfer to 1000 ml volumetric flask and dissolve in distilled water. Dilute to volume and mix thoroughly. Standardize by the titration method given in Section 5.4.2.

5.1.5. Distilled/Demineralized Water.

Note 4—Deionized water may be used in place of distilled water for samples where extreme precision and accuracy are not demanded.

5.1.6. Methyl orange indicator.

5.1.7. Ethanol—denatured or methanol, technical.
5.2. **AASHTO T 260 Procedure and Modifications.**

5.2.1. Weigh to the nearest milligram a 3 gram powdered sample representative of the material under test.

*Note 5*—Some users dry the sample to constant weight in a 105°C oven and determine the dry sample weight prior to analysis. This optional procedure provides a constant base for comparison of all results by eliminating moisture content as a variable. It is generally believed that drying is only necessary when very high accuracy is desired.

5.2.2. Transfer the sample quantitatively to a 150 ml beaker, add 10 ml of distilled H$_2$O swirling to bring the powder into suspension. Add 3 ml of concentrated HNO$_3$ with continued swirling until the material is completely decomposed. Break up any lumps with a stirring rod and dilute with hot H$_2$O to 50 ml. Stir thoroughly to ensure complete sample digestion. Add five (5) drops of methyl orange indicator and stir. If yellow to yellow-orange color appears, solution is not sufficiently acidic. Add additional concentrated HNO$_3$ drop-wise with continuous stirring until a faint pink or red color persists in the solution. Cover with a watch glass. Heat the acid solution or slurry to boiling on a hot plate at medium heat (250°C to 400°C) and boil for about 1 minute. Remove from the hot plate, filter through double filter paper (Whatman No. 41 over No. 40 filter paper or equivalent), into a 250 ml beaker which has been pre-weighed with the tare weight recorded.

*Note 6*—A blank and a known chloride concentration standard are run every 10 samples for internal Quality Assurance. The blank and known are made using only reagents and distilled H$_2$O. The known contains 10 ml of 100 ppm chloride (Cl$^-$) standard.

*Note 7*—Due to the presence of relatively insoluble materials in the sample, the solution generally will have a strong gray color, making the detection of indicator color difficult at times. Running of several trial samples is suggested to give the analyst practice in detecting the indicator color.

*Note 8*—A sample prepared to 100 percent passing No. 50 sieve (0.300 mm) should generally allow determination of any expected chloride level with adequate precision and accuracy. Samples containing highly siliceous aggregates may require finer grinding to minimize solution bumping during boiling. This may also be the case when the concrete contains modifiers such as latex or polymer.

5.2.3. Transfer solution and wash the filter papers thoroughly with hot distilled H$_2$O 3 to 5 times. After washing is complete, lift the filter paper carefully from the funnel and wash the outside surface of the paper with hot distilled H$_2$O; then wash the tip of the funnel. **The final volume of the filtered solution should be less than 100 ml.** Cover with a watch glass and allow to cool to room temperature in the HCl fume-free atmosphere. Remove the watch glass and place the beaker on the balance. Add sufficient distilled water to bring the weight of solution to 100 ± 1 grams. This eliminates the need for the volume corrections.

Weigh the filtrate solution and beaker without the watch glass and record the weight.

5.3. **Method II Gran Plot Method with Cl$^-$ selective ion electrode.**

5.3.1. Setup and Calibration.

5.3.1.1. Polish the chloride electrode according to manufacturer's recommendations and attach to the Orion 901 Ionanalyzer. Fill the double junction reference electrode with inner and outer solutions according to manufacturer's instructions and attach to Ionanalyzer. Perform slope calibration as follows.
5.3.1.2. Prepare 150 ml beaker with 87 ml distilled water, 3 ml concentrated HNO₃, and 10 ml 100 PPM-Cl⁻ standard solution for calibration standard. Set instrument to mV and put electrodes in calibration solution, wait for a steady reading. Press "set conc." button on instrument and leave on. Add 10 ml 1000 ppm-Cl⁻ standard solution, wait for a steady reading. Final reading on digital readout is the daily slope along with standard value of 10.00. Slope reading is read as negative number. Record slope setting in instrument notebook and on chloride sample worksheet.

5.3.2. Calibration of AgNO₃.

Rinse electrodes with distilled water and dry. Fill a 25 ml buret with AgNO₃ solution. Prepare a 250 ml beaker with 10 ml 0.01N NaCl solution, 3 ml conc. HNO₃, 87 ml distilled water, and stir bar. Place sample on magnetic stirplate with electrode in solution and while stirring record initial mV reading. Add AgNO₃ until mV reading is between 300 and 310 mV, record reading. Continue to titrate in 0.50 ml increments recording volume added and mV reading for each increment for at least five increments. Calculate the exact normality as follows:

\[
\frac{V_{\text{AgNO}_3}}{N_{\text{AgNO}_3}} = \frac{V_{\text{NaCl}}(N_{\text{NaCl}})}{W_{\text{filtrate}}} \times 100
\]

N AgNO₃ = normality of AgNO₃ Solution
V NaCl = volume (ml) of NaCl Solution
N NaCl = normality of NaCl Solution
V AgNO₃ = volume (ml) of AgNO₃ Solution (Use blank and volume corrected end point) Follow steps 5.4.1 through 5.4.3 for correct calculation of V AgNO₃.

5.4. Chloride Sample Instrumental Analysis.

After calibration of Ionanalyzer and AgNO₃ solution prepare sample filtrate for mV readings. Weigh filtrate, record weight and add distilled water to bring volume to 100 ± 1 grams. Place rinsed and dry electrodes in sample solution. Read and record millivolt reading for sample before AgNO₃ is added. Using the 25 ml buret, titrate the sample between 300-310 mV with standard 0.01 NAgNO₃ solution to the nearest 0.50 ml increment. Record the volume added and the millivoltmeter reading on the chloride worksheet.

Continue to titrate in 0.50 ml increments, recording volume added and the millivoltmeter reading for each increment. Add and record the data for at least five increments on the chloride worksheet.

5.4.1. Gran Plot Method Calculations.

Calculate corrected values for each of the volumes recorded in Section 5.4 by the equation:

If filtrate weight is >101 grams, then:

\[
V_{\text{correct}} = \frac{VV_{\text{record}}}{Wt - 100}
\]

Where:

Wt = original solution weight in grams.
V record = volumes recorded in ml.

If filtrate weight is 100 ± 1 grams, then V correct = V record.
Proceed to 5.4.2.

5.4.2. Titration Volume Plotting & Calculation.

If any of the $V_{\text{correct}}$ values are greater than 10, see Section 5.4.3. If less than 10, plot these corrected values versus the corresponding millivolt readings on Orion Gran Plot Paper (10 percent volume corrected type with each major vertical scale division equal to 5 millivolts) or equivalent. Draw the best straight line through the points and read the endpoint at the intersection of the line with the horizontal axis of the graph. Calculate the actual endpoint by the equation:

$$E_a = \frac{E_g \cdot W}{W + X}$$

Where:
- $E_a$ = actual endpoint
- $E_g$ = endpoint determined from graph in ml. The reagent blank endpoint ml will be subtracted from all sample and standard endpoints before ppm-Cl⁻ or final lb. Cl⁻ /c.y. concrete calculations.
- $W$ = weight of solution in grams.

5.4.3. Volume Correction.

When the $V_{\text{correct}}$ volumes determined during titration are greater than 10, discard the values and follow the following procedure.

Choose a constant which, when subtracted from all $V_{\text{record}}$ volumes, yields values less than 10 ml.

**Note 9**—This constant, designated as $X$ in the formulas below, is normally assigned an even value such as 5, 10, 15, 20, etc.

Calculate a revised solution weight $W_t$ as:

$$W_{WWW}_{\text{XX}} = W_{WWW} + XX$$

Where:
- $W_t$ = original solution weight in grams
- $X$ = the constant

Then calculate corrected volumes for each recorded volume as:

$$V_{V_{\text{correct}}} = \frac{V_{V_{\text{correct}}}}{W_{WWW}} - XX$$

Plot these values and determine the graph endpoint $E_g$, as described in Section 5.42, above.

5.5. The actual endpoint $E_a$ is then:

$$E_{NN} = \frac{W_{WWW}_{\text{XX}}}{100}$$

where:
- $E_a$ = actual endpoint in ml.
- $E_g$ = endpoint from graph in ml with blank subtracted.
- $W_t$ = revised solution weight in grams.
X = the constant chosen above.

Calculate the chloride content using the formula given below.

Calculation or ppm recovery of Cl⁻ standard:

\[
\text{ppm}_{\text{Cl}} = \frac{35.453(E)(NN)}{1000}
\]

Percent Cl⁻ is calculated as follows:

\[
\text{Percent Cl⁻} = \frac{3.5453}{(E)(NN)} - \frac{3.5453}{(1000)(E)(NN)}
\]

where:

Eₐ = actual endpoint, in ml.

N = normality of AgNO₃ solution.

Wₜc = concrete sample weight in grams.

The percent chloride may be converted to pounds of Cl⁻ per cubic yard of concrete as follows:

\[
\frac{\text{ml Cl}⁻}{\text{yd}³} = \frac{3.5453}{3.0000}\frac{(E)(NN)}{100}\]

where:

Wₜₘ = unit weight of concrete per cubic yard

Note 10 – A unit weight of 3,915 lb./yd³ is often assumed for normal structural weight concrete when the actual unit weight is unknown.

Results are reported as lb. Cl⁻/yd³ concrete as follows for 3.0000 gram sample:

\[
\frac{\text{ml Cl}⁻}{\text{yd}³} = \frac{3.5453}{3.0000}\frac{(E)(NN)}{100}
\]

Which reduces to:

\[
\frac{\text{ml Cl}⁻}{\text{yd}³} = \frac{46.27(E)(NN)}{100}
\]

where:

N = normality of AgNO₃

Eₐ = actual endpoint in ml

Idaho specifications for Cl⁻ value = 2 lb. Cl⁻/yd³ max.

Precision and Accuracy Data – As documented in AASHTO T 260.
Idaho Standard Method of Test for

Determination of the Rate of Evaporation of Surface Moisture from Concrete

IDAHO Designation: IT-133-17

1. SCOPE

1.1. This method shall be used to determine the rate of evaporation of surface moisture from concrete surfaces.

1.2. This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. REFERENCE DOCUMENTS

2.1. ACI Manual of Concrete Practice, Section 305R.

3. APPARATUS

3.1. Thermometer, 0°F to 180°F, Dial Type.

3.2. Wind meter.

3.3. Hygrometer, stationary mason's form.

4. TEST PROCEDURE

4.1. Determine the ambient air temperature by reading the dry-bulb on the hygrometer. For example, 80°F.

4.2. Determine the relative humidity by reading both the dry-bulb and the wet-bulb on the hygrometer.

4.2.1. Then, using the Relative Humidity Table (Figure 1), locate in the margin the reading corresponding to the dry-bulb indication.

4.2.2. Locate in the other margin the reading corresponding to the wet-bulb indication. The relative humidity is read at the intersection of these two columns. For example, given dry-bulb temperature 80°F and wet-bulb temperature 67°F, the relative humidity is 50 percent.

4.3. Determine the concrete temperature by placing the dial thermometer into a sample of the concrete. For example, 88°F.

4.4. Determine the wind velocity by using the wind meter.

4.4.1. Face the wind. Hold the meter in front of you in a vertical position with the scale side facing you.
4.4.2. Do not block the bottom holes.

4.4.3. The height of the ball indicates the wind velocity.

*Note 1*—For winds in excess of 10 mph, use the high scale. For high scale, cover the hole at the extreme top of the wind meter with a finger. For example, 12 mph.

4.5. Determine the evaporation rate by using the chart (Figure 2).

4.5.1. Enter the chart at air temperature, degrees F. For example, 80°F.

4.5.2. Move up to relative humidity. For example, 50 percent.

4.5.3. Move right to the concrete temperature. For example, 88°F.

4.5.4. Move down to wind velocity. For example, 12 mph.

4.5.5. Move left and read approximate rate of evaporation. For example, 0.25 lb/sq ft/hr.

### 5. PRECAUTIONS

5.1. Read the instructions furnished with both the hygrometer and wind meter for accurate operation of both instruments.

5.2. In determining the evaporation rate of surface moisture, keep in mind that later in the day the air temperature, relative humidity, and wind velocity may change drastically, causing a considerable increase in the evaporation rate.

### 6. RATE OF EVAPORATION

6.1. The rate of evaporation is influenced by the relative humidity, concrete and air temperature, and wind velocity. Even relatively small changes in these atmospheric conditions may have a pronounced effect on the rate of evaporation, especially if they occur simultaneously.

*Note 2*—For example, when the relative humidity changes from 90 to 50 percent, the rate of evaporation is increased five times. If further reduced to 10%, evaporation is increased nine times.

6.2. When both concrete and air temperature increase from 50°F to 70°F, evaporation is doubled. If further increased to 90°F, evaporation is increased four times.

6.3. With an air temperature of 40°F, the rate of evaporation is tripled when the concrete temperature is raised from 60°F to 80°F.

6.4. The rate of evaporation is four times greater when the wind velocity increases from 0 to 10 mph and is nine times greater when the wind velocity further increases to 25 mph.

6.5. It is apparent, then, that the rate of evaporation is highest when the relative humidity is low, when concrete and air temperatures are high, when the concrete temperature is higher than the air temperature and when the wind is blowing over the concrete surface. The combination of hot, dry weather and high winds often prevailing during summer months removes moisture from the surface faster than it can be replaced by normal bleeding; but even in cold weather rapid drying is possible if the temperature of concrete, when placed, is high compared to the air temperature.
Figure 1: Relative Humidity Table
Figure 2: Evaporation Rate

Effect of concrete and air temperatures, relative humidity, and wind velocity on the rate of evaporation of surface moisture from concrete.

in.-lb Units

To use this chart:

1. Enter with air temperature, move up to relative humidity
2. Move right to concrete temperature
3. Move down to wind velocity
4. Move left; read approx. rate of evaporation
Idaho Standard Method of Test for
Measuring Texture Depth of Portland Cement Concrete Using a Tire Tread Depth Gauge

IDAHO Designation: IT-147-17

1. Scope

1.1. This method describes the procedure for depth measuring texture depth of fresh or hardened portland cement concrete by use of a tire tread gauge.

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

2. Referenced Documents

2.1. AASHTO Standards
   - T 261-78 (1999), Discontinued

3. Apparatus

3.1. Tire Tread Depth Gauge – A tire tread depth gauge with 1/32-in. graduations. The gauge end may be modified to a shape suitable for the measurement.

3.2. Wire or stiff bristle brush, carborundum stone.

3.3. Steel straightedge approximately 1/4 by 1 by 12 in.

3.4. 100 ft. Tape measure.

4. Selection of Test Locations

4.1. One test area shall be identified by ITD at a stratified random location transversely and longitudinally every 1,000 linear feet in each lane or fraction thereof as specified.

4.2. For bridge decks, urban concrete paving, and concrete overlays, a minimum of five test areas shall be identified as described in 4.1 unless otherwise specified.

5. Procedure

5.1. At each test area measure the texture depth of 10 consecutive grooves. The test location shall be in a line perpendicular to the grooves, starting at the point randomly located in accordance with Section 4.

5.2. The texture depth shall be measured from the original concrete surface. Any projections above the original surface shall be removed by brushing with a wire brush or carborundum stone as necessary to remove ridges adjacent to grooving, or with the steel straightedge prior to taking a
measurement on hardened concrete. If measurements are made on fresh concrete, the depth gauge guide shall be pressed down to the level of the original concrete surface.

5.3. With the depth gauge guides in contact with the original concrete surface, the plunger is depressed until contact is made with the bottom of the groove in the concrete. The gauge is then removed without disturbing the plunger. The texture depth is read to the nearest 1/32-in. on the calibrated plunger. The plunger is then zeroed and the procedure is repeated until all measurements are completed.

5.3.1. Make adjustments to the tining operation when more than three readings in a set of ten are outside the intended depth range.

6. **CALCULATIONS**

6.1. Calculate the average groove depth for each test area to the nearest 1/32-in.

7. **REPORT**

7.1. Report test results on Form ITD-798. See Figure 7.1.1
Idaho Standards

P.C.C. PAVEMENT TEXTURE DEPTH USING TIRE TREAD DEPTH GAUGE RECORDING FORM

State ☐ Contractor ☐ For use with Idaho IT-147

Key No. ___ Project No. ___ Sheet__ of __

Inspector's Name ___ Date ___

New Const. Yes ☐ No ☐ Concrete: Plastic ☐ Hardened ☐ Texture: Tining ☐ Grinding ☐ Traffic: Yes ☐ No ☐ Position: Wheel Path ☐ Outside WP ☐

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Figure 7.1.1: P.C.C. Pavement Texture Depth Using Tire Tread Depth Gauge Recording Form

530.00
ITD 0797 (Rev. 02-17)
itd.idaho.gov
Idaho Standard Practice for

Inspecting / Sampling Paint and Curing Compound

IDAHO Designation: IR-7-04

1. SCOPE

1.1. This method is intended to cover the inspection and sampling of product components and production batches of paints and curing compounds.

1.2. This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. REFERENCE DOCUMENTS

2.1. ASTM Standards


2.2. Federal Standard Test Methods 141

   ■ Method 1022 Sampling for Inspection and Testing

3. TERMINOLOGY

3.1. Batch – A batch is defined as a unit or quantity of material produced at one operation, the weight and volume of which may vary, depending on the manufacturing facilities. As an example, a number of small mill grinds may be combined together in a larger mixer. This material will be considered as one batch and should be labeled as such. Similarly, when a number of varnish cooks are reduced in the same tank the combined reduced material shall be considered as one batch.

3.2. Boxing – Boxing is a method by which a product that is exhibiting settlement is uniformly remixed without the use of power agitation equipment. (Boxing is accomplished by pouring approximately 60% of the liquid portion of the material into a new clean container that is the same size or larger than the package product. Stir the remaining liquid and the settled portions of the material into a uniform thin paste.) The previously removed liquid portion is then poured slowly and with constant stirring back into the original container. The contents are finally poured back and forth from container to container until the product is uniformly mixed and a representative sample can be taken.

3.3. Inspection – Refers to the collection of documentation and visual observation of materials. Inspection does not necessitate the destruction of the packaging or physical alteration of the product. Inspection should include the examination and reporting of the condition of the material in containers, number of units involved, type, class, grade, color, review of manufacturer’s documentation, or other visual considerations of the units as may be called out in the product
specifications. Inspection may also include the witnessing of a sample being taken by an authorized manufacturer’s representative.

3.4. *Cake* – Dry settlement found in the bottom of a container.

### 4. APPARATUS

4.1. One quart metal cans for solvent based curing compounds and paints.

4.2. One quart lined metal cans for water based curing compounds and paints.

4.3. Mixing equipment consisting of stir paddles, jiffy mixers, shakers, air stirrers, mechanical roller mixers, recirculation pumps, and buckets for boxing.

4.4. Dry pigment sampling equipment consists of Keystone Sampler and Splitter.

### 5. SAMPLING AT LOCATIONS

5.1. Manufacturing Plant

5.1.1. Materials are generally packaged and ready for shipment at the time of arrival of the inspector. However, in some instances when large amounts of material are involved, the manufacturer may not have filled the containers, but will hold the material in a large tank until the inspector arrives. Samples will be collected from either the containerized products or from the holding tanks.

5.2. Project Site or Fabrication Plant

5.2.1. The packaged materials are at the project site or fabrication plant and will be sampled by the inspector.

### 6. INSPECTION AND SAMPLING PROCEDURES

6.1. Products are inspected for uniformity and samples are taken for the purpose of having a representative quantity, from each batch of material, for physical examination and laboratory testing. The samples will be analyzed to ascertain if the materials meet the specification requirements, the covering product specification, and to determine uniformity within a batch.

6.2. No set of directions for sampling, however explicit, can take the place of judgment, skill and previous experience on the part of a person actually engaged in the sampling and in the supervision of the sampling. These directions are intended to supplement this experience and to serve as a guide in the selection of the sampling method.

6.3. All containers shall be marked with the production batch number, date of manufacture, and product name. At least one sample shall be taken from each batch.

6.4. For all grades of materials, precautions shall be taken to assure the sampling apparatus and the samples themselves are not contaminated and are clean and dry. Slight contamination of the product may lead to false test results. Use the appropriate container for the type of material that is being sampled (Refer to Section 3.1 and 3.2, above).

6.5. The batches shall be sampled according to the applicable plan as describe within this method. Samples shall be selected at random so that they are representative of the batch.
6.6. The samples shall be of such size as to permit the performance of all inspections and laboratory tests. In most cases, one quart of liquid or one pound of dry material is sufficient.

6.7. To the extent possible, it is advisable that original, unopened containers within each batch be selected as samples. When individual containers are less than the one quart or one pound size a sufficient number of containers shall be selected to achieve the required size. Obviously it is not always convenient or economical to have samples of very large size be submitted for testing. In these cases, care must be exercised so that samples are uniform and representative of the batch of material.

6.8. For dry pigments and resins, the package shall be opened by the inspector and a representative sample taken at random from the contents. This sample shall be placed in a clean, dry, metal container closed with an air tight cover, sealed, marked and sent to the Central Laboratory.

6.9. For liquid material the original unopened containers shall be sent to the Central Laboratory. When this is not applicable the inspector shall determine, by thorough testing with a paddle or spatula, if the material meets the absence of caking requirements in the container. The inspector shall thoroughly mix the contents of the container and draw a sample as specified, normally not less than one (1) quart. This sample shall be placed in a suitable clean and dry container. The sample should be filled as full as possible to minimize air contact within the container. The container is then closed with a tight cover, sealed, marked and sent to the Central Laboratory for testing.

6.9.1. With material that has a significant amount of pigment added such as single component zinc paint the zinc settles out rather quickly. The zinc needs to be mixed extensively by the use of a jiffy mixer so that the zinc is suspended back into the binder. Continue agitation with the mixer while taking a sample to insure proper sampling of the material.

6.10. The sample container should be dry and not cooler than room temperature. Because pigmented products are dispersions and not solutions, finely divided pigment particles may settle upon standing. Consequently, thorough and careful agitation of the product before sampling is necessary to restore the product to its original, uniform condition. The method of agitation or stirring is therefore of prime importance.

6.11. Do not place samples in plastic bottles because volatile solvents may diffuse through the walls. Loss of the solvents may introduce errors in such tests as viscosity, weight per gallon and nonvolatile content as well as other properties. (Refer to Section 3.1 and 3.2 for the appropriate containers.) Place either safety clips or a safety ring on the lid of the sample container prior to shipping.

6.12. When representative samples have been obtained and packaged in clean closed containers send them promptly to the Central Laboratory for testing along with all the batch and product information.

6.13. During the period between sampling and delivery, it is important that samples be kept at temperatures from 40 to 90°F. Extreme temperatures may change the properties of some products.

7. **UNIFORMITY OF SAMPLES**

7.1. *Clear Liquid Products.* Clear liquid products require stirring prior to sampling to achieve uniformity and a representative sample. Care must be taken so that any separation, sediment, gel or other matter indicative of non-uniformity is reincorporated back into the product prior to sampling.

7.2. *Pigment Liquid Products.* Pigmented liquid products require stirring prior to sampling to achieve uniformity and a representative sample. Where there is settling, or separation of constituents, these
should be reincorporated by “boxing” or other means of agitation that will sufficiently homogenize the sample to uniformity prior to sampling.

7.3.  

Dry Pigments and Powders. Ordinarily dry pigments, powders, hard resins, etc. are more likely to be uniform than pigmented liquids. Care must be exercised to ensure that samples of these materials are representative of the batch being sampled. For sampling very large containers of these materials a Keystone Sampler and Sample Splitter should be used.

8.  

SAMPLING ACCORDING TO CONTAINER SIZE

8.1.  

Containers Smaller Than 5 Gallons.

8.1.1.  

When the batch to be sampled is contained in multiple small containers and batch numbers are marked on the containers, put all containers from the same batch together. From each batch select at random one percent (1%) of the containers, but not more than five containers, for sampling. For example, if there are 275 containers in a batch, randomly select three for sampling. A minimum of one sample is required per batch.

8.1.2.  

After selection of the containers to be sampled, thoroughly agitate or stir the contents. Acceptable methods of mixing are mechanical shaking or stirring, or hand stirring with a paddle, followed by boxing. Mechanical shakers are desirable for most materials since there is thorough agitation in a closed container. Before mechanical shaking, open the container and check to be sure that the pigment has not caked on the bottom of the container. If caking exists, stir manually or with a jiffy mixer to break up the hard settling and then put the containers on the mechanical shaker again. Agitate products having a weight per gallon of 11 lbs/gal or less on the shaker for 5 minutes and those with a weight per gallon of more than 11 lbs/gal for 10 minutes. After agitation, check the products for uniformity again before sampling. If the product is not uniform repeat the process until the product is brought into uniform consistency. After thorough agitation decant a one quart can full and send to the Central Laboratory for testing.

8.2.  

Containers Larger than 5 Gallons.

8.2.1.  

From each batch select at random five percent (5%) of the containers, but not more than three containers, for sampling. A minimum of one sample is required per batch. Drums may be stirred satisfactorily by several means. With open-head types, mechanical or manual stirring may be used. Some drums contain their own agitators; drum shakers or rollers may also be used. After agitation, check the products for uniformity again before sampling. If the product is not uniform repeat the process until the product is brought into uniform consistency. After thorough agitation decant a one quart can full and send to the Central Laboratory for testing.

8.3.  

Containers from 250 to 500 Gallons (Totes)

8.3.1.  

From each batch randomly select one tote per 5000 gallons of material for testing. For example if the batch represents 12,000 gallons take three samples from three separate totes within the batch. The material shall be thoroughly agitated by using mechanical mixers or recirculating the material. Recirculating the material shall be done until the entire contents have been turned over within the tote a minimum of three times. The pump rate shall be adequate to achieve this recirculation rate of the material within 1 hour. Alternatively the material may be pump into an empty tote and then pumped back and forth, a minimum of three times, similarly to boxing the material until the material is thoroughly agitated and mixed. Once complete mixing has been accomplished open the valve of the tote and allow a minimum of 2 gallons of product to flow into a 5 gallon bucket. Examine the product for uniformity and then take a one quart sample from the 5 gallon bucket and send it to the Central Laboratory for testing.
8.3.1.1. Care should be used in pump selection as the gear driven pumps can cause shearing in waterborne products causing the emulsion components to separate.


8.4.1. When it is impractical, inconvenient, or dangerous to take samples as described above, and where permitted, samples may be taken in the manufacturer’s plant during filling operations or in the production line as applicable. In such cases samples should be taken near the beginning, in the middle, and near the end of the operation. These individual samples should be a minimum of one quart each. Sampling in this manner must be supervised by a representative of the purchaser. Once the three samples have been collected mix them together uniformly, decant the product into a one quart can and send the sample to the Central Laboratory.

8.5. Composite Samples.

8.5.1. While not recommended, occasionally composites samples may be permitted for economy in testing. The use of composite samples requires prior approval of the Central Laboratory. When permitted a composite sample shall be used to represent the batch of material in its final state.

9. DISPOSITION OF SAMPLES

9.1. Unless otherwise specified each sample taken as directed herein shall be sealed in a clean, dry one quart size container and marked so as to clearly identify the batch number of material involved. Unless otherwise specified, each sample shall be inspected and sampled in accordance with these specifications. Failures of any sample to meet the product specification requirements shall be cause for rejection of the material.

10. TERMINATION OF SAMPLING

10.1. When in the course of sampling, the material is found to have serious and obvious defects sampling shall be terminated and resumed only after defects have been corrected or the defective material is replaced.

11. TIME OF SAMPLING

11.1. Samples shall be taken as soon as possible after manufacturing or delivery to a site location.

12. LABORATORY TESTING TIME

12.1. Allow a minimum of two weeks for test results on all products after they have been received into the Central Laboratory.
Idaho Standard Method of Test for

**Determining Total Solids-Latex Percent**

**IDAHO Designation: IT-121-98**

1. **SCOPE**

1.1. This involves the determination of the percent of solids on all latex samples. It involves weighing a sample of wet latex, drying it in an oven, and expressing the weight ratio of dry/wet in percent.

1.2. *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. **PROCEDURE**

2.1. All samples to be tested must be at room temperature. If the sample is warm, it can be cooled in a pan of cold tap water.

2.2. Weigh three aluminum cups and record the weight of each (tare weight).

   **Note 1**—Every sample tested must be done in triplicate.

2.3. Mix by hand each sample when cool by inverting the container five to ten times.

2.4. Weigh approximately one gram of latex to the nearest milligram into each pre-weighed aluminum cup.

2.5. Place all three samples in the oven to dry for 120 minutes at a temperature of 285°F ± 2°F (140°C ± 1°C).

2.6. Remove the samples from the oven and place immediately in a desiccator for a few minutes or until cool. This prevents moisture pick-up from the air while cooling.

2.7. Reweigh each sample out of the desiccator to the nearest milligram and record.

3. **CALCULATIONS AND REPORT**

\[
\frac{(C - A) \times 100}{(B - A)}
\]

Where

A = The weight of the empty cup

B = The weight of the aluminum cup and the wet sample

C = The weight of the aluminum cup and the dried sample
3.1. Example:

If

\[ A = 1.374 \text{ g} \]
\[ B = 2.356 \text{ g} \]
\[ C = 1.779 \text{ g} \]

Then

\[ C - A = 1.779 - 1.374 = 0.405 \text{ g} \]
\[ B - A = 2.356 - 1.374 = 0.982 \text{ g} \]

Therefore:

\[ \frac{(C - A)}{(B - A)} \times 100 = \frac{0.405}{0.982} \times 100 = 41.2\% \]

3.2. If all three samples are within 2%, average the three samples to obtain the percent solids.

3.3. If all three samples are not within 2%, but two samples are within 1%, report the average between the two samples within 1% as the percent solids and discard the third determination.

3.4. If all three samples are not within 2% and no two are within 1%, discard all the values and repeat the solids procedure.
Idaho Standard Practice for

Taking Undisturbed Soil Samples for Laboratory Consolidation, Shear and Permeability Tests

IDAHO Designation: IR-62-17

1. SCOPE

1.1. This method of sampling is designed to secure relatively undisturbed soil samples for laboratory tests. Only soils relatively free of gravel and other rock fragments are considered suitable for this type of sampling.

1.2. This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. APPARATUS

2.1. Mobile drill or diamond drill with standard attachments.

2.2. Clean-out device to assure a clean hole.

2.3. A 2 1/2-in. I.D. sample barrel with a supply of 1-in. high brass liner rings and/or a supply of 2- to 3-in. diameter Shelby thin-wall tubes, 18 to 36 in. in length with a wall thickness not greater than No. 16 gage.

3. PROCEDURE

3.1. The boring should be cleaned out either by hand auger or air jetting to the sampling elevation. Make sure that the bottom of the boring is free of excess loose material.

3.2. With the sampling device resting on the bottom, push it into the soil by a continuous and rapid motion using the hydraulic ram on the mobile drill or diamond drill. The penetration should be approximately five times the diameter of the tube. Do not push the tube farther than the length provided for the sample. The time and pressure required, when measured, should be noted.

3.2.1. If driving is required, the number of blows, driving weight, drop, and penetration should be recorded. Heavy driving weights are preferable to light driving weights because they cause less sample disturbance.

3.3. Before pulling the sample, turn it two revolutions by hand to shear it on the bottom. Pull the sample tube to the surface.

3.4. After pulling the sample, measure and record the length of sample in the tube and also the length penetrated. If the ring-lined sampler is used, select a central portion of the sample and place it in the watertight containers. If the Shelby tube is used, discard the disturbed soil in the upper end.
Ream the lower end to a depth of at least 1 in., seal both ends with wax or other approved methods, and secure with masking tape.

3.5. Containers and/or tubes should be clearly labeled as to project, boring number and location, sample number, depth taken, date taken, and personnel.

3.6. Samples should be taken to supplement in-place vane shear tests or standard penetration tests. The number taken is left to the discretion of the investigator. Generally, enough samples should be taken to provide information on each soil type encountered.

3.7. Samples should not be shipped to the Central Laboratory by common carrier, but should be delivered by state vehicle. Sedans are preferred, as the sample can be laid on the seat and cushioned. Deliver as soon as possible. No storage is permitted. Protection should be provided for heat and cold.

3.8. Dropped samples or frozen samples are of no value. Thus, precautions must be taken to eliminate mishandling.

4. RECORDS

4.1. The following information should be taken in the field and transmitted with the samples.

4.1.1. Date of boring and project identification.

4.1.2. Location of boring, including offset distance.

4.1.3. Boring number.

4.1.4. Collar elevation.

4.1.5. Log of the boring.

4.1.6. Location of the samples taken in profile.

4.1.7. Water data.

4.2. Information regarding the present topography and landform, as well as dimensions of the proposed structure or embankment, should be noted. This, plus the estimated weight per ft$^3$ of a proposed embankment, should be recorded and the information supplied to the Central Materials Laboratory with the undisturbed sample.
Idaho Method of Test for

Resistance R-Value and Expansion Pressure of Compacted Soils and Aggregates

IDAHO Designation: IT-8-17

1. SCOPE

1.1. This method covers the procedures for determination of Resistance R-value and Expansion Pressure for compacted soils or aggregates. This test method is divided into the following parts:

I. Method of Preparation of Materials
II. Method of Compaction for Test Specimen
III. Method of Determination of Exudation Pressure
IV. Method of Determination of Expansion Pressure
V. Method of Determination of Resistance R-value by Means of the Hveem Stabilometer
VI. Method of Calculating the Densities of Test Specimens

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

2. PART I. METHOD OF PREPARATION OF MATERIALS

2.1. Scope

2.1.1. This part of the procedure describes the methods of batching, mixing and curing of the materials.

2.2. Apparatus

2.2.1. Mechanical mixer.

2.2.2. Scales, 5000 g. capacity, accurate to 1.0 g.

2.2.3. Scales, 175 lb. capacity, with 0.1 lb. graduations.

2.2.4. Set of screens, 3", 2", 1", 3/4", 1/2", and No. 4.

2.2.5. Fiberglass pans and cover.

2.2.6. Vinyl plastic sheets large enough to cover fiberglass pans.

2.2.7. Burette or graduated cylinder for measuring water.
2.2.8. Riffle splitter with chutes 3/4" wide.

2.3. Test Record Form

2.3.1. Keep all pertinent data regarding the soil sample on a preliminary soils worksheet.

2.4. Preparation of Sample

2.4.1. Refer to Test Method AASHTO R 58 for preparation of samples.

2.4.2. The preparation of test samples must include removal of coatings from coarse aggregates, and clay lumps must be broken down to pass the No. 4 sieve. This is important because relatively small test samples are used. It is also important that the test sample be accurately prepared.

2.5. Determining of Grading and Batch Weights Used in Preparing Test Samples

2.5.1. Definitions of "Original" and "As used" grading:

2.5.1.1. "Original": Original grading is grading on a sample prior to any adjustment such as scalping, wasting, or crushing.

2.5.1.2. "As used": As used grading is the grading after the material has been adjusted as necessary to meet the specifications or to eliminate material too large to test. This adjusted grading is referred to as the "As used" grading. In cases where 100% of the material as received passes the 3/4" sieve and no adjustments are necessary, the "Original" and the "As used" grading will be the same.

2.5.2. Criteria for scalping (removing the oversize material) samples containing oversize material.

2.5.2.1. If 75% or more of the sample as received passes the 3/4" sieve, scalp the sample on the 3/4" sieve.

2.5.2.2. If less than 75% of the sample as received passes the 3/4" sieve, scalp the sample on the 1" sieve.

2.5.3. A total of 13 lb. is used to ensure sufficient material for five specimens and a moisture sample.

2.5.4. Calculations required for determining the "As used" grading are as in the following example:

Given an aggregate with the following grading:

<table>
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<tr>
<th>Sieve</th>
<th>Original % Passing</th>
<th>Corrected % Passing</th>
<th>Corrected % Retained</th>
<th>Accumulated Weight, Lb.</th>
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<tr>
<td>1&quot;</td>
<td>90</td>
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<td></td>
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<tr>
<td>3/4&quot;</td>
<td>85</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1/2&quot;</td>
<td>75</td>
<td>88</td>
<td>12</td>
<td>1.6</td>
</tr>
<tr>
<td>No. 4</td>
<td>65</td>
<td>77</td>
<td>23</td>
<td>3.0</td>
</tr>
</tbody>
</table>

Weight of Sample 13.0 lb.
Using the above example, weigh out 1.6 lb. (13 x 12/100) of retained 1/2” materials; add to this 1.4 lbs (13 x (23-12)/100) of retained No. 4 material and 10.0 lb. of minus No. 4 material to make a total of 13.0 lb.

If the corrected percent retained on the No. 4 sieve is less than 6%, no plus No. 4 material need be added and the sample is treated as though 100% passed the No. 4 sieve.

2.5.5. Add to the sample enough water to approach optimum. This operation is performed by placing the 13.0 lb. sample in the mechanical mixer and adding water. The amount of water added is left to the discretion of the operator and need not be recorded. Continue mixing for at least 30 seconds after the water has been added. The period of mixing given is a minimum requirement. Place the sample in a large fiberglass pan and cover with a plastic sheet in order to prevent moisture loss. Allow to stand overnight.

2.5.6. Before preparing the individual test specimens, an initial moisture sample of approximately 500 g having the same grading as the test sample is taken. The moisture content is determined by weighing before and after drying to constant weight at temperature of 220-230°F.

2.5.7. The R-value test requires the preparation of three or four test specimens at different moisture contents. The first specimen is used as a pilot specimen. After completing the pilot specimen, it can be used as a guide in the preparation of the other three specimens, which shall conform to the following limitations:

2.5.7.1. Height = 2.5 ± 0.05 inches

2.5.7.2. Exudation: One should be above and two below the 2,500 lb. exudation load (200 psi pressure) or two above and one below 2,500 lb. load. The exudation load should be between 1000 and 5000 lbs.

2.5.7.3. Should the pilot specimen satisfy both height and exudation load requirements, it may be used as one of the sample specimens and only three (two additional) specimens need be fabricated. It often requires about 1000 g to 1100 g of material to produce a specimen of proper height. Experience will help in amount selection. Any correction of amount necessary may be made by use of the chart in Figure A2.1.

2.5.8. The amount of water needed to bring the exudation pressure into one of the above ranges is added to the soil and mixed in the mechanical mixer. Very granular and sandy materials can be mixed as thoroughly and as easily with a pan and trowel. It is necessary here to record the amount of water added.

2.5.8.1. With the use of the mixing machine, about 30 seconds at a moderate speed is ample time to mix the material. Any amount of time over this may cause excessive loss of water due to evaporation.

2.5.9. To obtain a representative test specimen when the sample contains plus No. 4 material, proceed as follows:

2.5.9.1. Roll the 13.0 lb. sample on a plastic splitting cloth.

2.5.9.2. From the thoroughly rolled and mixed material, scoop out a representative portion for the test specimen.

2.5.9.3. Thoroughly roll the sample again and scoop out the material for the next specimen.

2.5.9.4. Obtain all additional specimens in this manner.

2.5.10. To prevent evaporation loss of moisture, keep samples covered at all times except during immediate processing.
3. PART II. METHOD OF COMPACTION FOR TEST SPECIMEN

3.1. Scope

3.1.1. This part of the method describes the compaction procedure for test specimens using a kneading compactor. The kneading compactor densifies the material without depending on straight compression or damaging impact, but rather by a series of individual impressions made with a ram having a face shaped as a sector of a 4" diameter circle. The kneading action is developed by the application of pressures alternately to small localized areas of the specimen while the remainder of the surface is free to move.

3.2. Apparatus

3.2.1.1. Kneading compactor (Figure A2.2).
3.2.1.2. Tared steel molds 4" height.
3.2.1.3. Mold holders.
3.2.1.4. Basket fabrication equipment.
3.2.1.5. Paper strips for making baskets.
3.2.1.6. Supply of phosphor-bronze perforated disks.
3.2.1.7. Supply of 4" diameter manila disks.
3.2.1.8. Weighted brass rod.
3.2.1.9. Trowel shaped to fit trough on compactor.
3.2.1.10. Separate trough and trowel for use with soils requiring baskets.
3.2.1.11. 1/2" x 4" steel disk.

3.3. Preparation of Sample

3.3.1.1. Sample is prepared as in Part I.

3.4. Procedure

3.4.1. Place mold in mold holder with 1/4" thick shims between bottom of mold and base of mold holder. Place 4" diameter manila disk over 3 15/16" diameter and 1/8" thick rubber disk in bottom of mold. Place the assembled mold and holder on the compactor turntable and tighten with thumb screws.

3.4.2. Place well mixed sample in compactor feeder trough with the loose material distributed evenly along the full length.

3.4.3. Using trowel formed to fit feeder trough, push the lower three inches of material in the trough into the mold. Start compactor and maintain 75 psi foot pressure, if possible. The compactor is adjusted to give 30 blows per minute. Push the remainder of the material into the mold in 20 equal parts, using two blows of the compactor for each part of material, for a total of 40 blows. Constant adjustment of the mold stage must be made to obtain the correct length of stroke. The correct length of stroke does not allow the piston to strike the base of the cylinder, thus ensuring continuous pressure on the specimen during the loading part of the cycle. A mark is scribed on the foot guide.
giving a 3/4" clearance between the piston and the cylinder base. When all the material is in the mold, raise and clean the compactor foot. Remove the shims beneath the mold. Put a 4" diameter, 1/8" thick rubber disk on top of the soil and tamp 100 more times while maintaining the pressure at 100 psi for these 100 blows, if possible.

3.4.4.  Clays and clean sands may require lower compaction pressures. In these cases, use the greatest compaction pressure possible, but do not allow the foot to penetrate over 1/4" into the surface after all the material is in the mold. If the pressure is reduced, record the pressure used.

3.4.5.  If free water appears around the bottom of the mold during compaction, stop the compactor immediately and note the number of blows. In all probability, the sample is too wet.

3.4.6.  If the surface is left uneven by the action of the compactor foot, smooth and level the surface by gently tamping with the weighted rod. A square tipped spatula is helpful in removing the accumulation of material around the edge of the mold. Return the mold to the compactor with a 1/2" thick and 4" diameter steel disk on top of the specimen. Lower the stage 1/2" and apply about 10 additional blows without changing foot pressure. This additional leveling aids in more consistent exudation readings.

3.4.7.  Granular materials are very difficult to handle without damage and require a paper basket to keep the specimen intact. Baskets prevent the specimen from falling out of the mold and from crumbling when transferred from the mold to the stabilometer. When a basket is used, place the specimen in four approximately equal layers in a mold before compacting by use of the portable trough. Tamp each layer lightly with about ten strokes of the weighted brass rod to arrange the coarser particles in the mold. Apply 140 blows to the specimen with compactor maintaining 100 psi foot pressure. Then remove mold from compactor keeping it upright so specimen will not fall out. (To fabricate paper basket, see Annex A1, Method of Fabricating Paper Baskets)

3.4.8.  Record test data into an R-value worksheet

3.5.  Precautions

3.5.1.  It is important that the operator feed the material into the mold uniformly. Differences in the compactive effort can cause variation in the exudation pressures.

3.5.2.  Even distribution of the coarse aggregates throughout the length of the feeder trough is important in order to avoid segregation in the compacted specimen. The material should be evened out and leveled manually with the fingers or spatula along the trough before starting the feeding operations.

3.5.3.  The decision whether to use baskets on a given material must be based on experience. They should not be used if they are not needed. If baskets are not used and the specimen breaks up while being transferred into the stabilometer, the fact may not be apparent at the time, but it will result in both excessive stabilometer pressure readings and excessive displacement readings. Both of these errors tend to lower the R-value, and a group of four tests will be erratic with respect to one another. When this happens, the test must be repeated using baskets.

3.5.4.  Care must be taken to select the proper amount of material to produce a 2.5" pat. No material shall be removed from the trough or mold in order to produce the correct height.

3.5.5.  Precautions should be taken to avoid any drying of material during mixing, in the feed trough or in the mold.

3.6.  Hazards

3.6.1.  Caution must be used to make certain nothing comes in contact with the compactor foot while it is in operation. A finger caught between the edge of the mold and the compactor foot will receive serious injury.
4. **PART III. METHOD OF DETERMINATION OF EXUDATION PRESSURE**

4.1. **Scope**

4.1.1. This part of the method describes the procedure used to determine the pressure required to exude water from the compacted specimen. This pressure is the “Exudation Pressure” for the specimen at that particular moisture content.

4.2. **Apparatus**

4.2.1. Compression testing machine, 10,000 lb. minimum capacity with solid head (Figure A2.3). If head is spherically seated, use proper shims to lock it in such a manner that the contact face is fixed firmly in a horizontal plane.

4.2.2. Perforated phosphor-bronze disks, 4” diameter and 28 gage.

4.2.3. Moisture exudation device (Figure A2.4).

4.2.4. Press. A level equipped with a 4” diameter foot.

4.2.5. Filter paper. Smooth type, 4” diameter BKH qualitative, Catalog No. 28310, or equivalent.

4.2.6. Height gage.

4.2.7. Follower ram, 4” outside diameter and 6” height.

4.2.8. Supply of 4” diameter manila disks.

4.3. **Sample**

4.3.1. The specimens as prepared in Part II.

4.4. **Procedure**

4.4.1. Place perforated phosphor-bronze disk directly on tamped surface of specimen in mold and place a single piece of filter paper on the disk.

4.4.2. Invert mold with specimen so that filter paper is on the bottom, and place mold on the moisture exudation device. Place 4” manila disk on top surface. Then push specimen through to other end with press. It is very important that the mold be centered on the exudation device; this is accomplished by viewing in the mirror and adjusting as necessary. In the case of a basket specimen, do not invert the sample prior to placing on the exudation device; simply center a filter paper on the contact plate and wipe moisture from bronze disk. Then place mold containing basket and material on filter paper.

4.4.3. Insert the follower ram in top of the mold on the specimen. Attach battery clamp to mold and place exudation device with mold in the testing machine and center to ensure even loading.

4.4.4. Use the testing machine to apply an increasing load at the rate of 2,000 lb. per minute until there are lights on in five of the six sections of the moisture exudation indicator device (Figure A2.5). Note and record the load at this point. However, if free moisture becomes visible around the bottom of the mold, covering an area approximately 2” in length (which should touch four contact points) and there are lights on in at least three of the six sections, record the load at that moment in lieu of waiting for five sections.
4.4.5. Discard the specimen if the exudation load does not fall within the required range. A low of 1,000 lb and a high of 5,000 lb may be accepted if necessary.

4.4.6. Leave the mold with follower in place on the exudation device and then place the height gage over mold and follower. Allow dial to come to rest, then read and record. A constant of 2" is understood; that is, if the dial was to read 0.460, the actual height would be $2 + 0.460 = 2.460\"$.

4.4.7. Record all test data on a preliminary soils worksheet

4.4.8. Next, remove height gage, follower, manila paper, bronze disk, and filter paper and weigh the mold with specimen and record. In the cases where a basket is used, the weight of the basket must be taken into consideration and accounted for by adding its weight to the weight on the mold. The basket's average weight is about 33 g.

4.5. Precautions

4.5.1. When the exudation contact plate becomes worn or grooved and the contact points become raised or depressed, the plate should be machined to a plane surface or replaced.

4.5.2. The operator must wipe the contact plate dry between tests, since any moisture remaining will prematurely dampen the new filter paper and cause erroneous exudation pressure results.

4.5.3. The height gage must be checked and reset daily to ensure correct readings.

4.5.4. Wipe plate of basket prior to contact with filter paper.

4.6. Notes

4.6.1. Occasionally material from exceptionally heavy clay test specimens will extrude from under the mold and around the follower ram during the loading operation. Yet, when the 5,000 lb load point is reached, less than five sections are lit. When this occurs, the soil is of very poor quality and should be reported as having $R$-value less than 5.

4.6.2. There are many cases where high quality materials of a gravelly, sandy or silty nature will have exudation pressures that are extremely sensitive to slight changes in moisture content. Very often these pressures will appear erratic and out-of-step with the sequence of moistures. However, these materials generally exhibit uniform $R$-values having small variation throughout the entire range of exudation pressures and moisture contents. The $R$-value versus exudation curve is drawn as an average value in these cases.
PART IV. METHOD OF DETERMINATION OF EXPANSION PRESSURE

5.1. Scope
The expansion test is used to determine the amount of ballast required to prevent a reduction in density of a soil due to expansion when the soil becomes saturated.

5.2. Apparatus
5.2.1. Swell frames (Figure A2.6)
5.2.2. Micrometer dial calibrated to 0.0001" mounted on a tripod designed to fit the swell frame.
5.2.3. Proving ring for adjusting swell frames
5.2.4. Perforated disks with screw stems.
5.2.5. 5/16" open-end wrench.

5.3. Sample
5.3.1. The samples are the soil specimens as removed from the exudation device. Each specimen should be allowed to rebound for at least 30 minutes after the exudation test before assembling in the swell frame.

5.4. Procedure
5.4.1. Place micrometer dial in position on swell frame. Using the 5/16" open-end wrench, adjust the swell frame for an initial reading of minus (-) 0.0016" (the dial will read 0.0084"). You may notice a variance in the dial as there is a slight amount of play as the dial sits on the swell frame, so for the sake of uniformity, the dial is placed as far to the right as possible. The swell frames should be checked periodically with the proving ring and adjusted.

5.4.2. Place one of the perforated plates with screw stems on top of specimen. Place the mold in the swell frame, making sure the base of the frame is dry and free of dirt and sand. After the 30-minute rebound period, adjust the screw stem on the disk until the micrometer dial reads 0.0000" with the dial placed as far to the right as possible. This is equivalent to a surcharge pressure of 0.5 psi. It is necessary that the pointed end on the screw stem makes contact with the elastic steel bar exactly in the center. This can be accomplished by visually sighting it in from two different angles. Add water to a depth of approximately 3/4" above the perforated disk and allow the mold to remain in the swell frame overnight or a period of at least 16 hours. Do not readjust the screw stem after adding the water to the mold.

5.4.3. After the 16-hour waiting period, read the deflection of the steel bar by means of the micrometer dial and record on the work sheet. It is again important that the dial be pushed as far to the right as possible. The amount of drainage should also be indicated by the presence or absence of free water at the base of the mold. No drainage at all is indicated by a zero. Slight drainage will be denoted by "SL" and is recognized by a small amount of free water at the base of the mold. Moderate drainage will be "MOD" and is recognized by free water at the base of the mold and a definite drop of the water level inside the mold. Free drainage, denoted as "FD", will be completely void of standing water inside the mold. If the specimen is free draining, a little water must be added and allowed to percolate through in case the sample has dried out considerably.

5.4.4. The next step is to remove the mold from the swell frame, drain off the remaining water, and replace the perforated disk with a 4" Manila paper disk. Save the specimen for the R-value test.

5.4.5. Determine the expansion pressure in psi by multiplying the dial reading by 0.0308. Record the Expansion pressures on a preliminary soils worksheet.
6. PART V. METHOD OF DETERMINATION OF RESISTENCE R-VALUE BY HVEEM STABILOMETER

6.1. Scope

6.1.1. This method covers the procedure for determining the Resistance R-value of compacted soils or aggregates.

6.2. Apparatus

6.2.1. Hveem stabilometer (Figure A2.7) complete with standard metal specimen and follower.

6.2.2. Compression testing machine with spherically seated head.

6.2.3. Press. A lever equipped with a 4" diameter foot to push soil specimens from mold into stabilometer.

6.2.4. Dial on testing machine to measure head speed.

6.2.5. Stop watch.

6.2.6. Drying oven thermostatically controlled to maintain a temperature of 220-230°F.

6.3. Sample

6.3.1. The specimens as removed from the swell test frames.

6.4. Procedure

The correct volumetric adjustment of the air cell in the hydraulic chamber of the stabilometer is necessary in order to establish standardized horizontal pressure and displacement readings. The following is an outline of this calibration procedure.

6.4.1. Adjust the bronze nut on the stabilometer base so that the top of the stage is 3" below the bottom of the upper tapered ring. Perform all tests at this setting. The object is to have the entire briquette surface in contact with the diaphragm and any surplus diaphragm above the sample restrained by the follower.

6.4.2. Put standard metal specimen (4" diameter steel tube) in place in the stabilometer. Seat it firmly on the stage and by holding it in place with either the hand or a confining load of 100 lb. in the testing machine, turn the pump to cause a pressure of exactly 5.0 psi on the stabilometer gage. Adjust the turn indicator dial to zero. Turn pump handle at an approximate rate of two turns per second until the stabilometer dial reads 100 psi. The turns indicator dial should read 2.00 ± 0.05 turns. If it does not, the air in the cell must be adjusted. Remove or add air by means of the valve and repeat the displacement measurement after each air change until the proper number of turns is obtained. This initial displacement should be checked after each 3 or 4 specimens have been run through the stabilometer.

6.4.3. Place the mold containing the soil specimen on the stabilometer and push the specimen into the stabilometer using the press. The displacement pump should be backed off a sufficient number of turns to ensure no friction between the specimen and the diaphragm wall. Be certain free diaphragm is exposed above the top edge of specimen. All free diaphragm surface must be in contact with follower. Place the follower on top of the specimen and put the stabilometer in the testing machine with spherically seated head. Lower the testing machine head until it just engages the follower, but does not apply any load to the specimen.
6.4.4. Apply an initial reading of 5.0 psi on the stabilometer gage with the displacement pump. Then start the testing machine and adjust for a head speed of 0.05" per minute. The head speed must be checked and may need readjusting while the test is being made.

6.4.5. Record the stabilometer gage readings at loads of 500, 1,000, 1,500, and 2,000 lb, respectively, on the testing machine gage. In the case of a very expansive soil, a reading somewhat over 140 psi on the stabilometer gage at 2,000 lb. load may be encountered. In any case where 140 psi is reached before the 2,000 lb. is applied, do not continue to the 2,000 lb. point. Simply record the pressure at the 2,000 lb. load level as 140+ psi.

6.4.6. Vertical loading by the testing machine must cease at 2,000 lb. and the load must immediately be reduced to 1,000 lb. Turn the displacement pump so that the stabilometer gage reading is reduced to 5.0 psi. This will result in a further reduction in the applied testing machine load, which is normal and should be ignored. Set the displacement dial indicator to zero and turn the displacement pump handle to the right at a speed of 2 turns per second until the stabilometer gage reads 100 psi. During this operation, the applied testing machine load will increase and in some cases exceed the initial 1,000 lb. load. As before, these changes in testing machine loadings are normal and should be ignored.

6.4.7. Record the number of turns indicated on the dial as the displacement of the specimen. The turn indicator dial reads in 0.001" and each 0.1" is equal to one turn. Thus a net reading of 0.250" indicates that 2.50 turns were made and should be recorded as such on an R Value worksheet.

6.4.8. Remove the stabilometer from the testing machine and release the lateral pressure. Then remove the follower and the specimen from the stabilometer.

6.4.9. The Resistance R-value is computed from the following equation:

\[
RR - VVVVVVVVV = 100 - \frac{100}{D + \frac{P_v}{P_h} + 1}
\]

Where:  
R = Resistance R-value  
D = Turn Displacement  
P_v = 160 psi (Vertical pressure)  
P_h = Horizontal pressure, psi (at vertical pressure of 160 psi)

6.4.9.1. This value may also be taken from the chart shown in Figure A2.8. Another chart is shown in Figure A2.9 that can be used to correct the R-value of any specimen that must be used but exceed the height limits of 2.45" - 2.55". These R-values are then plotted against the corresponding exudation pressures and connected with a smooth curve.

6.4.9.2. Determine the point where the curve crosses the 2,500 lb. exudation load line (200 psi exudation pressure) and record it as the Resistance R-value for the tested material (see Example in Figure A2.10).
7. PART VI. METHOD OF CALCULATING THE DENSITIES OF TEST SPECIMENS

7.1. Scope

7.1.1. This part of the test method covers the procedure for calculating the densities of R-value test specimens.

7.2. Sample

7.2.1. The measurements of height and weight of the test specimen necessary for the density determination are made immediately after the determination of exudation pressure of R-value test specimens according to Part III of this test method and they are recorded on a preliminary soils worksheet.

7.3. Procedure

7.3.1. A moisture sample of approximately 500 g is taken from the original 13 lb. sample, as explained in Part I, and the data entered into an R Value worksheet.

The Moisture Content or Percent Water is computed by the following equation:

\[ \% \text{ moisture} = \frac{\text{Wt. of Water}}{\text{Wt. of Soil}} \times 100 \]

7.3.2. The Weight of Water is determined as follow:

\[ \text{Wt. of Water} = \text{Wt. of Soil} - \text{Dry Weight} \]

The Weight of Water is carried over to the line labeled "Wt. of Water" and entered for each specimen on an R Value worksheet. This is then added to the figures on the next line labeled "Water Added" giving the Total Water for each specimen. The Total Percent of Water is calculated as follow:

\[ \% \text{ Total Water} = \frac{\text{Wt. of Water}}{\text{Wt. of Soil}} \times 100 \]

7.3.3. The densities of the specimen are then computed from the following equations:

\[ \text{Density of Specimen} = \frac{\text{Wt. of Water}}{\text{Wt. of Soil}} \times 100 \]

8. REPORT

8.1. Report Test Results on Form ITD-803.
ANNEX

(Mandatory Information)

A1. METHOD OF FABRICATING PAPER BASKETS FOR R-VALUE SPECIMENS

A1.1. Scope:

A1.1.1. This method covers the procedure for fabricating paper baskets that are used in Test Methods No. California 301 and 304.

A1.2. Procedure:

A1.2.1. Apparatus

A1.2.1.1. Basket making device consisting of a 3 7/8" diameter cylindrical wooden block and a 1/2" masking tape dispenser (see Figure A2.11).

A1.2.2. Materials

A1.2.2.1. Strips of notched paper: 60 lb. brown Kraft paper 2 1/2" x 13 3/8" with slots 1 7/8" in length and 3/4" apart down the center of the strip (see Figure A2.12).

A1.2.2.2. 4" diameter phosphor-bronze perforated exudation pressure disks.

A1.2.3. 1/2" width masking tape.

A1.3. Fabrication Procedure

A1.3.1. Take a piece of slotted paper and fold around the cylindrical wooden block, hooking the slotted ends together. See photos B and C of Figure A2.11.

A1.3.2. Using four strips of 1/2" masking tape, tape phosphor-bronze disk to the paper so that the holes in the disk are not obscured in the process. See photos D and E of Figure A2.11.

A2. FIGURES DESCRIBED IN THIS METHOD

A2.1. This annex contains charts, photos of the apparatus, and worksheets used in this standard.
Figure A2.1— Chart for Determining Proper Amount of Material for 2-1/2" R-Value Briquette
Figure A2.2— Kneading Compactor

Figure A2.3— Compression Testing Machine
Figure A2.4— Moisture Exudation Device

Figure A2.5— Moisture Exudation Indicator Device
With 6 Light Sections
Figure A2.6—Swell Frames for Measuring Expansion Pressure

Figure A2.7—Hveem Stabilometer
Figure A2.8—Chart for Determining Resistance R-Value
CHART FOR CORRECTING R-VALUES TO SPECIMEN HEIGHT OF 2.50"

HEIGHT CORRECTION SHOULD BE MADE USING THE CHART BELOW.

NOTE: NO CORRECTION FOR SPECIMEN HEIGHTS BETWEEN 2.45" AND 2.55". INTERPOLATE R-VALUE CORRECTIONS FOR OTHER HEIGHTS.

EXAMPLE: OVERALL HEIGHT OF 2.65"
R-VALUE (UNCORRECTED) = 50
R-VALUE (CORRECTED) = 54

Figure A2.9—Chart for Correcting R-Value to Specimen Height of 2.5"
R-VALUE WORKSHEET

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Project No. 
Key Number: 

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<th>B</th>
<th>C</th>
<th>D</th>
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Coarse R-value Make up Calculations

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Make Up Moisture Content Calculations

To Achieve | % Moisture, Add Grams Of Water

Comments:

CAN NUMBER | M-2
WT. OF CAN + WET SOIL, GRAMS | 487.61
WT. OF CAN + DRY SOIL, GRAMS | 402.86
WT. OF WATER, GRAMS | 94.95
WT. OF CAN, GRAMS | 42.63
WT. OF DRY SOIL, GRAMS | 360.23
% WATER | 25.4%

TRIAL >>>>>> | A | B | C
ORIGINAL WT (gram) | 750.6 | 800.7 | 790.6
DRY WEIGHT (gram) | 594 | 634 | 626
WATER (grams) | 157 | 167 | 160

TRIAL >>>>>>>>>> | D | E
ORIGINAL WT (gram) | 770.9
DRY WEIGHT (gram) | 610
WATER (grams) | 181

SOIL DATA

TRAFFIC INDEX | 42
"R" VALUE | 
EXPANSION PRESS, PSI | 
BALLAST FROM "R" | 
FROM EXP. PRESSURE | 

Figure A2.10— Example of R-Value Test Worksheet
Figure A2.11— Fabricating Paper Basket for Test Specimen
Figure A2.12—Specifications for Paper Used To Fabricate Basket
Idaho Standard Practice for

Calibrating Torque Wrenches, Tightening and Testing Bolt Tension

IDAHO Designation: IR-12-17

1. SCOPE

1.1. This method is intended to provide a standard procedure for the calibration of torque wrenches.

1.2. This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. REFERENCE DOCUMENTS

2.1. ASTM Standards

   - E4-16, Standard Specification for Force Verification of Testing Machines

3. PROCEDURE

3.1. Before proceeding with calibration, assure that the tension measuring device has been calibrated by an approved testing agency within the last year in accordance with ASTM E4.

3.1.1. Prior to each day’s activities, verify the calibration of the wrench or wrenches being used. If a parameter is found to be out of calibration, adjust the wrench to assure the parameter is within the tolerable range. Report all calibration measurements including the date, out of tolerance values, and adjusted values.

4. CALIBRATION OF TORQUE WRENCH

4.1. Clamp the calibration unit on a solid immovable mount (e.g., beam, column, etc.)

4.2. Install front plate and matching rear bolt bushing for bolt size being used

4.3. Insert bolt from bushing side; washer and nut from plate side.

4.4. Torque Control Impact Wrenches:

4.4.1. Run up nut with impact wrench until wrench stalls. Read the dial for pounds tension. If reading is too high or low, adjust torque setting accordingly and repeat using new bolt and nut.

4.5. Conventional Impact Wrenches:

4.5.1. Set wrench air line regulator at desired power value. Run up nut until it stops rotating. Again, read the dial for pounds tension. Adjust regulator as necessary until wrench delivers desired bolt-tension dial reading.

4.6.1. Run up nut with wrench until reaching desired tension. Adjust ratchet release as necessary until wrench delivers desired bolt tension dial reading. For dial gage wrenches, document the dial reading to achieve the appropriate tension on the calibration unit, or adjust the dial gage if applicable.

4.7. Wrenches shall be calibrated to induce approximately 105 – 110% of the installation bolt tension listed in the ITD Standard Specifications Subsection 708.06 for the given bolt size, and in no case exceed 125% of the listed bolt tension. Acceptable calibration will consist of three (3) bolt assemblies testing within 10% of each other.
Idaho Standard Practice for

Calibrating the Skidmore-Wilhelm Torque-Wrench Calibration Unit

IDAHO Designation: IR-17-98

1. SCOPE

1.1. This method is intended to provide a standard procedure for the calibration of the Skidmore-Wilhelm Torque Wrench Calibration Unit.

1.2. This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. REFERENCE DOCUMENTS

2.1. ASTM Standards

2.2. OTHER Standards
   - Manufacturer’s Pamphlet

3. EQUIPMENT

3.1. Testing machine with a capacity of at least as high as the Skidmore unit and calibrated to ±1%.

3.2. Steel pressure plates (two each to fit piston No. 3 and inside plate screens No. 16).

4. PROCEDURE

4.1. Place torque-wrench calibration unit in the testing machine with the bolt plate No. 5 centered directly under the upper compression head. In centering the unit in the testing machine, make sure the steel pressure plates are in place. One pressure plate fits the piston No. 3 from the back sides, making sure it cleared the snap ring No. 7. The other steel pressure plate fits over bolt plate No. 5 and inside the plate screws No. 16.

4.2. After the forgoing has been accomplished, apply pressure with the testing machine to the torque-wrench calibration unit.

   Note 1— Before mating surfaces of the torque calibration unit with the testing machine heads, retain a small clearance. This clearance is then taken up with the hydraulic head of the testing machine. This step must be accomplished to prevent locking the heads of the testing machine together.

4.3. This pressure shall be at a slow, even rate so readings can be taken from both the testing machine dial and the torque-wrench calibration unit dial. This speed should not exceed 0.3125 in./minute.
The Skidmore unit is read at 5,000-lb. (20 kN) increments through the total range of the Skidmore unit.

4.4. The object of this calibration procedure is to relate the pounds pressure indicated by the torque-wrench calibration unit with the pounds pressure indicated by the calibrated testing machine in exact increments of pounds to each other. If there is any deviation between the two devices, the torque-wrench calibration unit must be sent to the manufacturer for repair, unless the repair is deemed minor and can be done by the laboratory accomplishing the calibrating.
<table>
<thead>
<tr>
<th>No.</th>
<th>Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Body</td>
</tr>
<tr>
<td>2</td>
<td>110,000# Gage</td>
</tr>
<tr>
<td>3</td>
<td>Piston</td>
</tr>
<tr>
<td>4</td>
<td>Set of Packing</td>
</tr>
<tr>
<td>5</td>
<td>Bolt Plate</td>
</tr>
<tr>
<td>6</td>
<td>Bolt Bushing</td>
</tr>
<tr>
<td>7</td>
<td>Snap Ring</td>
</tr>
<tr>
<td>8</td>
<td>Mounting Screw</td>
</tr>
<tr>
<td>9</td>
<td>Gage Guard</td>
</tr>
<tr>
<td>10</td>
<td>Dowel Pin (for Bushing)</td>
</tr>
<tr>
<td>11</td>
<td>Dowel Pin</td>
</tr>
<tr>
<td>12</td>
<td>S.A.E. 40 Oil (Non-Detergent)</td>
</tr>
<tr>
<td>13</td>
<td>Gage Saver</td>
</tr>
<tr>
<td>14</td>
<td>Pipe Coupling</td>
</tr>
<tr>
<td>15</td>
<td>Bushing Retainer</td>
</tr>
<tr>
<td>16</td>
<td>Plate Screw</td>
</tr>
</tbody>
</table>

Figure 1—Skidmore-Wilhelm Torque-Wrench Calibration Unit
Idaho Standard Practice for

Pavement Straightedge Procedures

IDAHO Designation: IR-87-17

1. **SCOPE**

1.1. This method establishes procedures for making straightedge measurements on the riding surfaces of pavements and is intended for use with the hand-held 10 ft. straightedge.

1.2. *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. **APPARATUS**

2.1. The apparatus shall consist of a 10 ft. straightedge. The straightedge shall be visually straight when checked periodically against a taut fine (about 1/64 in. diameter) wire.

3. **PROCEDURE**

3.1. Surface irregularities shall be measured from the straightedge to various points on the pavement surface below the straightedge. The straightedge shall be firmly supported by the pavement.

3.2. Tests for surface irregularities shall be made parallel to centerline and normal (transverse) to centerline as required to verify conformance with specified limits.

3.3. All transverse construction joints shall be measured. Make these measurements with the straightedge centered on each joint.

3.4. Individual judgment shall be exercised when taking measurements on short, steep, super-elevated sections and crowned sections of short radii such as at intersections of city streets, etc.

3.5. On bridge decks where the specifications require 90 percent of the readings to be less than 1/8 in., measurements shall be taken in each wheel path in continuous lines as provided in paragraph 3.2 above for the full length of the structure. In addition, at locations determined by the Engineer, straightedge measurements are to be taken perpendicular to centerline. These transverse measurements may be made either in continuous lines or as individual 10 ft. samples at selected locations. Measure the lengths of irregularities, which are less than 1/8 in. below the straightedge, to the nearest 1 in. Add up the lengths having less than 1/8 in. deviation within each 10 ft. increment, divide by the straightedge length and multiply by 100 to obtain the percentage less than 1/8 in. Also measure any deviations greater than 1/4 in. when the specification requires. Measure joints separately as provided in Paragraph 3.3 above.
Idaho Standard Method of Test for

Determining Volume of Liquids in horizontal or Vertical Storage Tanks

IDAHO Designation: IT-120-17

1. SCPE

1.1. This method is used to determine the volume of liquids in horizontal and vertical storage tanks. It is usually called "sticking" the tank.

1.2. This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. PURPOSE

2.1. The quantity of liquid materials at the beginning and end of shifts are needed to determine approximately how much material is being used each day and to compare with invoice totals at specific intervals when the tank is empty, full, etc.

3. APPARATUS

3.1. A 50-foot flexible steel tape graduated in inches or tenths of feet.

3.2. Graduated wooden rod made for tank measurements, if available.

3.3. Rags.

3.4. Insulated gloves (see Section 5, Safety Precautions).

3.5. Ladder, string, flashlight, etc., as found necessary.

Note 1—Many tanks have some indicator showing the height of liquid in the tank. This indicator may be a glass sight gauge; a permanently installed metal ladder gauge inside, visible from the top or through windows; a float with a pulley and indication on the outside; or other method. In case of doubt about the accuracy of these indicators, they should be calibrated using the data in this Test Method.

4. TEST PROCEDURE

4.1. Horizontal Tanks

4.1.1. The volume of the tank must be known or calculated as follows.

4.1.2. Determine the length and the diameter of the tank using calculated inside measurements. Calculate the volume:
Where:

\[ VV(\text{tank}) = \frac{\pi D^2}{4} \times LL \times 7.48 \]

- **D** = Diameter of the tank, in feet and tenths of feet
- **L** = Length of the tank, in feet and tenths of feet

4.1.3. Measure the depth of the liquid (h) in the tank by use of the "stick" or a weighted tape.

4.1.3.1. Divide (h) by the diameter of the tank and multiply by 100 to get the percent depth filled.

4.1.3.2. Using this percent depth filled value from Table 1, obtain the percent of capacity.

4.1.4. Multiply the known volume of the tank, \( V \) by the percent capacity just obtained and divide by 100 to give the volume of hot liquid.

4.2. **Vertical Tanks**

4.2.1. Measure the inside diameter of the tank. Calculate the volume per foot as follows.

\[ VV(\text{tank}) = \frac{\pi D^2}{4} \times 7.48 \]

Where:

- **D** = Diameter of the tank, in feet and tenths of feet

4.2.2. Measure the depth of liquid (h) in feet to the nearest tenth.

4.2.3. Calculate the volume of hot liquid as follows:

\[ VV(\text{tank}) = \frac{\pi D^2}{4} \times h \]

4.2.4. Convert the volume of hot liquid obtained from Paragraph 4.1.4 or 4.2.3 to standard 60°F volume using standard temperature conversion charts such as Tables IV-1, 2, and 3 of the Asphalt Institute Manual Number MS-6.

4.2.5. Convert standard temperature volume in gallons to English tons using Table 2.

5. **SAFETY PRECAUTIONS**

5.1. Materials being sampled are usually hazardous. They may be hot (asphalt), flammable (gas, fuel oil, or solvents), caustic (lime solutions), poison (weed killers), etc., and every care must be taken to protect the person sampling. Protective clothing should be worn. Hard hats, goggles or safety glasses, insulated gloves, long-sleeved shirts, heavy shoes, and face masks, if necessary, should be used.
### Table 1—Quantities for Various Depths of Cylindrical Tanks in a Horizontal Position

![Table 1](https://example.com/table1.png)

Asphalt Institute MS-6
Table 2 — Weight and Volume Relations [60°F]

<table>
<thead>
<tr>
<th>SP. GR.</th>
<th>Pounds per Gallon</th>
<th>Gallons per Ton</th>
<th>SP. GR.</th>
<th>Pounds per Gallon</th>
<th>Gallons per Ton</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.855</td>
<td>7.119</td>
<td>280.9</td>
<td>0.970</td>
<td>8.078</td>
<td>247.6</td>
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<tr>
<td>0.860</td>
<td>7.161</td>
<td>279.3</td>
<td>0.975</td>
<td>8.120</td>
<td>246.3</td>
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<td>0.865</td>
<td>7.203</td>
<td>277.7</td>
<td>0.980</td>
<td>8.162</td>
<td>245.0</td>
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<td>0.870</td>
<td>7.244</td>
<td>276.1</td>
<td>0.985</td>
<td>8.203</td>
<td>243.8</td>
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<td>0.875</td>
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<td>0.990</td>
<td>8.245</td>
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<td>0.995</td>
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<td>1.000</td>
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<td>1.070</td>
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<td>8.036</td>
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</table>
SAMPLING OF AGGREGATES
FOP FOR AASHTO T 2

Scope

This procedure covers sampling of coarse, fine, or a combination of coarse and fine aggregates (CA and FA) in accordance with AASHTO T 2-91. Sampling from conveyor belts, transport units, roadways, and stockpiles is covered.

Apparatus

- Shovels or scoops, or both
- Sampling tubes of acceptable dimensions
- Mechanical sampling systems: normally a permanently attached device that allows a sample container to pass perpendicularly through the entire stream of material or diverts the entire stream of material into the container by manual, hydraulic, or pneumatic operation
- Belt template
- Sampling containers

Procedure – General

Sampling is as important as testing. The technician shall use every precaution to obtain samples that are representative of the material. Determine the time or location for sampling in a random manner.

1. Wherever samples are taken, obtain multiple increments of approximately equal size.

2. Mix the increments thoroughly to form a field sample that meets or exceeds the minimum mass recommended in Table 1.
TABLE 1
Recommended Sample Sizes

<table>
<thead>
<tr>
<th>Nominal Maximum Size* mm (in.)</th>
<th>Minimum Mass g (lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>90 (3 1/2)</td>
<td>175,000 (385)</td>
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<tr>
<td>75 (3)</td>
<td>150,000 (330)</td>
</tr>
<tr>
<td>63 (2 1/2)</td>
<td>125,000 (275)</td>
</tr>
<tr>
<td>50 (2)</td>
<td>100,000 (220)</td>
</tr>
<tr>
<td>37.5 (1 1/2)</td>
<td>75,000 (165)</td>
</tr>
<tr>
<td>25.0 (1)</td>
<td>50,000 (110)</td>
</tr>
<tr>
<td>19.0 (3/4)</td>
<td>25,000 (55)</td>
</tr>
<tr>
<td>12.5 (1/2)</td>
<td>15,000 (35)</td>
</tr>
<tr>
<td>9.5 (3/8)</td>
<td>10,000 (25)</td>
</tr>
<tr>
<td>4.75 (No. 4)</td>
<td>10,000 (25)</td>
</tr>
<tr>
<td>2.36 (No. 8)</td>
<td>10,000 (25)</td>
</tr>
</tbody>
</table>

* One sieve larger than the first sieve to retain more than 10 percent of the material using an agency specified set of sieves based on cumulative percent retained. Where large gaps in specification sieves exist, intermediate sieve(s) may be inserted to determine nominal maximum size. Maximum size is one size larger than nominal maximum size.

**Note 1:** Sample size is based upon the test(s) required. As a general rule, the field sample size should be such that, when split twice will provide a testing sample of proper size. For example, the sample size may be four times that shown in Table 2 of the FOP for AASHTO T 27/T 11, if that mass is more appropriate.

**Procedure – Specific Situations**

**Conveyor Belts**

Avoid sampling at the beginning or end of the aggregate run due to the potential for segregation. Be careful when sampling in the rain. Make sure to capture fines that may stick to the belt or that the rain tends to wash away.

**Method A (From the Belt)**

1. Stop the belt.
2. Set the sampling template in place on the belt, avoiding intrusion by adjacent material.
3. Remove the material from inside the template, including all fines.
4. Obtain at least three approximately equal increments.
5. Combine the increments to form a single sample.
Method B (From the Belt Discharge)

1. Pass a sampling device through the full stream of the material as it runs off the end of the conveyor belt. The sampling device may be manually, semi-automatic or automatically powered.

2. The sampling device shall pass through the stream at least twice, once in each direction, without overfilling while maintaining a constant speed during the sampling process.

3. When emptying the sampling device into the container, include all fines.

4. Combine the increments to form a single sample.

Transport Units

1. Visually divide the unit into four quadrants.

2. Identify one sampling location in each quadrant.

3. Dig down and remove approximately 0.3 m (1 ft.) of material to avoid surface segregation. Obtain each increment from below this level.

4. Combine the increments to form a single sample.

Roadways

Method A (Berm or Windrow)

1. Obtain sample before spreading.

2. Take the increments from at least three random locations along the fully-formed windrow or berm. Do not take the increments from the beginning or the end of the windrow or berm.

3. Obtain full cross-section samples of approximately equal size at each location. Take care to exclude the underlying material.

4. Combine the increments to form a single sample.

Note 2: Obtaining samples from berms or windrows may yield extra-large samples and may not be the preferred sampling location.
Method B (In-Place)

1. Obtain sample after spreading and before compaction.

2. Take the increments from at least three random locations.

3. Obtain full-depth increments of approximately equal size from each location. Take care to exclude the underlying material.

4. Combine the increments to form a single sample.

Stockpiles

Method A – Loader sampling

1. Direct the loader operator to enter the stockpile with the bucket at least 150 mm (6 in.) above ground level without contaminating the stockpile.

2. Discard the first bucketful.

3. Have the loader re-enter the stockpile and obtain a full loader bucket of the material, tilt the bucket back and up.

4. Form a small sampling pile at the base of the stockpile by gently rolling the material out of the bucket with the bucket just high enough to permit free-flow of the material. (Repeat as necessary.)

5. Create a flat surface by having the loader back drag the small pile.

6. Visually divide the flat surface into four quadrants.

7. Collect an increment from each quadrant by fully inserting the shovel into the flat pile as vertically as possible, take care to exclude the underlying material, roll back the shovel and lift the material slowly out of the pile to avoid material rolling off the shovel.

Method B – Stockpile Face Sampling

1. Create horizontal surfaces with vertical faces in the top, middle, and bottom third of the stockpile with a shovel or loader.

2. Prevent continued sloughing by shoving a flat board against the vertical face. Sloughed material will be discarded to create the horizontal surface.

3. Obtain sample from the horizontal surface as close to the intersection as possible of the horizontal and vertical faces.
4. Obtain at least one increment of equal size from each of the top, middle, and bottom thirds of the pile.

5. Combine the increments to form a single sample.

**Method C – Alternate Tube Method (Fine Aggregate)**

1. Remove the outer layer that may have become segregated.

2. Using a sampling tube, obtain one increment of equal size from a minimum of five random locations on the pile.

3. Combine the increments to form a single sample.

*Note 3:* Obtaining samples at stockpiles should be avoided whenever possible due to problems involved in obtaining a representative gradation of material.

**Report**

- On forms approved by the agency
- Date
- Time
- Sample ID
- Location
- Quantity represented
PERFORMANCE EXAM CHECKLIST

SAMPLING OF AGGREGATES
FOP FOR AASHTO T 2

Participant Name __________________________ Exam Date ________________

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Conveyor Belts – Method A (From the Belt)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Belt stopped?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Sampling template set on belt, avoiding intrusion of adjacent material?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Sample, including all fines, scooped off?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Samples taken in at least three approximately equal increments?</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Conveyor Belts – Method B (From the Belt Discharge)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Sampling device passed through full stream of material twice (once in each direction) as it runs off end of belt?</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Transport Units</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Unit divided into four quadrants?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Increment obtained from each quadrant, 0.3 m (1ft.) below surface?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Increments combined to make up the sample?</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Roadways Method A (Berm or Windrow)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Sample taken prior to spreading?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Full depth of material taken?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Underlying material excluded?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Samples taken in at least three approximately equal increments?</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Roadways Method B (In-place)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Sample taken after spreading?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. Full depth of material taken?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. Underlying material excluded?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16. Samples taken in at least three approximately equal increments?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

OVER
Stockpile Method A – (Loader sampling)

17. Loader operator directed to enter the stockpile with the bucket at least 150 mm (6 in.) above ground level without contaminating the stockpile?  

18. First bucketful discarded?  

19. The loader re-entered the stockpile and obtained a full loader bucket of the material with the bucket tilted back and up?  

20. A small sampling pile formed at the base of the stockpile by gently rolling the material out of the bucket with the bucket just high enough to permit free-flow of the material?  

21. A flat surface created by the loader back dragging the small pile?  

22. Increment sampled from each quadrant by fully inserting the shovel into the flat pile as vertically as possible, care taken to exclude the underlying material?  

Stockpile Method B (Stockpile Face)

23. Created horizontal surfaces with vertical faces?  

24. At least one increment taken from each of the top, middle, and bottom thirds of the stockpile.  

Stockpile Method C – Alternate Tube Method (Fine Aggregate)

25. Outer layer removed?  

26. Increments taken from at least five locations with a sampling tube?  

General

27. Increments mixed thoroughly to form sample?  

Comments:  

First attempt:  Pass____ Fail____ Second attempt: Pass____ Fail____

Examiner Signature_________________________ WAQTC #:______________________
PERFORMANCE EXAM CHECKLIST (ORAL)

SAMPLING OF AGGREGATES
FOP FOR AASHTO T 2

Participant Name______________________________ Exam Date ________________

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. How is a sample obtained from a conveyor belt using Method A?</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Stop the belt.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b) Set the sampling template on belt, avoiding intrusion of adjacent material.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c) All the material is removed from belt including all fines.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d) Take at least approximately three equal increments.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>2. How is a sample obtained from a conveyor belt using Method B?</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Pass the sampling device through a full stream of material as it runs off the end of the belt.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b) The device must be passed through at least twice (once in each direction).</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>3. How is a sample obtained from a Transport Unit?</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Divide the unit into four quadrants.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b) Dig 0.3 m (1 ft.) below surface.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c) Obtain an increment from each quadrant.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>4. Describe the procedure for sampling from roadways Method A (Berm or Windrow).</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Sample prior to spreading</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b) Sample the material full depth without obtaining underlying material.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c) Take at least three approximately equal increments.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>5. Describe the procedure for sampling from roadway Method B (In-place).</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Sample after spreading, prior to compaction.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b) Sample the material full depth without obtaining underlying material.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c) Take at least three approximately equal increments.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>6. Describe the procedure for sampling a stockpile Method A (Loader Sampling).</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Loader creates sampling pile with a flat surface.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b) Divide the flat surface into four quadrants.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c) Take an approximately equal increment from each quadrant, excluding the underlying material.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

OVER
7. Describe the procedure for sampling a stockpile Method B (Stockpile Face Sampling).
   a) Create horizontal surfaces with vertical faces and at least one increment taken from each of the top, middle, and bottom thirds of the stockpile.

8. Describe the procedure for sampling a stockpile Method C – Alternate Tube Method (Fine Aggregate).
   a) Remove the outer layer and increments taken from at least five locations.

9. After obtaining the increments what should you do before performing R 76?
   a) Increments mixed thoroughly to form sample.

Comments: First attempt: Pass Fail Second attempt: Pass Fail

Examiner Signature________________________ WAQTC #:________________________
REDUCING SAMPLES OF AGGREGATES TO TESTING SIZE
FOP FOR AASHTO R 76

Scope

This procedure covers the reduction of samples to the appropriate size for testing in accordance with AASHTO R 76-16. Techniques are used that minimize variations in characteristics between test samples and field samples. Method A (Mechanical Splitter) and Method B (Quartering) are covered.

This FOP applies to fine aggregate (FA), coarse aggregate (CA), and mixes of the two (FA/CA), and may also be used on soils.

Apparatus

Method A – Mechanical Splitter

Splitter chutes:

- Even number of equal width chutes
- Discharge alternately to each side
- Minimum of 8 chutes total for CA and FA/CA, 12 chutes total for FA
- Width:
  - Minimum 50 percent larger than largest particle
  - Maximum chute width of 19 mm (3/4 in.) for fine aggregate passing the 9.5 mm (3/8 in.) sieve

Feed control:

- Hopper or straightedge pan with a width equal to or slightly less than the overall width of the assembly of chutes
- Capable of feeding the splitter at a controlled rate

Splitter receptacles / pans:

- Capable of holding two halves of the sample following splitting

The splitter and accessory equipment shall be so designed that the sample will flow smoothly without restriction or loss of material.
Method B – Quartering

- Straightedge scoop, shovel, or trowel
- Broom or brush
- Canvas or plastic sheet, approximately 2 by 3 m (6 by 9 ft)

Method Selection

Samples of CA may be reduced by either Method A or Method B.

Samples of FA which are drier than the saturated surface dry (SSD) condition, as described in AASHTO T 84, shall be reduced by a mechanical splitter according to Method A. As a quick approximation, if the fine aggregate will retain its shape when molded with the hand, it is wetter than SSD.

Samples of FA / CA which are drier than SSD may be reduced by Method A or Method B.

Samples of FA and FA / CA that are at SSD or wetter than SSD shall be reduced by Method B, or the entire sample may be dried to the SSD condition – using temperatures that do not exceed those specified for any of the tests contemplated – and then reduced to test sample size using Method A.

<table>
<thead>
<tr>
<th></th>
<th>Drier than SSD</th>
<th>Wetter than SSD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fine Aggregate (FA)</td>
<td>Method A (Mechanical)</td>
<td>Method B (Quartering)</td>
</tr>
<tr>
<td>Mixture of FA/CA</td>
<td>Either Method</td>
<td>Method B (Quartering)</td>
</tr>
<tr>
<td>Coarse Aggregate (CA)</td>
<td>Either Method</td>
<td>Either Method</td>
</tr>
</tbody>
</table>

Table 1

Procedure

Method A – Mechanical Splitter

1. Place the sample in the hopper or pan and uniformly distribute it from edge to edge so that approximately equal amounts flow through each chute. The rate at which the sample is introduced shall be such as to allow free flowing through the chutes into the pans below.
2. Reduce the sample from one of the two pans as many times as necessary to reduce the sample to meet the minimum size specified for the intended test. The portion of the material collected in the other pan may be reserved for reduction in size for other tests.

3. As a check for effective reduction, determine the mass of each reduced portion. If the percent difference of the two masses is greater than 5 percent, corrective action must be taken. In lieu of the check for effective reduction, use the method illustrated in Figure 1.

**Figure 1**

Sample (S) is an amount greater than or equal to twice the mass needed for testing. Sample (S) is reduced in a mechanical splitter to yield parts (1) and (2).

Part (1) is further reduced yielding (A) and (B) while part (2) is reduced to yield (B) and (A).

Final testing sample is produced by combining alternate pans, i.e. A/A or B/B only.

**Calculation**

\[
\begin{align*}
\text{Splitter check: } 5127 \text{ g total sample mass} \\
\text{Splitter pan } #1: 2583 \text{ g} \\
\text{Splitter pan } #2: 2544 \text{ g} \\
\frac{2544 \text{ g}}{2583 \text{ g}} = 0.985 \\
(1 - 0.985) \times 100 = 1.5% 
\end{align*}
\]
Procedure

Method B – Quartering

Use either of the following two procedures or a combination of both.

Procedure # 1: Quartering on a clean, hard, level surface:

1. Place the sample on a hard, clean, level surface where there will be neither loss of material nor the accidental addition of foreign material.

2. Mix the material thoroughly by turning the entire sample over a minimum of four times. With the last turning, shovel the entire sample into a conical pile by depositing each shovelful on top of the preceding one.

3. Flatten the conical pile to a uniform thickness and diameter by pressing down with a shovel. The diameter should be four to eight times the thickness.

4. Divide the flattened pile into four approximately equal quarters with a shovel or trowel.

5. Remove two diagonally opposite quarters, including all fine material, and brush the cleared spaces clean.

6. Successively mix and quarter the remaining material until the sample is reduced to the desired size.

7. The final test sample consists of two diagonally opposite quarters.

Procedure # 2: Quartering on a canvas or plastic sheet:

1. Place the sample on the sheet.

2. Mix the material thoroughly a minimum of four times by pulling each corner of the sheet horizontally over the sample toward the opposite corner. After the last turn, form a conical pile.

3. Flatten the conical pile to a uniform thickness and diameter by pressing down with a shovel. The diameter should be four to eight times the thickness.

4. Divide the flattened pile into four approximately equal quarters with a shovel or trowel, or, insert a stick or pipe beneath the sheet and under the center of the pile, then lift both ends of the stick, dividing the sample into two roughly equal parts. Remove the stick leaving a fold of the sheet between the divided portions. Insert the stick under the center of the pile at right angles to the first division and again lift both ends of the stick, dividing the sample into four roughly equal quarters.
5. Remove two diagonally opposite quarters, being careful to clean the fines from the sheet.

6. Successively mix and quarter the remaining material until the sample size is reduced to the desired size.

7. The final test sample consists of two diagonally opposite quarters.
PERFORMANCE EXAM CHECKLIST

REDUCING FIELD SAMPLES OF AGGREGATES TO TESTING SIZE
FOP FOR AASHTO R 76

Participant Name_________________________ Exam Date ____________

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

Method A - Splitting

1. Material spread uniformly on feeder? __________

2. Rate of feed slow enough so that sample flows freely through chutes? __________

3. Material in one pan re-split until desired mass is obtained? __________

Method B - Quartering

1. Sample placed on clean, hard, and level surface? __________

2. Mixed by turning over 4 times with shovel or by pulling sheet horizontally over pile? __________

3. Conical pile formed? __________

4. Diameter equal to about 4 to 8 times thickness? __________

5. Pile flattened to uniform thickness and diameter? __________

6. Divided into 4 equal portions with shovel or trowel? __________

7. Two diagonally opposite quarters, including all fine material, removed? __________

8. Cleared space between quarters brushed clean? __________

9. Process continued until desired sample size is obtained when two opposite quarters combined? __________

   The sample may be placed upon a sheet and a stick or pipe may be placed under the sheet to divide the pile into quarters.

Comments: First attempt: Pass____ Fail____ Second attempt: Pass____ Fail____

Examiner Signature_________________________ WAQTC #: ______________

2_R76_pr_16.docx Aggregate 2-7 Pub. October 2017
TOTAL EVAPORABLE MOISTURE CONTENT OF AGGREGATE BY DRYING FOP FOR AASHTO T 255

Scope

This procedure covers the determination of moisture content of aggregate in accordance with AASHTO T 255-00. It may also be used for other construction materials.

Overview

Moisture content is determined by comparing the wet mass of a sample and the mass of the sample after drying to constant mass. The term constant mass is used to define when a sample is dry.

*Constant mass* – the state at which a mass does not change more than a given percent, after additional drying for a defined time interval, at a required temperature.

Apparatus

- Balance or scale: Capacity sufficient for the principle sample mass, accurate to 0.1 percent of sample mass or readable to 0.1 g, meeting the requirements of AASHTO M 231.
- Containers: clean, dry and capable of being sealed
- Suitable drying containers
- Microwave safe container with ventilated lids
- Heat source, controlled
  - Forced draft oven
  - Ventilated oven
  - Convection oven
- Heat source, uncontrolled
  - Infrared heater, hot plate, fry pan, or any other device/method that will dry the sample without altering the material being dried
  - Microwave oven (900 watts minimum)
• Hot pads or gloves

• Utensils such as spoons

Sample Preparation

In accordance with the FOP for AASHTO T 2 obtain a representative sample in its existing condition. The representative sample size is based on Table 1 or other information that may be specified by the agency.

TABLE 1
Sample Sizes for Moisture Content of Aggregate

<table>
<thead>
<tr>
<th>Nominal Maximum Size* mm (in.)</th>
<th>Minimum Sample Mass g (lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>150 (6)</td>
<td>50,000 (110)</td>
</tr>
<tr>
<td>100 (4)</td>
<td>25,000 (55)</td>
</tr>
<tr>
<td>90 (3 1/2)</td>
<td>16,000 (35)</td>
</tr>
<tr>
<td>75 (3)</td>
<td>13,000 (29)</td>
</tr>
<tr>
<td>63 (2 1/2)</td>
<td>10,000 (22)</td>
</tr>
<tr>
<td>50 (2)</td>
<td>8000 (18)</td>
</tr>
<tr>
<td>37.5 (1 1/2)</td>
<td>6000 (13)</td>
</tr>
<tr>
<td>25.0 (1)</td>
<td>4000 (9)</td>
</tr>
<tr>
<td>19.0 (3/4)</td>
<td>3000 (7)</td>
</tr>
<tr>
<td>12.5 (1/2)</td>
<td>2000 (4)</td>
</tr>
<tr>
<td>9.5 (3/8)</td>
<td>1500 (3.3)</td>
</tr>
<tr>
<td>4.75 (No. 4)</td>
<td>500 (1.1)</td>
</tr>
</tbody>
</table>

* One sieve larger than the first sieve to retain more than 10 percent of the material using an agency specified set of sieves based on cumulative percent retained. Where large gaps in specification sieves exist, intermediate sieve(s) may be inserted to determine nominal maximum size.

Immediately seal or cover samples to prevent any change in moisture content or follow the steps in “Procedure.”

Procedure

Determine all masses to the nearest 0.1 percent of the sample mass or to the nearest 0.1 g.

When determining the mass of hot samples or containers or both, place and tare a buffer between the sample container and the balance. This will eliminate damage to or interference with the operation of the balance or scale.
1. Determine and record the mass of the container (and lid for microwave drying).

2. Place the wet sample in the container.
   a. For oven(s), hot plates, infrared heaters, etc.: Spread the sample in the container.
   b. For microwave oven: Heap sample in the container; cover with ventilated lid.

3. Determine and record the total mass of the container and wet sample.

4. Determine and record the wet mass of the sample by subtracting the container mass determined in Step 1 from the mass of the container and sample determined in Step 3.

5. Place the sample in one of the following drying apparatus:
   b. Uncontrolled heat source (Hot plate, infrared heater, etc.): Stir frequently to avoid localized overheating.

6. Dry until sample appears moisture free.

7. Determine mass of sample and container.

8. Determine and record the mass of the sample by subtracting the container mass determined in Step 1 from the mass of the container and sample determined in Step 7.

9. Return sample and container to the heat source for additional drying.
   a. Controlled (oven): 30 minutes
   b. Uncontrolled (Hot plate, infrared heater, etc.): 10 minutes
   c. Uncontrolled (Microwave oven): 2 minutes

**Caution:** Some minerals in the sample may cause the aggregate to overheat, altering the aggregate gradation.

10. Determine mass of sample and container.

11. Determine and record the mass of the sample by subtracting the container mass determined in Step 1 from the mass of the container and sample determined in Step 10.

12. Determine percent change by subtracting the new mass determination \( M_n \) from the previous mass determination \( M_p \) divide by the previous mass determination \( M_p \) multiply by 100.
13. Continue drying, performing steps 9 through 12, until there is less than a 0.10 percent change after additional drying time.

14. Constant mass has been achieved, sample is defined as dry.

15. Allow the sample to cool. Determine and record the total mass of the container and dry sample.

16. Determine and record the dry mass of the sample by subtracting the mass of the container determined in Step 1 from the mass of the container and sample determined in Step 15.

17. Determine and record percent moisture by subtracting the final dry mass determination \( M_D \) from the initial wet mass determination \( M_W \) divide by the final dry mass determination \( M_D \) multiply by 100.

### Table 2

**Methods of Drying**

<table>
<thead>
<tr>
<th>Heat Source</th>
<th>Specific Instructions</th>
<th>Drying intervals to achieve constant mass (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Controlled:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Forced Draft Oven (preferred),</td>
<td>110 ±5°C (230 ±9°F)</td>
<td>30</td>
</tr>
<tr>
<td>Ventilated Oven, or Convection Oven</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Uncontrolled:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hot plate, Infrared heater, etc.</td>
<td>Stir frequently</td>
<td>10</td>
</tr>
<tr>
<td>Microwave</td>
<td>Heap sample and cover with ventilated lid</td>
<td>2</td>
</tr>
</tbody>
</table>

### Calculation

#### Constant Mass:

Calculate constant mass using the following formula:

\[
\frac{MM_{pp} - MM_{nn}}{MM_{pp}} \times 100 = \% \text{ Change}
\]

Where:

- \( M_p \) = previous mass measurement
- \( M_n \) = new mass measurement
Example:

Mass of container: 1232.1 g

Mass of container after first drying cycle: 2637.2 g

Mass, $M_p$, of possibly dry sample: $2637.2 \text{ g} - 1232.1 \text{ g} = 1405.1 \text{ g}$

Mass of container and dry sample after second drying cycle: 2634.1 g

Mass, $M_n$, of dry sample: $2634.1 \text{ g} - 1232.1 \text{ g} = 1402.0 \text{ g}$

\[
\frac{1405.1 \text{ g} - 1402.0 \text{ g}}{1405.1 \text{ g}} \times 100 = 0.22\%
\]

0.22 percent is not less than 0.10 percent, so continue drying

Mass of container and dry sample after third drying cycle: 2633.0 g

Mass, $M_n$, of dry sample: $2633.0 \text{ g} - 1232.1 \text{ g} = 1400.9 \text{ g}$

\[
\frac{1402.0 \text{ g} - 1400.9 \text{ g}}{1402.0 \text{ g}} \times 100 = 0.08\%
\]

0.08 percent is less than 0.10 percent, so constant mass has been reached

**Moisture Content:**

Calculate the moisture content, $w$, as a percent, using the following formula:

\[
\frac{M_W - M_D}{M_D} \times 100 = \% M = \text{wet mass} \\
M_D = \text{dry mass}
\]
Example:

Mass of container: 1232.1 g

Mass of container and wet sample: 2764.7 g

Mass, M_w, of wet sample: 2764.7 g - 1232.1 g = 1532.6 g

Mass of container and dry sample (COOLED): 2633.0 g

Mass, M_D, of dry sample: 2633.0 g - 1232.1 g = 1400.9 g

\[ w_w = \frac{1532.6g - 1400.9g}{1400.9g} \times 100 = \frac{131.7g}{1400.9g} = 9.40\% \text{ rounded to 9.4\%} \]

Report

- Results on forms approved by the agency
- Sample ID
- M_w, wet mass
- M_D, dry mass
- w, moisture content to nearest 0.1 percent
PERFORMANCE EXAM CHECKLIST

TOTAL MOISTURE CONTENT OF AGGREGATE BY DRYING FOP FOR AASHTO T 255

Participant Name ___________________________ Exam Date ______________

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Representative sample of appropriate mass obtained?</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>2. Mass of container determined to 0.1 percent or 0.1 g?</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>3. Sample placed in container and wet mass determined to 0.1 percent or 0.1 g?</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>4. Test sample mass conforms to the required mass?</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>5. Wet mass of sample determined to 0.1 percent or 0.1 g?</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>6. Loss of moisture avoided prior to mass determination?</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>7. Sample dried by a suitable heat source?</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>8. If aggregate heated by means other than a controlled oven, is sample stirred to avoid localized overheating?</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>9. Is aggregate heated for the additional, specified time (forced draft, ventilated, convection – 30 minutes; microwave – 2 minutes; other – 10 minutes) and then mass determined and compared to previous mass – showing less than 0.10 percent loss?</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>10. Sample cooled prior to dry mass determination to 0.1 percent or 0.1 g?</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>11. Calculations performed properly and results reported to the nearest 0.1 percent?</td>
<td>_____</td>
<td>_____</td>
</tr>
</tbody>
</table>

Comments: First attempt: Pass_____Fail_____; Second attempt: Pass_____Fail_____

OVER
<table>
<thead>
<tr>
<th></th>
<th>TRIAL: #1</th>
<th>TRIAL #2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mw + pan</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pan</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mw</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mp1 + pan</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mp1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mp2 + pan</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mp2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mp3 + pan</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mp3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Md + pan</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Md</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Moisture content Check</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Examiner Signature__________________________ WAQTC #:__________________
SIEVE ANALYSIS OF FINE AND COARSE AGGREGATES
FOP FOR AASHTO T 27

MATERIALS FINER THAN 75 µm (No. 200) SIEVE IN MINERAL AGGREGATE
BY WASHING
FOP FOR AASHTO T 11

Scope

A sieve analysis, or ‘gradation,’ measures distribution of aggregate particle sizes within a given sample.

Accurate determination of the amount of material smaller than 75 µm (No. 200) cannot be made using just AASHTO T 27. If quantifying this material is required, use AASHTO T 11 in conjunction with AASHTO T 27.

This FOP covers sieve analysis in accordance with AASHTO T 27-14 and materials finer than 75 µm (No. 200) in accordance with AASHTO T 11-05 performed in conjunction with AASHTO T 27. The procedure includes three methods: A, B, and C.

Apparatus

- Balance or scale: Capacity sufficient for the masses shown in Table 1, accurate to 0.1 percent of the sample mass or readable to 0.1 g, and meeting the requirements of AASHTO M 231
- Sieves: Meeting the requirements of ASTM E11
- Mechanical sieve shaker: Meeting the requirements of AASHTO T 27
- Suitable drying equipment (refer to FOP for AASHTO T 255)
- Containers and utensils: A pan or vessel of sufficient size to contain the test sample covered with water and permit vigorous agitation without loss of test material or water
- Optional: mechanical washing device

Sample Sieving

- In all procedures, the test sample is shaken in nested sieves. Sieves are selected to furnish information required by specification. Intermediate sieves are added for additional information or to avoid overloading sieves, or both.
- The sieves are nested in order of increasing size from the bottom to the top, and the test sample, or a portion of the test sample, is placed on the top sieve.
• The loaded sieves are shaken in a mechanical shaker for approximately 10 minutes, refer to Annex A; *Time Evaluation*.

• Care must be taken so that sieves are not overloaded, refer to Annex B; *Overload Determination*. The test sample may be sieved in increments and the mass retained for each sieve added together from each test sample increment to avoid overloading sieves.

**Sample Preparation**

Obtain samples according to the FOP for AASHTO T 2 and reduce to test sample size, shown in Table 1, according to the FOP for AASHTO R 76.

<table>
<thead>
<tr>
<th>Nominal Maximum Size* mm (in.)</th>
<th>Minimum Dry Mass g (lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>125 (5)</td>
<td>300,000 (660)</td>
</tr>
<tr>
<td>100 (4)</td>
<td>150,000 (330)</td>
</tr>
<tr>
<td>90 (3 1/2)</td>
<td>100,000 (220)</td>
</tr>
<tr>
<td>75 (3)</td>
<td>60,000 (130)</td>
</tr>
<tr>
<td>63 (2 1/2)</td>
<td>35,000 (77)</td>
</tr>
<tr>
<td>50 (2)</td>
<td>20,000 (44)</td>
</tr>
<tr>
<td>37.5 (1 1/2)</td>
<td>15,000 (33)</td>
</tr>
<tr>
<td>25.0 (1)</td>
<td>10,000 (22)</td>
</tr>
<tr>
<td>19.0 (3/4)</td>
<td>5000 (11)</td>
</tr>
<tr>
<td>12.5 (1/2)</td>
<td>2000 (4)</td>
</tr>
<tr>
<td>9.5 (3/8)</td>
<td>1000 (2)</td>
</tr>
<tr>
<td>6.3 (1/4)</td>
<td>1000 (2)</td>
</tr>
<tr>
<td>4.75 (No. 4)</td>
<td>500 (1)</td>
</tr>
</tbody>
</table>

*Nominal maximum size: One sieve larger than the first sieve to retain more than 10 percent of the material using an agency specified set of sieves based on cumulative percent retained. Where large gaps between specification sieves exist, intermediate sieve(s) may be inserted to determine nominal maximum size.

Test sample sizes in Table 1 are standard for aggregate sieve analysis, due to equipment restraints samples may need to be divided into several “subsamples.” For example, a gradation that requires 100 kg (220 lbs.) of material would not fit into a large tray shaker all at once.

Some agencies permit reduced test sample sizes if it is proven that doing so is not detrimental to the test results. Some agencies require larger test sample sizes. Check agency guidelines for required or permitted test sample sizes.
Selection of Procedure

Agencies may specify which method to perform. If a method is not specified, perform Method A.

Overview

Method A

- Determine dry mass of original test sample
- Wash over a 75μm (No. 200) sieve
- Determine dry mass of washed test sample
- Sieve washed test sample
- Calculate and report percent retained and passing each sieve

Method B

- Determine dry mass of original test sample
- Wash over a 75μm (No. 200) sieve
- Determine dry mass of washed test sample
- Sieve test sample through coarse sieves, 4.75 mm (No. 4) sieves and larger
- Determine dry mass of fine material, minus 4.75 mm (No. 4)
- Reduce fine material
- Determine mass of reduced portion
- Sieve reduced portion
- Calculate and report percent retained and passing each sieve

Method C

- Determine dry mass of original test sample
- Sieve test sample through coarse sieves, 4.75 mm (No. 4) sieves and larger
- Determine mass of fine material, minus 4.75 mm (No. 4)
- Reduce fine material
- Determine mass of reduced portion
- Wash reduced portion over a 75μm (No. 200) sieve
- Determine dry mass of washed reduced portion
- Sieve washed reduced portion
- Calculate and report percent retained and passing each sieve
Procedure Method A

1. Dry the test sample to constant mass according to the FOP for AASHTO T 255. Cool to room temperature. Determine and record the total dry mass of the sample to the nearest 0.1 percent or 0.1 g. Designate this mass as $M$.

   When the specification does not require the amount of material finer than 75 µm (No. 200) be determined by washing, skip to Step 11.

2. Nest a sieve, such as a 2.0 mm (No. 10), above the 75 µm (No. 200) sieve.

3. Place the test sample in a container and cover with water.

   *Note 1:* A detergent, dispersing agent, or other wetting solution may be added to the water to assure a thorough separation of the material finer than the 75 µm (No. 200) sieve from the coarser particles. There should be enough wetting agent to produce a small amount of suds when the sample is agitated. Excessive suds may overflow the sieves and carry material away with them.

4. Agitate vigorously to ensure complete separation of the material finer than 75 µm (No. 200) from coarser particles and bring the fine material into suspension above the coarser material. Avoid degradation of the sample when using a mechanical washing device.

5. Immediately pour the wash water containing the suspended material over the nested sieves; be careful not to pour out the coarser particles or over fill the 75 µm (No. 200) sieve.

6. Add water to cover material remaining in the container, agitate, and repeat Step 5. Continue until the wash water is reasonably clear.

7. Remove the upper sieve and return material retained to the washed test sample.

8. Rinse the material retained on the 75 µm (No. 200) sieve until water passing through the sieve is reasonably clear and detergent or dispersing agent is removed, if used.

9. Return all material retained on the 75 µm (No. 200) sieve to the container by rinsing into the washed sample.

   *Note 2:* Excess water may be carefully removed with a bulb syringe; the removed water must be discharged back over the 75 µm (No. 200) sieve to prevent loss of fines.

10. Dry the washed test sample to constant mass according to the FOP for AASHTO T 255. Cool to room temperature. Determine and record the dry mass.

11. Select sieves required by the specification and those necessary to avoid overloading. With a pan on bottom, nest the sieves increasing in size starting with the 75 µm (No. 200).
12. Place the test sample, or a portion of the test sample, on the top sieve. Sieves may already be in the mechanical shaker, if not place sieves in mechanical shaker and shake for the minimum time determined to provide complete separation for the sieve shaker being used (approximately 10 minutes, the time determined by Annex A).

Note 3: Excessive shaking (more than 10 minutes) may result in degradation of the sample.

13. Determine and record the individual or cumulative mass retained for each sieve and in the pan. Ensure that all material trapped in full openings of the sieve are removed and included in the mass retained.

Note 4: For sieves 4.75 mm (No. 4) and larger, check material trapped in less than a full opening by sieving over a full opening. Use coarse wire brushes to clean the 600 µm (No. 30) and larger sieves, and soft bristle brushes for smaller sieves.

Note 5: In the case of coarse / fine aggregate mixtures, distribute the minus 4.75 mm (No. 4) among two or more sets of sieves to prevent overloading of individual sieves.

14. Perform the Check Sum calculation – Verify the total mass after sieving agrees with the dry mass before sieving to within 0.3 percent. The dry mass before sieving is the dry mass after wash or the original dry mass (M) if performing the sieve analysis without washing. Do not use test results for acceptance if the Check Sum result is greater than 0.3 percent.

15. Calculate the total percentages passing, and the individual or cumulative percentages retained to the nearest 0.1 percent by dividing the individual sieve masses or cumulative sieve masses by the total mass of the initial dry sample (M).

16. Report total percent passing to 1 percent except report the 75 µm (No. 200) sieve to 0.1 percent.
Method A Calculations

Check Sum

\[ \text{Check Sum} = \frac{\text{Total Dry Sample mass before washing} - \text{Total Dry Sample mass after washing}}{\text{Total Dry Sample mass before washing}} \times 100 \]

Percent Retained

\[ \text{Percent Retained} = \frac{\text{Individual Percent Retained}}{100} \quad \text{and} \quad \text{Cumulative Percent Retained} = \frac{\text{Cumulative Mass Retained}}{100} \]

Where:
- IPR = Individual Percent Retained
- CPR = Cumulative Percent Retained
- M = Total Dry Sample mass before washing
- IMR = Individual Mass Retained
- CMR = Cumulative Mass Retained

Percent Passing (PP)

\[ \text{Percent Passing} = \text{Percent Passing} - \text{Previous Percent Passing} \]

Where:
- PP = Percent Passing
- PPP = Previous Percent Passing
Method A Example Individual Mass Retained

Dry mass of total sample before washing ($M$): 5168.7 g

Dry mass of sample after washing: 4911.3 g

Total mass after sieving is equals

Sum of Individual Masses Retained (IPR), including pan: 4905.9 g

Amount of 75µm (No. 200) minus washed out (5168.7 g – 4911.3 g): 257.4 g

Check Sum

$$\frac{4911.3 \text{ ss} - 4905.9 \text{ ss}}{4911.3 \text{ ss}} \times 100 = 0.1\%$$

The result is less than 0.3 percent therefore the results can be used for acceptance purposes.

Individual Percent Retained (IPR) for 9.5 mm (3/8 in.) sieve:

$$\text{IIII} = \frac{619.2 \text{ ss}}{5168.7 \text{ ss}} \times 100 = 12.0\%$$

Percent Passing (PP) 9.5 mm (3/8 in.) sieve:

$$\text{III} = 86.0\% - 12.0\% = 74.0\%$$

Reported Percent Passing = 74%
As shown in the following table:

<table>
<thead>
<tr>
<th>Sieve Size mm (in.)</th>
<th>Individual Mass Retained g (IMR)</th>
<th>Individual Percent Retained (IPR)</th>
<th>Percent Passing (PP)</th>
<th>Reported Percent Passing*</th>
</tr>
</thead>
<tbody>
<tr>
<td>19.0 (3/4)</td>
<td>0</td>
<td>0</td>
<td>100.0</td>
<td>100</td>
</tr>
<tr>
<td>12.5 (1/2)</td>
<td>724.7</td>
<td>14.0</td>
<td>86.0</td>
<td>86</td>
</tr>
<tr>
<td>9.5 (3/8)</td>
<td>619.2</td>
<td>12.0</td>
<td>74.0</td>
<td>74</td>
</tr>
<tr>
<td>4.75 (No. 4)</td>
<td>1189.8</td>
<td>23.0</td>
<td>51.0</td>
<td>51</td>
</tr>
<tr>
<td>2.36 (No. 8)</td>
<td>877.6</td>
<td>17.0</td>
<td>34.0</td>
<td>34</td>
</tr>
<tr>
<td>1.18 (No. 16)</td>
<td>574.8</td>
<td>11.1</td>
<td>22.9</td>
<td>23</td>
</tr>
<tr>
<td>0.600 (No. 30)</td>
<td>329.8</td>
<td>6.4</td>
<td>16.5</td>
<td>17</td>
</tr>
<tr>
<td>0.300 (No. 50)</td>
<td>228.5</td>
<td>4.4</td>
<td>12.1</td>
<td>12</td>
</tr>
<tr>
<td>0.150 (No. 100)</td>
<td>205.7</td>
<td>4.0</td>
<td>8.1</td>
<td>8</td>
</tr>
<tr>
<td>0.075 (No. 200)</td>
<td>135.4</td>
<td>2.6</td>
<td>5.5</td>
<td>5.5</td>
</tr>
<tr>
<td>Pan</td>
<td>20.4</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Report total percent passing to 1 percent except report the 75 µm (No. 200) sieve to 0.1 percent.

**Method A Example Cumulative Mass Retained**

Dry mass of total sample before washing \( (M) \): 5168.7 g

Dry mass of sample after washing: 4911.3 g

Total mass after sieving is equals

Final Cumulative Mass Retained (CMR) in pan: 4905.9 g

Amount of 75µm (No. 200) minus washed out \((5168.7 \text{ g} - 4911.3 \text{ g})\): 257.4 g

**Check Sum**

\[
\text{Check Sum} = \frac{4911.3\ ss - 4905.9\ ss}{4911.3\ ss} \times 100 = 0.1\%
\]

The result is less than 0.3 percent therefore the results can be used for acceptance purposes.
Cumulative Percent Retained (CPR) for 9.5 mm (3/8 in.) sieve:

\[ \text{CPR} = \frac{1343.9 \text{ g}}{5168.7 \text{ g}} \times 100 = 26.0\% \]

Percent Passing (PP) 9.5 mm (3/8 in.) sieve:

\[ \text{PP} = 100.0\% - 26.0\% = 74.0\% \]

Reported Percent Passing = 74%

As shown in the following table:

<table>
<thead>
<tr>
<th>Sieve Size mm (in.)</th>
<th>Cumulative Mass Retained g (CMR)</th>
<th>Cumulative Percent Retained (CPR)</th>
<th>Percent Passing (PP)</th>
<th>Reported Percent Passing*</th>
</tr>
</thead>
<tbody>
<tr>
<td>19.0 (3/4)</td>
<td>0</td>
<td>0.0</td>
<td>100.0</td>
<td>100</td>
</tr>
<tr>
<td>12.5 (1/2)</td>
<td>724.7</td>
<td>14.0</td>
<td>86.0</td>
<td>86</td>
</tr>
<tr>
<td>9.5 (3/8)</td>
<td>1343.9</td>
<td>26.0</td>
<td>74.0</td>
<td>74</td>
</tr>
<tr>
<td>4.75 (No. 4)</td>
<td>2533.7</td>
<td>49.0</td>
<td>51.0</td>
<td>51</td>
</tr>
<tr>
<td>2.36 (No. 8)</td>
<td>3411.3</td>
<td>66.0</td>
<td>34.0</td>
<td>34</td>
</tr>
<tr>
<td>1.18 (No. 16)</td>
<td>3986.1</td>
<td>77.1</td>
<td>22.9</td>
<td>23</td>
</tr>
<tr>
<td>0.600 (No. 30)</td>
<td>4315.9</td>
<td>83.5</td>
<td>16.5</td>
<td>17</td>
</tr>
<tr>
<td>0.300 (No. 50)</td>
<td>4544.4</td>
<td>87.9</td>
<td>12.1</td>
<td>12</td>
</tr>
<tr>
<td>0.150 (No. 100)</td>
<td>4750.1</td>
<td>91.9</td>
<td>8.1</td>
<td>8</td>
</tr>
<tr>
<td>0.075 (No. 200)</td>
<td>4885.5</td>
<td>94.5</td>
<td>5.5</td>
<td>5.5</td>
</tr>
<tr>
<td>Pan</td>
<td>4905.9</td>
<td>Pan</td>
<td>Pan</td>
<td>Pan</td>
</tr>
</tbody>
</table>

* Report total percent passing to 1 percent except report the 75 µm (No. 200) sieve to 0.1 percent.


**Procedure Method B**

1. Dry the test sample to constant mass according to the FOP for AASHTO T 255. Cool to room temperature. Determine and record the total dry mass of the sample to the nearest 0.1 percent or 0.1 g. Designate this mass as $M$.

   When the specification does not require the amount of material finer than 75 µm (No. 200) be determined by washing, skip to Step 11.

2. Nest a protective sieve, such as a 2.0 mm (No. 10), above the 75 µm (No. 200) sieve.

3. Place the test sample in a container and cover with water.

   *Note 1:* A detergent, dispersing agent, or other wetting solution may be added to the water to assure a thorough separation of the material finer than the 75 µm (No. 200) sieve from the coarser particles. There should be enough wetting agent to produce a small amount of suds when the sample is agitated. Excessive suds may overflow the sieves and carry material away with them.

4. Agitate vigorously to ensure complete separation of the material finer than 75 µm (No. 200) from coarser particles and bring the fine material into suspension above the coarser material. Avoid degradation of the sample when using a mechanical washing device.

5. Immediately pour the wash water containing the suspended material over the nested sieves; be careful not to pour out the coarser particles or over fill the 75 µm (No. 200) sieve.

6. Add water to cover material remaining in the container, agitate, and repeat Step 5. Continue until the wash water is reasonably clear.

7. Remove the upper sieve and return material retained to the washed test sample.

8. Rinse the material retained on the 75 µm (No. 200) sieve until water passing through the sieve is reasonably clear and detergent or dispersing agent is removed, if used.

9. Return all material retained on the 75 µm (No. 200) sieve to the container by rinsing into the washed sample.

   *Note 2:* Excess water may be carefully removed with a bulb syringe; the removed water must be discharged back over the 75 µm (No. 200) sieve to prevent loss of fines.

10. Dry the washed test sample to constant mass according to the FOP for AASHTO T 255. Cool to room temperature. Determine and record the dry mass.

11. Select sieves required by the specification and those necessary to avoid overloading. With a pan on bottom, nest the sieves increasing in size starting with the 4.75 mm (No. 4).

12. Place the test sample, or a portion of the test sample, on the top sieve. Sieves may already be in the mechanical shaker, if not place the sieves in the mechanical shaker and
shake for the minimum time determined to provide complete separation for the sieve shaker being used (approximately 10 minutes, the time determined by Annex A).

Note 3: Excessive shaking (more than 10 minutes) may result in degradation of the sample.

13. Determine and record the individual or cumulative mass retained for each sieve. Ensure that all particles trapped in full openings of the sieve are removed and included in the mass retained.

Note 4: For sieves 4.75 mm (No. 4) and larger, check material trapped in less than a full opening by sieving over a full opening. Use coarse wire brushes to clean the 600 µm (No. 30) and larger sieves, and soft hair bristle for smaller sieves.

14. Determine and record the mass of the minus 4.75 mm (No. 4) material in the pan. Designate this mass as $M_1$.

15. Perform the Coarse Check Sum calculation – Verify the total mass after coarse sieving agrees with the dry mass before sieving to within 0.3 percent. The dry mass before sieving is the dry mass after wash or the original dry mass ($M$) if performing the sieve analysis without washing. Do not use test results for acceptance if the Check Sum result is greater than 0.3 percent.

16. Reduce the minus 4.75 mm (No. 4) according to the FOP for AASHTO R 76 to produce a sample with a minimum mass of 500 g. Determine and record the mass of the minus 4.75 mm (No. 4) split, designate this mass as $M_2$.

17. Select sieves required by the specification and those necessary to avoid overloading. With a pan on bottom, nest the sieves increasing in size starting with the 75 µm (No. 200) up to, but not including, the 4.75 mm (No. 4) sieve.

18. Place the test sample portion on the top sieve and place the sieves in the mechanical shaker. Shake for the minimum time determined to provide complete separation for the sieve shaker being used (approximately 10 minutes, the time determined by Annex A).

19. Determine and record the individual or cumulative mass retained for each sieve and in the pan. Ensure that all particles trapped in full openings of the sieve are removed and included in the mass retained.

Note 4: For sieves 4.75 mm (No. 4) and larger, check material trapped in less than a full opening by sieving over a full opening. Use coarse wire brushes to clean the 600 µm (No. 30) and larger sieves, and soft hair bristle for smaller sieves.

20. Perform the Fine Check Sum calculation – Verify the total mass after sieving agrees with the dry mass before sieving ($M_2$) to within 0.3 percent. Do not use test results for acceptance if the Check Sum result is greater than 0.3 percent.

21. Calculate to the nearest 0.1 percent, the Individual Mass Retained (IMR) or Cumulative Mass Retained (CMR) of the size increment of the reduced sample and the original sample.

22. Calculate the total percent passing.
23. Report total percent passing to 1 percent except report the 75 µm (No. 200) sieve to 0.1 percent.

**Method B Calculations**

**Check Sum**

\[
\text{Check Sum} = \frac{\text{cumulative mass retained}}{\text{total dry test sample mass before washing}} \times 100
\]

\[
\text{Percent Retained for 4.75 mm (No. 4) and larger}
\]

\[
\text{Percent Retained} = \left( 100 - \frac{\text{cumulative mass retained}}{\text{total dry test sample mass before washing}} \right) \times 100
\]

Where:

- **IPR** = Individual Percent Retained
- **CPR** = Cumulative Percent Retained
- **M** = Total dry test sample mass before washing
- **IMR** = Individual Mass Retained
- **CMR** = Cumulative Mass Retained

**Percent Passing (PP) for 4.75 mm (No. 4) and larger**

\[
\text{Percent Passing} = 100 - \frac{\text{cumulative mass retained}}{\text{total dry test sample mass before washing}} \times 100
\]

Where:

- **PP** = Percent Passing
- **PPP** = Previous Percent Passing
Minus 4.75mm (No. 4) adjustment factor (R)

The mass of material retained for each sieve is multiplied by the adjustment factor, the total mass of the minus 4.75 mm (No. 4) from the pan, \( M_1 \), divided by the mass of the reduced split of minus 4.75 mm (No. 4), \( M_2 \). For consistency, this adjustment factor is carried to three decimal places.

\[
I = \frac{I_1}{I_2}
\]

where:

- \( R \) = minus 4.75 mm (No. 4) adjustment factor
- \( M_1 \) = total mass of minus 4.75 mm (No. 4) before reducing
- \( M_2 \) = mass of the reduced split of minus 4.75 mm (No. 4)

**Adjusted Individual Mass Retained (AIMR):**

\[
\text{AIMR} = I \times B
\]

where:

- AIMR = Adjusted Individual Mass Retained
- \( R \) = minus 4.75 mm (No. 4) adjustment factor
- \( B \) = individual mass of the size increment in the reduced portion sieved

**Adjusted Cumulative Mass Retained (ACMR)**

\[
\text{ACMR} = (I \times B) + D
\]

where:

- ACMR = Adjusted Cumulative Mass Retained
- \( R \) = minus 4.75 mm (No. 4) adjustment factor
- \( B \) = cumulative mass of the size increment in the reduced portion sieved
- \( D \) = cumulative mass of plus 4.75mm (No. 4) portion of sample
Method B Example Individual Mass Retained

Dry mass of total sample, before washing: 3214.0 g

Dry mass of sample after washing: 3085.1 g

Total mass after sieving
Sum of Individual Masses Retained (IPR) and pan 3085.0 g

Amount of 75 µm (No. 200) minus washed out (3214.0 g – 3085.1 g): 128.9 g

Coarse Check Sum

\[ C_{\text{CH}} = \frac{3085.1 - 3085.0}{3085.1} \times 100 = 0.0\% \]

The result is less than 0.3 percent therefore the results can be used for acceptance purposes.

Individual Percent Retained (IPR) for 9.5 mm (3/8 in.) sieve

\[ I_{III} = \frac{481.4}{3214.0} \times 100 = 15.0\% \]

Percent Passing (PP) for 9.5 mm (3/8 in.) sieve:

\[ I_{IIII} = 95.0\% - 15.0\% = 80.0\% \]
As shown in the following table:

<table>
<thead>
<tr>
<th>Sieve Size mm (in.)</th>
<th>Individual Mass Retained g (IMR)</th>
<th>Individual Percent Retained (IPR)</th>
<th>Percent Passing (PP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>16.0 (5/8)</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>12.5 (1/2)</td>
<td>161.1</td>
<td>5.0</td>
<td>95.0</td>
</tr>
<tr>
<td>9.50 (3/8)</td>
<td>481.4</td>
<td>15.0</td>
<td>80.0</td>
</tr>
<tr>
<td>4.75 (No. 4)</td>
<td>475.8</td>
<td>14.8</td>
<td>65.2</td>
</tr>
<tr>
<td>Pan</td>
<td>1966.7 (M₁)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total mass after sieving = sum of sieves + pan = 3085.0
Dry mass of total sample, before washing (M): 3214.0 g

**Fine Test Sample**

The pan, $M₁$ (1966.7 g), was reduced according to the FOP for AASHTO R 76, to at least 500 g. In this case, the reduced mass was determined to be **512.8 g**. This is $M₂$.

The reduced mass was sieved.

Total mass after sieving equals

$$\textbf{Sum of Individual Masses Retained (IPR) and pan} = 511.8 \text{ g}$$

**Fine Check Sum**

$$\text{Fine Check Sum} = \frac{512.8 ss - 511.8 s}{512.8 ss} \times 100 = 0.2\%$$

The result is less than 0.3 percent therefore the results can be used for acceptance purposes.
Adjustment Factor ($R$) for Adjusted Individual Mass Retained (AIMR) on minus 4.75 (No. 4) sieves

The mass of material retained for each sieve is multiplied by the adjustment factor ($R$) carried to three decimal places.

\[ II = \frac{II_1}{II_2} = \frac{1,966.7 \text{ ss}}{512.8 \text{ ss}} = 3.835 \]

where:

- $R$ = minus 4.75 mm (No. 4) adjustment factor
- $M_1$ = total mass of minus 4.75 mm (No. 4) from the pan
- $M_2$ = mass of the reduced split of minus 4.75 mm (No. 4)

Each “individual mass retained” on the fine sieves must be multiplied by $R$ to obtain the Adjusted Individual Mass Retained.

Adjusted Individual Mass Retained (AIMR) for 2.00 mm (No. 10) sieve

\[ AAIMR = 3.835 \times 207.1 \text{ ss} = 794.2 \text{ ss} \]

Individual Percent Retained (IPR) for 2.00 mm (No. 10) sieve:

\[ IIII = \frac{794.2 \text{ ss}}{3214.0 \text{ ss}} \times 100 = 24.7\% \]

Percent Passing (PP) 2 mm (No. 10) sieve:

\[ III = 65.2\% - 24.7\% = 40.5\% \]
As shown in the following table:

### Final Gradation on All Sieves

<table>
<thead>
<tr>
<th>Sieve Size mm (in.)</th>
<th>Individual Mass Retained, g (IMR)</th>
<th>Adjusted Individual Mass Retained (AIMR)</th>
<th>Individual Percent Retained (IPR)</th>
<th>Percent Passing (PP)</th>
<th>Reported Percent Passing*</th>
</tr>
</thead>
<tbody>
<tr>
<td>16.0 (5/8)</td>
<td>0</td>
<td>0.0</td>
<td>100.0</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>12.5 (1/2)</td>
<td>161.1</td>
<td>5.0</td>
<td>95.0</td>
<td>95</td>
<td>95</td>
</tr>
<tr>
<td>9.5 (3/8)</td>
<td>481.4</td>
<td>15.0</td>
<td>80.0</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td>4.75 (No. 4)</td>
<td>475.8</td>
<td>14.8</td>
<td>65.2</td>
<td>65</td>
<td>65</td>
</tr>
<tr>
<td>2.00 (No. 10)</td>
<td>207.1 $\times 3.835$</td>
<td>794.2</td>
<td>24.7</td>
<td>40.5</td>
<td>41</td>
</tr>
<tr>
<td>0.425 (No. 40)</td>
<td>187.9 $\times 3.835$</td>
<td>720.6</td>
<td>22.4</td>
<td>18.1</td>
<td>18</td>
</tr>
<tr>
<td>0.210 (No. 80)</td>
<td>59.9 $\times 3.835$</td>
<td>229.7</td>
<td>7.1</td>
<td>11.0</td>
<td>11</td>
</tr>
<tr>
<td>0.075 (No. 200)</td>
<td>49.1 $\times 3.835$</td>
<td>188.3</td>
<td>5.9</td>
<td>5.1</td>
<td>5.1</td>
</tr>
<tr>
<td>Pan</td>
<td>7.8 $\times 3.835$</td>
<td>29.9</td>
<td>1.4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total Sum of masses on fine sieves + pan = 511.8 g

Dry mass of total sample, before washing: 3214.0 g

* Report total percent passing to 1 percent except report the 75 µm (No. 200) sieve to 0.1 percent.

**Method B Example Cumulative Mass Retained**

Dry mass of total sample, before washing: 3214.0 g

Dry mass of sample, after washing out the 75 µm (No. 200) minus: 3085.1 g

Total mass after sieving equals

\[
\text{Cumulative Mass Retained (CMR) on the 4.75 (No. 4) plus the pan:} \]

\[3085.0 \text{ g}\]

Amount of 75 µm (No. 200) minus washed out (3214.0 g – 3085.1 g): 128.9 g

**Coarse Check Sum**

\[
\frac{3085.1 \text{ ss} - 3085.0 \text{ ss}}{3085.1 \text{ ss}} \times 100 = 0.0\%
\]

The result is less than 0.3 percent therefore the results can be used for acceptance purposes.
Cumulative Percent Retained (CPR) for 9.5 mm (3/8 in.) sieve

\[ CCIII = \frac{642.5 \times 100}{3214.0} = 20.0\% \]

Percent Passing (PP) for 9.5 mm (3/8 in.) sieve

\[ III = 100.0\% - 20.0\% = 80.0\% \]

Reported Percent Passing = 80%

As shown in the following table:

<table>
<thead>
<tr>
<th>Sieve Size mm (in.)</th>
<th>Cumulative Mass Retained g (CMR)</th>
<th>Cumulative Percent Retained (CPR)</th>
<th>Percent Passing (PP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>16.0 (5/8)</td>
<td>0</td>
<td>0</td>
<td>100</td>
</tr>
<tr>
<td>12.5 (1/2)</td>
<td>161.1</td>
<td>5.0</td>
<td>95.0</td>
</tr>
<tr>
<td>9.50 (3/8)</td>
<td>642.5</td>
<td>20.0</td>
<td>80.0</td>
</tr>
<tr>
<td>4.75 (No. 4)</td>
<td>1118.3 (D)</td>
<td>34.8</td>
<td>65.2</td>
</tr>
<tr>
<td>Mass in Pan</td>
<td>1966.7 (M₁)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Cumulative sieved mass: 1118.3 + 1966.7 = 3085.0

Dry mass of total sample, before washing (M): 3214.0 g

The mass of minus 4.75 mm (No. 4) material in the pan, \( M₁ \) (1966.7 g), was reduced according to the FOP for AASHTO R 76, to at least 500 g. In this case, the reduced mass was determined to be 512.8 g. This is \( M₂ \).

The reduced mass was sieved.

Total mass after sieving equals

Final Cumulative Mass Retained (CMR) in pan: 511.8 g
Fine Check Sum

\[
\frac{512.8 \text{ ss} - 511.8 \text{ ss}}{512.8 \text{ ss}} \times 100 = 0.2\%
\]

The result is less than 0.3 percent therefore the results can be used for acceptance purposes.

The cumulative mass of material retained for each sieve is multiplied by the adjustment factor \( R \) carried to three decimal places and added to the cumulative mass retained on the 4.75 mm (No. 4) sieve, \( D \), to obtain the Adjusted Cumulative Mass Retained (ACMR).

**Adjustment factor \( (R) \) for Cumulative Mass Retained (CMR) in minus 4.75 (No. 4) sieves**

\[
II = \frac{I_1}{I_2} = \frac{1966.7 \text{ ss}}{512.8 \text{ ss}} = 3.835
\]

where:
- \( R \) = minus 4.75 mm (No. 4) adjustment factor
- \( M_1 \) = total mass of minus 4.75 mm (No. 4) from the pan
- \( M_2 \) = mass of the reduced split of minus 4.75 mm (No. 4)

**Adjusted Cumulative Mass Retained (ACMR) for the 2.00 mm (No. 10) sieve**

\[
AACCI = 3.835 \times 207.1 \text{ ss} = 794.2 \text{ ss}
\]

**Total Cumulative Mass Retained (TCMR) for the 2.00 mm (No. 10) sieve**

\[
TTCIII = 794.2 \text{ ss} + 1118.3 \text{ ss} = 1912.5 \text{ ss}
\]
**Cumulative Percent Retained (CPR) for 2.00 mm (No. 10) sieve:**

\[ CCIII = \frac{1912.5 \text{ ss}}{3214.0 \text{ ss}} \times 100 = 59.5\% \]

**Percent Passing (PP) 2.00 mm (No. 10) sieve:**

\[ IIII = 100.0\% - 59.5\% = 40.5\% \]

**Reported Percent Passing = 41%**

As shown in the following table:

<table>
<thead>
<tr>
<th>Sieve Size mm (in.)</th>
<th>Cumulative Mass Retained g (CMR)</th>
<th>Adjusted Cumulative Mass Retained, g (ACMR)</th>
<th>Total Cumulative Mass Retained g (TCMR)</th>
<th>Cumulative Percent Retained (CPR)</th>
<th>Percent Passing (PP)</th>
<th>Reported Percent Passing*</th>
</tr>
</thead>
<tbody>
<tr>
<td>16.0 (5/8)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>100.0</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>12.5 (1/2)</td>
<td>161.1</td>
<td>161.1</td>
<td>5.0</td>
<td>95.0</td>
<td>95</td>
<td></td>
</tr>
<tr>
<td>9.5 (3/8)</td>
<td>642.5</td>
<td>642.5</td>
<td>20.0</td>
<td>80.0</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>4.75 (No. 4)</td>
<td>1118.3</td>
<td>1118.3</td>
<td>34.8</td>
<td>65.2</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>Pan</td>
<td>511.8 × 3.835</td>
<td>1962.8 + 1118.3</td>
<td>3081.1</td>
<td>5.1</td>
<td>5.1</td>
<td></td>
</tr>
</tbody>
</table>

Total sum of masses on fine sieves + pan = 511.8

Dry mass of total sample, before washing: 3214.0 g

* Report total percent passing to 1 percent except report the 75 µm (No. 200) sieve to 0.1 percent.
Procedure Method C

1. Dry the test sample to constant mass according to the FOP for AASHTO T 255. Cool to room temperature. Determine and record the total dry mass of the sample to the nearest 0.1 percent or 0.1 g. Designate this mass as $M$.

2. Break up any aggregations or lumps of clay, silt or adhering fines to pass the 4.75 mm (No. 4) sieve.

3. Select sieves required by the specification and those necessary to avoid overloading. With a pan on bottom, nest the sieves increasing in size starting with the 4.75 mm (No. 4) sieve.

4. Place the sample, or a portion of the sample, on the top sieve. Sieves may already be in the mechanical shaker, if not place the sieves in the mechanical shaker and shake for the minimum time determined to provide complete separation for the sieve shaker being used (approximately 10 minutes, the time determined by Annex A).

   **Note 3:** Excessive shaking (more than 10 minutes) may result in degradation of the sample.

5. Determine and record the cumulative mass retained for each sieve. Ensure that all material trapped in full openings of the sieve are removed and included in the mass retained.

   **Note 4:** For sieves 4.75 mm (No. 4) and larger, check material trapped in less than a full opening sieving over a full opening. Use coarse wire brushes to clean the 600 µm (No. 30) and larger sieves, and soft bristle brush for smaller sieves.

6. Determine and record the mass of the minus 4.75 mm (No. 4) material in the pan. Designate this mass as $M_1$.

7. Perform the **Coarse Check Sum calculation** – Verify the total mass after coarse sieving agrees with the dry mass before sieving ($M$) within 0.3 percent.

8. Reduce the minus 4.75 mm (No. 4) according to the FOP for AASHTO R 76, to produce a sample with a minimum mass of 500 g.

9. Determine and record the mass of the minus 4.75 mm (No. 4) split, designate this mass as $M_3$.

10. Nest a protective sieve, such as a 2.0 mm (No. 10), above the 75 µm (No. 200) sieve.

11. Place the test sample in a container and cover with water.

   **Note 1:** A detergent, dispersing agent, or other wetting solution may be added to the water to assure a thorough separation of the material finer than the 75 µm (No. 200) sieve from the coarser particles. There should be enough wetting agent to produce a small amount of suds when the sample is agitated. Excessive suds may overflow the sieves and carry material away with them.

12. Agitate vigorously to ensure complete separation of the material finer than 75 µm (No. 200) from coarser particles and bring the fine material into suspension above the
coarser material. Avoid degradation of the sample when using a mechanical washing device.

13. Immediately pour the wash water containing the suspended material over the nested sieves; be careful not to pour out the coarser particles or over fill the 75 µm (No. 200) sieve.

14. Add water to cover material remaining in the container, agitate, and repeat Step 12. Repeat until the wash water is reasonably clear.

15. Remove the upper sieve and return material retained to the washed test sample.

16. Rinse the material retained on the 75 µm (No. 200) sieve until water passing through the sieve is reasonably clear and detergent or dispersing agent is removed, if used.

17. Return all material retained on the 75 µm (No. 200) sieve to the container by flushing into the washed sample.

Note 2: Excess water may be carefully removed with a bulb syringe; the removed water must be discharged back over the 75 µm (No. 200) sieve to prevent loss of fines.

18. Dry the washed test sample to constant mass according to the FOP for AASHTO T 255. Cool to room temperature. Determine and record the dry mass, designate this mass as dry mass before sieving.

19. Select sieves required by the specification and those necessary to avoid overloading. With a pan on bottom, nest the sieves increasing in size starting with the 75 µm (No. 200) sieve up to, but not including, the 4.75 mm (No. 4) sieve.

20. Place the sample on the top sieve. Place the sieves in the mechanical shaker and shake for the minimum time determined to provide complete separation for the sieve shaker being used (approximately 10 minutes, the time determined by Annex A).

Note 3: Excessive shaking (more than 10 minutes) may result in degradation of the sample.

21. Determine and record the cumulative mass retained for each sieve. Ensure that all material trapped in full openings of the sieve are removed and included in the mass retained.

Note 4: For sieves 4.75 mm (No. 4) and larger, check material trapped in less than a full opening by sieving over a full opening. Use coarse wire brushes to clean the 600 µm (No. 30) and larger sieves, and soft bristle brushes for smaller sieves.

22. Perform the Fine Check Sum calculation – Verify the total mass after fine sieving agrees with the dry mass before sieving within 0.3 percent. Do not use test results for acceptance if the Check Sum is greater than 0.3 percent.

23. Calculate the Cumulative Percent Retained (CPR) and Percent Passing (PP) for the 4.75 mm (No. 4) and larger.
24. Calculate the Cumulative Percent Retained (CPR) and the Percent Passing (PP) for minus 4.75 mm (No. 4) split and Percent Passing (PP) for the minus 4.75 mm (No. 4).

25. Report total percent passing to 1 percent except report the 75 µm (No. 200) sieve to 0.1 percent.

**Method C Calculations**

**Check Sum**

\[
CC\text{hen} = \frac{II - \text{sum} \times 100}{II} \times 100
\]

\[
FF\text{hen} = \frac{dddd \times 100}{dddd \times 100}
\]

where:

- \(C\) = Total dry sample mass before washing

**Cumulative Percent Retained (CPR) for 4.75 mm (No. 4) sieve and larger**

\[
CC\text{hen} = \frac{C}{II} \times 100
\]

where:

- \(C\) = Cumulative Percent Retained of the size increment for the total sample
- \(M\) = Cumulative Mass Retained of the size increment for the total sample
- \(M\) = Total dry sample mass before washing

**Percent Passing (PP) 4.75 mm (No. 4) sieve and larger**

\[
III = 100 - CC\text{hen}
\]

where:

- \(P\) = Percent Passing of the size increment for the total sample
- \(C\) = Cumulative Percent Retained of the size increment for the total sample
Or, calculate PP for sieves larger than 4.75 mm (No. 4) sieve without calculating CPR

\[
\frac{II - CCIII}{II} \times 100
\]

Cumulative Percent Retained (CPR\#4) for minus 4.75 mm (No. 4) split

\[
CCIII_{-4} = \frac{CCIII_{-4}}{II_3} \times 100
\]

where:

CPR\#4 = Cumulative Percent Retained for the sieve sizes of M3
CMR\#4 = Cumulative Mass Retained for the sieve sizes of M3
M3 = Total mass of the minus 4.75 mm (No. 4) split before washing

Percent Passing (PP\#4) for minus 4.75 mm (No. 4) split

\[
III_{-4} = 100 - CCIII_{-4}
\]

where:

PP\#4 = Percent Passing for the sieve sizes of M3
CPR\#4 = Cumulative Percent Retained for the sieve sizes of M3

Percent Passing (PP) for sieves smaller than 4.75 mm (No. 4) sieve

\[
III = \frac{(III_{-4} \times #4 IIII)}{100}
\]

where:

PP = Total Percent Passing
PP\#4 = Percent Passing for the sieve sizes of M3
#4 PP = Total Percent Passing the 4.75 mm (No. 4) sieve
Or, calculate PP for sieves smaller than 4.75 mm (No. 4) sieve without calculating CPR-#4 and PP-#4

\[ IIII = \frac{#4 \times IIII}{III} \times (III - CCIII - #4) \]

where:

PP = Total Percent Passing

#4 PP = Total Percent Passing the 4.75 mm (No. 4) sieve

M3 = Total mass of the minus 4.75 mm (No. 4) split before washing

CMR-#4 = Cumulative Mass Retained for the sieve sizes of M3

**Method C Example**

Dry Mass of total sample \((M)\):

3304.5 g

Total mass after sieving equals

Cumulative Mass Retained (CMR) on the 4.75 (No. 4) plus the pan:

3085.0 g

**Coarse Check Sum**

\[ CC = \frac{3304.5 - 3304.5}{3304.5} \times 100 = 0.0\% \]

The result is less than 0.3 percent therefore the results can be used for acceptance purposes.

**Cumulative Percent Retained (CPR) for the 9.5 mm (3/8 in.) sieve:**

\[ CCIII = \frac{604.1}{3304.5} \times 100 = 18.3\% \]
Percent Passing (PP) for the 9.5 mm (3/8 in.) sieve:

\[ III = 100.0\% - 18.3\% = 81.7\% \]

Reported Percent Passing = 82%

Example for Alternate Percent Passing (PP) formula for the 9.5 mm (3/8 in.) sieve:

\[ IIII = \frac{3304.5 - 604.1}{3304.5} \times 100 = 81.7\% \]

Reported Percent Passing = 82%

Gradation on Coarse Sieves

<table>
<thead>
<tr>
<th>Sieve Size mm (in.)</th>
<th>Cumulative Mass Retained, g (CMR)</th>
<th>Cumulative Percent Retained (CPR)</th>
<th>Percent Passing (PP)</th>
<th>Reported Percent Passing*</th>
</tr>
</thead>
<tbody>
<tr>
<td>16.0 (5/8)</td>
<td>0</td>
<td>0.0</td>
<td>100.0</td>
<td>100</td>
</tr>
<tr>
<td>12.5 (1/2)</td>
<td>125.9</td>
<td>3.8</td>
<td>96.2</td>
<td>96</td>
</tr>
<tr>
<td>9.5 (3/8)</td>
<td>604.1</td>
<td>18.3</td>
<td>81.7</td>
<td>82</td>
</tr>
<tr>
<td>4.75 (No. 4)</td>
<td>1295.6</td>
<td>39.2</td>
<td>60.8 (#4 PP)</td>
<td>61</td>
</tr>
</tbody>
</table>

Total Dry Sample (\(M\)) = 3304.5

Fine Test Sample

The pan (2008.9 g) was reduced according to the FOP for AASHTO R 76, to at least 500 g. In this case, the reduced mass was determined to be 527.6 g. This is \(M_3\).

Dry Mass of minus 4.75mm (No. 4) reduced portion before wash (\(M_3\)): 527.6 g

Dry Mass of minus 4.75mm (No. 4) reduced portion after wash: 495.3 g

Total mass after sieving equals

Final Cumulative Mass Retained (CMR) in pan: 495.1 g
Fine Check Sum

\[ FFsssee \text{CChheeeeee SSSSSS = } \frac{495.3 ss - 495.1 ss}{495.3 ss} \times 100 = 0.04\% \]

The result is less than 0.3 percent therefore the results can be used for acceptance purposes.

Cumulative Percent Retained (CPR\#4) for minus 4.75 mm (No. 4) for the 2.0 mm (No. 10) sieve:

\[ CCIII\#4 = \frac{194.3 ss}{527.6 ss} \times 100 = 36.8\% \]

Percent Passing (PP\#4) for minus 4.75 mm (No. 4) for the 2.0 mm (No. 10) sieve:

\[ IIII\#4 = 100.0\% - 36.8\% = 63.2\% \]

Gradation on Minus No. 4 Sieves

<table>
<thead>
<tr>
<th>Sieve Size mm (in.)</th>
<th>Cumulative Mass Retained g (CMR#4)</th>
<th>Cumulative Percent Retained #4 (CPR#4)</th>
<th>Percent Passing #4 (PP#4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.0 (No. 10)</td>
<td>194.3</td>
<td>36.8</td>
<td>63.2</td>
</tr>
<tr>
<td>0.425 (No. 40)</td>
<td>365.6</td>
<td>69.3</td>
<td>30.7</td>
</tr>
<tr>
<td>0.210 (No. 80)</td>
<td>430.8</td>
<td>81.7</td>
<td>18.3</td>
</tr>
<tr>
<td>0.075 (No. 200)</td>
<td>484.4</td>
<td>91.8</td>
<td>8.2</td>
</tr>
<tr>
<td>Pan</td>
<td>495.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry mass before washing (M3):</td>
<td>527.6 g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry mass after washing:</td>
<td>495.3 g</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Percent Passing (PP) for the 2.0 mm (No. 10) sieve for the entire test sample:

#4 PP (Total Percent Passing the 4.75 mm (No. 4) sieve) = 60.8%

\[ III = \frac{63.2\% \times 60.8\%}{100} = 38.4\% \]

Reported Percent Passing = 38%

As shown in the following table:

<table>
<thead>
<tr>
<th>Sieve Size mm (in.)</th>
<th>Cumulative Mass Retained, g (CMR)</th>
<th>Cumulative Percent Retained (CPR)</th>
<th>Percent Passing (PP/#4)</th>
<th>Percent Passing (PP)</th>
<th>Reported Percent Passing*</th>
</tr>
</thead>
<tbody>
<tr>
<td>16.0 (5/8)</td>
<td>0</td>
<td>0.0</td>
<td>100.0</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>12.5 (1/2)</td>
<td>125.9</td>
<td>3.8</td>
<td>96.2</td>
<td>96</td>
<td></td>
</tr>
<tr>
<td>9.5 (3/8)</td>
<td>604.1</td>
<td>18.3</td>
<td>81.7</td>
<td>82</td>
<td></td>
</tr>
<tr>
<td>4.75 (No. 4)</td>
<td>1295.6</td>
<td>39.2</td>
<td>60.8</td>
<td>61</td>
<td></td>
</tr>
<tr>
<td>2.0 (No. 10)</td>
<td>194.3</td>
<td>36.8</td>
<td>63.2</td>
<td>38.4</td>
<td>38</td>
</tr>
<tr>
<td>0.425 (No. 40)</td>
<td>365.6</td>
<td>69.3</td>
<td>30.7</td>
<td>18.7</td>
<td>19</td>
</tr>
<tr>
<td>0.210 (No. 80)</td>
<td>430.8</td>
<td>81.7</td>
<td>18.3</td>
<td>11.1</td>
<td>11</td>
</tr>
<tr>
<td>0.075 (No. 200)</td>
<td>484.4</td>
<td>91.8</td>
<td>8.2</td>
<td>5.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Pan</td>
<td>495.1</td>
<td>91.8</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Report total percent passing to 1 percent except report the 75 µm (No. 200) sieve to 0.1 percent.

Example for Alternate Percent Passing (PP) for the 2.0 mm (No. 10) sieve for the entire test sample:

#4 PP (Total Percent Passing the 4.75 mm (No. 4) sieve) = 60.8%

\[ III = \frac{60.8\%}{527.6} \times (527.6 - 194.3) = 38.4\% \]

Reported Percent Passing = 38%
As shown in the following table:

<table>
<thead>
<tr>
<th>Sieve Size mm (in.)</th>
<th>Cumulative Mass Retained, g (CMR)</th>
<th>Cumulative Percent Retained (CPR)</th>
<th>Determined Percent Passing (PP)</th>
<th>Reported Percent Passing*</th>
</tr>
</thead>
<tbody>
<tr>
<td>16.0 (5/8)</td>
<td>0</td>
<td>0.0</td>
<td>100.0</td>
<td>100</td>
</tr>
<tr>
<td>12.5 (1/2)</td>
<td>125.9</td>
<td>3.8</td>
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<tr>
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<td></td>
<td>38.4</td>
<td>38</td>
</tr>
<tr>
<td>0.425 (No. 40)</td>
<td>365.6</td>
<td></td>
<td>18.7</td>
<td>19</td>
</tr>
<tr>
<td>0.210 (No. 80)</td>
<td>430.8</td>
<td></td>
<td>11.2</td>
<td>11</td>
</tr>
<tr>
<td>0.075 (No. 200)</td>
<td>484.4</td>
<td></td>
<td>5.0</td>
<td>5.0</td>
</tr>
<tr>
<td>Pan</td>
<td>495.1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Dry mass before washing ($M_3$): 527.6 g

* Report total percent passing to 1 percent except report the 75 µm (No. 200) sieve to 0.1 percent.
FINENESS MODULUS

Fineness Modulus (FM) is used in determining the degree of uniformity of the aggregate gradation in PCC mix designs. It is an empirical number relating to the fineness of the aggregate. The higher the FM, the coarser the aggregate. Values of 2.40 to 3.00 are common for fine aggregate in PCC.

The sum of the cumulative percentages retained on specified sieves in the following table divided by 100 gives the FM.

**Sample Calculation**

<table>
<thead>
<tr>
<th>Sieve Size mm (in)</th>
<th>Passing</th>
<th>Retained</th>
<th>On Spec’d Sieves*</th>
<th>Passing</th>
<th>Retained</th>
<th>On Spec’d Sieves*</th>
</tr>
</thead>
<tbody>
<tr>
<td>75*(3)</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>37.5*(11/2)</td>
<td>100</td>
<td>0</td>
<td>0</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>19*(3/4)</td>
<td>15</td>
<td>85</td>
<td>85</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>9.5*(3/8)</td>
<td>0</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4.75*(No.4)</td>
<td>0</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2.36*(No.8)</td>
<td>0</td>
<td>100</td>
<td>100</td>
<td>87</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>1.18*(No.16)</td>
<td>0</td>
<td>100</td>
<td>100</td>
<td>69</td>
<td>31</td>
<td>31</td>
</tr>
<tr>
<td>0.60*(No.30)</td>
<td>0</td>
<td>100</td>
<td>100</td>
<td>44</td>
<td>56</td>
<td>56</td>
</tr>
<tr>
<td>0.30*(No.50)</td>
<td>0</td>
<td>100</td>
<td>100</td>
<td>18</td>
<td>82</td>
<td>82</td>
</tr>
<tr>
<td>0.15*(100)</td>
<td>0</td>
<td>100</td>
<td>100</td>
<td>4</td>
<td>96</td>
<td>96</td>
</tr>
</tbody>
</table>

\[ \sum = 785 \quad \text{FM} = 7.85 \]
\[ \sum = 278 \quad \text{FM} = 2.78 \]

In decreasing size order, each * sieve is one-half the size of the preceding * sieve.
Report

- Results on forms approved by the agency
- Sample ID
- Percent passing for each sieve
- Individual mass retained for each sieve
- Individual percent retained for each sieve
  or
- Cumulative mass retained for each sieve
- Cumulative percent retained for each sieve
- FM to the nearest 0.01

Report percentages to the nearest 1 percent except for the percent passing the 75 µm (No. 200) sieve, which shall be reported to the nearest 0.1 percent.
ANNEX A TIME EVALUATION

The sieving time for each mechanical sieve shaker shall be checked at least annually to determine the time required for complete separation of the test sample by the following method:

1. Shake the sample over nested sieves for approximately 10 minutes.
2. Provide a snug-fitting pan and cover for each sieve, and hold in a slightly inclined position in one hand.
3. Hand-shake each sieve by striking the side of the sieve sharply and with an upward motion against the heel of the other hand at the rate of about 150 times per minute, turning the sieve about one sixth of a revolution at intervals of about 25 strokes.

If more than 0.5 percent by mass of the total sample before sieving passes any sieve after one minute of continuous hand shaking adjust shaker time and re-check.

In determining sieving time for sieve sizes larger than 4.75 mm (No. 4), limit the material on the sieve to a single layer of particles.
ANNEX B OVERLOAD DETERMINATION

Additional sieves may be necessary to keep from overloading sieves or to provide other information, such as fineness modulus. The sample may also be sieved in increments to prevent overloading.

- For sieves with openings smaller than 4.75 mm (No. 4), the mass retained on any sieve shall not exceed 7 kg/m$^2$ (4 g/in$^2$) of sieving surface.

- For sieves with openings 4.75 mm (No. 4) and larger, the mass, in grams shall not exceed the product of 2.5 × (sieve opening in mm) × (effective sieving area). See Table B1.

<table>
<thead>
<tr>
<th>TABLE B1</th>
<th>Maximum Allowable Mass of Material Retained on a Sieve, g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal Sieve Size, mm (in.)</td>
<td>Sieve Size mm (in.)</td>
</tr>
<tr>
<td>90</td>
<td>(3 1/2)</td>
</tr>
<tr>
<td>75</td>
<td>(3)</td>
</tr>
<tr>
<td>63</td>
<td>(2 1/2)</td>
</tr>
<tr>
<td>50</td>
<td>(2)</td>
</tr>
<tr>
<td>37.5</td>
<td>(1 1/2)</td>
</tr>
<tr>
<td>25.0</td>
<td>(1)</td>
</tr>
<tr>
<td>19.0</td>
<td>(3/4)</td>
</tr>
<tr>
<td>16.0</td>
<td>(5/8)</td>
</tr>
<tr>
<td>12.5</td>
<td>(1/2)</td>
</tr>
<tr>
<td>9.5</td>
<td>(3/8)</td>
</tr>
<tr>
<td>6.3</td>
<td>(1/4)</td>
</tr>
<tr>
<td>4.75</td>
<td>(No. 4)</td>
</tr>
<tr>
<td>-4.75</td>
<td>(-No. 4)</td>
</tr>
</tbody>
</table>
PERFORMANCE EXAM CHECKLIST

METHOD A
SIEVE ANALYSIS OF FINE AND COARSE AGGREGATES
FOP FOR AASHTO T 27
MATERIALS FINER THAN 75 µm (No. 200) SIEVE IN MINERAL AGGREGATE
BY WASHING
FOP FOR AASHTO T 11

Participant Name ________________________ Exam Date ____________

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Minimum sample mass meets requirement of Table 1?</td>
<td>_______</td>
<td>_______</td>
</tr>
<tr>
<td>2. Test sample dried to a constant mass by FOP for AASHTO T 255?</td>
<td>_______</td>
<td>_______</td>
</tr>
<tr>
<td>3. Test sample cooled and mass determined to nearest 0.1 percent or 0.1 g?</td>
<td>_______</td>
<td>_______</td>
</tr>
<tr>
<td>4. Test sample placed in container and covered with water?</td>
<td>_______</td>
<td>_______</td>
</tr>
<tr>
<td>5. Contents of the container vigorously agitated?</td>
<td>_______</td>
<td>_______</td>
</tr>
<tr>
<td>6. Complete separation of coarse and fine particles achieved?</td>
<td>_______</td>
<td>_______</td>
</tr>
<tr>
<td>7. Wash water poured through nested sieves such as 2 mm (No. 10) and 75 µm (No. 200)?</td>
<td>_______</td>
<td>_______</td>
</tr>
<tr>
<td>8. Operation continued until wash water is clear?</td>
<td>_______</td>
<td>_______</td>
</tr>
<tr>
<td>9. Material retained on sieves returned to washed sample?</td>
<td>_______</td>
<td>_______</td>
</tr>
<tr>
<td>10. Washed test sample dried to a constant mass by FOP for AASHTO T 255?</td>
<td>_______</td>
<td>_______</td>
</tr>
<tr>
<td>11. Washed test sample cooled and mass determined to nearest 0.1 percent or 0.1 g?</td>
<td>_______</td>
<td>_______</td>
</tr>
<tr>
<td>12. Test sample placed in nest of sieves specified? (Additional sieves may be used to prevent overloading as allowed in FOP.)</td>
<td>_______</td>
<td>_______</td>
</tr>
<tr>
<td>13. Material sieved in verified mechanical shaker for proper time?</td>
<td>_______</td>
<td>_______</td>
</tr>
<tr>
<td>14. Mass of material on each sieve and pan determined to 0.1 g?</td>
<td>_______</td>
<td>_______</td>
</tr>
<tr>
<td>15. Total mass of material after sieving agrees with mass before sieving to within 0.3 percent?</td>
<td>_______</td>
<td>_______</td>
</tr>
</tbody>
</table>

OVER
### Procedure Element

<table>
<thead>
<tr>
<th></th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>16. Percentages calculated to the nearest 0.1 percent and reported to the nearest whole number, except 75 µm (No. 200) which is reported to the nearest 0.1 percent?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17. Percentage calculations based on original dry sample mass?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18. Calculations performed properly?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Comments:**

First attempt: Pass Fail Second attempt: Pass Fail

---

Examiner Signature_________________________ WAQTC #:___________________
PERFORMANCE EXAM CHECKLIST

METHOD B
SIEVE ANALYSIS OF FINE AND COARSE AGGREGATES
FOP FOR AASHTO T 27
MATERIALS FINER THAN 75 µm (No. 200) SIEVE IN MINERAL AGGREGATE
BY WASHING
FOP FOR AASHTO T 11

Participant Name ____________________________  Exam Date ______________

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Minimum sample mass meets requirement of Table 1?</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>2. Test sample dried to a constant mass by FOP for AASHTO T 255?</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>3. Test sample cooled and mass determined to nearest 0.1 percent or 0.1 g?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Test sample placed in container and covered with water?</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>5. Contents of the container vigorously agitated?</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>6. Complete separation of coarse and fine particles achieved?</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>7. Wash water poured through nested sieves such as 2 mm (No. 10) and 75 µm (No. 200)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Operation continued until wash water is clear?</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>9. Material retained on sieves returned to washed sample?</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>10. Washed test sample dried to a constant mass by FOP for AASHTO T 255?</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>11. Washed test sample cooled and mass determined to nearest 0.1 percent or 0.1 g?</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>12. Test sample placed in nest of sieves specified? (Additional sieves may be used to prevent overloading as allowed in FOP.)</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>13. Material sieved in verified mechanical shaker for proper time?</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>14. Mass of material on each sieve and pan determined to the nearest 0.1 percent or 0.1 g?</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>15. Total mass of material after sieving agrees with mass before sieving to within 0.3 percent?</td>
<td>_____</td>
<td>_____</td>
</tr>
</tbody>
</table>

OVER
### Procedure Element

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>16. Material in pan reduced in accordance with FOP for AASHTO R 76 to at least 500 g and weighed to the nearest 0.1 g?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17. Test sample placed in nest of sieves specified? (Additional sieves may be used to prevent overloading as allowed in FOP.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18. Material sieved in verified mechanical shaker for proper time?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19. Mass of material on each sieve and pan determined to the nearest percent or 0.1 g?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20. Total mass of material after sieving agrees with mass before sieving to within 0.3 percent?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21. Percentages calculated to the nearest 0.1 percent and reported to the nearest whole number, except 75 µm (No.200) which is reported to the nearest 0.1 percent?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22. Percentage calculations based on original dry sample mass?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23. Calculations performed properly?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Comments:** First attempt: Pass Fail Second attempt: Pass Fail

---

Examiner Signature_________________________ WAQTC #:________________
DETERMINING THE PERCENTAGE OF FRACTURE IN COARSE AGGREGATE FOP FOR AASHTO T 335

Scope

This procedure covers the determination of the percentage, by mass, of a coarse aggregate (CA) sample that consists of fractured particles meeting specified requirements in accordance with AASHTO T 335-09.

In this FOP, a sample of aggregate is screened on the sieve separating CA and fine aggregate (FA). This sieve will be identified in the agency’s specifications, but might be the 4.75 mm (No. 4) sieve. CA particles are visually evaluated to determine conformance to the specified fracture. The percentage of conforming particles, by mass, is calculated for comparison to the specifications.

Apparatus

- Balance or scale: Capacity sufficient for the principle sample mass, accurate to 0.1 percent of the sample mass or readable to 0.1 g, and meeting the requirements of AASHTO M 231.
- Sieves: Meeting requirements of the FOP for AASHTO T 27/T 11.
- Splitter: Meeting the requirements of FOP for AASHTO R 76.

Terminology

1. Fractured Face: An angular, rough, or broken surface of an aggregate particle created by crushing or by other means. A face is considered a “fractured face” whenever one-half or more of the projected area, when viewed normal to that face, is fractured with sharp and well defined edges. This excludes small nicks.

2. Fractured particle: A particle of aggregate having at least the minimum number of fractured faces specified. (This is usually one or two.)

Sampling and Sample Preparation

1. Sample and reduce the aggregate in accordance with the FOPs for AASHTO T 2 and R 76.

2. When the specifications list only a total fracture percentage, the sample shall be prepared in accordance with Method 1. When the specifications require that the fracture be counted and reported on each sieve, the sample shall be prepared in accordance with Method 2.
3. Method 1 - Combined Fracture Determination

   a. Dry the sample sufficiently to obtain a clean separation of FA and CA material in the sieving operation.

   b. Sieve the sample in accordance with the FOP for AASHTO T 27/ T 11 over the 4.75 mm (No. 4) sieve, or the appropriate sieve listed in the agency’s specifications for this material.

   Note 1: Where necessary, wash the sample over the sieve designated for the determination of fractured particles to remove any remaining fine material, and dry to a constant mass in accordance with the FOP for AASHTO T 255.

   c. Reduce the sample using Method A – Mechanical Splitter, in accordance with the FOP for AASHTO R 76, to the appropriate test size. This test size should be slightly larger than shown in Table 1, to account for loss of fines through washing if necessary.

   **TABLE 1**
   
   Sample Size
   Method 1 (Combined Sieve Fracture)

<table>
<thead>
<tr>
<th>Nominal Maximum Size*</th>
<th>Minimum Cumulative Sample Mass Retained on 4.75 mm (No. 4) Sieve g (lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>37.5 (1 1/2)</td>
<td>2500 (6)</td>
</tr>
<tr>
<td>25.0 (1)</td>
<td>1500 (3.5)</td>
</tr>
<tr>
<td>19.0 (3/4)</td>
<td>1000 (2.5)</td>
</tr>
<tr>
<td>12.5 (1/2)</td>
<td>700 (1.5)</td>
</tr>
<tr>
<td>9.5 (3/8)</td>
<td>400 (0.9)</td>
</tr>
<tr>
<td>4.75 (No. 4)</td>
<td>200 (0.4)</td>
</tr>
</tbody>
</table>

   * One sieve larger than the first sieve to retain more than 10 percent of the material using an agency specified set of sieves based on cumulative percent retained. Where large gaps in specification sieves exist, intermediate sieve(s) may be inserted to determine nominal maximum size.

4. Method 2 – Individual Sieve Fracture Determination

   a. Dry the sample sufficiently to obtain a clean separation of FA and CA material in the sieving operation. A washed sample from the gradation determination (the FOP for T 27/T 11) may be used.

   b. If not, sieve the sample in accordance with the FOP for AASHTO T 27 over the sieves listed in the specifications for this material.

   Note 2: If overload (buffer) sieves are used the material from that sieve must be added to the next specification sieve.
c. The size of test sample for each sieve shall meet the minimum size shown in Table 2. Utilize the total retained sieve mass or select a representative portion from each sieve mass by splitting or quartering in accordance with the FOP for AASHTO R 76.

Note 3: Where necessary, wash the sample over the sieves designated for the determination of fractured particles to remove any remaining fine material, and dry to a constant mass in accordance with the FOP for AASHTO T 255.

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Sample Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Method 2 (Individual Sieve Fracture)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sieve Size mm (in.)</th>
<th>Minimum Sample Mass g (lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>31.5 (1 1/4)</td>
<td>1500 (3.5)</td>
</tr>
<tr>
<td>25.0 (1)</td>
<td>1000 (2.2)</td>
</tr>
<tr>
<td>19.0 (3/4)</td>
<td>700 (1.5)</td>
</tr>
<tr>
<td>16.0 (5/8)</td>
<td>500 (1.0)</td>
</tr>
<tr>
<td>12.5 (1/2)</td>
<td>300 (0.7)</td>
</tr>
<tr>
<td>9.5 (3/8)</td>
<td>200 (0.5)</td>
</tr>
<tr>
<td>6.3 (1/4)</td>
<td>100 (0.2)</td>
</tr>
<tr>
<td>4.75 (No. 4)</td>
<td>100 (0.2)</td>
</tr>
<tr>
<td>2.36 (No. 8)</td>
<td>25 (0.1)</td>
</tr>
<tr>
<td>2.00 (No. 10)</td>
<td>25 (0.1)</td>
</tr>
</tbody>
</table>

Note 4: If fracture is determined on a sample obtained for gradation, use the mass retained on the individual sieves, even if it is less than the minimum listed in Table 2. If less than 5 percent of the total mass is retained on a single specification sieve, include that material on the next smaller specification sieve. If a smaller specification sieve does not exist, this material shall not be included in the fracture determination.

Procedure

1. After cooling, spread the dried sample on a clean, flat surface.

2. Examine each particle face and determine if the particle meets the fracture criteria.

3. Separate the sample into three categories:
   - Fractured particles meeting the criteria
   - Particles not meeting the criteria
   - Questionable or borderline particles

4. Determine the dry mass of particles in each category to the nearest 0.1 g.

5. Calculate the percent questionable particles.
6. Resort the questionable particles when more than 15 percent is present. Continue sorting until there is no more than 15 percent in the questionable category.

7. Calculate the percent fractured particles meeting criteria to nearest 0.1 percent. Report to 1 percent.

**Calculation**

Calculate the mass percentage of questionable particles to the nearest 1 percent using the following formula:

\[
\%QQ = \frac{QQ}{FF + QQ + NN} \times 100
\]

where:
- \(\%Q\) = Percent of questionable fractured particles
- \(F\) = Mass of fractured particles
- \(Q\) = Mass of questionable or borderline particles
- \(N\) = Mass of unfractured particles

**Example:**

- Mass of unfractured particles = 632.6 g
- Mass of questionable particles = 97.6 g
- Mass of unfractured particles = 352.6 g

\[
\frac{97.6 \text{ g}}{632.6 \text{ g} + 97.6 \text{ g} + 352.6 \text{ g}} \times 100 = 9.0\%
\]

Calculate the mass percentage of fractured faces to the nearest 0.1 percent using the following formula:

\[
P = \frac{QQ + FF}{2(FF + QQ + NN)} \times 100
\]

where:
- \(P\) = Percent of fracture
- \(F\) = Mass of fractured particles
- \(Q\) = Mass of questionable particles
- \(N\) = Mass of unfractured particles
Example:

Mass of fractured particles = 632.6 g,
Mass of questionable particles = 97.6 g
Mass of unfractured particles = 352.6 g

\[ P = \frac{\frac{97.6 \text{ gg}}{2} + 632.6 \text{ g}}{632.6 \text{ gg} + 97.6 \text{ gg} + 352.6 \text{ gg}} \times 100 = 62.9\% \]

Report

- Results on forms approved by the agency
- Sample ID
- Fractured particles to the nearest 1 percent.
**PERFORMANCE EXAM CHECKLIST**

**DETERMINING THE PERCENTAGE OF FRACTURE IN COARSE AGGREGATE FOP FOR AASHTO T 335**

Participant Name ___________________________ Exam Date _______________

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Sample properly sieved through specified sieve(s)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Sample reduced to correct size?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Sample dried and cooled, if necessary?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Particles separated into fractured, unfractured, and questionable categories?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Dry mass of each category determined to nearest 0.1 g?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Questionable category resorted if more than 15 percent of total mass falls in that category?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Fracture calculation performed correctly?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comments:  
First attempt: Pass____  Fail____    Second attempt: Pass____  Fail____

Examiner Signature__________________________  WAQTC #:______________
PLASTIC FINES IN GRADED AGGREGATES AND SOILS BY THE USE OF THE SAND EQUIVALENT TEST
FOP FOR AASHTO T 176

Scope

This procedure covers the determination of plastic fines in accordance with AASHTO T 176-08. It serves as a rapid test to show the relative proportion of fine dust or clay-like materials in fine aggregates (FA) and soils.

Apparatus

See AASHTO T 176 for a detailed listing of sand equivalent apparatus. Note that the siphon tube and blow tube may be glass or stainless steel as well as copper.

- Graduated plastic cylinder.
- Rubber stopper.
- Irrigator tube.
- Weighted foot assembly: Having a mass of 1000 ±5g. There are two models of the weighted foot assembly. The older model has a guide cap that fits over the upper end of the graduated cylinder and centers the rod in the cylinder. It is read using a slot in the centering screws. The newer model has a sand-reading indicator 254 mm (10 in.) above this point and is preferred for testing clay-like materials.
- Bottle: clean, glass or plastic, of sufficient size to hold working solution
- Siphon assembly: The siphon assembly will be fitted to a 4 L (1 gal.) bottle of working calcium chloride solution placed on a shelf 915 ±25 mm (36 ±1 in.) above the work surface.
- Measuring can: With a capacity of 85 ±5 mL (3 oz.).
- Funnel: With a wide-mouth for transferring sample into the graduated cylinder.
- Quartering cloth: 600 mm (2 ft.) square nonabsorbent cloth, such as plastic or oilcloth.
- Mechanical splitter: See the FOP for AASHTO R 76.
- Strike-off bar: A straightedge or spatula.
- Clock or watch reading in minutes and seconds.
• Manually-operated sand equivalent shaker: Capable of producing an oscillating motion at a rate of 100 complete cycles in 45 ±5 seconds, with a hand assisted half stroke length of 127 ±5 mm (5 ±0.2 in.). It may be held stable by hand during the shaking operation. It is recommended that this shaker be fastened securely to a firm and level mount, by bolts or clamps, if a large number of determinations are to be made.

• Mechanical shaker: See AASHTO T 176 for equipment and procedure.

• Oven: Capable of maintaining a temperature of 110 ±5°C (230 ±9°F).

• Thermometer: Calibrated liquid-in-glass or electronic digital type designed for total immersion and accurate to 0.1°C (0.2°F).

Materials

• Stock calcium chloride solution: Obtain commercially prepared calcium chloride stock solution meeting AASHTO requirements.

• Working calcium chloride solution: Dilute one 3 oz. measuring can (85 ±5 mL) of stock calcium chloride solution with 3.8 L (1 gal) distilled or demineralized water. Thoroughly mix the solution by filling the bottle with 2 L (1/2 gal) of water. Add the stock solution and agitate vigorously for 1 to 2 minutes. Add the remainder of the water, approximately 2 L (1/2 gal.). Repeat the agitation process. The shelf life of the working solution is approximately 30 days. Label working solution with the date mixed. Discard working solutions more than 30 days old.

  Note 1: The graduated cylinder filled to 4.4 in. contains 88 mL and may be used to measure the stock solution.

  Note 2: Tap water may be used if it is proven to be non-detrimental to the test and if it is allowed by the agency.

Control

The temperature of the working solution should be maintained at 22 ±3°C (72 ±5°F) during the performance of the test. If field conditions preclude the maintenance of the temperature range, reference samples should be submitted to the Central/Regional Laboratory, as required by the agency, where proper temperature control is possible. Samples that meet the minimum sand equivalent requirement at a working solution temperature outside of the temperature range need not be subject to reference testing.

Sample Preparation

1. Obtain the sample in accordance with the FOP for AASHTO T 2 and reduce in accordance with the FOP for AASHTO R 76.
2. Prepare sand equivalent test samples from the material passing the 4.75 mm (No. 4) sieve. If the material is in clods, break it up and re-screen it over a 4.75 mm (No. 4) sieve. All fines shall be cleaned from particles retained on the 4.75 mm (No. 4) sieve and included with the material passing that sieve.

3. Split or quarter 1000 to 1500 g of material from the portion passing the 4.75 mm (No. 4) sieve. Use extreme care to obtain a truly representative portion of the original sample.

   **Note 3:** Experiments show that, as the amount of material being reduced by splitting or quartering is decreased, the accuracy of providing representative portions is reduced. It is imperative that the sample be split or quartered carefully. When it appears necessary, dampen the material before splitting or quartering to avoid segregation or loss of fines.

   **Note 4:** All tests, including reference tests, will be performed utilizing Alternative Method No. 2 as described in AASHTO T 176, unless otherwise specified.

4. The sample must have the proper moisture content to achieve reliable results. This condition is determined by tightly squeezing a small portion of the thoroughly mixed sample in the palm of the hand. If the cast that is formed permits careful handling without breaking, the correct moisture content has been obtained.

   **Note 5:** Clean sands having little 75 µm (No. 200), such as sand for Portland Cement Concrete (PCC), may not form a cast.

   If the material is too dry, the cast will crumble and it will be necessary to add water and remix and retest until the material forms a cast. When the moisture content is altered to provide the required cast, the altered sample should be placed in a pan, covered with a lid or with a damp cloth that does not touch the material, and allowed to stand for a minimum of 15 minutes. Samples that have been sieved without being air-dried and still retain enough natural moisture are exempted from this requirement.

   If the material shows any free water, it is too wet to test and must be drained and air dried. Mix frequently to ensure uniformity. This drying process should continue until squeezing provides the required cast.

5. Place the sample on the quartering cloth and mix by alternately lifting each corner of the cloth and pulling it over the sample toward the diagonally opposite corner, being careful to keep the top of the cloth parallel to the bottom, thus causing the material to be rolled. When the material appears homogeneous, finish the mixing with the sample in a pile near the center of the cloth.

6. Fill the measuring can by pushing it through the base of the pile while exerting pressure with the hand against the pile on the side opposite the measuring can. As the can is moved through the pile, hold enough pressure with the hand to cause the material to fill the tin to overflowing. Press firmly with the palm of the hand, compacting the material and placing the maximum amount in the can. Strike off the can level full with the straightedge or spatula.

7. When required, repeat steps 5 and 6 to obtain additional samples.
**Procedure**

1. Start the siphon by forcing air into the top of the solution bottle through the tube while the pinch clamp is open. Siphon 101.6 ±2.5 mm (4 ±0.1 in.) of working calcium chloride solution into the plastic cylinder.

2. Pour the prepared test sample from the measuring can into the plastic cylinder, using the funnel to avoid spilling.

3. Tap the bottom of the cylinder sharply on the heel of the hand several times to release air bubbles and to promote thorough wetting of the sample.

4. Allow the wetted sample to stand undisturbed for 10 ±1 minutes.

5. At the end of the 10-minute period, stopper the cylinder and loosen the material from the bottom by simultaneously partially inverting and shaking the cylinder.

6. After loosening the material from the bottom of the cylinder, shake the cylinder and contents by any one of the following methods:

   a. **Mechanical Method** – Place the stoppered cylinder in the mechanical shaker, set the timer, and allow the machine to shake the cylinder and contents for 45 ±1 seconds.

   **Caution:** Agencies may require additional operator qualifications for the next two methods.

   b. **Manually-operated Shaker Method** – Secure the stoppered cylinder in the three spring clamps on the carriage of the manually-operated sand equivalent shaker and set the stroke counter to zero. Stand directly in front of the shaker and force the pointer to the stroke limit marker painted on the backboard by applying an abrupt horizontal thrust to the upper portion of the right hand spring strap.

   Remove the hand from the strap and allow the spring action of the straps to move the carriage and cylinder in the opposite direction without assistance or hindrance. Apply enough force to the right-hand spring steel strap during the thrust portion of each stroke to move the pointer to the stroke limit marker by pushing against the strap with the ends of the fingers to maintain a smooth oscillating motion. The center of the stroke limit marker is positioned to provide the proper stroke length and its width provides the maximum allowable limits of variation.

   Proper shaking action is accomplished when the tip of the pointer reverses direction within the marker limits. Proper shaking action can best be maintained by using only the forearm and wrist action to propel the shaker. Continue shaking for 100 strokes.

   c. **Hand Method** – Hold the cylinder in a horizontal position and shake it vigorously in a horizontal linear motion from end to end. Shake the cylinder 90 cycles in approximately 30 seconds using a throw of 229 mm ±25 mm (9 ±1 in.). A cycle is defined as a complete back and forth motion. To properly shake the cylinder at this
speed, it will be necessary for the operator to shake with the forearms only, relaxing
the body and shoulders.

7. Set the cylinder upright on the work table and remove the stopper.

8. Insert the irrigator tube in the cylinder and rinse material from the cylinder walls as the
irrigator is lowered. Force the irrigator through the material to the bottom of the cylinder
by applying a gentle stabbing and twisting action while the working solution flows from
the irrigator tip. Work the irrigator tube to the bottom of the cylinder as quickly as
possible, since it becomes more difficult to do this as the washing proceeds. This flushes
the fine material into suspension above the coarser sand particles.

Continue to apply a stabbing and twisting action while flushing the fines upward until the
cylinder is filled to the 381 mm (15 in.) mark. Then raise the irrigator slowly without
shutting off the flow so that the liquid level is maintained at about 381 mm (15 in.) while
the irrigator is being withdrawn. Regulate the flow just before the irrigator is entirely
withdrawn and adjust the final level to 381 mm (15 in.).

*Note 6:* Occasionally the holes in the tip of the irrigator tube may become clogged by a particle of sand. If
the obstruction cannot be freed by any other method, use a pin or other sharp object to force it out,
using extreme care not to enlarge the size of the opening. Also, keep the tip sharp as an aid to
penetrating the sample.

9. Allow the cylinder and contents to stand undisturbed for 20 minutes ±15 seconds. Start
timing immediately after withdrawing the irrigator tube.

*Note 7:* Any vibration or movement of the cylinder during this time will interfere with the normal settling
rate of the suspended clay and will cause an erroneous result.

10. Clay and sand readings:

a. At the end of the 20-minute sedimentation period, read and record the level of the top
of the clay suspension. This is referred to as the clay reading.

*Note 8:* If no clear line of demarcation has formed at the end of the 20-minute sedimentation period, allow
the sample to stand undisturbed until a clay reading can be obtained, then immediately read and record
the level of the top of the clay suspension and the total sedimentation time. If the total sedimentation
time exceeds 30 minutes, rerun the test using three individual samples of the same material. Read and
record the clay column height of the sample requiring the shortest sedimentation period only. Once a
sedimentation time has been established, subsequent tests will be run using that time. The time will be
recorded along with the test results on all reports.

b. After the clay reading has been taken, place the weighted foot assembly over the
cylinder and gently lower the assembly until it comes to rest on the sand. Do not
allow the indicator to hit the mouth of the cylinder as the assembly is being lowered.
Subtract 254 mm (10 in.) from the level indicated by the extreme top edge of the
indicator and record this value as the sand reading.

c. If clay or sand readings fall between 2.5 mm (0.1 in.) graduations, record the level of
the higher graduation as the reading. For example, a clay reading that appears to be
7.95 would be recorded as 8.0; a sand reading that appears to be 3.22 would be
recorded as 3.3.
d. If two Sand Equivalent (SE) samples are run on the same material and the second varies by more than ±4, based on the first cylinder result, additional tests shall be run.

e. If three or more Sand Equivalent (SE) samples are run on the same material, average the results. If an individual result varies by more than ±4, based on the average result, additional tests shall be run.

Calculations

Calculate the SE to the nearest 0.1 using the following formula:

\[
SSS = \frac{SSSSRRSSSSR}{CSSCRRRSSSRR} \times 100
\]

Example:

Sand Reading  =  3.3
Clay Reading   =  8.0

\[
SSS = \frac{3.3}{8.0} \times 100 = 41.25 \quad \text{Report 42}
\]

Note 9: This example reflects the use of equipment made with English units. At this time, equipment made with metric units is not available.

Report the SE as the next higher whole number. In the example above, the 41.3 would be reported as 42. An SE of 41.0 would be reported as 41.

When averaging two or more samples, raise each calculated SE value to the next higher whole number (reported value) before averaging.

Example:

\[
\begin{align*}
\text{calculated value 1} &= 41.3 \\
\text{calculated value 2} &= 42.8 \\
\end{align*}
\]

These values are reported as 42 and 43, respectively.
Average the two reported values:

\[
\frac{42 + 43}{2} = 42.5 \quad \text{Report 43}
\]

If the average value is not a whole number, raise it to the next higher whole number.

**Report**

- Results on forms approved by the agency
- Sample ID
- Results to the whole number
- Sedimentation time if over 20 minutes
PERFORMANCE EXAM CHECKLIST

PLASTIC FINES IN GRADED AGGREGATES AND SOILS BY THE USE OF THE SAND EQUIVALENT TEST
FOP FOR AASHTO T 176

Participant Name_________________________ Exam Date ____________

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

Procedure Element Trial 1 Trial 2

Sample Preparation

1. Sample passed through 4.75 mm (No. 4) sieve? ____________
2. Material in clods broken up and re-screened? ____________
3. Split or quarter 1,000 to 1,500g of material passing the 4.75 mm (No. 4) sieve? NOTE: If necessary, the material may be dampened before splitting to avoid segregation or loss of fines. __ __
4. No fines lost? ____________
5. Working solution dated? ____________
6. Temperature of working solution 22 ±3°C (72 ±5°F)? __ __
7. Working calcium chloride solution 915 ±25 mm (36 ±1in) above the work surface? __ __
8. 101.6 ±2.5 mm (4 ±0.1in) working calcium chloride solution siphoned into cylinder? ____________
9. Material checked for moisture condition by tightly squeezing small portion in palm of hand and forming a cast? __ __
10. Sample at proper water content?
    a. If too dry (cast crumbles easily) water added, re-mixed, covered, and allowed to stand for at least 15 minutes? __ __
    b. If too wet (shows free water) sample drained, air dried and mixed frequently? __ __
11. Sample placed on splitting cloth and mixed by alternately lifting each corner of the cloth and pulling it over the sample toward diagonally opposite corner, causing material to be rolled? __ __
12. Is material thoroughly mixed? __ __
13. When material appears to be homogeneous, mixing finished with sample in a pile near center of cloth? __ __
14. Fill the 85 mL (3 oz) tin by pushing through base of pile with other hand on opposite side of pile? __ __
15. Material fills tin to overflowing? __ __

OVER
### Procedure Element


**Comments:** First attempt: Pass Fail Second attempt: Pass Fail

---

Examiner Signature_________________________ WAQTC #:__________
FOP for AASHTO T 176

Plastic Fines in Graded Aggregates and Soils by the Use of the Sand Equivalent Test

Sample Preparation

Add the following to Step 1:

The samples must be maintained at field moist condition until testing. Do not allow the sample to dry out. If testing will not be performed immediately, the sample must be kept in a sealed container.

Procedure

Add the following to Step 6a:

Only the Mechanical Method will be used.

Delete Step 6b and 6c.
SAMPLING OF BITUMINOUS PAVING MIXTURES
FOP FOR AASHTO T 168

Scope

This procedure covers the sampling of bituminous paving mixtures from HMA plants, haul units, and roadways in accordance with AASHTO T 168-03. Sampling is as important as testing, and every precaution must be taken to obtain a truly representative sample.

Apparatus

- Shovel

- Sample containers: such as cardboard boxes, metal cans, stainless steel bowls, or other agency-approved containers

- Scoops, trowels, or other equipment to obtain mix

- Sampling plate: Thick metal plate, minimum 8 gauge, sized to accommodate sample requirements, with a wire attached to one corner long enough to reach from the center of the paver to the outside of the farthest auger extension. Holes ¼ in. in diameter should be provided in each corner.

- Cookie cutter sampling device: Formed steel angle with two 100 mm by 150 mm by 9 mm (4 in. by 6 in. by 3/8 in.) handles, sized to accommodate sample requirements. Minimum 2 in. smaller than the sampling plate when used together.

  Example: Sampling plate 380 mm (15 in.) square and a cookie cutter sampling device 330 mm (13 in.) square.

- Mechanical sampling device

Sample Size

Sample size depends on the test methods specified by the agency for acceptance. Check agency requirement for the size required.

Sampling

General

- The material shall be tested to determine variations. The supplier/contractor shall provide equipment for safe and appropriate sampling, including sampling devices on plants when required.
• For dense graded mixture samples use cardboard boxes, stainless steel bowls or other agency-approved containers.

• For hot open graded mixture samples use stainless steel bowls. Do not put open graded mixture samples in boxes until they have cooled to the point that bituminous material will not migrate from the aggregate.

**Attached Sampling Devices**

Some agencies require mechanical sampling devices for hot mix asphalt (HMA) and cold feed aggregate on some projects. These are normally permanently attached devices that allow a sample container to pass perpendicularly through the entire stream of material or divert the entire stream of material into the container. Operation may be hydraulic, pneumatic, or manual and allows the sample container to pass through the stream twice, once in each direction, without overfilling. Special caution is necessary with manually operated systems since a consistent speed is difficult to maintain and non-representative samples may result. Check agency requirements for the specifics of required sampling systems.

1. Lightly coat the container attached to the sampling device with an agency-approved release agent or preheat it, or both, to approximately the same discharge temperature of the mix.

2. Pass the container twice through the material perpendicularly without overfilling the container.

3. Repeat until proper sample size has been obtained.

4. Transfer the HMA to an agency-approved container without loss of material.

**Sampling from Haul Units**

1. Visually divide the haul unit into approximately four equal quadrants.

2. Identify one sampling location in each quadrant.

3. Dig down and remove approximately 0.3 m (1 ft.) of material to avoid surface segregation. Obtain each increment from below this level.

4. Combine the increments to form a sample of the required size.

**Sampling from Roadway Prior to Compaction (Plate Method)**

Plate method using the “cookie cutter” sampling device.

There are two conditions that will be encountered when sampling hot mix asphalt (HMA) from the roadway prior to compaction. The two conditions are:
• Laying HMA on grade or untreated base material requires Method 1.

• Laying HMA on existing asphalt or laying a second lift of HMA requires Method 2.

**SAFETY:**

Sampling is performed behind the paving machine and in front of the breakdown roller. For safety, the roller must remain at least 3 m (10 ft.) behind the sampling operation until the sample has been taken and the hole filled with loose HMA.

Method 1 requires a plate to be placed in the roadway in front of the paving operation and therefore there is always concern with moving, operating equipment. It is safest to stop the paving train while a plate is installed in front of the paver. When this is not possible the following safety rules must be followed.

1. The plate placing operation must be at least 3 m (10 ft.) in front of the paver or pickup device. The technician placing the plate must have eye contact and communication with the paving machine operator. If eye contact cannot be maintained at all time, a third person must be present to provide communication between the operator and the technician.

2. No technician is to be between the asphalt supply trucks and the paving machine. The exception to this rule is if the supply truck is moving forward creating a windrow, in which case the technician must be at least 3 m (10 ft.) behind the truck.

If at any time the Engineer feels that the sampling technique is creating an unsafe condition, the operation is to be halted until it is made safe or the paving operation will be stopped while the plate is being placed.

**Method 1 - Obtaining a Sample on Untreated Base:**

1. Following the safety rules detailed above, the technician is to:

   a. Smooth out a location in front of the paver at least 0.5 m (2 ft.) inside the edge of the mat.

   b. Lay the plate down diagonally with the direction of travel, keeping it flat and tight to the base with the lead corner facing the paving machine.

2. Secure the plate in place by driving a nail through the hole in the lead corner of the plate.

3. Pull the wire, attached to the outside corner of the plate, taut past the edge of the HMA mat and secure with a nail.
4. Let the paving operation proceed over the plate and wire. Immediately proceed with the sampling.

5. Using the exposed end of the wire, pull the wire up through the fresh HMA to locate the corner of the plate. Place the “cookie cutter” sample device, just inside the end of the wire; align the cutter over the plate. Press “cookie cutter” device down through the HMA to the plate.

6. Using a small square tipped shovel or scoop, or both, carefully remove all the HMA from inside of the cutter and place in a sample container. Care shall be taken to prevent contamination of bituminous mixes by dust or other foreign matter, and to avoid segregation of aggregate and bituminous materials.

7. Remove the sample cutter and the plate from the roadway. The hole made from the sampling must be filled by the contractor with loose HMA.

Method 2 - Obtaining a Sample on Asphalt Surface:

1. After the paving machine has passed the sampling point, immediately place the “cookie cutter” sampling device on the location to be sampled. Push the cutter down through the HMA until it is flat against the underlying asphalt mat.

2. Using a small square tipped shovel or scoop, or both, carefully remove all the HMA from inside of the cutter and place in a sample container. The hole made from the sampling must be filled by the contractor with loose HMA.

Identification and Shipping

1. Identify sample containers as required by the agency.

2. Ship samples in containers that will prevent loss, contamination, or damage.

Report

- On forms approved by the agency
- Sample ID
- Date
- Time
- Location
- Quantity represented
PERFORMANCE EXAM CHECKLIST

SAMPLING BITUMINOUS PAVING MIXTURES
FOP FOR AASHTO T 168

Participant Name ___________________________ Exam Date ____________

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Was sample taken with an attached sampling device correctly?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Container coated or preheated or both?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Sampling device passed through stream twice perpendicular to material?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Sampling device not over filled?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Samples from truck transports taken from four quadrants at required depth of 300 mm (12 in)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Samples from roadway taken correctly with plate(s).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. When on untreated base plate placed well in front of paver?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Wire pulled to locate plate corner?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Cookie cutter placed on asphalt and pushed through to plate?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. All material removed from inside the cutter?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Sample placed in appropriate container.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Sample size meets agency requirements?</td>
<td></td>
<td></td>
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<tr>
<td>6. Sample identified as required?</td>
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</tbody>
</table>

Comments: First attempt: Pass____ Fail____ Second attempt: Pass____ Fail____

Examiner Signature__________________________ WAQTC #:________________
PERFORMANCE EXAM CHECKLIST (ORAL)

SAMPLING BITUMINOUS PAVING MIXTURES
FOP FOR AASHTO T 168

Participant Name ___________________________ Exam Date ____________

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

Procedure Element | Trial 1 | Trial 2
--- | --- | ---
1. At the hot plant how must a sample be obtained using an attached sampling device?
   a. Coat or preheat sample container. | ___ | ___
   b. Sampling device passed through stream twice perpendicular to material. | ___ | ___
   c. The sampling device cannot be overfilled. | ___ | ___

2. What must be done to sample from transport units?
   a. Divide the unit into four quadrants. | ___ | ___
   b. Obtain increments from each quadrant, 300 mm (12 in) below surface. | ___ | ___

3. Describe how to take samples from the roadway using a plate.
   a. Place the plate well in front of the paver. | ___ | ___
   b. Pull the wire to locate the corner of the plate. | ___ | ___
   c. Place the cutter on the HMA above the plate and push it down to the plate. | ___ | ___
   d. Collect all the material inside the cutter. | ___ | ___

4. What types of containers can be used?
   a. Cardboard boxes, stainless steel bowls, or other agency approved containers. | ___ | ___

5. What dictates size of sample?
   a. Agency requirements. | ___ | ___
   b. Specified by test method. | ___ | ___

Comments: First attempt: Pass____ Fail____ Second attempt: Pass____ Fail____

Examiner Signature_________________________ WAQTC #:_________________
FOP for AASHTO T 168

Sampling of Bituminous Paving Mixtures

**Sampling from the Roadway Prior to Compaction (Plate Method).**

Add the following after the fourth paragraph

When the sample container is large enough to accommodate the full dimensions of the sampling plate a sample may be obtained without using the “cookie cutter”, see Method 3.

Add the following after Method 2

**Method 3 - Obtaining Sample Without the “Cookie Cutter” Device:**

1. Following the safety rules detailed above, smooth out a location in front of the paver at least 2 ft. inside the edge of the mat.

2. Lay the plate down diagonally with the direction of travel, keeping it flat and tight to the base with the lead corner facing the paving machine.

3. Secure the plate in place by driving a nail through the hole in the lead corner of the plate.

4. Pull the wire, attached to the outside corner of the plate, taut past the edge of the HMA mat and secure with a nail.

5. Let the paving operation proceed over the plate and wire. Immediately proceed with the sampling.

6. Using the exposed end of the wire, pull the wire up through the fresh HMA to locate the corner of the plate.

7. Lift the sampling plate and the HMA sample carefully placed directly into the sample container.

8. The hole made from the sampling must be filled by the Contractor with loose HMA.

**Identification and Shipping.**

Add the following:

3. After the loose mix sample is obtained, the sample must not be held in a hot oven greater than 200°F for more than 4 hours to avoid aging or oxidation. However, the sample may be held overnight as long as the oven temperature does not exceed 200 °F.
REducing samples of hot mix asphalt (HMA) to testing size
FOP for AASHTO R 47

Scope

This procedure covers sample reduction of Hot Mix Asphalt (HMA) to testing size in accordance with AASHTO R 47-14. The reduced portion is to be representative of the original sample.

Apparatus

- Thermostatically controlled oven capable of maintaining a temperature of at least 110°C (230°F) or high enough to heat the material to a pliable condition for splitting.
- Non-contact temperature measuring device.
- Metal spatulas, trowels, metal straightedges, or drywall taping knives, or a combination thereof; for removing HMA samples from the quartering device, cleaning surfaces used for splitting, etc.
- Square-tipped, flat-bottom scoop, shovel or trowel for mixing HMA prior to quartering.
- Miscellaneous equipment including hot plate, non-asbestos heat-resistant gloves or mittens, pans, buckets, and cans.
- Sheeting: Non-stick heavy paper, heat-resistant plastic, or other material as approved by the agency.
- Agency-approved release agent, free of solvent or petroleum-based material that could affect asphalt binder.
- Mechanical Splitter Type A (Quartermaster): having four equal-width chutes discharging into four appropriately sized sample receptacles. Splitter is to be equipped with a receiving hopper that will hold the sample until the release lever is activated with four sample receptacles of sufficient capacity to accommodate the reduced portion of the HMA sample from the mechanical splitter. Refer to AASHTO R 47, Figures 1 through 3, for configuration and required dimensions of the mechanical splitter.
- Mechanical Splitter Type B (Riffle): having a minimum of eight equal-width chutes discharging alternately to each side with a minimum chute width of at least 50% larger than the largest particle size. A hopper or straight-edged pan with a width equal to or slightly smaller than the assembly of chutes in the riffle splitter to permit uniform discharge of the HMA through the chutes without segregation or loss of material. Sample receptacles of sufficient width and capacity to receive the reduced portions of HMA from the riffle splitter without loss of material.
• Quartering Template: formed in the shape of a cross with equal length sides at right angles to each other. Template shall be manufactured of metal that will withstand heat and use without deforming. The sides of the quartering template should be sized so that the length exceeds the diameter of the flattened cone of HMA by an amount allowing complete separation of the quartered sample. Height of the sides must exceed the thickness of the flattened cone of HMA.

• Non-stick mixing surface that is hard, heat-resistant, clean, level, and large enough to permit HMA samples to be mixed without contamination or loss of material.

**Sampling**

Obtain samples according to the FOP for AASHTO T 168.

**Sample Preparation**

The sample must be warm enough to separate. If not, warm in an oven until it is sufficiently soft to mix and separate easily. Do not exceed either the temperature or time limits specified in the test method(s) to be performed.

**Selection of Procedure (Method)**

Refer to agency requirements when determining the appropriate method(s) of sample reduction. In general, the selection of a particular method to reduce a sample depends on the initial size of the sample vs. the size of the sample needed for the specific test to be performed. It is recommended that, for large amounts of material, the initial reduction be performed using a mechanical splitter. This decreases the time needed for reduction and minimizes temperature loss. Further reduction of the remaining HMA may be performed by a combination of the following methods, as approved by the agency. The methods for reduction are:

- Mechanical Splitter Method
  - Type A (Quartermaster)
  - Type B (Riffle Splitter)

- Quartering Method
  - Full Quartering
  - By Apex

- Incremental Method
Procedure

Mechanical Splitter Type A (Quartermaster)

1. Clean the splitter and apply a light coating of approved release agent to the surfaces that will contact HMA.

2. Close and secure hopper gates.

3. Place the four sample receptacles in the splitter so that there is no loss of material.

4. Remove the sample from the agency-approved container(s) and place in the mechanical splitter hopper. Avoid segregation, loss of HMA or the accidental addition of foreign material.

5. Release the handle, allowing the HMA to drop through the divider chutes and discharge into the four receptacles.

6. Any HMA that is retained on the surface of the splitter shall be removed and placed into the appropriate receptacle.

7. Close and secure the hopper gates.

8. Reduce the remaining HMA as needed by this method or a combination of the following methods as approved by the agency.

9. Combine the material contained in the receptacles from opposite corners and repeat the splitting process until an appropriate sample size is obtained.

10. Retain and properly identify the remaining unused portion of the HMA sample for further testing if required by the agency.

Mechanical Splitter Type B (Riffle)

1. When heating of the testing equipment is desired, it shall be heated to a temperature not to exceed 110ºC (230ºF).

2. Clean the splitter and apply a light coating of approved release agent to the surfaces that will come in contact with HMA (hopper or straight-edged pan, chutes, receptacles).

3. Place two empty receptacles under the splitter.

4. Carefully empty the HMA from the agency-approved container(s) into the hopper or straight-edged pan without loss of material. Uniformly distribute from side to side of the hopper or pan.
5. Discharge the HMA at a uniform rate, allowing it to flow freely through the chutes.

6. Any HMA that is retained on the surface of the splitter shall be removed and placed into the appropriate receptacle.

7. Reduce the remaining HMA as needed by this method or a combination of the following methods as approved by the agency.

8. Using one of the two receptacles containing HMA, repeat the reduction process until the HMA contained in one of the two receptacles is the appropriate size for the required test.

9. After each split, remember to clean the splitter hopper and chute surfaces if needed.

10. Retain and properly identify the remaining unused HMA sample for further testing if required by the agency.

**Quartering Method**

1. When heating of the testing equipment is desired, it shall be heated to a temperature not to exceed the maximum mixing temperature.

2. If needed, apply a light coating of release agent to quartering template.

3. Dump the sample from the agency approved container(s) into a conical pile on a hard, “non-stick,” clean, level surface where there will be neither a loss of material nor the accidental addition of foreign material. The surface can be made non-stick by the application of an approved asphalt release agent, or sheeting.

4. Mix the material thoroughly by turning the entire sample over a minimum of four times with a flat-bottom scoop; or by alternately lifting each corner of the sheeting and pulling it over the sample diagonally toward the opposite corner, causing the material to be rolled. Create a conical pile by either depositing each scoop or shovelful of the last turning on top of the preceding one, or lifting both opposite corners.

5. Flatten the conical pile to a uniform diameter and thickness where the diameter is four to eight times the thickness. Make a visual observation to ensure that the material is homogeneous.

6. Divide the flattened cone into four equal quarters using the quartering template. Press the template down until it is in complete contact with the surface on which the sample has been placed, assuring complete separation.

   *Note 1:* Straightedges may be used in lieu of the quartering device to completely separate the material in approximately equal quarters.

7. Reduce the sample by quartering the sample completely or by removing the sample from the apex.
8. Full Quartering

8a. Remove two diagonally opposite quarters, including all of the fine material.

8b. Remove the quartering template and combine the remaining quarters, again forming a conical pile.

8c. Repeat steps 4, 5, 6, 8a, and 8b until a sample of the required size has been obtained. The final sample must consist of the two remaining diagonally opposite quarters.

8d. Retain and properly identify the remaining unused portion of the HMA sample for further testing if required by the agency.

9. By Apex

9a. Using a straightedge, slice through a quarter of the HMA from the center point to the outer edge of the quarter.

9b. Pull or drag the material from the quarter with two straight edges or hold one edge of the straightedge in contact with quartering device.

9c. Remove an equal portion from the opposite quarter and combine these increments to create the required sample size.

9d. Continue using the apex method with the unused portion of the HMA until samples have been obtained for all required tests.

9e. Retain and properly identify the remaining unused portion of the HMA sample for further testing if required by the agency.

Incremental Method

1. Cover a hard, clean, level surface with sheeting. This surface shall be large enough that there will be neither a loss of material nor the accidental addition of foreign material.

2. Place the sample from the agency approved container(s) into a conical pile on that surface.

3. Mix the material thoroughly by turning the entire sample over a minimum of four times with a flat-bottom scoop; or by alternately lifting each corner of the sheeting and pulling it over the sample diagonally toward the opposite corner, causing the material to be rolled. Create a conical pile by either depositing each scoop or shovelful of the last turning on top of the preceding one, or lifting both opposite corners.
4. Grasp the sheeting and roll the conical pile into a cylinder (loaf), then flatten the top. Make a visual observation to determine that the material is homogenous.

5. Pull the sheeting so at least ¼ of the length of the loaf is off the edge of the counter. Allow this material to drop into a container to be saved. As an alternate, using a straightedge, slice off approximately ¼ of the length of the loaf and place in a container to be saved.

6. Pull material off the edge of the counter and drop into an appropriate size sample pan or container for the test to be performed. Continue removing material from the loaf until the proper size sample has been acquired. As an alternate, using a straightedge, slice off an appropriate size sample from the length of the loaf and place in a sample pan or container.

7. Repeat step 6 until all the samples for testing have been obtained.

Note2: When reducing the sample to test size it is advisable to take several small increments, determining the mass each time until the proper minimum size is achieved. Unless the sample size is grossly in excess of the minimum or exceeds the maximum test size, use the sample as reduced for the test.

8. Retain and properly identify the remaining unused portion of the HMA sample for further testing if required by the agency.
# PERFORMANCE EXAM CHECKLIST

## REDUCING SAMPLES OF HOT MIX ASPHALT (HMA) TO TESTING SIZE

**FOP FOR AASHTO R 47**

### Participant Name ___________________________ Exam Date ____________

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Sample made soft enough to separate easily without exceeding temperature limits?</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mechanical Splitter Method Type A (Quartermaster)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Splitter cleaned and surfaces coated with release agent?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Hopper closed and receptacles in place?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Sample placed into hopper without segregation or loss of material?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Hopper handle released allowing the HMA to uniformly flow into receptacles?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Splitter surfaces cleaned of all retained HMA, allowing it to fall into appropriate receptacles?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Further reduction with the quartermaster:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Material in receptacles from opposite corners combined?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Splitting process repeated until appropriate sample size is obtained?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Remaining HMA stored in suitable container and properly labeled?</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mechanical Splitter Method Type B (Riffle)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Splitting apparatus and tools, if preheated, not exceeding 110°C (230°F)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Splitter cleaned and surfaces coated with release agent?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Two empty receptacles placed under splitter?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Sample placed in hopper or straight edged pan without loss of material and uniformly distributed from side to side?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Material discharged across chute assembly at controlled rate allowing free flow of HMA through chutes?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. Splitter surfaces cleaned of all retained HMA allowing it to fall into appropriate receptacles?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

OVER
Procedure Element

15. Further reduction with the riffle splitter:
   a. Material from one receptacle discharged across chute assembly at controlled rate, allowing free flow of HMA through chutes?
   b. Splitting process continued until appropriate sample size obtained, with splitter surfaces cleaned of all retained HMA after every split?

16. Remaining unused HMA stored in suitable container, properly labeled?

Quartering Method

17. Testing equipment preheated to a temperature not to exceed mix temperature?

18. Sample placed in a conical pile on a hard, non-stick, heat-resistant splitting surface such as metal or sheeting?

19. Sample mixed by turning the entire sample over a minimum of 4 times?

20. Conical pile formed and then flattened uniformly to diameter equal to about 4 to 8 times thickness?

21. Sample divided into 4 equal portions either with a metal quartering template or straightedges such as drywall taping knives?

22. Reduction by Full Quartering:
   a. Two diagonally opposite quarters removed and returned to sample container?
   b. Two other diagonally opposite quarters combined and process continued until appropriate sample size has been achieved?

23. Reduction by Apex:
   a. Using two straightedges or a splitting device and one straightedge, was one of the quarters split from apex to outer edge of material?
   b. Similar amount of material taken from opposite quarter?
   c. Increments combined to produce appropriate sample size?

24. Remaining unused HMA stored in suitable container, properly labeled?

Incremental Method

25. Sample placed on hard, non-stick, heat-resistant splitting surface covered with sheeting?

26. Sample mixed by turning the entire sample over a minimum of 4 times?

OVER
### Procedure Element

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>27. Conical pile formed?</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>28. HMA rolled into loaf and then flattened?</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>29. The first quarter of the loaf removed by slicing off or dropping off edge of counter and set aside?</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>30. Proper sample size sliced off or dropped off edge of counter into sample container?</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>31. Process continued until all samples are obtained?</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>32. All remaining unused HMA stored in suitable container, properly labeled?</td>
<td>_____</td>
<td>_____</td>
</tr>
</tbody>
</table>

### Comments:

<table>
<thead>
<tr>
<th>Comments: First attempt: Pass_____ Fail____</th>
<th>Second attempt: Pass_____ Fail_____</th>
</tr>
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Examiner Signature_________________________ WAQTC #: __________
FOP for AASHTO R-47

Reducing Samples of Hot Mix Asphalt to Testing Size

Delete all references to Mechanical Splitter Type A (Quartermaster). Not an accepted method.
MOISTURE CONTENT OF ASPHALT MIXTURES BY OVEN METHOD
FOP FOR AASHTO T 329

Scope

This procedure covers the determination of moisture content of asphalt mixtures in accordance with AASHTO T 329-15.

Overview

Moisture content is determined by comparing the wet mass of a sample and the mass of the sample after drying to constant mass. The term constant mass is used to define when a sample is dry.

*Constant mass* – the state at which a mass does not change more than a given percent, after additional drying for a defined time interval, at a required temperature.

Apparatus

- Balance or scale: 2 kg capacity, readable to 0.1 g and conforming to AASHTO M 231.
- Forced draft, ventilated, or convection oven: Capable of maintaining the temperature surrounding the sample at 163 ±14°C (325 ±25°F).
- Sample Container: Clean, dry, not affected by heat and of sufficient size to contain a test sample without danger of spilling.
- Thermometer or other suitable device with a temperature range of 10-260°C (50-500°F).

Sample

The test sample shall be obtained in accordance with the FOP for AASHTO T 168, and reduced in accordance with the FOP for AASHTO R 47. The size of the test sample shall be a minimum of 1000 g.

Procedure

1. Preheat the oven to the Job Mix Formula (JMF) mixing temperature range. If the mixing temperature is not supplied, a temperature of 163 ±14°C (325 ±25°F) is to be used.
   
   *Note 1:* For repeatability between laboratories, the preferred practice is to dry the sample at no less than 9° C (15° F) below the JMF mixing temperature.

2. Determine and record the mass of the sample container, including release media, to the nearest 0.1 g.
   
   *Note 2:* When using paper or other absorptive material to line the sample container ensure it is dry before determining initial mass of sample container.
3. Place the test sample in the sample container.

4. Determine and record the temperature of the test sample.

5. Determine and record the total mass of the sample container and test sample to the nearest 0.1 g.

6. Calculate the initial, moist mass (M_i) of the test sample by subtracting the mass of the sample container as determined in Step 2 from the total mass of the sample container and the test sample as determined in Step 5.

7. The test sample shall be initially dried for 90 ±5 minutes, and its mass determined. Then it shall be dried at 30 ±5 min intervals until further drying does not alter the mass by more than 0.05 percent.

8. Cool the sample container and test sample to ±9°C (±15°F) of the temperature determined in Step 4.

9. Determine and record the total mass of the sample container and test sample to the nearest 0.1 g.

   Note 3: Do not attempt to remove the test sample from the sample container for the purposes of determining mass.

10. Calculate the final, dry mass (M_f) of the test sample by subtracting the mass of the sample container as determined in Step 2 from the total mass of the sample container and the test sample as determined in Step 9.

   Note 4: Moisture content and the number of samples in the oven will affect the rate of drying at any given time. Placing wet samples in the oven with nearly dry samples could affect the drying process.

Calculations

**Constant Mass:**

Calculate constant mass using the following formula:

\[
\%\text{CB} = \left( \frac{M_p - M_n}{M_p} \right) \times 100
\]

Where:

- \(M_p\) = previous mass measurement
- \(M_n\) = new mass measurement
Example:

Mass of container: 232.6 g

Mass of container and sample after first drying cycle: 1361.8 g

Mass, $M_p$, of possibly dry sample: $1361.8 \text{ g} - 232.6 \text{ g} = 1129.2 \text{ g}$

Mass of container and possibly dry sample after second drying cycle: 1360.4 g

Mass, $M_n$, of possibly dry sample: $1360.4 \text{ g} - 232.6 \text{ g} = 1127.8 \text{ g}$

$$\frac{1129.2 \text{ aa} - 1127.8 \text{ aa}}{1129.2 \text{ aa}} \times 100 = 0.12\%$$

0.12 percent is not less than 0.05 percent, so continue drying the sample.

Mass of container and possibly dry sample after third drying cycle: 1359.9 g

Mass, $M_n$, of dry sample: $1359.9 \text{ g} - 232.6 \text{ g} = 1127.3 \text{ g}$

$$\frac{1127.8 \text{ aa} - 1127.3 \text{ aa}}{1127.8 \text{ aa}} \times 100 = 0.04\%$$

0.04 percent is less than 0.05 percent, so constant mass has been reached.

**Moisture Content:**

Calculate the moisture content, as a percent, using the following formula.

$$\text{Moisture Content} = \frac{M_i - M_f}{M_f} \times 100$$

Where:

$M_i$ = initial, moist mass

$M_f$ = final, dry mass
Example:

\[ M_i = 1134.9 \text{ g} \]
\[ M_f = 1127.3 \text{ g} \]

\[
\frac{M_i - M_f}{M_f} \times 100 = \frac{1134.9 \text{ aa} - 1127.3 \text{ aa}}{1127.3 \text{ aa}} \times 100 = 0.674, \text{ say 0.67\%}
\]

Report

- Results on forms approved by the agency
- Sample ID
- Moisture content to 0.01 percent
PERFORMANCE EXAM CHECKLIST

MOISTURE CONTENT OF ASPHALT MIXTURES BY OVEN METHOD
FOP FOR AASHTO T 329

Participant Name __________________________ Exam Date ____________

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

Procedure Element Trial 1 Trial 2

1. Mass of clean dry container including release media determined to 0.1 g? ______ ______
2. Representative sample obtained; 1000 g minimum? ______ ______
3. Initial temperature taken and recorded? ______ ______
4. Mass of sample determined to 0.1 g? ______ ______
5. Sample placed in drying oven for 90 ±5 minutes? ______ ______
6. Sample dried at a temperature not to exceed the JMF mixing temp? ______ ______
7. Constant mass checked at 30 ±5 minute intervals and reached? ______ ______
8. Sample and container cooled to ±9°C (15°F) of the initial temperature before final mass determined to 0.1 g? ______ ______
9. Calculation of moisture content performed correctly to 0.01 percent? ______ ______

\[ \frac{M_{i} - M_{f}}{M_{f}} \times 100 \]

Comments: First attempt: Pass____ Fail____ Second attempt: Pass____ Fail____

<table>
<thead>
<tr>
<th>Mi + pan</th>
<th>Pan</th>
<th>Mi</th>
<th>Mp1 + pan</th>
<th>Mp1</th>
<th>Mp2 + pan</th>
<th>Mp2</th>
</tr>
</thead>
</table>

% Moisture Content Check

Examiner Signature ___________________________ WAQTC #: ____________
DETERMINING THE ASPHALT BINDER CONTENT OF HOT MIX ASPHALT (HMA) BY THE IGNITION METHOD
FOP FOR AASHTO T 308

Scope

This procedure covers the determination of asphalt binder content of hot mix asphalt (HMA) by ignition of the binder in accordance with AASHTO T 308-16.

Overview

The sample is heated in a furnace at 538°C (1000°F) or less; samples may be heated by convection or direct infrared irradiation (IR). The aggregate remaining after burning can be used for sieve analysis using the FOP for AASHTO T 30.

Some agencies allow the use of recycled HMA. When using recycled HMA, check with the agency for specific correction procedures.

Asphalt binder in the HMA is ignited in a furnace. Asphalt binder content is calculated as the percentage difference between the initial mass of the HMA and the mass of the residual aggregate, with the asphalt binder correction factor, and moisture content subtracted. The asphalt binder content is expressed as percent of moisture-free mix mass.

Two methods, A and B, are presented.

Apparatus

Note 1: The apparatus must be calibrated for the specific mix design. See “Correction Factors” at the end of this FOP.

There are two methods – A and B. The apparatus for the two methods are the same except that the furnace for Method A has an internal balance.

- Ignition Furnace: A forced-air ignition furnace that heats the specimens by either the convection or direct IR irradiation method. The convection-type furnace must be capable of maintaining the temperature at 538 ± 5°C (1000 ± 9°F).

For Method A, the furnace will be equipped with an internal scale thermally isolated from the furnace chamber and accurate to 0.1 g. The scale shall be capable of determining the mass of a 3500 g sample in addition to the sample baskets. A data collection system will be included so that mass can be automatically determined and displayed during the test. The furnace shall have a built-in computer program to calculate the change in mass of the sample baskets and provide for the input of a correction factor for aggregate loss. The furnace shall provide a printed ticket with the initial specimen mass, specimen mass loss, temperature compensation, correction factor, corrected asphalt binder content, test time, and test temperature. The furnace shall provide an audible alarm and indicator light when the sample mass loss does not exceed
0.01 percent of the total sample mass for three consecutive minutes. Perform lift test according to manufacturer’s instructions weekly during use.

*Note 2:* The furnace shall be designed to permit the operator to change the ending mass loss percentage from 0.01 percent to 0.02 percent.

For both Method A and Method B, the furnace chamber dimensions shall be adequate to accommodate a 3500 g sample. The furnace door shall be equipped so that it cannot be opened during the ignition test. A method for reducing furnace emissions shall be provided and the furnace shall be vented so that no emissions escape into the laboratory. The furnace shall have a fan to pull air through the furnace to expedite the test and to eliminate the escape of smoke into the laboratory.

- Sample Basket Assembly: consisting of sample basket(s), catch pan, and basket guards. Sample basket(s) will be of appropriate size allowing samples to be thinly spread and allowing air to flow through and around the sample particles. Sets of two or more baskets shall be nested. A catch pan: of sufficient size to hold the sample basket(s) so that aggregate particles and melting asphalt binder falling through the screen mesh are caught. Basket guards will completely enclose the basket and be made of screen mesh, perforated stainless steel plate, or other suitable material.

- Thermometer, or other temperature measuring device, with a temperature range of 10 - 260°C (50-500°F).

- Oven capable of maintaining 110 ±5°C (230 ±9°F).

- Balance or scale: Capacity sufficient for the sample mass and conforming to the requirements of M 231, Class G2.

- **Safety equipment:** Safety glasses or face shield, high temperature gloves, long sleeved jacket, a heat resistant surface capable of withstanding 650°C (1202°F), a protective cage capable of surrounding the sample baskets during the cooling period, and a particle mask for use during removal of the sample from the basket assembly.

- Miscellaneous equipment: A pan larger than the sample basket(s) for transferring sample after ignition, spatulas, bowls, and wire brushes.

**Sampling**

1. Obtain samples of HMA in accordance with the FOP for AASHTO T 168.

2. Reduce HMA samples in accordance with the FOP for AASHTO R 47.

3. If the mixture is not sufficiently soft to separate with a spatula or trowel, place it in a large flat pan in an oven at 110 ±5°C (230 ±9°F) until soft enough.
4. Test sample size shall conform to the mass requirement shown in Table 1.

**Note 3:** When the mass of the test specimen exceeds the capacity of the equipment used or for large samples of fine mixes, the test specimen may be divided into suitable increments, tested, and the results appropriately combined through a weighted average for calculation of the asphalt binder content.

**Table 1**

<table>
<thead>
<tr>
<th>Nominal Maximum Aggregate Size*</th>
<th>Minimum Mass Specimen g</th>
<th>Maximum Mass Specimen g</th>
</tr>
</thead>
<tbody>
<tr>
<td>mm (in.)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>37.5 (1 ½)</td>
<td>4000</td>
<td>4500</td>
</tr>
<tr>
<td>25.0 (1)</td>
<td>3000</td>
<td>3500</td>
</tr>
<tr>
<td>19.0 (3/4)</td>
<td>2000</td>
<td>2500</td>
</tr>
<tr>
<td>12.5 (1/2)</td>
<td>1500</td>
<td>2000</td>
</tr>
<tr>
<td>9.5 (3/8)</td>
<td>1200</td>
<td>1700</td>
</tr>
<tr>
<td>4.75 (No. 4)</td>
<td>1200</td>
<td>1700</td>
</tr>
</tbody>
</table>

* One sieve larger than the first sieve to retain more than 10 percent of the material using an agency specified set of sieves based on cumulative percent retained. Where large gaps in specification sieves exist, intermediate sieve(s) may be inserted to determine nominal maximum size.

**Procedure – Method A (Internal Balance)**

1. For the convection-type furnace, preheat the ignition furnace to 538 ± 5°C (1000 ± 9°F) or to the temperature determined in the “Correction Factor” section, Step 9 of this method. Manually record the furnace temperature (set point) prior to the initiation of the test if the furnace does not record automatically. For the direct IR irradiation-type furnace, use the same burn profile as used during the correction factor determination.

2. Dry the sample to constant mass, according to the FOP for AASHTO T 329; or determine the moisture content of a companion sample in accordance with the FOP for AASHTO T 329.

3. Determine and record the mass to the nearest 0.1 g of the sample basket assembly.

4. Evenly distribute the sample in the sample basket assembly, taking care to keep the material away from the edges of the basket. Use a spatula or trowel to level the sample.

5. Determine and record the total mass of the sample and sample basket assembly to the nearest 0.1 g. Calculate and record the initial mass of the sample (total mass minus the mass of the sample basket assembly) to the nearest 0.1 g. Designate this mass as \( M_i \).

6. Record the correction factor or input into the furnace controller for the specific HMA.

7. Input the initial mass of the sample \( M_i \) into the ignition furnace controller. Verify that the correct mass has been entered.
CAUTION: Operator should wear safety equipment – high temperature gloves, face shield, fire-retardant shop coat – when opening the door to load or unload the sample.

8. Open the chamber door and gently set the sample basket assembly in the furnace. Carefully position the sample basket assembly so it is not in contact with the furnace wall. Close the chamber door and verify that the sample mass displayed on the furnace scale equals the total mass of the sample and sample basket assembly recorded in Step 5 within ±5 g.

Note 4: Furnace temperature will drop below the set point when the door is opened, but will recover when the door is closed and ignition begins. Sample ignition typically increases the temperature well above the set point – relative to sample size and asphalt binder content.

9. Initiate the test by pressing the start button. This will lock the sample chamber and start the combustion blower.

Safety note: Do not attempt to open the furnace door until the asphalt binder has been completely burned off.

10. Allow the test to continue until the stable light and audible stable indicator indicate that the change in mass does not exceed 0.01 percent for three consecutive minutes. Press the stop button. This will unlock the sample chamber and cause the printer to print out the test results.

Note 5: An ending mass loss percentage of 0.02 may be used, if allowed by the agency, when aggregate that exhibits an excessive amount of loss during ignition testing is used.

11. Open the chamber door, remove the sample basket assembly, and place on the cooling plate or block. Place the protective cage over the sample basket assembly and allow it to cool to room temperature (approximately 30 minutes).

12. Determine and record the total after ignition mass to the nearest 0.1 g. Calculate and record the mass of the sample, after ignition (total after ignition mass minus the mass of the sample basket assembly) to the nearest 0.1 g. Designate this mass as Mf.

13. Use the asphalt binder content percentage from the printed ticket. Subtract the moisture content from the printed ticket asphalt binder content and report the difference as the corrected asphalt binder content.

Asphalt binder content percentage can also be calculated using the formula from “Method B” Step 16.
Calculation

Corrected asphalt binder content:

\[ P_b = B_{BBB} - M_{MBB} - B_{f} \]

(if not input in the furnace controller)

where:

\[ P_b = \text{the corrected asphalt binder content as a percent by mass of the HMA} \]

Procedure – Method B (External Balance)

1. Preheat the ignition furnace to 538 ± 5°C (1000 ± 9°F) or to the temperature determined in the “Correction Factor” section, Step 9 of this method. Manually record the furnace temperature (set point) prior to the initiation of the test if the furnace does not record automatically.

2. Dry the sample to constant mass, according to the FOP for AASHTO T 329; or determine the moisture content of a companion sample in accordance with the FOP for AASHTO T 329.

3. Determine and record the mass of the sample basket assembly to the nearest 0.1 g.

4. Place the sample basket(s) in the catch pan. Evenly distribute the sample in the sample basket(s), taking care to keep the material away from the edges of the basket. Use a spatula or trowel to level the sample.

5. Determine and record the total mass of the sample and sample basket assembly to the nearest 0.1 g. Calculate and record the initial mass of the sample (total mass minus the mass of the sample basket assembly) to the nearest 0.1 g. Designate this mass as \( M_i \).

6. Record the correction factor for the specific HMA.

7. Open the chamber door and gently set the sample basket assembly in the furnace. Carefully position the sample basket assembly so it is not in contact with the furnace wall. Burn the HMA sample in the furnace for 45 minutes or the length of time determined in the “Correction Factors” section.
8. Open the chamber door, remove the sample basket assembly, and place on the cooling plate or block. Place the protective cage over the sample and allow it to cool to room temperature (approximately 30 min).

9. Determine and record the total after ignition mass to the nearest 0.1 g. Calculate and record the mass of the sample, after ignition (total after ignition mass minus the mass of the sample basket assembly) to the nearest 0.1 g.

10. Place the sample basket assembly back into the furnace.

11. Burn the sample for at least 15 minutes after the furnace reaches the set temperature.

12. Open the chamber door, remove the sample basket assembly, and place on the cooling plate or block. Place the protective cage over the sample basket assembly and allow it to cool to room temperature (approximately 30 min.).

13. Determine and record the total after ignition mass to the nearest 0.1 g. Calculate and record the mass of the sample, after ignition (total after ignition mass minus the mass of the sample basket assembly) to the nearest 0.1 g.

14. Repeat Steps 10 through 13 until the change in measured mass of the sample after ignition does not exceed 0.01 percent of the previous sample mass after ignition.

   Note 6: An ending mass loss percentage of 0.02 may be used, if allowed by the agency, when aggregate that exhibits an excessive amount of loss during ignition testing is used.

15. Determine and record the total after ignition mass to the nearest 0.1 g. Calculate and record the mass of the sample, after ignition (total after ignition mass minus the mass of the sample basket assembly) to the nearest 0.1 g. Designate this mass as Mf.

16. Calculate the asphalt binder content of the sample.
Calculations

Calculate the asphalt binder content of the sample as follows:

\[ PP_{bb} = \frac{MM_i - MM_{ff}}{MM_i} \times 100 - MMBB - BB \]

where:

- \( PP_{bb} \) = the corrected asphalt binder content as a percent by mass of the HMA sample
- \( M_Mi \) = the final mass of aggregate remaining after ignition
- \( M_Mi \) = the initial mass of the HMA sample prior to ignition
- \( MC \) = moisture content of the companion HMA sample, percent, as determined by the FOP for AASHTO T 329 (if the specimen was oven-dried prior to initiating the procedure, \( MC = 0 \)).
- \( C_c \) = correction factor as a percent by mass of the HMA sample

Example

Correction Factor = 0.42%
Moisture Content = 0.04%
Initial Mass of Sample and Basket = 5292.7 g
Mass of Basket Assembly = 2931.5 g
\( M_Mi \) = 2361.2 g
Total Mass after First ignition + basket = 5154.4 g
Sample Mass after First ignition = 2222.9 g
Sample Mass after additional 15 min ignition = 2222.7 g

\[ \frac{2222.9 \, gg - 2222.7 \, gg}{2222.9 \, gg} \times 100 = 0.009\% \]

Not greater than 0.01 percent, so \( M_Mf = 2222.7 \, g \)
\[ P_b = \frac{2361.2 \text{ } \text{ } g - 2222.7 \text{ } \text{ } g}{2361.2 \text{ } \text{ } g} \times 100 - 0.42\% - 0.04\% = 5.41\% \]

\[ P_b = 5.41\% \]

**Gradation**

1. Empty contents of the basket(s) into a flat pan, being careful to capture all material. Use a small wire brush to ensure all residual fines are removed from the baskets.
   
   *Note 7:* Particle masks are a recommended safety precaution.

2. Perform the gradation analysis in accordance with the FOP for AASHTO T 30.

**Report**

- Results on forms approved by the agency
- Sample ID
- Method of test (A or B)
- Corrected asphalt binder content, \( P_b \), per agency standard
- Correction factor, \( C_f \), to 0.01 percent
- Temperature compensation factor (if applicable)
- Total percent loss
- Sample mass
- Moisture content to 0.01%
- Test temperature

Attach the original printed ticket with all intermediate values (continuous tape) to the report for furnaces with internal balances.
Annex – Correction Factors

(Mandatory Information)

**Asphalt Binder and Aggregate**

Asphalt binder content results may be affected by the type of aggregate in the mixture and by the ignition furnace. Asphalt binder and aggregate correction factors must, therefore, be established by testing a set of correction specimens for each Job Mix Formula (JMF) mix design. Each ignition furnace will have its own unique correction factor determined in the location where testing will be performed.

This procedure must be performed before any acceptance testing is completed, and repeated each time there is a change in the mix ingredients or design. Any changes greater than 5 percent in stockpiled aggregate proportions should require a new correction factor.

Historical data or scientific studies may be used to determine the correction factor(s) in lieu of using this testing procedure if the testing agency provides reference to the studies/data. All correction samples will be prepared by a central / regional laboratory unless otherwise directed.

**Asphalt binder correction factor:** A correction factor must be established by testing a set of correction specimens for each Job Mix Formula (JMF). Certain aggregate types may result in unusually high correction factors (> 1.00 percent). Such mixes should be corrected and tested at a lower temperature as described below.

**Aggregate correction factor:** Due to potential aggregate breakdown during the ignition process, a correction factor will need to be determined for the following conditions:

a. Aggregates that have a proven history of excessive breakdown

b. Aggregate from an unknown source.

This correction factor will be used to adjust the acceptance gradation test results obtained according to the FOP for AASHTO T 30.

**Procedure**

1. Obtain samples of aggregate in accordance with the FOP for AASHTO T 2.
2. Obtain samples of asphalt binder in accordance with the FOP for AASHTO R 66.
   
   *Note 8:* Include other additives that may be required by the JMF.
3. Prepare an initial, or “butter,” mix at the design asphalt binder content. Mix and discard the butter mix prior to mixing any of the correction specimens to ensure accurate asphalt content.
4. Prepare two correction specimens at the JMF design asphalt binder content. Aggregate used for correction specimens shall be sampled from material designated for use on the project. An agency approved method will be used to combine aggregate. An additional “blank” specimen shall be batched and tested for aggregate gradation in accordance with the FOP for AASHTO T 30. The gradation from the “blank” shall fall within the agency specified mix design tolerances.

5. Place the freshly mixed specimens directly into the sample basket assembly. If mixed specimens are allowed to cool prior to placement in the sample basket assembly, the specimens must be dried to constant mass according to the FOP for AASHTO T 329. Do not preheat the sample basket assembly.

6. Test the specimens in accordance with Method A or Method B of the procedure.

7. Once both of the correction specimens have been burned, determine the asphalt binder content for each specimen by calculation or from the printed oven tickets, if available.

8. If the difference between the asphalt binder contents of the two specimens exceeds 0.15 percent, repeat with two more specimens and, from the four results, discard the high and low result. Determine the correction factor from the two original or remaining results, as appropriate. Calculate the difference between the actual and measured asphalt binder contents for each specimen to 0.01 percent. The asphalt binder correction factor, \( C_f \), is the average of the differences expressed as a percent by mass of HMA.

9. If the asphalt binder correction factor exceeds 1.00 percent, the test temperature must be lowered to \( 482 \pm 5 ^\circ \text{C} \) (\( 900 \pm 9 ^\circ \text{F} \)) and new samples must be burned. The temperature for determining the asphalt binder content of HMA samples by this procedure shall be the same temperature determined for the correction samples.

10. For the direct IR irradiation-type burn furnaces, the default burn profile should be used for most materials. The operator may select burn-profile Option 1 or Option 2 to optimize the burn cycle. The burn profile for testing HMA samples shall be the same burn profile selected for correction samples.

   **Option 1** is designed for aggregate that requires a large asphalt binder correction factor (greater than 1.00 percent) – typically very soft aggregate (such as dolomite).

   **Option 2** is designed for samples that may not burn completely using the default burn profile.

11. Perform a gradation analysis on the residual aggregate in accordance with the FOP for AASHTO T 30, if required. The results will be utilized in developing an “Aggregate Correction Factor” and should be calculated and reported to 0.1 percent.
12. From the gradation results subtract the percent passing for each sieve, for each sample, from the percent passing each sieve of the “Blank” specimen gradation results from Step 4.

13. Determine the average difference of the two values. If the difference for any single sieve exceeds the allowable difference of that sieve as listed in Table 2, then aggregate gradation correction factors (equal to the resultant average differences) for all sieves shall be applied to all acceptance gradation test results determined by the FOP for AASHTO T 30. If the 75 µm (No. 200) is the only sieve outside the limits in Table 2, apply the aggregate correction factor to only the 75 µm (No. 200) sieve.

Table 2
Permitted Sieving Difference

<table>
<thead>
<tr>
<th>Sieve</th>
<th>Permitted Sieving Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sizes larger than or equal to 2.36 mm (No. 8)</td>
<td>± 5.0%</td>
</tr>
<tr>
<td>Sizes larger than to 75 µm (No. 200) and smaller 2.36 mm (No. 8)</td>
<td>± 3.0%</td>
</tr>
<tr>
<td>Sizes 75 µm (No. 200) and smaller</td>
<td>± 0.5%</td>
</tr>
</tbody>
</table>

Examples:

<table>
<thead>
<tr>
<th>Sieve Size mm (in.)</th>
<th>Correction Factor Blank Sample % Passing</th>
<th>Correction Factor Sample #1 % Passing</th>
<th>Correction Factor Sample #2 % Passing</th>
<th>Difference 1/2</th>
<th>Avg. Diff.</th>
<th>Sieves to adjust</th>
</tr>
</thead>
<tbody>
<tr>
<td>19.0 (3/4)</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>0/0</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>12.5 (1/2)</td>
<td>86.3</td>
<td>87.4</td>
<td>86.4</td>
<td>-1.1/-0.1</td>
<td>-0.6</td>
<td></td>
</tr>
<tr>
<td>9.5 (3/8)</td>
<td>77.4</td>
<td>76.5</td>
<td>78.8</td>
<td>+0.9/1.4</td>
<td>-0.3</td>
<td></td>
</tr>
<tr>
<td>4.75 (No. 4)</td>
<td>51.5</td>
<td>53.6</td>
<td>55.9</td>
<td>-2.1/-4.4</td>
<td>-3.3</td>
<td></td>
</tr>
<tr>
<td>2.36 (No. 8)</td>
<td>34.7</td>
<td>36.1</td>
<td>37.2</td>
<td>-1.4/-2.5</td>
<td>-2.0</td>
<td></td>
</tr>
<tr>
<td>0.18 (No. 16)</td>
<td>23.3</td>
<td>25.0</td>
<td>23.9</td>
<td>-1.7/-0.6</td>
<td>-1.2</td>
<td></td>
</tr>
<tr>
<td>0.600 (No. 30)</td>
<td>16.4</td>
<td>19.2</td>
<td>18.1</td>
<td>-2.8/-1.7</td>
<td>-2.3</td>
<td></td>
</tr>
<tr>
<td>0.300 (No. 50)</td>
<td>12.0</td>
<td>11.1</td>
<td>12.7</td>
<td>+0.9/0.7</td>
<td>+0.1</td>
<td></td>
</tr>
<tr>
<td>0.150 (No. 100)</td>
<td>8.1</td>
<td>9.9</td>
<td>6.3</td>
<td>-1.8/+1.8</td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td>75 µm (No. 200)</td>
<td>5.5</td>
<td>5.9</td>
<td>6.2</td>
<td>-0.4/-0.7</td>
<td>-0.6</td>
<td>- 0.6</td>
</tr>
</tbody>
</table>

In this example, all gradation test results performed on the residual aggregate (FOP for AASHTO T 30) would have an aggregate correction factor applied to the percent passing the 75 µm (No. 200) sieve. The correction factor must be applied because the average difference on the 75 µm (No. 200) sieve is outside the tolerance from Table 2.
In the following example, aggregate correction factors would be applied to each sieve because the average difference on the 4.75 mm (No. 4) is outside the tolerance from Table 2.

<table>
<thead>
<tr>
<th>Sieve Size mm (in.)</th>
<th>Correction Factor Blank Sample % Passing</th>
<th>Correction Factor Sample #1 % Passing</th>
<th>Correction Factor Sample #2 % Passing</th>
<th>Difference 1 / 2</th>
<th>Avg. Diff.</th>
<th>Sieves to adjust</th>
</tr>
</thead>
<tbody>
<tr>
<td>19.0 (3/4)</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>0/0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>12.5 (1/2)</td>
<td>86.3</td>
<td>87.4</td>
<td>86.4</td>
<td>-1.1/-0.1</td>
<td>-0.6</td>
<td>-0.6</td>
</tr>
<tr>
<td>9.5 (3/8)</td>
<td>77.4</td>
<td>76.5</td>
<td>78.8</td>
<td>+0.9/-1.4</td>
<td>-0.3</td>
<td>-0.3</td>
</tr>
<tr>
<td>4.75 (No. 4)</td>
<td>51.5</td>
<td>55.6</td>
<td>57.9</td>
<td>-4.1/-6.4</td>
<td>-5.3</td>
<td>-5.3</td>
</tr>
<tr>
<td>2.36 (No. 8)</td>
<td>34.7</td>
<td>36.1</td>
<td>37.2</td>
<td>-1.4/-2.5</td>
<td>-2.0</td>
<td>-2.0</td>
</tr>
<tr>
<td>0.018 (No. 16)</td>
<td>23.3</td>
<td>25.0</td>
<td>23.9</td>
<td>-1.7/-0.6</td>
<td>-1.2</td>
<td>-1.2</td>
</tr>
<tr>
<td>0.060 (No. 30)</td>
<td>16.4</td>
<td>19.2</td>
<td>18.1</td>
<td>-2.8/-1.7</td>
<td>-2.3</td>
<td>-2.3</td>
</tr>
<tr>
<td>0.030 (No. 50)</td>
<td>12.0</td>
<td>11.1</td>
<td>12.7</td>
<td>+0.9/-0.7</td>
<td>+0.1</td>
<td>+0.1</td>
</tr>
<tr>
<td>0.015 (No. 100)</td>
<td>8.1</td>
<td>9.9</td>
<td>6.3</td>
<td>-1.8/+1.8</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>0.075 µm (No. 200)</td>
<td>5.5</td>
<td>5.9</td>
<td>6.2</td>
<td>-0.4/-0.7</td>
<td>-0.6</td>
<td>-0.6</td>
</tr>
</tbody>
</table>
PERFORMANCE EXAM CHECKLIST

DETERMINING THE ASPHALT BINDER CONTENT OF HOT MIX ASPHALT (HMA) BY THE IGNITION METHOD
FOP FOR AASHTO T 308

Participant Name___________________________________ Exam Date ______________

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Oven at correct temperature 538 ± 5°C (1000 ± 9°F) or correction factor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>temperature? Or: for IR ovens, correct burn profile applied?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Sample reduced to correct size?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. HMA sample or companion moisture sample taken and dried per FOP for AASHTO T29</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Mass of sample basket assembly recorded to 0.1 g?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. With pan below basket(s) sample evenly distributed in basket(s)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Sample conforms to the required mass and mass recorded to 0.1 g?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Method A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Initial mass entered into furnace controller?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Sample correctly placed into furnace?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Test continued until stable indicator signals?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. Uncorrected asphalt binder content obtained on printed ticket?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. Sample mass determined to nearest 0.1 g.?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Method B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Sample correctly placed into furnace?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Sample burned for 45 min or time determined by correction process?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Sample cooled to room temperature?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. Sample burned to constant mass?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. Sample mass determined to nearest 0.1 g.?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>f. Uncorrected asphalt binder content calculated correctly and recorded?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

OVER
### Procedure Element

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>9. Asphalt binder content corrected for Correction Factor if needed?</td>
<td>_______</td>
<td>_______</td>
</tr>
<tr>
<td>10. Asphalt binder content corrected for moisture per the FOP for AASHTO T 329 if needed?</td>
<td>_______</td>
<td>_______</td>
</tr>
<tr>
<td>11. Corrected asphalt binder content recorded?</td>
<td>_______</td>
<td>_______</td>
</tr>
<tr>
<td>12. Contents of the basket(s) carefully emptied into a pan?</td>
<td>_______</td>
<td>_______</td>
</tr>
</tbody>
</table>

**Comments:**

First attempt: Pass____ Fail____

Second attempt: Pass____ Fail____

Examiner Signature__________________________ WAQTC #: __________
FOP for AASHTO T 308

Determining the Asphalt Binder Content of Hot Mix Asphalt (HMA) by the Ignition Method

- **Apparatus**
  
  Add the following:

  Ignition furnace: The testing laboratory owner must perform the Ignition Furnace Verification Procedure as outlined in the ITD Laboratory Qualification Program. The lift test will be performed and recorded weekly when the furnace is in use. The balance verification will be performed and recorded every 30 days when the furnace is in use and following furnace transport.

- **Procedure – Method A (Internal Balance)**
  
  Delete the following from step 13

  Asphalt binder content percentage can also be calculated using the formula from “Method B” Step 16.

  Add the following Steps 14 & 15

  14. Using $M_i$ and $M_f$ from above and formula in the “Calculation” portion of Method B calculate the asphalt binder content percent. Compare the results from the “Calculation” portion of Method A with the result from the “Calculation” portion from Method B. If the asphalt binder content from Method B is within 0.15% of the binder content from Method A use the results from Method A (Internal Balance) / printed ticket. If the difference is greater than 0.15% use the asphalt binder content percent as calculated from Method B’s formula.

  15. Determine, correct, and record the source of the variation between the two results prior to further testing. When the source of variation cannot be corrected then the furnace shall be placed out-of-service until repaired.

- **Annex – Correction Factors**
  
  Add the following to Procedure, Step 4:

  Combining Aggregates for Producing Calibration Factor Samples All samples shall be the same gradation and shall be combined sieve by sieve down to and including the material passing the No. 200 sieve.
MECHANICAL ANALYSIS OF EXTRACTED AGGREGATE
FOP FOR AASHTO T 30

Scope

This procedure covers mechanical analysis of aggregate recovered from asphalt mix samples in accordance with AASHTO T 30-15. This FOP utilizes the aggregate recovered from the ignition oven used in AASHTO T 308. AASHTO T 30 was developed for analysis of extracted aggregate and thus includes references to extracted bitumen and filter element, which do not apply in this FOP.

Sieve analyses determine the gradation or distribution of aggregate particles within a given sample in order to determine compliance with design and production standards.

Apparatus

- Balance or scale: Capacity sufficient for the sample mass, accurate to 0.1 percent of the sample mass or readable to 0.1 g
- Sieves, meeting the requirements of FOP for AASHTO T 27/T 11.
- Mechanical sieve shaker, meeting the requirements of FOP for AASHTO T 27/T 11.
- Mechanical Washing Apparatus (optional)
- Suitable drying equipment, meeting the requirements of the FOP for AASHTO T 255.
- Containers and utensils: A pan or vessel of a size sufficient to contain the sample covered with water and to permit vigorous agitation without loss of any part of the sample or water

Sample Sieving

- In this procedure, it is required to shake the sample over nested sieves. Sieves are selected to furnish information required by specification. Intermediate sieves are added for additional information or to avoid overloading sieves, or both.
- The sieves are nested in order of increasing size from the bottom to the top, and the test sample, or a portion of the test sample, is placed on the top sieve.
- The loaded sieves are shaken in a mechanical shaker for approximately 10 minutes, refer to Annex A; *Time Evaluation*. 
Mass Verification

Using the aggregate sample obtained from the FOP for AASHTO T 308, determine and record the mass of the sample, \( M_{(T30)} \), to 0.1 g. This mass shall agree with the mass of the aggregate remaining after ignition, \( M_f \) from T 308, within 0.10 percent. If the variation exceeds 0.10 percent the results cannot be used for acceptance.

Calculation

\[
\frac{M_f (T308) - M_{(T30)}}{M_f (T308)} \times 100
\]

Where:
- \( M_f (T308) \) = Mass of aggregate remaining after ignition from the FOP for AASHTO T 308
- \( M_{(T30)} \) = Mass of aggregate sample obtained from the FOP for AASHTO T 308

Example:

\[
\frac{2422.5 \text{ g} - 2422.3 \text{ g}}{2422.5 \text{ g}} \times 100 = 0.01\%
\]

Where:
- \( M_f (T308) = 2422.5 \text{ g} \)
- \( M_{(T30)} = 2422.3 \text{ g} \)

Procedure

1. Nest a sieve, such as a 2.0 mm (No. 10) or 1.18 mm (No. 16), above the 75\( \mu \)m (No. 200) sieve.

2. Place the test sample in a container and cover with water. Add a detergent, dispersing agent, or other wetting solution to the water to assure a thorough separation of the material finer than the 75\( \mu \)m (No. 200) sieve from the coarser particles. There should be enough wetting agent to produce a small amount of suds when the sample is agitated. Excessive suds may overflow the sieves and carry material away with them.
3. Agitate vigorously to ensure complete separation of the material finer than 75µm (No. 200) from coarser particles and bring the fine material into suspension above the coarser material. Avoid degradation of the sample when using a mechanical washing device. Maximum agitation is 10 min.

   Note 1: When mechanical washing equipment is used, the introduction of water, agitating, and decanting may be a continuous operation. Use care not to overflow or overload the 75µm (No. 200) sieve.

4. Immediately pour the wash water containing the suspended material over the nested sieves; be careful not to pour out the coarser particles or over fill the 75 µm (No. 200) sieve.

5. Add water to cover material remaining in the container, agitate, and repeat Step 4. Continue until the wash water is reasonably clear.

6. Remove the upper sieve, return material retained to the washed sample.

7. Rinse the material retained on the 75 µm (No. 200) sieve until water passing through the sieve is reasonably clear and detergent or dispersing agent is removed.

8. Return all material retained on the 75 µm (No. 200) sieve to the washed sample by rinsing into the washed sample.

9. Dry the washed test sample to constant mass according to the FOP for AASHTO T 255. Cool to room temperature. Determine and record the “dry mass after washing.”

10. Select sieves required by the specification and those necessary to avoid overloading. With a pan on bottom, nest the sieves increasing in size starting with the 75 µm (No. 200).

11. Place the test sample, or a portion of the test sample, on the top sieve. Place sieves in mechanical shaker and shake for the minimum time determined to provide complete separation for the sieve shaker being used (approximately 10 minutes, the time determined by Annex A).

   Note 2: Excessive shaking (more than 10 minutes) may result in degradation of the sample.

12. Determine and record the individual or cumulative mass retained for each sieve including the pan. Ensure that all material trapped in full openings of the sieves are removed and included in the mass retained.

   Note 3: For sieves 4.75 mm (No. 4) and larger, check material trapped in less than a full opening by sieving over a full opening. Use coarse wire brushes to clean the 600 µm (No. 30) and larger sieves, and soft bristle brushes for smaller sieves.

13. Perform the Check Sum calculation – Verify the total mass after sieving of material agrees with the dry mass after washing within 0.2 percent. Do not use test results for acceptance if the Check Sum result is greater than 0.2 percent.
14. Calculate the total percentages passing, and the individual or cumulative percentages retained, to the nearest 0.1 percent by dividing the individual sieve masses or cumulative sieve masses by the total mass of the initial dry sample.

15. Apply the Aggregate Correction Factor (ACF) to the calculated percent passing, as required in the FOP for AASHTO T 308 “Correction Factor,” to obtain the reported percent passing.

16. Report total percent passing to 1 percent except report the 75 µm (No. 200) sieve to 0.1 percent.

**Calculations**

**Check Sum**

\[
\text{Percent Retained} = \frac{\text{Individual Mass Retained} - \text{Cumulative Mass Retained}}{\text{Total dry sample mass before washing}} \times 100
\]

**Percent Retained**

**Individual**

\[
\text{IPR} = \frac{\text{IMR}}{\text{MT30}} \times 100
\]

**Cumulative**

\[
\text{CPR} = \frac{\text{CMR}}{\text{MT30}} \times 100
\]

Where:

IPR = Individual Percent Retained

CPR = Cumulative Percent Retained

MT30 = Total dry sample mass before washing

IMR = Individual Mass Retained

CMR = Cumulative Mass Retained
Percent Passing

Individual

\[ PPPP = PPCCPP - IIPPII \]

Cumulative

\[ PPP = 100 - CCPII \]

Where:

\[ PP = \text{Calculated Percent Passing} \]

\[ PCP = \text{Previous Calculated Percent Passing} \]

Reported Percent Passing

\[ IIIPPPP = PPPP + AACCAA \]

Where:

\[ RPP = \text{Reported Percent Passing} \]

Example

Dry mass of total sample, before washing \( (M_{T30}) \):

\[ 2422.3 \text{ g} \]

Dry mass of sample, after washing out the 75 µm (No. 200) minus:

\[ 2296.2 \text{ g} \]

Amount of 75 µm (No. 200) minus washed out \( (2422.3 \text{ g} - 2296.2 \text{ g}) \):

\[ 126.1 \text{ g} \]
Check sum

\[
\text{Check sum} = \frac{2296.2 - 2295.3}{22962} \times 100 = 0.04\%
\]

This is less than 0.2 percent therefore the results can be used for acceptance purposes.

**Percent Retained for the 75 µm (No. 200) sieve**

\[
\text{IPPII} = \frac{63.5}{2422.3} \times 100 = 2.6\%
\]

\[
\text{CPPPII} = \frac{2289.6}{2422.3} \times 100 = 94.5\%
\]

**Percent Passing using IPR and PCP for the 75 µm (No. 200) sieve**

\[
PPP = 8.1\% - 2.6\% = 5.5\%
\]

**Percent Passing using CPR for the 75 µm (No. 200) sieve**

\[
PPP = 100.0\% - 94.5\% = 5.5\%
\]

**Reported Percent Passing**

\[
\text{IIPPP} = 5.5\% = (-0.6\%) = 4.9\%
\]
Gradation on All Screens

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>19.0 (3/4)</td>
<td>0.0</td>
<td></td>
<td>0.0</td>
<td>0</td>
<td>100.0</td>
<td></td>
<td>100</td>
</tr>
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<td>12.5 (1/2)</td>
<td>346.9</td>
<td>14.3</td>
<td>346.9</td>
<td>14.3</td>
<td>85.7</td>
<td>86</td>
<td></td>
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<tr>
<td>9.5 (3/8)</td>
<td>207.8</td>
<td>8.6</td>
<td>554.7</td>
<td>22.9</td>
<td>77.1</td>
<td>77</td>
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<tr>
<td>4.75 (No. 4)</td>
<td>625.4</td>
<td>25.8</td>
<td>1180.1</td>
<td>48.7</td>
<td>51.3</td>
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<td></td>
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<tr>
<td>2.36 (No. 8)</td>
<td>416.2</td>
<td>17.2</td>
<td>1596.3</td>
<td>65.9</td>
<td>34.1</td>
<td>34</td>
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<td>0.018 (No. 16)</td>
<td>274.2</td>
<td>11.3</td>
<td>1870.5</td>
<td>77.2</td>
<td>22.8</td>
<td>23</td>
<td></td>
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<tr>
<td>0.600 (No. 30)</td>
<td>152.1</td>
<td>6.3</td>
<td>2022.6</td>
<td>83.5</td>
<td>16.5</td>
<td>16</td>
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<tr>
<td>0.300 (No. 50)</td>
<td>107.1</td>
<td>4.4</td>
<td>2129.7</td>
<td>87.9</td>
<td>12.1</td>
<td>12</td>
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<tr>
<td>0.150 (No. 100)</td>
<td>96.4</td>
<td>4.0</td>
<td>2226.1</td>
<td>91.9</td>
<td>8.1</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>75 µm (No. 200)</td>
<td>63.5</td>
<td>2.6</td>
<td>2289.6</td>
<td>94.5</td>
<td>5.5</td>
<td>-0.6</td>
<td>4.9</td>
</tr>
<tr>
<td>Pan</td>
<td>5.7</td>
<td></td>
<td>2295.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Report total percent passing to 1 percent except report the 75 µm (No. 200) sieve to 0.1 percent.

Report

- Results on forms approved by the agency
- Sample ID
- Depending on the agency, this may include:
  - Individual mass retained on each sieve
  - Individual percent retained on each sieve
  - Cumulative mass retained on each sieve
  - Cumulative percent retained on each sieve
  - Aggregate Correction Factor for each sieve from AASHTO T 308
  - Calculated percent passing each sieve to 0.1 percent
- Percent passing to the nearest 1 percent, except 75 µm (No. 200) sieve to the nearest 0.1 percent.
ANNEX A TIME EVALUATION

The minimum time requirement should be evaluated for each shaker at least annually by the following method:

1. Shake the sample over nested sieves for approximately 10 minutes.

2. Provide a snug-fitting pan and cover for each sieve, and hold in a slightly inclined position in one hand.

3. Hand-shake each sieve by striking the side of the sieve sharply and with an upward motion against the heel of the other hand at the rate of about 150 times per minute, turning the sieve about one sixth of a revolution at intervals of about 25 strokes.

If more than 0.5 percent by mass of the total sample before sieving passes any sieve after one minute of continuous hand sieving adjust shaker time and re-check.

In determining sieving time for sieve sizes larger than 4.75 mm (No. 4), limit the material on the sieve to a single layer of particles.
ANNEX B OVERLOAD DETERMINATION

- For sieves with openings smaller than 4.75 mm (No. 4), the mass retained on any sieve shall not exceed 7 kg/m² (4 g/in²) of sieving surface.

- For sieves with openings 4.75 mm (No. 4) and larger, the mass (in kg) shall not exceed the product of 2.5 x (sieve opening in mm) x (effective sieving area). See Table B1.

Additional sieves may be necessary to keep from overloading the specified sieves. The sample may also be sieved in increments or sieves with a larger surface area.

<table>
<thead>
<tr>
<th>Sieve Size mm (in.)</th>
<th>203 dia (8)</th>
<th>305 dia (12)</th>
<th>305 by 305 (12 x 12)</th>
<th>350 by 350 (14 x 14)</th>
<th>372 by 580 (16 x 24)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sieving Area m²</td>
<td>0.0285</td>
<td>0.0670</td>
<td>0.0929</td>
<td>0.1225</td>
<td>0.2158</td>
</tr>
<tr>
<td>90 (3 1/2)</td>
<td>*</td>
<td>15,100</td>
<td>20,900</td>
<td>27,600</td>
<td>48,500</td>
</tr>
<tr>
<td>75 (3)</td>
<td>*</td>
<td>12,600</td>
<td>17,400</td>
<td>23,000</td>
<td>40,500</td>
</tr>
<tr>
<td>63 (2 1/2)</td>
<td>*</td>
<td>10,600</td>
<td>14,600</td>
<td>19,300</td>
<td>34,000</td>
</tr>
<tr>
<td>50 (2)</td>
<td>3600</td>
<td>8400</td>
<td>11,600</td>
<td>15,300</td>
<td>27,000</td>
</tr>
<tr>
<td>37.5 (1 1/2)</td>
<td>2700</td>
<td>6300</td>
<td>8700</td>
<td>11,500</td>
<td>20,200</td>
</tr>
<tr>
<td>25.0 (1)</td>
<td>1800</td>
<td>4200</td>
<td>5800</td>
<td>7700</td>
<td>13,500</td>
</tr>
<tr>
<td>19.0 (3/4)</td>
<td>1400</td>
<td>3200</td>
<td>4400</td>
<td>5800</td>
<td>10,200</td>
</tr>
<tr>
<td>16.0 (5/8)</td>
<td>1100</td>
<td>2700</td>
<td>3700</td>
<td>4900</td>
<td>8600</td>
</tr>
<tr>
<td>12.5 (1/2)</td>
<td>890</td>
<td>2100</td>
<td>2900</td>
<td>3800</td>
<td>6700</td>
</tr>
<tr>
<td>9.5 (3/8)</td>
<td>670</td>
<td>1600</td>
<td>2200</td>
<td>2900</td>
<td>5100</td>
</tr>
<tr>
<td>6.3 (1/4)</td>
<td>440</td>
<td>1100</td>
<td>1500</td>
<td>1900</td>
<td>3400</td>
</tr>
<tr>
<td>4.75 (No. 4)</td>
<td>330</td>
<td>800</td>
<td>1100</td>
<td>1500</td>
<td>2600</td>
</tr>
<tr>
<td>-4.75 (-No. 4)</td>
<td>200</td>
<td>470</td>
<td>650</td>
<td>860</td>
<td>1510</td>
</tr>
</tbody>
</table>
PERFORMANCE EXAM CHECKLIST

MECHANICAL ANALYSIS OF EXTRACTED AGGREGATE
FOP FOR AASHTO T 30

Participant Name ___________________________ Exam Date __________

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Total dry mass determined to 0.1 g</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Dry mass agrees with sample mass after ignition ( M_f ) from AASHTO T 308 within 0.1 percent?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Sample placed in container and covered with water?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Wetting agent added?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Contents of container agitated vigorously?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Wash water poured through proper nest of two sieves?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Washing continued until wash water is clear and no wetting agent remaining?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Retained material returned to washed sample?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Washed material coarser than 75 µm (No. 200) dried to constant mass at 110 ±5°C (230 ±9°F)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Sample cooled to room temperature?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Dry mass after washing determined to 0.1 g?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Material sieved on specified sieves?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Mass of each fraction of aggregate, including minus 75 µm (No. 200), determined and recorded to 0.1 g?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. Total mass of material after sieving agrees with mass before sieving to within 0.2 percent?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. Percent passing each sieve determined correctly to the nearest 0.1 percent?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16. Aggregate correction factor applied?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17. Percent passing on each sieve reported correctly to the nearest 1 percent and nearest 0.1 percent on the 75 µm (No. 200)?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comments: First attempt: Pass_____ Fail_____ Second attempt: Pass_____ Fail_____

Examiner Signature ___________________________ WAQTC #: __________

5_T30_pr_17.docx  Asphalt 5-11  Pub. October 2017
THEORETICAL MAXIMUM SPECIFIC GRAVITY ($G_{mm}$) AND DENSITY OF HOT MIX ASPHALT (HMA) PAVING MIXTURES
FOP FOR AASHTO T 209

Scope

This procedure covers the determination of the maximum specific gravity ($G_{mm}$) of uncompacted hot mix asphalt (HMA) paving mixtures in accordance with AASHTO T 209-12. Two methods using different containers – bowl and pycnometer / volumetric flask – are covered.

Specimens prepared in the laboratory shall be cured according to agency standards.

Apparatus

- Balance or scale: 10,000 g capacity, readable to 0.1 g
- Container: A glass, metal, or plastic bowl, pycnometer or volumetric flask between 2000 and 10,000 mL as required by the minimum sample size requirements in Table 1 sample and capable of withstanding a partial vacuum
- Pycnometer / volumetric flask cover: A glass plate or a metal or plastic cover with a vented opening
- Vacuum lid: A transparent lid with a suitable vacuum connection, with a vacuum opening to be covered with a fine wire mesh
- Vacuum pump or water aspirator: Capable of evacuating air from the container to a residual pressure of 4.0 kPa (30 mm Hg)
- Residual pressure manometer or vacuum gauge: Traceable to NIST and capable of measuring residual pressure down to 4.0 kPa (30 mm Hg) or less
- Manometer or vacuum gauge: Capable of measuring the vacuum being applied at the source of the vacuum
- Water bath: A constant-temperature water bath (optional)
- Thermometers: Standardized liquid-in-glass, or electronic digital total immersion type, accurate to 0.5°C (1°F)
- Bleeder valve to adjust vacuum
- Timer
Standardization of Pycnometer or Volumetric Flask

Use a pycnometer / volumetric flask that is standardized to accurately determine the mass of water, at 25 ±0.5°C (77 ±1°F), in the pycnometer / volumetric flask. The pycnometer / volumetric flask shall be standardized periodically in conformance with procedures established by the agency.

Test Sample Preparation

1. Obtain samples in accordance with the FOP for AASHTO T 168 and reduce according to the FOP for AASHTO R 47.

2. Test sample size shall conform to the requirements of Table 1. Samples larger than the capacity of the container may be tested in two or more increments. Results will be combined and averaged. If the increments have a specific gravity difference greater than 0.014 the test must be re-run.

<table>
<thead>
<tr>
<th>Nominal Maximum* Aggregate Size mm (in.)</th>
<th>Minimum Mass g</th>
</tr>
</thead>
<tbody>
<tr>
<td>37.5 or greater (1½)</td>
<td>4000</td>
</tr>
<tr>
<td>19 to 25 (3/4 to 1)</td>
<td>2500</td>
</tr>
<tr>
<td>12.5 or smaller (1/2)</td>
<td>1500</td>
</tr>
</tbody>
</table>

*Nominal maximum size: One sieve larger than the first sieve to retain more than 10 percent of the material using an agency specified set of sieves based on cumulative percent retained.

Procedure – General

Two procedures – bowl and pycnometer / volumetric flask – are covered. The first 11 steps are the same for both.

1. Separate the particles of the sample, taking care not to fracture the mineral particles, so that the particles of the fine aggregate portion are not larger than 6.3 mm (1/4 in.). If the mixture is not sufficiently soft to be separated manually, place it in a large flat pan and warm in an oven only until it is pliable enough for separation.

2. Cool the sample to room temperature.

3. Determine and record the mass of the dry container to the nearest 0.1 g.

4. Place the sample in the container.

5. Determine and record the mass of the dry container and sample to the nearest 0.1 g.

6. Determine and record the mass of the sample by subtracting the mass determined in Step 3 from the mass determined in Step 5. Designate this mass as “A.”
7. Add sufficient water at approximately 25°C (77°F) to cover the sample by about 25 mm (1 in.).

*Note 1:* The release of entrapped air may be facilitated by the addition of a wetting agent. Check with the agency to see if this is permitted and, if it is, for a recommended agent.

8. Place the lid on the container and attach the vacuum line. To ensure a proper seal between the container and the lid, wet the O-ring or use a petroleum gel.

9. Remove entrapped air by subjecting the contents to a partial vacuum of 3.7 ±0.3 kPa (27.5 ±2.5 mm Hg) residual pressure for 15 ±2 minutes.

10. Agitate the container and contents, either continuously by mechanical device or manually by vigorous shaking, at 2 minute intervals. This agitation facilitates the removal of air.

11. Release the vacuum, increasing the pressure to atmospheric pressure in 10 to 15 seconds, turn off the vacuum pump, and remove the lid. When performing the pycnometer / volumetric flask method, complete steps 12B through 16B within 10±1 minutes.

**Procedure – Bowl**

12A. Fill the water bath to overflow level with water at 25 ±1°C (77 ±2°F) and allow the water to stabilize.

13A. Zero or tare the balance with the immersion apparatus attached, ensuring that the device is not touching the sides or the bottom of the water bath.

14A. Suspend and immerse the bowl and contents in water at 25 ±1°C (77 ±2°F) for 10 ±1 minutes. The holder shall be immersed sufficiently to cover both it and the bowl.

15A. Determine and record the submerged weight of the bowl and contents to the nearest 0.1 g.

16A. Refill the water bath to overflow level.

17A. Empty and re-submerge the bowl following Step 12A to determine the submerged weight of the bowl to the nearest 0.1 g.

18A. Determine and record the submerged weight of the sample to the nearest 0.1 g by subtracting the submerged weight of the bowl from the submerged weight determined in Step 15A. Designate this submerged weight as “C.”
Procedure – Pycnometer or Volumetric Flask

12B. Immediately fill the pycnometer / volumetric flask with water without reintroducing air.

13B. Stabilize the temperature of the pycnometer / volumetric flask and contents so that the final temperature is within 25 ±1°C (77 ±2°F).

14B. Finish filling the pycnometer / volumetric flask with water that is 25 ±1°C (77 ±2°F), place the cover or a glass plate on the pycnometer / volumetric flask, and eliminate all air.

Note 2: When using a metal pycnometer and cover, place the cover on the pycnometer and push down slowly, forcing excess water out of the hole in the center of the cover. Use care when filling the pycnometer to avoid reintroducing air into the water.

15B. Towel dry the outside of the pycnometer / volumetric flask and cover.

16B. Determine and record the mass of the pycnometer / volumetric flask, cover, de-aired water, and sample to the nearest 0.1 g. within 10 ±1 minutes of completion of Step 11. Designate this mass as “E.”

Procedure – Mixtures Containing Uncoated Porous Aggregate

If the pores of the aggregates are not thoroughly sealed by a bituminous film, they may become saturated with water during the vacuuming procedure, resulting in an error in maximum density. To determine if this has occurred, complete the general procedure and then:

1. Carefully drain water from sample through a towel held over the top of the container to prevent loss of material.

2. Spread sample in a flat shallow pan and place before an electric fan to remove surface moisture.

3. Determine the mass of the sample when the surface moisture appears to be gone.

4. Continue drying and determine the mass of the sample at 15-minute intervals until less than a 0.5 g loss is found between determinations.

5. Record the mass as the saturated surface dry mass to the nearest 0.1 g. Designate this mass as “ASSD.”

6. Calculate, as indicated below, \( G_{mm} \) using “A” and “ASSD,” and compare the two values.
Calculation

Calculate the $G_{mm}$ to three decimal places as follows:

**Bowl Procedure**

$$G_{mm} = \frac{AA}{AA - CC} \quad \text{(0000)}$$

$$G_{mm} = \frac{AA}{AA_{SSD} - CC} \quad \text{(for mixes containing uncoated aggregate materials)}$$

where:

- $A$ = mass of dry sample in air, g
- $A_{SSD}$ = Mass of saturated surface dry sample in air, g
- $C$ = submerged weight of sample in water, g

**Example:**

\[
\begin{align*}
A &= 1432.7 \text{ g} \\
A_{SSD} &= 1434.2 \text{ g} \\
C &= 848.6 \text{ g}
\end{align*}
\]

\[
\begin{align*}
G_{mm} &= \frac{1432.7 \text{ g}}{1432.7 \text{ g} - 848.6 \text{ g}} = 2.453 \\
G_{mm} &= \frac{1432.7 \text{ g}}{1434.2 \text{ g} - 848.6 \text{ g}} = 2.447
\end{align*}
\]

**Pycnometer / Volumetric Flask Procedure**

$$G_{mm} = \frac{AA}{AA + DD - EE} \quad \text{(0000)}$$

$$G_{mm} = \frac{AA}{AA_{SSD} + DD - EE} \quad \text{(for mixtures containing uncoated materials)}$$

where:

- $A$ = Mass of dry sample in air, g
- $A_{SSD}$ = Mass of saturated surface-dry sample in air, g
- $D$ = Mass of pycnometer / volumetric flask filled with water at 25°C (77°F), g, determined during the Standardization of Pycnometer / Volumetric Flask procedure
- $E$ = Mass of pycnometer / volumetric flask filled with water and the test sample at test temperature, g
Example (in which two increments of a large sample are averaged):

<table>
<thead>
<tr>
<th>Increment 1</th>
<th>Increment 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>A = 2200.3 g</td>
<td>A = 1960.2 g</td>
</tr>
<tr>
<td>D = 7502.5 g</td>
<td>D = 7525.5 g</td>
</tr>
<tr>
<td>E = 8812.0 g</td>
<td>E = 8690.8 g</td>
</tr>
</tbody>
</table>

Temperature = 26.2°C  Temperature = 25.0°C

\[
\begin{align*}
G_{\text{mmm}1} &= \frac{2200.3 \text{ g}}{2200.3 \text{ g} + 7502.5 \text{ g} - 8812.0 \text{ g}} = 2.470 \\
G_{\text{mmm}2} &= \frac{1960.2 \text{ g}}{1960.2 \text{ g} + 7525.5 \text{ g} - 8690.8 \text{ g}} \times 1.00000 = 2.466
\end{align*}
\]

Allowable variation is: 0.014

2.470 - 2.466 = 0.004, which is < 0.014, so they can be averaged.

Average

\[
\begin{align*}
2.470 + 2.466 &= 4.936 \\
4.936 \div 2 &= 2.468
\end{align*}
\]
Theoretical Maximum Density

To calculate the theoretical maximum density at 25°C (77°F) use one of the following formulas. The density of water at 25°C (77°F) is 997.1 in Metric units or 62.245 in English units.

Theoretical maximum density $\text{kg/m}^3 = G_{\text{mm}} \times 997.1 \text{ kg/ m}^3$

$2.468 \times 997.1 \text{ kg/ m}^3 = 2461 \text{ kg/ m}^3$

or

Theoretical maximum density $\text{lb/ft}^3 = G_{\text{mm}} \times 62.245 \text{ lb/ft}^3$

$2.468 \times 62.245 \text{ lb/ft}^3 = 153.6 \text{ lb/ft}^3$

Report

- Results on forms approved by the agency
- Sample ID
- $G_{\text{mm}}$ to three decimal places
- Theoretical maximum density to 1 $\text{kg/m}^3$ (0.1 $\text{lb/ft}^3$)
PERFORMANCE EXAM CHECKLIST

THEORETICAL MAXIMUM SPECIFIC GRAVITY AND DENSITY OF HOT MIX ASPHALT (HMA) PAVING MIXTURES
FOP FOR AASHTO T 209

Participant Name_________________________________________ Exam Date ____________

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Sample reduced to correct size?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Particles carefully separated insuring that aggregate is not fractured?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. After separation, fine aggregate particles not larger than 6.3 mm (1/4 in.)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Sample at room temperature?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Mass of container determined to 0.1 g?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Mass of sample and container determined to 0.1 g?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Mass of sample calculated and conforms to required size?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Water at approximately 25°C (77°F) added to cover sample?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Entrapped air removed using partial vacuum for 15 ±2 min?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Container and contents agitated continuously by mechanical device or manually by vigorous shaking at intervals of about 2 minutes?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Bowl determination:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Water bath filled to the overflow level?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Bowl and contents suspended in water at 25 ±1°C (77 ±2°F) for 10 ±1 minutes?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Submerged weight of bowl and contents determined to 0.1 g?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. Submerged weight of empty bowl determined to 0.1 g?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. Net submerged weight of contents calculated?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Pycnometer / Volumetric Flask determination:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Pycnometer / volumetric flask filled with water without reintroducing air into the sample?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Contents stabilized at 25 ±1°C (77 ±2°F)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Pycnometer / volumetric flask completely filled with water that is 25 ±1°C (77 ±2°F)?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

OVER
<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>d. Mass of filled pycnometer / volumetric flask and cover determined to 0.1 g, 10 ±1 minutes after removal of entrapped air completed?</td>
<td>___</td>
<td>___</td>
</tr>
<tr>
<td>e. Mass of pycnometer / volumetric flask, cover, and water obtained from the Standardization of Pycnometer or Volumetric Flask procedure?</td>
<td>___</td>
<td></td>
</tr>
</tbody>
</table>

13. G_mn calculated correctly and reported to 0.001?  
14. Density calculated correctly and reported to 1 kg/m³ (0.1 lb/ft³)?

**Comments:** First attempt: Pass Fail Second attempt: Pass Fail

Examiner Signature: ____________________________ WAQTC #: ______________
FOP for AASHTO T 209

Theoretical Maximum Specific Gravity ($G_{mm}$) and Density of Hot-Mix Asphalt Paving Mixtures

Test Sample Preparation

Add the following to Step 1

All laboratory-developed mix samples will be conditioned per AASHTO R30 (Mixture Conditioning of Hot Mix Asphalt) for two hours plus or minus 5 minutes at the asphalt binder manufacturer’s recommended temperature for compaction.

Add Step 3

3. The final test result will be determined from an average of the results from two specimens. The initial dry mass of these specimens shall have a variance not to exceed 50.0 grams. The allowable $G_{mm}$ variance between these specimens is 0.014. When the variance is greater than 0.014, review testing procedures, check test equipment and make adjustments needed before performing the next random sample testing. Record in the “Remarks” section the reason for the variation. If the two specimens from the next sample have a variance greater than 0.014, no further testing can be performed until the Independent Assurance Inspector evaluates the tester, equipment, and testing procedure to determine the reason for the variation.

The IA will document the findings of the investigation. Make adjustments to correct deficiencies before performing the next random sample testing.

Report.

Add the following

Average result of two gyratory specimens to three decimal places

AASHTO T 209

- 9. Sample Preparation
  - 9.1.

Add the following
The final test result will be determined from an average of the results from two specimens. The initial dry mass of these specimens shall have a variance not to exceed 50.0 grams. The allowable $G_{mm}$ variance between these specimens is 0.014. When the variance is greater than 0.14, review testing procedures, check test equipment and make adjustments needed before performing the next random sample testing. Record in the “Remarks” section the reason for the variation. If the two specimens from the next sample have a variance greater than 0.014, no further testing can be performed until the Independent Assurance Inspector evaluates the tester, equipment, and testing procedure to determine the reason for the variation.

The IA will document the findings of the investigation. Make adjustments to correct deficiencies before performing the next random sample testing.

- **9.2.**

Delete the first two sentences

Add the following first sentence:

All laboratory developed mix samples will be conditioned per AASHTO R30 (Mixture Conditioning of Hot Mix Asphalt) for two hours plus or minus 5 minutes at the asphalt binder manufactures recommended temperature for compaction.

- **16. REPORT**

Add the following

16.1.1.1. Average result of two specimens reported to the nearest thousandth.
BULK SPECIFIC GRAVITY (G_{mb}) OF COMPACTED ASPHALT MIXTURES USING SATURATED SURFACE-DRY SPECIMENS
FOP FOR AASHTO T 166

Scope

This procedure covers the determination of bulk specific gravity (G_{mb}) of compacted asphalt mixtures using three methods – A, B, and C – in accordance with AASHTO T 166-16. This FOP is for use on specimens not having open or interconnecting voids or absorbing more than 2.00 percent water by volume, or both. When specimens have open or interconnecting voids or absorbing more than 2.00 percent water by volume, or both, AASHTO T 275 or AASHTO T 331 should be performed.

Overview

- Method A: Suspension
- Method B: Volumeter
- Method C: Rapid test for A or B

Test Specimens

Test specimens may be either laboratory-molded or from asphalt mixture pavement. For specimens, it is recommended that the diameter be equal to four times the maximum size of the aggregate and the thickness be at least one and one half times the maximum size.

Test specimens from asphalt mixture pavement will be sampled according to AASHTO R 67.

Terminology

Constant Mass: The state at which a mass does not change more than a given percent, after additional drying for a defined time interval, at a required temperature.

Apparatus - Method A (Suspension)

Balance or scale: 5 kg capacity, readable to 0.1 g, and fitted with a suitable suspension apparatus and holder to permit weighing the specimen while suspended in water, conforming to AASHTO M 231.

- Suspension apparatus: Wire of the smallest practical size and constructed to permit the container to be fully immersed.
- Water bath: For immersing the specimen in water while suspended under the balance or scale, and equipped with an overflow outlet for maintaining a constant water level.
• Towel: Damp cloth towel used for surface drying specimens.

• Oven: Capable of maintaining a temperature of 110 ±5°C (230 ±9°F) for drying the specimens to a constant mass.

• Pan: Pan or other suitable container of known mass, large enough to hold a sample for drying in oven.

• Thermometer: Having a range of 19 to 27°C (66 to 80°F), graduated in 0.1°C (0.2°F) subdivisions.

**Procedure - Method A (Suspension)**

Recently molded laboratory samples that have not been exposed to moisture do not need drying.

1. Dry the specimen to constant mass, if required.
   a. Initially dry overnight at 52 ±3°C (125 ±5°F).
   b. Determine and record the mass of the specimen (M₀).
   c. Return the specimen to the oven for at least 2 hours.
   d. Determine and record the mass of the specimen (M₁).
   e. Determine percent change by subtracting the new mass determination (M₁) from the previous mass determination (M₀) divide by the previous mass determination (M₀) multiply by 100.
   f. Continue drying until there is less than 0.05 percent change in specimen mass after 2-hour drying intervals (constant mass).
   g. Constant mass has been achieved, sample is defined as dry.

*Note 1:* To expedite the procedure, steps 1 and 2 may be performed last. To further expedite the process, see Method C.

2. Cool the specimen in air to 25 ±5°C (77 ±9°F), and determine and record the dry mass to the nearest 0.1 g. Designate this mass as “A.”

3. Fill the water bath to overflow level with water at 25 ±1°C (77 ±1.8°F) and allow the water to stabilize.

4. Zero or tare the balance with the immersion apparatus attached, ensuring that the device is not touching the sides or the bottom of the water bath.
5. Immerse the specimen shaking to remove the air bubbles. Place the specimen on its side in the suspension apparatus. Leave it immersed for 4 ±1 minutes.

6. Determine and record the submerged weight to the nearest 0.1 g. Designate this submerged weight as “C.”

7. Remove the sample from the water and quickly surface dry with a damp cloth towel within 5 seconds.

8. Zero or tare the balance.

9. Immediately determine and record the mass of the SSD specimen to nearest 0.1 g. Designate this mass as “B.” Any water that seeps from the specimen during the mass determination is considered part of the saturated specimen. Do not to exceed 15 seconds performing Steps 7 through 9.

**Calculations - Method A (Suspension)**

**Constant Mass:**

Calculate constant mass using the following formula:

\[
\%\text{CC} = \frac{M_p - M_n}{M_p} \times 100
\]

Where:
- \(M_p\) = previous mass measurement, g
- \(M_n\) = new mass measurement, g

**Bulk specific gravity \(G_{mb}\) and percent water absorbed:**

\[
G_{mb} = \frac{AA}{BB - CC}
\]

\[
\%\text{water absorbed} = \left(\frac{BB - AA}{BB - CC}\right) \times 100
\]

where:
- \(A\) = Mass of dry specimen in air, g
- \(B\) = Mass of SSD specimen in air, g
- \(C\) = Weight of specimen in water at 25 ±1°C (77 ±1.8°F), g
Example:

\[ \% \text{Wet or damp sample} = \frac{4833.6 \text{ aa}}{4842.4 \text{ aa} - 2881.3 \text{ aa}} = 2.465 \]

\[ \% \text{Wet or damp sample} = \frac{4842.4 \text{ aa} - 4833.6 \text{ aa}}{4842.4 \text{ aa} - 2881.3 \text{ aa}} \times 100 = 0.45\% \]

**Apparatus - Method B (Volumeter)**

- Balance or scale: 5 kg capacity, readable to 0.1 g and conforming to AASHTO M 231.
- Water bath: Thermostatically controlled to 25 ±0.5°C (77 ±0.9°F).
- Thermometer: Range of 19 to 27°C (66 to 80°F), and graduated in 0.1°C (0.2°F) subdivisions.
- Volumeter: Calibrated to 1200 mL or appropriate capacity for test sample and having a tapered lid with a capillary bore.
- Oven: Capable of maintaining a temperature of 110 ±5°C (230 ±9°F) for drying the specimens to a constant mass.
- Pan: Pan or other suitable container of known mass, large enough to hold a sample for drying in oven.
- Towel: Damp cloth towel used for surface drying specimens.

**Procedure - Method B (Volumeter)**

Recently molded laboratory samples that have not been exposed to moisture do not need drying.

1. Dry the specimen to constant mass, if required.
   a. Initially dry overnight at 52 ±3°C (125 ±5°F).
   b. Determine and record the mass of the specimen (M_p).
   c. Return the specimen to the oven for at least 2 hours.
   d. Determine and record the mass of the specimen (M_n).
e. Determine percent change by subtracting the new mass determination (M_n) from the previous mass determination (M_p) divide by the previous mass determination (M_p) multiply by 100.

f. Continue drying until there is less than 0.05 percent change in specimen mass after 2-hour drying intervals (constant mass).

g. Constant mass has been achieved, sample is defined as dry.

Note 1: To expedite the procedure, steps 1 and 2 may be performed last. To further expedite the process, see Method C.

2. Cool the specimen in air to 25 ±5°C (77 ±9°F), and determine and record the dry mass to the nearest 0.1 g. Designate this mass as “A.”

3. Immerse the specimen in the temperature-controlled water bath for at least 10 minutes.

4. Fill the volumeter with distilled water at 25 ±1°C (77 ±1.8°F) making sure some water escapes through the capillary bore of the tapered lid. Wipe the volumeter dry. Determine the mass of the volumeter to the nearest 0.1 g. Designate this mass as “D.”

5. At the end of the ten minute period, remove the specimen from the water bath and quickly surface dry with a damp cloth towel within 5 seconds.

6. Immediately determine and record the mass of the SSD specimen to the nearest 0.1 g.

7. Designate this mass as “B.” Any water that seeps from the specimen during the mass determination is considered part of the saturated specimen.

8. Place the specimen in the volumeter and let stand 60 seconds.

9. Bring the temperature of the water to 25 ±1°C (77 ±1.8°F) and cover the volumeter, making sure some water escapes through the capillary bore of the tapered lid.

10. Wipe the volumeter dry.

11. Determine and record the mass of the volumeter and specimen to the nearest 0.1 g. Designate this mass as “E.”

Note 2: Method B is not acceptable for use with specimens that have more than 6 percent air voids.
Calculations - Method B (Volumeter)

**Constant Mass:**

Calculate constant mass using the following formula:

\[
\% \text{CH mass} = \frac{M_p - M_n}{M_p} \times 100
\]

Where:

- \( M_p \) = previous mass measurement, g
- \( M_n \) = new mass measurement, g

**Bulk specific gravity (G\text{mb}) and percent water absorbed:**

\[
G_{\text{mm}} = \frac{AA}{BB + DD - EE}
\]

where:

- \( A \) = Mass of dry specimen in air, g
- \( B \) = Mass of SSD specimen in air, g
- \( D \) = Mass of volumeter filled with water at 25 ±1°C (77 ±1.8°F), g
- \( E \) = Mass of volumeter filled with specimen and water, g

Example:

\[
G_{\text{mm}} = \frac{4833.6 \text{ aa}}{4842.4 \text{ aa} + 2924.4 \text{ aa} - 5806.0 \text{ aa}} = 2.465
\]

\[
\% \text{WW} = \frac{4842.4 \text{ aa} - 4833.6 \text{ aa}}{4842.4 \text{ aa} + 2924.4 \text{ aa} - 5806.0 \text{ aa}} \times 100 = 0.45\%
\]
Apparatus - Method C (Rapid Test for Method A or B)

See Methods A or B.

Note 3: This procedure can be used for specimens that are not required to be saved and contain substantial amounts of moisture. Cores can be tested the same day as obtained by this method.

Procedure - Method C (Rapid Test for Method A or B)

1. Start on Step 3 of Method A or B, and complete that procedure, then determine dry mass, “A,” as follows.

2. Determine and record mass of a large, flat-bottom container.

3. Place the specimen in the container.

4. Place in an oven at a minimum of 105°C (221°F). Do not exceed the Job Mix Formula mixing temperature.

5. Dry until the specimen can be easily separated into fine aggregate particles that are not larger than 6.3 mm (¼ in.).

6. Determine and record the mass of the specimen (M_p).

7. Return the specimen to the oven for at least 2 hours.

8. Determine and record the mass of the specimen (M_n).

9. Determine percent change by subtracting the new mass determination (M_n) from the previous mass determination (M_p) divide by the previous mass determination (M_p) multiply by 100.

10. Continue drying until there is less than 0.05 percent change in specimen mass after 2-hour drying intervals (constant mass).

11. Constant mass has been achieved, sample is defined as dry.


13. Determine and record the mass of the container and dry specimen to the nearest 0.1 g.

14. Determine and record the mass of the dry specimen to the nearest 0.1 g by subtracting the mass of the container from the mass determined in Step 13. Designate this mass as “A.”
Calculations - Method C (Rapid Test for Method A or B)

Complete the calculations as outlined in Methods A or B, as appropriate.

Report

- Results on forms approved by the agency
- Sample ID
- $G_{mb}$ to 0.001
- Absorption to 0.01 percent
- Method performed
# PERFORMANCE EXAM CHECKLIST

**BULK SPECIFIC GRAVITY OF COMPACTED ASPHALT MIXTURES USING SATURATED SURFACE-DRY SPECIMENS**  
**FOP FOR AASHTO T 166**

Participant Name_________________________________________ Exam Date _____________

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
</table>

### Method A:

1. Mass of dry sample in air determined.
   - Dried overnight at 52 ±3°C (125 ±5°F) and at successive 2-hour intervals to constant mass?
   - Cooled in air to 25 ±5°C (77 ±9°F)?
   - Dry mass determined to 0.1g?

2. Water at the overflow?

3. Balance zeroed?

4. Immersed weight determined.
   - Water at 25 ±1°C (77 ±1.8°F)?
   - Immersed, shaken, on side, for 4 ±1 minutes?
   - Immersed weight determined to 0.1g?

5. Sample rapidly surface dried with damp towel and saturated surface dry (SSD) mass determined to 0.1 g (entire operation performed within 15 seconds)?

6. $G_{nh}$ calculated to 0.001?

7. Absorption calculated to 0.01 percent

### Method B:

1. Specimen dried, cooled, and mass determined as in Method A?

2. Saturated surface dry (SSD) mass determined to 0.1g.
   - Immersed at least 10 minutes at 25 ±1°C (77 ±1.8°F)?
   - Sample rapidly dried with damp towel?
   - Specimen mass determined to 0.1 g?
   - Any water that seeps from specimen included in mass?

3. Mass of volumeter filled with distilled water at 25 ±1°C (77 ±1.8°F) determined?

4. SSD specimen placed into volumeter and let stand for 1 minute?

OVER
Procedure Element

5. Temperature of water brought to 25 ±1°C (77 ±1.8°F) and volumeter covered, allowing some water to escape through the capillary bore of the tapered lid?

6. Volumeter wiped dry, and mass of volumeter and contents determined?

7. \( G_{mb} \) calculated to 0.001?

8. Absorption calculated to 0.01 percent?

Method C/A:

1. Immersed weight determined.
   a. Water at 25 ±1°C (77 ±1.8°F)?
   b. Immersed, shaken, on side, for 4 ±1 minutes?
   c. Immersed weight determined to 0.1 g?

2. Sample rapidly surface dried with damp cloth (within 5 seconds)?

3. Saturated surface dry mass determined to 0.1 g?

4. Dry mass determined by:
   a. Heating in oven at a minimum of 105°C (221°F)?
   b. Breaking down to 6.3 mm (¼ in.) particles?
   c. Drying in oven to constant mass (change less than 0.05 percent in 2 hours of additional drying)?

   d. Cooled in air to 25 ±5°C (77 ±9°F) and mass determined to 0.1 g?

5. \( G_{mb} \) calculated to 0.001?

6. Absorption calculated to 0.01?

Method C/B:

1. Saturated surface dry (SSD) mass determined to 0.1 g.
   a. Immersed at least 10 minutes at 25 ±1°C (77 ±1.8°F)?
   b. Sample rapidly dried with damp towel (within 5 seconds)?
   c. Specimen mass determined to 0.1 g?

   d. Any water that seeps from specimen included in mass?

2. Mass of volumeter filled with distilled water at 25 ±1°C (77 ±1.8°F) determined to 0.1 g?

3. SSD specimen placed into volumeter and let stand for 1 minute?

4. Temperature of water brought to 25 ±1°C (77 ±1.8°F) and volumeter covered, allowing some water to escape through the capillary pore of the tapered lid?

5. Volumeter wiped dry, and mass of volumeter and contents determined to 0.1 g?

OVER
**Procedure Element**

6. Dry mass determined by:

   a. Warming in oven at a minimum of 105°C (221°F)?

   b. Breaking down to 6.3 mm (¼ in.) particles?

   c. Drying in oven to constant mass (change less than 0.05 percent in 2 hours of additional drying)?

   d. Cooled in air to 25 ±5°C (77 ±9°F) and mass determined to 0.1 g?

7. $G_{nb}$ calculated to 0.001?

8. Absorption calculated to 0.01 percent?

**Comments:**

First attempt: Pass Fail

Second attempt: Pass Fail

Examiner Signature________________________________________WAQTC #: ___________________________
**FOP for AASHTO T 166**

Bulk Specific Gravity ($G_{mb}$) of compacted Hot Mix Asphalt using Saturated Surface-Dry Specimens

Test Specimens

Add the following after the second paragraph

Two specimens are required for testing when produced using the [FOP for AASHTO T 312](#). These gyratory produced specimens will have a surface temperature between 68° F and 80° F and must be documented on test forms. The use of a fan will aid in the process.

The final test result will be determined from an average of the results from two specimens. The allowable $G_{mb}$ variance between these specimens is 0.012. When the variance is greater than 0.012, review test procedures, check test equipment and make adjustments needed before performing the next random sample testing. Record in the “Remarks” section the reason for the variation. If the two specimens from the next sample have a variance greater than 0.012 no further testing can be performed until the Independent Assurance Inspector evaluates the tester, equipment, and test procedure to determine the reason for the variation.

The IA will document the findings of the investigation. Make adjustments to correct deficiencies before performing the next random sample testing.

Report.

Add the following:

- Average result of two gyratory specimens to 0.001

**AASHTO T 166**

4. TEST SPECIMENS

Add subsection 4.7.

4.7. Two specimens are required for testing when produced using the [FOP for AASHTO T 312](#). These gyratory produced specimens will have a surface temperature between 68° F and 80° F and must be documented on test forms. The use of a fan will aid in the process.
Add subsection 4.7.1.

The final test result will be determined from an average of the results from two specimens. The allowable $G_{mb}$ variance between these specimens is 0.012. When the variance is greater than 0.012, review test procedures, check test equipment and make adjustments needed before performing the next random sample testing. Record in the "Remarks" section the reason for the variation. If the two specimens from the next sample have a variance greater than 0.012 no further testing can be performed until the Independent Assurance Inspector evaluates the tester, equipment, and test procedure to determine the reason for the variation.

The IA will document the findings of the investigation. Make adjustments to correct deficiencies before performing the next random sample testing.

13. REPORT.

Add subsection 13.1.4.

- Average result of two gyratory specimens reported to the nearest thousandth.
SAMPLING ASPHALT MATERIALS
FOP FOR AASHTO R 66

Scope

This procedure covers obtaining samples of liquid asphalt materials in accordance with AASHTO R 66-16. Sampling of solid and semi-solid asphalt materials – included in AASHTO R 66 – is not covered here.

Agencies may be more specific on exactly who samples, where to sample, and what type of sampling device to use.

Warning: Always use appropriate safety equipment and precautions for hot liquids.

Terminology

- Asphalt binder: Asphalt cement or modified asphalt cement that binds the aggregate particles into a dense mass.
- Asphalt emulsion: A mixture of asphalt binder and water.
- Cutback asphalt: Asphalt binder that has been modified by blending with a chemical solvent.

Procedure

1. Coordinate sampling with contractor or supplier.
2. Allow a minimum of 4 L (1 gal) to flow before obtaining a sample(s).
3. Obtain samples of:
   - Asphalt binder from the line between the storage tank and the mixing plant while the plant is in operation, or from the delivery truck.
   - Cutback and emulsified asphalt from distributor spray bar or application device; or from the delivery truck before it is pumped into the distributor. Sample emulsified asphalt at delivery or prior to dilution.

Containers

Sample containers must be new and the inside may not be washed or rinsed. The outside may be wiped with a clean, dry cloth.

All samples shall be put in 1 L (1 qt) containers and properly identified on the outside of the container with contract number, date sampled, data sheet number, brand and grade of material, and sample number. Include lot and sublot numbers when appropriate.
• Emulsified asphalt: Use wide-mouth plastic jars with screw caps. Protect the samples from freezing since water is a part of the emulsion. The sample container should be completely filled to minimize a skin formation on the sample.

• Asphalt binder and cutbacks: Use metal cans.

  Note: The sample container shall not be submerged in solvent, nor shall it be wiped with a solvent saturated cloth. If cleaning is necessary, use a clean dry cloth.

Report

• On forms approved by the agency

• Sample ID

• Date

• Time

• Location

• Quantity represented
ASPHALT MIXTURE SPECIMENS BY MEANS OF THE SUPERPAVE GYRATORY COMPACTOR
FOP FOR AASHTO T 312

Scope
This procedure covers preparing specimens, using samples of plant produced asphalt mixtures, for determining the mechanical and volumetric properties of asphalt mixtures in accordance with AASHTO T 312-15.

Apparatus
- Superpave Gyratory Compactor (SGC) meeting the requirements of AASHTO T 312
- Molds meeting the requirements of AASHTO T 312
- Chute, mold funnel or both (Optional)
- Scale meeting the requirements of AASHTO M 231 Class G 5
- Oven, thermostatically controlled, capable of maintaining set temperature within ±3°C (±5°F)
- Thermometers accurate to ±1°C (±2°F) between 10 and 232°C (50 - 450°F)

Note 1: Non-Contact thermometers are not acceptable.
- Miscellaneous pans, spoons, spatulas, hot pads, gloves, paper discs, markers, etc.

Equipment Requirements
The calibration shall be performed on the SGC per the Manufacturer’s instructions. See agency requirements for the calibration frequency.

The mold and base plate dimensions shall be checked every twelve months or 80 hours of operation to determine that they are within the tolerances listed in AASHTO T 312.

Equipment Preparation
Prepare the equipment in accordance with manufacturer’s recommendations. At a minimum preparation includes:

- Warm-up gyratory compactor
- Verify machine settings
  - Internal Angle: 1.16 ±0.02°
  - Ram Pressure: 600 kPa ±18 kPa
  - Number of gyrations
Note 2: The number of gyrations \( N_{des} \) is obtained from the Job Mix Formula (JMF).

- Lubricate bearing surfaces
- Prepare recording device as required
- Pre-heat molds and plates at the compaction temperature range (minimum of 30 min.) or before reuse reheat (minimum of 5 min.)

Note 3: The use of multiple molds will speed up the compaction process.

- Pre-heat chute, mold funnel, spatulas, and other apparatus (not to exceed the maximum compaction temperature)

Sample Preparation

Laboratory Prepared Asphalt Mixtures

This is a sample produced during the Mix Design process using aggregate and binder that is combined in the laboratory. When designing asphalt mixtures using the gyratory compactor refer to AASHTO T 312.

Plant Produced Asphalt Mixtures

- Determine initial sample size, number of gyrations \( N_{des} \), and compaction temperature range from the Job Mix Formula (JMF).
- Obtain the sample in accordance with the FOP for AASHTO T 168.
- Reduce the sample in accordance with the FOP for AASHTO R 47.
- The sample size should be such that it results in a compacted specimen that is 115 ±5mm at the desired number of gyrations.

Note 4: Replicate specimens are generally prepared. Refer to agency requirements.

If the material is not in the compaction temperature range:

1. Place the appropriate sample mass into a container.
2. Spread to a depth of 1 to 2 in. for even heating of mixture.
3. Place in the oven until the material is within the compaction temperature range.

Note 5: The material properties may be altered when the times of delivery of the test sample and the placement of the material on the roadway are different.
Compaction Procedure

Follow the manufacturer’s recommended loading procedure. This may require the steps below to be performed in a different order. Steps 1 through 8 must be performed before the sample and mold cools below minimum compaction temperature.

1. Remove pre-heated mold and plate(s) from the oven (verify mold and plate(s) has been cleaned if previously used).
2. Place the base plate and paper disc in bottom of mold.
3. Place the mix into the mold in a single lift (care should be taken to avoid segregation or loss of material).
4. Level the mix in the mold.
5. Place a paper disc and the heated upper plate (if required) on top of the leveled sample.
6. Load the mold into the compactor; check settings.
7. Start the compaction process.
   a. Check the pressure (600 ±18 kPa).
   b. Check the angle (1.16 ±0.02°).
8. Upon completion of the compaction process, record the number of gyrations and specimen height.

*Note 6:* If the specimen is not 115 ±5mm follow agency requirements.

9. Extrude the specimen from the mold; a brief cooling period may be necessary before fully extruding some specimens to ensure the specimens are not damaged.

*Note 7:* Clean molds after each use.

10. Carefully remove the paper discs.
11. Cool the compacted specimen to room temperature.
12. Identify the specimen with chalk or other marker.

Report

- On forms approved by the agency
- Sample ID
- Number of gyrations
- Specimen height
PERFORMANCE EXAM CHECKLIST

GYRATORY COMPACTION OF ASPHALT MIXTURES
FOP FOR AASHTO T 312

Participant Name ___________________________ Exam Date ____________

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

### Procedure Element

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Angle, pressure and number of gyrations set?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Bearing surfaces, rotating base surface, and rollers lubricated?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Representative sample obtained according to the FOP for AASHTO T 168?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Sample reduced according to FOP AASHTO R 47?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Asphalt mixture heated to compaction temperature range?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Mold, base plate, and upper plate heated to compaction temperature range?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Mold, base plate, and upper plate (if required) removed from oven and paper disk placed on bottom of mold?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Mix placed into mold in one lift without segregation?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Paper disk placed on top of the asphalt mixture?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Mold placed into compactor and upper plate clamped into place?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Pressure applied at 600 kPa ±18 kPa?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Specified number of gyrations applied?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Proper angle confirmed from display?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. Compacted specimen removed from mold, paper disc(s) removed, and allowed to cool to room temperature?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. Asphalt mixture sample measured to a height of 115 ±5 mm at required gyrations?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Comments:

First attempt: Pass_____ Fail_____

Second attempt: Pass_____ Fail_____

Examiner Signature_________________________ WAQTC #: ____________
FOP for AASHTO T 312

Asphalt Mixture Specimens by Means of the Superpave Gyratory Compactor

Sample Preparation

Laboratory Produced Asphalt Mixtures

Add the following:

The compacted specimen shall have dimensions of 150 mm in diameter and 115 ± 2 mm in height at the desired number of gyrations.

Report the mass necessary to produce a trial specimen to achieve this height requirement in the Mix Design submittal.

Plant Produced Asphalt Mixtures

Delete the 4th bullet and substitute the following:

- The final test result will be determined from an average of two specimens.
- The initial dry mass of these specimens shall not vary more than 15.0 grams from the mass determined in the Mix Design to achieve the height requirement.

AASHTO T 312

8. HMA Mixture Preparation

8.1. Laboratory Prepared:

8.1.1 Delete last sentence and Add the following:

If the specimens are to be used for the determination of volumetric properties, the batch weights will be adjusted to result in a compacted specimen having dimensions of 150 mm in diameter and 115 ± 2 mm in height at the desired number of gyrations.

Report the mass necessary to produce a trial specimen to achieve this height requirement in the Mix Design submittal.

8.2. Plant Produced:

Add the following:

8.2.6. The final test result will be determined from an average of two specimens.

8.2.7. The initial dry mass of these specimens shall not vary more than 15.0 grams from the mass determined in the Mix Design (tolerance).
VOLUMETRIC PROPERTIES OF HOT MIX ASPHALT (HMA)
WAQTC TM 13

Scope

This procedure covers the determination of volumetric properties of plant produced Hot Mix Asphalt, i.e., air voids ($V_a$), voids in mineral aggregate (VMA), voids filled with asphalt binder (VFA), effective asphalt binder content ($P_{be}$) and Dust to Binder Ratio ($P_{#200}/P_{be}$). The in-production volumetric properties are then compared to agency specifications.

Definition of Terms

- $G_{nm}$ = theoretical maximum specific gravity ($Gravity_{mix\ max}$)
- $G_{mb}$ = measured bulk specific gravity ($Gravity_{mix\ bulk}$)
- $G_{sb}$ = oven-dry bulk specific gravity of aggregate ($Gravity_{stone\ bulk}$)
- $G_{sa}$ = apparent specific gravity of aggregate ($Gravity_{stone\ apparent}$)
- $G_{se}$ = effective specific gravity of aggregate ($Gravity_{stone\ effective}$)
- $G_b$ = specific gravity of the binder ($Gravity_{binder}$)
- $V_a$ = air Voids ($Voids_{air}$)
- VMA = Voids in Mineral Aggregate
- VFA = Voids Filled with Asphalt (binder)
- $V_{ba}$ = absorbed binder volume ($Voids_{binder\ absorbed}$)
- $V_{be}$ = effective binder volume ($Voids_{binder\ effective}$)
- $P_b$ = percent binder content ($Percent_{binder}$)
- $P_{ba}$ = percent absorbed binder ($Percent_{binder\ absorbed}$)
- $P_{be}$ = percent effective binder content ($Percent_{binder\ effective}$)
- $P_s$ = percent of aggregate ($Percent_{stone}$)
- $DP$ = Dust proportion to effective binder ratio ($P_{#200}/P_{be}$)
Background

Whether a mix design is developed through a Marshall, Hveem, or Superpave mix design process there are basic volumetric requirements of all. Volumetric properties are the properties of a defined material contained in a known volume. HMA Volumetric properties can include bulk specific gravity, theoretical maximum specific gravity, air voids, and voids in mineral aggregate.

Many agencies specify values of the volumetric properties to ensure optimum performance of the pavement. The HMA must be designed to meet these criteria. In production the HMA is evaluated to determine if the mix still meets the specifications and is consistent with the original mix design (JMF). The production HMA may vary from the mix design and may need to be modified to meet the specified volumetric criteria.

To compare the in-production volumetric properties to agency specifications and the JMF a sample of loose HMA mix is obtained in accordance with FOP for AASHTO T 168. The sample is then compacted in a gyratory compactor to simulate the in-place HMA pavement after it has been placed, compacted, and the volumetric properties of the compacted sample are determined.

HMA Phase Diagram

Each of the properties in the HMA phase diagram can be measured or calculated. For example: The mass of the aggregate is measured; the voids in mineral aggregate (VMA) is calculated; total asphalt binder can be measured but the amount available to act as a binder in the mix must be calculated because it is the quantity left after the aggregate has absorbed some of the asphalt binder.
The volumetric proportions of the asphalt binder and aggregate components of an asphalt mixture and their relationship to the other components are considered. The mass of the components and their specific gravities are used to determine the volumes of each of the components in the mix. The volumetric properties of a compacted HMA paving mixture: air voids ($V_a$), voids in mineral aggregate (VMA), voids filled with asphalt binder (VFA), and effective asphalt binder content ($P_{be}$) provide some indication of the mixtures probable performance.

**Volumetric Properties**

**Volumetric Relationship of HMA Constituents**

![HMA Cross Section](image)

**Required Values**

The specific gravities listed in Table 1 and the percent by mass of each of the components in the HMA are needed to determine the volumetric properties. Other values required are also listed. Some of these values are obtained from the JMF and some are measured from a plant produced HMA sample.
**Table 1**

<table>
<thead>
<tr>
<th>Data</th>
<th>Test Method</th>
<th>Obtained</th>
</tr>
</thead>
<tbody>
<tr>
<td>$G_{sb}$ - combined aggregate bulk specific gravity</td>
<td>AASHTO T 84 / T 85 or agency approved test method</td>
<td>JMF or performed at the beginning of placement</td>
</tr>
<tr>
<td>$G_b$ – measured specific gravity of the asphalt binder</td>
<td>AASHTO T 228</td>
<td>JMF or from the supplier</td>
</tr>
<tr>
<td>$G_{mm}$ – measured maximum specific gravity of the loose mix</td>
<td>FOP for AASHTO T 209</td>
<td>Performed on the field test sample</td>
</tr>
<tr>
<td>$G_{mb}$ – measured bulk specific gravity of the compacted paving mix</td>
<td>FOP for AASHTO T 166</td>
<td>Performed on the field compacted specimen</td>
</tr>
<tr>
<td>$P_b$ – percent asphalt binder</td>
<td>FOP for AASHTO T 308</td>
<td>Performed on the field test sample</td>
</tr>
<tr>
<td>$P_{#200}$ – aggregate passing the #200 (75 µm) sieve</td>
<td>FOP for AASHTO T 30</td>
<td>Performed on the field test sample</td>
</tr>
</tbody>
</table>

**Air Voids ($V_a$)**

Air voids are the total volume of the small pockets of air between the coated aggregate particles throughout a compacted paving mixture. Appropriate air voids contribute to the stability of the HMA and help the pavement withstand the combined action of environment and traffic loads. The designated percent air voids allows for thermal expansion of the asphalt binder and contributes a cushion for future compaction. Air voids are expressed as a percent of the bulk volume of the compacted mixture ($G_{mb}$) when compared to the maximum specific gravity ($G_{mm}$).

$$V_{va} = 100 \frac{(G_{mm} - G_{mb})}{G_{mm}}$$

Where:

$V_a = $ air voids in compacted mixture, percent of total volume (report to 0.1)

$G_{mm} =$ maximum specific gravity of paving mixture (AASHTO T209)

$G_{mb} =$ bulk specific gravity of compacted mixture (AASHTO T 166)
Percent Aggregate (Stone) ($P_s$)

$P_s$ is the percent aggregate (stone) content, expressed as a percentage of the total mass of the sample.

$$PP_{ss} = 100 - PP_{mn}$$

Where:

- $P_s = $ percent aggregate (stone) percent by total weight
- $P_b = $ asphalt binder content (AASHTO T 308)

Voids in the Mineral Aggregate (VMA)

VMA is the volume of intergranular void space between the aggregate particles of the compacted paving mixture that includes the air voids and the effective binder content, expressed as a percent of the total volume of the sample.

$$VMA = 100 \left( G_{gb} \times \frac{P_s}{P_b} \right)$$

Where:

- $VMA = $ voids in mineral aggregate, percent of bulk volume (report to 0.1)
- $G_{gb} = $ bulk specific gravity of combined aggregate (AASHTO T 85 / T 84 or agency approved method from Job Mix Formula)
- $G_{mb} = $ bulk specific gravity of compacted mixture (AASHTO T 166)
- $P_s = $ aggregate content, percent by total weight = $100 - P_b$
- $P_b = $ asphalt binder content (AASHTO T 308) percent by total weight

Voids Filled with Asphalt (binder) (VFA)

VFA is the volume of space between the aggregate particles of the compacted paving mixture filled with asphalt binder, expressed as a percent of the total volume of the sample. The VFA increases as the asphalt binder content increases as it is the percent of voids that are filled with asphalt which doesn’t include the absorbed asphalt.

$$VFA = 100 \frac{VMA - V_a}{VMA}$$

Where:

- $VFA = $ voids filled with asphalt, percent of VMA (report to 1)
- $VMA = $ voids in mineral aggregate, percent of bulk volume
- $V_a = $ air voids in compacted mixture, percent of total volume.
**Effective Specific Gravity of the Aggregate (Stone) \( (G_{se}) \)**

The \( G_{se} \) is used to quantify the asphalt binder absorbed into the aggregate particle. This is a calculated value based on the specific gravity of the mixture, \( G_{mm} \), and the specific gravity of the asphalt binder, \( G_b \). This measurement includes the volume of the aggregate particle plus the void volume that becomes filled with water during the test soak period minus the volume of the voids that absorb asphalt binder. Effective specific gravity lies between apparent and bulk specific gravity.

\( G_{se} \) is formally defined as the ratio of the mass in air of a unit volume of a permeable material (excluding voids permeable to asphalt binder) at a stated temperature to the mass in air (of equal density) of an equal volume of gas-free distilled water at a stated temperature.

\[
G_{iss} = \frac{P_s}{G_{mm}}
\]

Where:

- \( G_{se} \) = effective specific gravity of combined aggregate (report to 0.001)
- \( P_s \) = aggregate content, percent by total weight = 100 – \( P_b \)
- \( G_{mm} \) = maximum specific gravity of mix (AASHTO T 209)
- \( P_b \) = asphalt binder content (AASHTO T 308) percent by total weight
- \( G_b \) = specific gravity of asphalt binder (JMF or asphalt binder supplier)

**Percent of Absorbed (asphalt) Binder (\( P_{ba} \))**

\( P_{ba} \) is the total percent of the asphalt binder that is absorbed into the aggregate, expressed as a percentage of the mass of aggregate rather than as a percentage of the total mass of the mixture. This portion of the asphalt binder content does not contribute to the performance of the mix.

\[
P_{ba} \times 100 = \frac{GG_{iss} - GG_{ssm}}{GG_{mm} \times GG_{iss}} \times GG
\]

Where:

- \( P_{ba} \) = absorbed asphalt binder (report to 0.01) percent of aggregate
- \( G_{se} \) = effective specific gravity of combined aggregate
- \( G_{sb} \) = bulk specific gravity of combined aggregate (AASHTO T 85 / T 84 or agency approved method from Job Mix Formula)
- \( G_b \) = specific gravity of asphalt binder (JMF or asphalt binder supplier)
**Percent of Effective (asphalt) Binder ($P_{be}$)**

$P_{be}$ is the total asphalt binder content of a paving mixture minus the portion of asphalt binder that is lost by absorption into the aggregate particles, expressed as a percentage of the mass of aggregate. It is the portion of the asphalt binder content that remains as a coating on the outside of the aggregate particles. This is the asphalt content that controls the performance of the mix.

$$PP_{\text{e}} = PP - \frac{PP_{\text{mna}}}{100} \times PP$$

Where:

- $P_{be}$ = effective asphalt binder content (report to 0.01), percent by total weight
- $P_s$ = aggregate content, percent by total weight = $100 - P_b$
- $P_b$ = asphalt binder content (AASHTO T 308) percent by total weight
- $P_{ba}$ = absorbed asphalt binder

**Dust Proportion – DP (Dust to Effective (asphalt) Binder Ratio)**

The DP is the percent passing the No. 200 sieve of the gradation divided by the percent of effective asphalt binder. Excessive dust reduces asphalt binder film thickness on the aggregate which reduces the durability. Insufficient dust may allow excessive asphalt binder film thickness, which may result in a tender, unstable mix.

$$DP = \frac{PP_{\#200}}{PP_{\text{e}}_{\text{mna}}}$$

Where:

- $DP$ = Dust Proportion, (dust-to-binder ratio) (report to 0.01)
- $P_{\#200}$ = aggregate passing the #200 (75 µm) sieve, percent by mass of aggregate (AASHTO T 30)
- $P_{be}$ = effective asphalt binder content, percent by total weight
Mix Design and Production Values

Job Mix Formula

Table 2 includes example data required from the JMF. Some of these values are used in the example calculations.

*Note:* Some of the targets may change after the HMA is in production based on field test data.

<table>
<thead>
<tr>
<th>Table 2</th>
<th>JMF Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asphalt binder grade</td>
<td>PG 64-28</td>
</tr>
<tr>
<td>(N_{\text{values}})</td>
<td>(N_{\text{ini}} = 7)</td>
</tr>
<tr>
<td></td>
<td>(N_{\text{des}} = 75)</td>
</tr>
<tr>
<td></td>
<td>(N_{\text{max}} = 115)</td>
</tr>
<tr>
<td>(G_{\text{sb}}) (combined specific gravity of the aggregate)</td>
<td>2.678</td>
</tr>
<tr>
<td>Target (P_b)</td>
<td>4.75%</td>
</tr>
<tr>
<td>Initial sample mass for gyratory specimens</td>
<td>4840 grams</td>
</tr>
<tr>
<td>Mixing temperature range</td>
<td>306 – 312 °F</td>
</tr>
<tr>
<td>Laboratory compaction temperature range</td>
<td>286 – 294 °F</td>
</tr>
<tr>
<td>(G_b) (specific gravity of the asphalt binder)</td>
<td>1.020</td>
</tr>
</tbody>
</table>

**Target gradation**

<table>
<thead>
<tr>
<th>Sieve Size mm (in.)</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>19.0 (3/4)</td>
<td>100</td>
</tr>
<tr>
<td>12.5 (1/2)</td>
<td>85</td>
</tr>
<tr>
<td>9.5 (3/8)</td>
<td>80</td>
</tr>
<tr>
<td>4.75 (No. 4)</td>
<td>50</td>
</tr>
<tr>
<td>2.36 (No. 8)</td>
<td>30</td>
</tr>
<tr>
<td>0.18 (No. 16)</td>
<td>25</td>
</tr>
<tr>
<td>0.600 (No. 30)</td>
<td>15</td>
</tr>
<tr>
<td>0.300 (No. 50)</td>
<td>10</td>
</tr>
<tr>
<td>0.150 (No. 100)</td>
<td>7</td>
</tr>
<tr>
<td>75 µm (No. 200)</td>
<td>5.0</td>
</tr>
</tbody>
</table>
Sample Test Result

Tables 3 and 4 include data from test results performed on a field sample of HMA used in the example calculations.

<table>
<thead>
<tr>
<th>Field Data</th>
<th>Test method</th>
<th>Example values</th>
</tr>
</thead>
<tbody>
<tr>
<td>$P_b$</td>
<td>FOP for AASHTO T 308</td>
<td>4.60%</td>
</tr>
<tr>
<td>$G_{mb}$</td>
<td>FOP for AASHTO T 166</td>
<td>2.415</td>
</tr>
<tr>
<td>$G_{mm}$</td>
<td>FOP for AASHTO T 209</td>
<td>2.516</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sieve Analysis</th>
<th>FOP for AASHTO T 30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sieve Size</td>
<td>Percent Passing</td>
</tr>
<tr>
<td>mm (in.)</td>
<td></td>
</tr>
<tr>
<td>19.0 (3/4)</td>
<td>100</td>
</tr>
<tr>
<td>12.5 (1/2)</td>
<td>86</td>
</tr>
<tr>
<td>9.5 (3/8)</td>
<td>77</td>
</tr>
<tr>
<td>4.75 (No. 4)</td>
<td>51</td>
</tr>
<tr>
<td>2.36 (No. 8)</td>
<td>34</td>
</tr>
<tr>
<td>0.18 (No. 16)</td>
<td>23</td>
</tr>
<tr>
<td>0.600 (No. 30)</td>
<td>16</td>
</tr>
<tr>
<td>0.300 (No. 50)</td>
<td>12</td>
</tr>
<tr>
<td>0.150 (No. 100)</td>
<td>8</td>
</tr>
<tr>
<td>75 µm (No. 200)</td>
<td>4.9</td>
</tr>
</tbody>
</table>

Sample Calculations

**Air Voids ($V_a$)**

\[
V_a = 100 \times \frac{G_{mm} - G_{mb}}{G_{mm}}
\]

\[
W_a = 100 \times \frac{2.516 - 2.415}{2.516} = 4.01431\% \approx 4.0\%
\]

Given:

$G_{mm} = 2.516$

$G_{mb} = 2.415$
Percent Aggregate (Stone) ($P_s$)

\[ P_{ss} = 100 - P_{mm} \]

\[ P_{ss} = 100.0 - 4.60\% = 95.40\% \]

Given:

\[ P_b = 4.60\% \]

Voids in the Mineral Aggregate (VMA)

\[ VV = 100 - \left( \frac{G_{mm} \times P_s}{G_{mm}} \right) \]

\[ VV = 100 - \frac{2.415 \times 95.40\%}{2.678} \approx 13.96\% \]

Given:

\[ G_{sb} = 2.678 \]

Voids Filled with Asphalt (binder) (VFA)

\[ VV = 100 \left( \frac{VV - V_{ss}}{VV} \right) \]

\[ VV = 100 \left( \frac{14.0\% - 4.0\%}{14.0\%} \right) = 71.4\% \]
Effective Specific Gravity of the Aggregate (Stone) \( (G_{se}) \)

\[
G_{se} = \frac{pp}{G_{sm} \times G_{bm}}
\]

\[
G_{se} = \frac{(100 - 4.60\%)}{2.516 \times 1.020} =
\]

\[
G_{se} = \frac{95.40\%}{39.74563 - 4.50980} = 2.70747 2.707
\]

Given:

\[ G_b = 1.020 \]

Percent of Absorbed (asphalt) Binder \( (P_{ba}) \)

\[
pp_{true} = 100 \frac{(G_{esss} - G_{ssmm})}{(G_{asmm} \times G_{ssmm})} \times G
\]

\[
pp_{true} = 100 \frac{(2.707 - 2.678)}{(2.678 \times 2.707)} \times 1.020 =
\]

\[
pp_{true} = 100 \frac{0.02900}{7.24935} \times 1.020 = 0.40800\% 0.41\%
\]

Percent of Effective (asphalt) Binder \( (P_{be}) \)

\[
pp_{true} = P - \frac{pp_{true}}{100} \times pp_{true}
\]

\[
pp_{true} = 4.60 - \frac{0.41\%}{100} \times (100 - 4.60\%) = 4.20886\% 4.21\%
\]
Dust Proportion – DP (Dust to Effective (asphalt) Binder Ratio)

\[
DDPP = \frac{P_{-#200}}{P_{rem}}
\]

\[
DDPP = \frac{4.9\%}{4.21\%} = 1.16390 \approx 1.16
\]

Given:
\[P_{-#200} = 4.9\%\]

Report

- Results on forms approved by the agency
- Sample ID
- Air Voids, \(V_a\) to 0.1 percent
- Voids in the Mineral Aggregate, \(VMA\) to 0.1 percent
- Voids Filled with Asphalt, \(VFA\) to nearest whole value
- Effective Specific Gravity of Aggregate (stone), \(G_{se}\) to 0.001
- Percent of Absorbed (asphalt) Binder, \(P_{ba}\) to 0.01
- Percent Effective (asphalt) Binder, \(P_{be}\) to 0.01
- Dust Proportion, \(DP\) to 0.01
Appendix - Formulas

Air Voids ($V_a$)

$$V_{air} = 100 \times \frac{(G_{mm} - G_{mb})}{G_{mm}}$$

Where:

$V_a$ = air voids in compacted mixture, percent of total volume (report to 0.1)
$G_{mm}$ = maximum specific gravity of paving mixture (AASHTO T 209)
$G_{mb}$ = bulk specific gravity of compacted mixture (AASHTO T 166)

Percent Aggregate (Stone) ($P_s$)

$$P_{ss} = 100 - P_m$$

Where:

$P_s$ = percent aggregate (stone) percent by total weight
$P_b$ = asphalt binder content (AASHTO T 308)

Voids in the Mineral Aggregate (VMA)

$$V_{VMA} = 100 - \frac{(G_{mm} \times P_s)}{G_{jm}}$$

Where:

VMA = voids in mineral aggregate, percent of bulk volume (report to 0.1)
$G_{sb}$ = bulk specific gravity of combined aggregate (AASHTO T 85 / T 84 or agency approved method from Job Mix Formula)
$G_{mb}$ = bulk specific gravity of compacted mixture (AASHTO T 166)
$P_s$ = aggregate content, percent by total weight = $100 - P_b$
$P_b$ = asphalt binder content (AASHTO T 308) percent by total weight

Voids Filled with Asphalt (binder) (VFA)

$$V_{VFA} = 100 \times \frac{(V_{VMA} - V_a)}{V_{VMA}}$$

Where:

VFA = voids filled with asphalt, percent of VMA (report to 1)
VMA = voids in mineral aggregate, percent of bulk volume
$V_a$ = air voids in compacted mixture, percent of total volume.
Effective Specific Gravity of the Aggregate (Stone) ($G_{se}$)

$$G_{se} = \frac{PP_s}{PP_{ma} \times G_{mb}}$$

Where:
- $G_{se}$ = effective specific gravity of combined aggregate (report to 0.001)
- $P_s$ = aggregate content, percent by total weight = 100 – $P_b$
- $G_{mm}$ = maximum specific gravity of mix (AASHTO T 209)
- $P_b$ = asphalt binder content (AASHTO T 308) percent by total weight
- $G_b$ = specific gravity of asphalt binder (JMF or asphalt binder supplier)

Percent of Absorbed (asphalt) Binder ($P_{ba}$)

$$PP_{na} = 100 \left( \frac{G_{G_{st}} - G_{G_{mm}}}{G_{G_{mm}} \times G_{G_{bs}}} \right)$$

Where:
- $P_{ba}$ = absorbed asphalt binder (report to 0.01) percent of aggregate
- $G_{se}$ = effective specific gravity of combined aggregate
- $G_{sb}$ = bulk specific gravity of combined aggregate (AASHTO T 85 from Job Mix Formula)
- $G_b$ = specific gravity of asphalt binder (JMF or asphalt binder supplier)

Percent of Effective (asphalt) Binder ($P_{be}$)

$$PP_{ns} = P - PP_{maa} \times PP_{ss} \div 100$$

Where:
- $P_{be}$ = effective asphalt binder content (report to 0.01), percent by total weight
- $P_s$ = aggregate content, percent by total weight = 100 – $P_b$
- $P_b$ = asphalt binder content (AASHTO T 308) percent by total weight
- $P_{ba}$ = absorbed asphalt binder

Dust Proportion – DP (Dust to Effective (asphalt) Binder Ratio)

$$DDPP = \frac{PP_{#200}}{PP_{na}}$$

Where:
- DP = Dust Proportion, (dust-to-binder ratio) (report to 0.01)
- $P_{#200}$ = aggregate passing the #200 (75 µm) sieve, percent by mass of aggregate (AASHTO T 30)
- $P_{be}$ = effective asphalt binder content, percent by total weight
SAMPLING FRESHLY MIXED CONCRETE
FOP FOR WAQTC TM 2

Scope
This method covers procedures for obtaining representative samples of fresh concrete delivered to the project site. The method includes sampling from stationary, paving and truck mixers, and from agitating and non-agitating equipment used to transport central mixed concrete.

This method also covers the removal of large aggregate particles by wet sieving.

Sampling concrete may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices.

Warning—Fresh Hydraulic cementitious mixtures are caustic and may cause chemical burns to skin and tissue upon prolonged exposure.

Apparatus
- Wheelbarrow
- Cover for wheelbarrow (plastic, canvas, or burlap)
- Buckets
- Shovel
- Cleaning equipment, including scrub brush, rubber gloves, water
- Apparatus for wet sieving, including: a sieve(s), meeting the requirements of FOP for AASHTO T 27/T 11, minimum of 2 ft² (0.19 m²) of sieving area, conveniently arranged and supported so that the sieve can be shaken rapidly by hand.

Procedure
1. Use every precaution in order to obtain samples representative of the true nature and condition of the concrete being placed being careful not to obtain samples from the very first or very last portions of the batch. The size of the sample will be 1.5 times the volume of concrete required for the specified testing, but not less than 0.03 m³ (1 ft³).

2. Dampen the surface of the receptacle just before sampling, empty any excess water.

Note 1: Sampling should normally be performed as the concrete is delivered from the mixer to the conveying vehicle used to transport the concrete to the forms; however, specifications may require other points of sampling, such as at the discharge of a concrete pump.
3. Use one of the following methods to obtain the sample:

- **Sampling from stationary mixers**
  Obtain the sample after a minimum of $1/2 \text{ m}^3 (1/2 \text{ yd}^3)$ of concrete has been discharged. Perform sampling by passing a receptacle completely through the discharge stream, or by completely diverting the discharge into a sample container. Take care not to restrict the flow of concrete from the mixer, container, or transportation unit so as to cause segregation. These requirements apply to both tilting and nontilting mixers.

- **Sampling from paving mixers**
  Obtain the sample after the contents of the paving mixer have been discharged. Obtain material from at least five different locations in the pile and combine into one test sample. Avoid contamination with subgrade material or prolonged contact with absorptive subgrade. To preclude contamination or absorption by the subgrade, the concrete may be sampled by placing a shallow container on the subgrade and discharging the concrete across the container.

- **Sampling from revolving drum truck mixers or agitators**
  Obtain the sample after a minimum of $1/2 \text{ m}^3 (1/2 \text{ yd}^3)$ of concrete has been discharged. Obtain samples after all of the water has been added to the mixer. Do not obtain samples from the very first or last portions of the batch discharge. Perform sampling by repeatedly passing a receptacle through the entire discharge stream or by completely diverting the discharge into a sample container. Regulate the rate of discharge of the batch by the rate of revolution of the drum and not by the size of the gate opening.

- **Sampling from open-top truck mixers, agitators, non-agitating equipment or other types of open-top containers**
  Obtain the sample by whichever of the procedures described above is most applicable under the given conditions.

- **Sampling from pump or conveyor placement systems**
  Obtain sample after a minimum of $1/2 \text{ m}^3 (1/2 \text{ yd}^3)$ of concrete has been discharged. Obtain samples after all of the pump slurry has been eliminated. Perform sampling by repeatedly passing a receptacle through the entire discharge system or by completely diverting the discharge into a sample container. Do not lower the pump arm from the placement position to ground level for ease of sampling, as it may modify the air content of the concrete being sampled. Do not obtain samples from the very first or last portions of the batch discharge.

4. Transport samples to the place where fresh concrete tests are to be performed and specimens are to be molded. They shall then be combined and remixed with a shovel the minimum amount necessary to ensure uniformity. Protect the sample from direct sunlight, wind, rain, and sources of contamination.
5. Complete test for temperature and start tests for slump and air content within 5 minutes of obtaining the sample. Start molding specimens for strength tests within 15 minutes of obtaining the sample. Complete the test methods as expeditiously as possible.

**Wet Sieving**

When required due to oversize aggregate, the concrete sample shall be wet sieved, after transporting but prior to remixing, for slump testing, air content testing or molding test specimens, by the following:

1. Place the sieve designated by the test procedure over the dampened sample container.
2. Pass the concrete over the designated sieve. Do not overload the sieve (one particle thick).
3. Shake or vibrate the sieve until no more material passes the sieve. A horizontal back and forth motion is preferred.
4. Discard oversize material including all adherent mortar.
5. Repeat until sample of sufficient size is obtained. Mortar adhering to the wet-sieving equipment shall be included with the sample.
6. Using a shovel, remix the sample the minimum amount necessary to ensure uniformity.

*Note 2:* Wet sieving is not allowed for samples being used for density determinations according to the FOP for AASHTO T 121.

**Report**

- On forms approved by the agency
- Sample ID
- Date
- Time
- Location
- Quantity represented
PERFORMANCE EXAM CHECKLIST

SAMPLING FRESHLY MIXED CONCRETE
FOP FOR WAQTC TM 2

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Receptacle dampened and excess water removed?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Obtain a representative sample from drum mixer:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Concrete sampled after 1/2 m$^3$ (1/2 yd$^3$) discharged?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b) Receptacle passed through entire discharge stream or discharge stream completely diverted into sampling container?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Obtain a representative sample from a paving mixer:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Concrete sampled after all the concrete has been discharged?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b) Material obtained from at least 5 different locations in the pile?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c) Avoid contaminating the sample with sub-grade materials.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Obtain a representative sample from a pump:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Concrete sampled after 1/2 m$^3$ (1/2 yd$^3$) has been discharged?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b) All the pump slurry is out of the lines?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c) Receptacle passed through entire discharge stream or discharge stream completely diverted into sampling container?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d) Do not lower the pump arm from the placement position.</td>
<td></td>
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<tr>
<td>5. Samples transported to place of testing?</td>
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<tr>
<td>6. Sample(s) combined, or remixed, or both?</td>
<td></td>
<td></td>
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<tr>
<td>7. Sample protected?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Minimum size of sample used for strength tests 0.03 m$^3$ (1ft$^3$)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Completed temperature test within 5 minutes of obtaining sample?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Start tests for slump and air within 5 minutes of obtaining sample?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Start molding cylinders within 15 minutes of obtaining sample?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Protect sample against rapid evaporation and contamination?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Wet Sieving:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Required sieve size determined for test method to be performed?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b) Concrete placed on sieve and doesn’t overload the sieve.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c) Sieve shaken until no more material passes the sieve.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d) Sieving continued until required testing size obtained.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

OVER
**Procedure Element**

e) Oversized aggregate discarded.

f) Sample remixed.

**Trial 1 Trial 2**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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</tbody>
</table>

**Comments:**

First attempt: Pass Fail  
Second attempt: Pass Fail

Examiner Signature_________________________ WAQTC #: __________________

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PERFORMANCE EXAM CHECKLIST (ORAL)

SAMPLING FRESHLY MIXED CONCRETE
FOP FOR WAQTC TM 2

Participant Name ___________________________ Exam Date ____________

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What is the minimum sample size? a) 0.03 m³ or 1 ft³</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Describe how to obtain a representative sample from a drum mixer. a) Dampen receptacle and empty excess water. b) Sample the concrete after 1/2 m³ (1/2 yd³) has been discharged. c) Pass receptacle through entire discharge stream or completely divert discharge stream into sampling container.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Describe how to obtain a representative sample from a paving mixer. a) Dampen receptacle and empty excess water. b) Sample the concrete after all the concrete has been discharged. c) Obtain the material from at least 5 different locations in the pile. d) Avoid contaminating the sample with sub-grade materials.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Describe how to obtain a representative sample from a pump: a) Dampen receptacle and empty excess water. b) Sample the concrete after 1/2 m³ (1/2 yd³) has been discharged. c) Make sure all the pump slurry is out of the lines. d) Pass receptacle through entire discharge stream or completely divert discharge stream into sampling container. e) Do not lower the pump arm from the placement position.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. After obtaining the sample or samples what must you do? a) Transport samples to place of testing.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. What must be done with the sample or samples once you have transported them to the place of testing? a) Combine and remix the sample. b) Protect sample against rapid evaporation and contamination.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. What are the two time parameters associated with this test? a) Complete temperature test and start tests for slump and air within 5 minutes of sample being obtained? b) Start molding cylinders within 15 minutes of sample being obtained?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. What test methods may require wet sieving? a) Slump, air content, and strength specimens?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

OVER
**Procedure Element**

9. The sieve size used for wet sieving is based on?
   a) The test method to be performed. __ __

10. How long must you continue wet sieving?
    a) Until a sample of sufficient size for the test being performed is obtained. __ __

11. What is done with the oversized aggregate?
    a) Discard it. __ __

12. What must be done to the sieved sample before testing?
    a) Remix. __ __

**Comments:** First attempt: Pass____Fail______ Second attempt: Pass____Fail______

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TEMPERATURE OF FRESHLY MIXED PORTLAND CEMENT CONCRETE FOP FOR AASHTO T 309

Scope
This procedure covers the determination of the temperature of freshly mixed Portland Cement Concrete in accordance with AASHTO T 309-15.

Warning—Fresh Hydraulic cementitious mixtures are caustic and may cause chemical burns to skin and tissue upon prolonged exposure.

Apparatus
- Container — The container shall be made of non-absorptive material and large enough to provide at least 75 mm (3 in.) of concrete in all directions around the sensor; concrete cover must also be at least three times the nominal maximum size of the coarse aggregate.

- Temperature measuring device — The temperature measuring device shall be calibrated and capable of measuring the temperature of the freshly mixed concrete to ±0.5°C (±1°F) throughout the temperature range likely to be encountered. Partial immersion liquid-in-glass thermometers (and possibly other types) shall have a permanent mark to which the device must be immersed without applying a correction factor.

- Reference temperature measuring device — The reference temperature measuring device shall be a thermometric device readable to 0.2°C (0.5°F) that has been verified and calibrated. The calibration certificate or report indicating conformance to the requirements of ASTM E 77 shall be available for inspection.

Calibration of Temperature Measuring Device
Each temperature measuring device shall be verified for accuracy annually and whenever there is a question of accuracy. Calibration shall be performed by comparing readings on the temperature measuring device with another calibrated instrument at two temperatures at least 15°C or 27°F apart.

Sample Locations and Times
The temperature of freshly mixed concrete may be measured in the transporting equipment, in forms, or in sample containers, provided the sensor of the temperature measuring device has at least 75 mm (3 in.) of concrete cover in all directions around it.

Complete the temperature measurement of the freshly mixed concrete within 5 minutes of obtaining the sample.

Concrete containing aggregate of a nominal maximum size greater than 75 mm (3 in.) may require up to 20 minutes for the transfer of heat from the aggregate to the mortar after batching.
Procedure
1. Dampen the sample container.
2. Obtain the sample in accordance with the FOP for WAQTC TM 2.
3. Place sensor of the temperature measuring device in the freshly mixed concrete so that it has at least 75 mm (3 in.) of concrete cover in all directions around it.
4. Gently press the concrete in around the sensor of the temperature measuring device at the surface of the concrete so that air cannot reach the sensor.
5. Leave the sensor of the temperature measuring device in the freshly mixed concrete for a minimum of two minutes, or until the temperature reading stabilizes.
6. Complete the temperature measurement of the freshly mixed concrete within 5 minutes of obtaining the sample.
7. Read and record the temperature to the nearest 0.5°C (1°F).

Report
- Results on forms approved by the agency
- Sample ID
- Measured temperature of the freshly mixed concrete to the nearest 0.5°C (1°F)
PERFORMANCE EXAM CHECKLIST

TEMPERATURE OF FRESHLY MIXED CONCRETE
FOP FOR AASHTO T 309

Participant Name_________________________ Exam Date ____________

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Obtain sample of concrete large enough to provide a minimum of 75 mm (3 in.) of</td>
<td>___</td>
<td>___</td>
</tr>
<tr>
<td>concrete cover around sensor in all directions?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Place temperature measuring device in sample with a minimum of 75 mm (3 in.)</td>
<td>___</td>
<td>___</td>
</tr>
<tr>
<td>cover around sensor?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Read temperature after a minimum of 2 minutes or when temperature reading</td>
<td>___</td>
<td>___</td>
</tr>
<tr>
<td>stabilizes?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Complete temperature measurement within 5 minutes of obtaining sample?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Record temperature to nearest 0.5°C (1°F)?</td>
<td>___</td>
<td>___</td>
</tr>
</tbody>
</table>

Comments: First attempt: Pass____Fail______ Second attempt: Pass____Fail______

Examiner Signature_________________________ WAQTC #:________________

This checklist is derived, in part, from copyrighted material printed in ACI CP-1, published by the American Concrete Institute.
SLUMP OF HYDRAULIC CEMENT CONCRETE
FOP FOR AASHTO T 119

Scope
This procedure provides instructions for determining the slump of hydraulic cement concrete in accordance with AASHTO T 119-13. It is not applicable to non-plastic and non-cohesive concrete.

Warning—Fresh Hydraulic cementitious mixtures are caustic and may cause chemical burns to skin and tissue upon prolonged exposure.

Apparatus
- Mold: A metal frustum of a cone provided with foot pieces and handles. The mold must be constructed without a seam. The interior of the mold shall be relatively smooth and free from projections such as protruding rivets. The mold shall be free from dents. A mold that clamps to a rigid nonabsorbent base plate is acceptable provided the clamping arrangement is such that it can be fully released without movement of the mold.
- Mold: If other than metal, it must conform to AASHTO T 119, Sections 5.1.2.1 and 5.1.2.2.
- Tamping rod: 16 mm (5/8 in.) diameter and 400 mm (16 in.) to 600 mm (24 in.) long, having a hemispherical tip the same diameter as the rod. (Hemispherical means “half a sphere”; the tip is rounded like half of a ball.)
- Scoop: a receptacle of appropriate size so that each representative increment of the concrete sample can be placed in the container without spillage.
- Tape measure or ruler with at least 5 mm or 1/8 in. graduations
- Base: Flat, rigid, non-absorbent moistened surface on which to set the slump mold

Procedure
1. Obtain the sample in accordance with the FOP for WAQTC TM 2. If the concrete mixture contains aggregate retained on the 37.5mm (1½ in.) sieve, the aggregate must be removed in accordance with the Wet Sieving portion of the FOP for WAQTC TM 2.
   *Note 1:* Testing shall begin within five minutes of obtaining the sample.
2. Dampen the inside of the mold and place it on a dampened, rigid, nonabsorbent surface that is level and firm.
3. Stand on both foot pieces in order to hold the mold firmly in place.
4. Use the scoop to fill the mold 1/3 full by volume, to a depth of approximately 67 mm (2 5/8 in.) by depth.
5. Consolidate the layer with 25 strokes of the tamping rod, using the rounded end. Distribute the strokes evenly over the entire cross section of the concrete. For this bottom layer, incline the rod slightly and make approximately half the strokes near the perimeter, and then progress with vertical strokes, spiraling toward the center.

6. Use the scoop to fill the mold 2/3 full by volume, to a depth of approximately 155 mm (6 1/8 in.) by depth.

7. Consolidate this layer with 25 strokes of the tamping rod, penetrate approximately 25 mm (1 in.) into the bottom layer. Distribute the strokes evenly.

8. Use the scoop to fill the mold to overflowing.

9. Consolidate this layer with 25 strokes of the tamping rod, penetrate approximately 25 mm (1 in.) into the second layer. Distribute the strokes evenly. If the concrete falls below the top of the mold, stop, add more concrete, and continue rodding for a total of 25 strokes. Keep an excess of concrete above the top of the mold at all times. Distribute strokes evenly as before.

10. Strike off the top surface of concrete with a screeding and rolling motion of the tamping rod.

11. Clean overflow concrete away from the base of the mold.

12. Remove the mold from the concrete by raising it carefully in a vertical direction. Raise the mold 300 mm (12 in.) in 5 ±2 seconds by a steady upward lift with no lateral or torsional (twisting) motion being imparted to the concrete.

   The entire operation from the start of the filling through removal of the mold shall be carried out without interruption and shall be completed within an elapsed time of 2 1/2 minutes. Immediately measure the slump.

13. Invert the slump mold and set it next to the specimen.

14. Lay the tamping rod across the mold so that it is over the test specimen.

15. Measure the distance between the bottom of the rod and the displaced original center of the top of the specimen to the nearest 5 mm (1/4 in.).

   Note 2: If a decided falling away or shearing off of concrete from one side or portion of the mass occurs, disregard the test and make a new test on another portion of the sample. If two consecutive tests on a sample of concrete show a falling away or shearing off of a portion of the concrete from the mass of the specimen, the concrete probably lacks the plasticity and cohesiveness necessary for the slump test to be applicable.

16. Discard the tested sample.

**Report**

- Results on forms approved by the agency
- Sample ID
- Slump to the nearest 5 mm (1/4 in.).
PERFORMANCE EXAM CHECKLIST

SLUMP OF HYDRAULIC CEMENT CONCRETE
FOP FOR AASHTO T 119

Participant Name_________________________ Exam Date _______________

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>First layer</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Mold and floor or base plate dampened?</td>
<td></td>
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</tr>
<tr>
<td>2. Mold held firmly against the base by standing on the two foot pieces? Mold not allowed to move in any way during filling?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Representative sample scooped into the mold, moving a scoop around the perimeter of the mold to evenly distribute the concrete as discharged?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Mold approximately one third (by volume), 67 mm (2 5/8 in.) deep?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Layer rodded throughout its depth 25 times with hemispherical end of rod, uniformly distributing strokes?</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Second layer</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Representative samples scooped into the mold, moving a scoop around the perimeter of the mold to evenly distribute the concrete as discharged?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Mold filled approximately two thirds (by volume), 155 mm (6 1/8 in.), deep?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Layer rodded throughout its depth 25 times with hemispherical end of rod, uniformly distributing strokes, penetrate approximately 25 mm (1 in.) into the bottom layer?</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Third layer</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Representative sample scooped into the mold, moving a scoop around the perimeter of the mold to evenly distribute the concrete as discharged??</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Mold filled to just over the top of the mold?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Layer rodded throughout its depth 25 times with hemispherical end of rod, uniformly distributing strokes, penetrate approximately 25 mm (1 in.) into the second layer?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Excess concrete kept above the mold at all times while rodding?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Concrete struck off level with top of mold using tamping rod?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

OVER
**Procedure Element**

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>14. Concrete removed from around the outside bottom of the mold?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. Mold lifted upward 300 mm (12 in.) in one smooth motion, without a lateral or twisting motion of the mold, in 5 ±2 seconds?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16. Test performed from start of filling through removal of the mold within 2 1/2 minutes?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17. Slump immediately measured to the nearest 5 mm (1/4 in.) from the top of the mold to the displaced original center of the top surface of the specimen?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Comments:**

First attempt: Pass_____ Fail_____ Second attempt: Pass_____ Fail_____

---

Examiner Signature_________________________ WAQTC #:_________________

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CONCRETE  WAQTC / IDAHO  FOP AASHTO T 121 (17)

DENSITY (UNIT WEIGHT), YIELD, AND AIR CONTENT (GRAVIMETRIC) OF CONCRETE
FOP FOR AASHTO T 121

Scope

This procedure covers the determination of density, or unit weight, of freshly mixed concrete in accordance with AASHTO T 121-17. It also provides formulas for calculating the volume of concrete produced from a mixture of known quantities of component materials, and provides a method for calculating cement content and cementitious material content – the mass of cement or cementitious material per unit volume of concrete. A procedure for calculating water/cement ratio is also covered.

Warning—Fresh Hydraulic cementitious mixtures are caustic and may cause chemical burns to skin and tissue upon prolonged exposure.

Apparatus

- Measure: May be the bowl portion of the air meter used for determining air content under the FOP for AASHTO T 152. Otherwise, it shall be a metal cylindrical container meeting the requirements of AASHTO T 121. The capacity and dimensions of the measure shall conform to those specified in Table 1.

- Balance or scale: Accurate to within 45 g (0.1 lb) or 0.3 percent of the test load, whichever is greater, at any point within the range of use.

- Tamping rod: 16 mm (5/8 in.) diameter and 400 mm (16 in.) to 600 mm (24 in.) long, having a hemispherical tip the same diameter as the rod. (Hemispherical means “half a sphere”; the tip is rounded like half of a ball.)

- Vibrator: 7000 vibrations per minute, 19 to 38 mm (3/4 to 1 1/2 in.) in diameter, and the length of the shaft shall be at least 610 mm (24 in.).

- Scoop: a receptacle of appropriate size so that each representative increment of the concrete sample can be placed in the container without spillage.

- Strike-off plate: A flat rectangular metal plate at least 6 mm (1/4 in.) thick or a glass or acrylic plate at least 12 mm (1/2 in.) thick, with a length and width at least 50 mm (2 in.) greater than the diameter of the measure with which it is to be used. The edges of the plate shall be straight and smooth within tolerance of 1.5 mm (1/16 in.).

- Mallet: With a rubber or rawhide head having a mass of 0.57 ±0.23 kg (1.25 ±0.5 lb) for use with measures of 0.014 m³ (1/2 ft³) or less, or having a mass of 1.02 ±0.23 kg (2.25 ±0.5 lb) for use with measures of 0.028 m³ (1 ft³).
Table 1
Dimensions of Measures*

<table>
<thead>
<tr>
<th>Capacity m³ (ft³)</th>
<th>Inside Diameter mm (in.)</th>
<th>Inside Height mm (in.)</th>
<th>Minimum Thicknesses mm (in.)</th>
<th>Nominal Maximum Size of Coarse Aggregate*** mm (in.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0071</td>
<td>203 ±2.54</td>
<td>213 ±2.54</td>
<td>5.1</td>
<td>25</td>
</tr>
<tr>
<td>(1/4)**</td>
<td>(8.0 ±0.1)</td>
<td>(8.4 ±0.1)</td>
<td>(0.20)</td>
<td>(1)</td>
</tr>
<tr>
<td>0.0142</td>
<td>254 ±2.54</td>
<td>279 ±2.54</td>
<td>5.1</td>
<td>50</td>
</tr>
<tr>
<td>(1/2)</td>
<td>(10.0 ±0.1)</td>
<td>(11.0 ±0.1)</td>
<td>(0.20)</td>
<td>(2)</td>
</tr>
<tr>
<td>0.0283</td>
<td>356 ±2.54</td>
<td>284 ±2.54</td>
<td>5.1</td>
<td>76</td>
</tr>
<tr>
<td>(1)</td>
<td>(14.0 ±0.1)</td>
<td>(11.2 ±0.1)</td>
<td>(0.20)</td>
<td>(3)</td>
</tr>
</tbody>
</table>

* Note: The indicated size of measure shall be for aggregates of nominal maximum size equal to or smaller than that listed.

** Measure may be the base of the air meter used in the FOP for AASHTO T 152.

*** Nominal maximum size: One sieve larger than the first sieve to retain more than 10 percent of the material using an agency specified set of sieves based on cumulative percent retained. Where large gaps in specification sieves exist, intermediate sieve(s) may be inserted to determine nominal maximum size.

Procedure Selection

There are two methods of consolidating the concrete – rodding and vibration. If the slump is greater than 75 mm (3 in.), consolidation is by rodding. When the slump is 25 to 75 mm (1 to 3 in.), internal vibration or rodding can be used to consolidate the sample, but the method used must be that required by the agency in order to obtain consistent, comparable results. For concrete with slump less than 25 mm (1 in.), consolidate the sample by internal vibration. Do not consolidate self-consolidating concrete (SCC).

When using measures greater than 0.0142 m³ (1/2 ft³) see AASHTO T 121.

Procedure – Rodding

1. Obtain the sample in accordance with the FOP for WAQTC TM 2. Testing may be performed in conjunction with the FOP for AASHTO T 152. When doing so, this FOP should be performed prior to the FOP for AASHTO T 152.
   
   Note 1: If the two tests are being performed using the same sample, this test shall begin within five minutes of obtaining the sample.

2. Determine the mass of the dry empty measure.

3. Dampen the inside of the measure.

4. Use the scoop to fill the measure approximately 1/3 full with concrete. Evenly distribute the concrete in a circular motion around the inner perimeter of the measure.
5. Consolidate the layer with 25 strokes of the tamping rod, using the rounded end. Distribute the strokes evenly over the entire cross section of the concrete. Rod throughout its depth without hitting the bottom too hard.

6. Tap around the perimeter of the measure smartly 10 to 15 times with the mallet to close voids and release trapped air.

7. Add the second layer, filling the measure about 2/3 full. Evenly distribute the concrete in a circular motion around the inner perimeter of the measure.

8. Consolidate this layer with 25 strokes of the tamping rod, penetrating about 25 mm (1 in.) into the bottom layer.

9. Tap around the perimeter of the measure smartly 10 to 15 times with the mallet.

10. Add the final layer, slightly overfilling the measure. Evenly distribute the concrete in a circular motion around the inner perimeter of the measure.

11. Consolidate this layer with 25 strokes of the tamping rod, penetrating about 25 mm (1 in.) into the second layer.

12. Tap around the perimeter of the measure smartly 10 to 15 times with the mallet.

   **Note 2:** The measure should be slightly over full, about 3 mm (1/8 in.) above the rim. If there is a great excess of concrete, remove a portion with the scoop. If the measure is under full, add a small quantity. This adjustment may be done only after consolidating the final layer and before striking off the surface of the concrete.

13. Strike off by pressing the strike-off plate flat against the top surface, covering approximately 2/3 of the measure. Withdraw the strike-off plate with a sawing motion to finish the 2/3 originally covered. Cover the original 2/3 again with the plate; finishing the remaining 1/3 with a sawing motion (do not lift the plate; continue the sawing motion until the plate has cleared the surface of the measure). Final finishing may be accomplished with several strokes with the inclined edge of the strike-off plate. The surface should be smooth and free of voids.

14. Clean off all excess concrete from the exterior of the measure including the rim.

15. Determine and record the mass of the measure and the concrete.

16. If the air content of the concrete is to be determined, proceed to Rodding Procedure Step 13 of the FOP for AASHTO T 152.
Procedure - Internal Vibration

1. Perform Steps 1 through 3 of the rodding procedure.

2. Use the scoop to fill the measure approximately 1/2 full with concrete. Evenly distribute the concrete in a circular motion around the inner perimeter of the measure.

3. Insert the vibrator at three different points in each layer. Do not let the vibrator touch the bottom or side of the measure.

   Note 3: Remove the vibrator slowly, so that no air pockets are left in the material.

   Note 4: Continue vibration only long enough to achieve proper consolidation of the concrete. Over vibration may cause segregation and loss of appreciable quantities of intentionally entrained air.

4. Slightly overfill the measure. Evenly distribute the concrete in a circular motion around the inner perimeter of the measure.

5. Insert the vibrator as in Step 3. Do not let the vibrator touch the side of the measure, but do penetrate the first layer approximately 25 mm (1 in.).

6. Return to Step 13 of the rodding procedure and continue.

Procedure – Self Consolidating Concrete

1. Perform Steps 1 through 3 of the rodding procedure.

2. Use the scoop to slightly overfill the measure. Evenly distribute the concrete in a circular motion around the inner perimeter of the measure.

3. Complete steps 13 thru 16 of the rodding procedure.

Calculations

Density

\[
DD = \frac{MM_{mm}}{VV_{mm}}
\]

Where:

\( D \) = density of the concrete mix

\( M_m \) = mass of concrete in measure

\( V_m \) = volume of measure (Annex A)
Yield m$^3$

\[ Y_{m^3} = \frac{WW}{D} \]

Where:

\[ Y_{m^3} \quad = \quad \text{yield (m}^3\text{ of the batch of concrete)} \]
\[ W \quad = \quad \text{total mass of the batch of concrete} \]

Yield yd$^3$

\[ Y_{yd^3} = \frac{WW}{D} \quad \quad \quad \quad \quad \quad \quad \quad Y_{yd^3} = \frac{Y_{yd^3}}{27} \]

Where:

\[ Y_{ft^3} \quad = \quad \text{yield (ft}^3\text{ of the batch of concrete)} \]
\[ Y_{yd^3} \quad = \quad \text{yield (yd}^3\text{ of the batch of concrete)} \]

Note 5: The total mass, W, includes the masses of the cement, water, and aggregates in the concrete.

Cement Content

\[ N_N = \frac{N_{ft^3}}{Y_{yd^3}} \]

Where:

\[ N \quad = \quad \text{actual cementitious material content per Y}_{m^3} \text{ or Y}_{yd^3} \]
\[ N_t \quad = \quad \text{mass of cementitious material in the batch} \]
\[ Y \quad = \quad Y_{m^3} \text{ or Y}_{yd^3} \]

Note 6: Specifications may require Portland Cement content and supplementary cementitious materials content.
Water Content

The mass of water in a batch of concrete is the sum of:

- water added at batch plant
- water added in transit
- water added at jobsite
- free water on coarse aggregate*
- free water on fine aggregate*
- liquid admixtures (if required by the agency)

This information is obtained from concrete batch tickets collected from the driver. Use the Table 2 to convert liquid measures.

### Table 2

<table>
<thead>
<tr>
<th>To Convert From</th>
<th>To</th>
<th>Multiply By</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liters, L</td>
<td>Kilograms, kg</td>
<td>1.0</td>
</tr>
<tr>
<td>Gallons, gal</td>
<td>Kilograms, kg</td>
<td>3.785</td>
</tr>
<tr>
<td>Gallons, gal</td>
<td>Pounds, lb</td>
<td>8.34</td>
</tr>
<tr>
<td>Milliliters, mL</td>
<td>Kilograms, kg</td>
<td>0.001</td>
</tr>
<tr>
<td>Ounces, oz</td>
<td>Milliliters, mL</td>
<td>28.4</td>
</tr>
<tr>
<td>Ounces, oz</td>
<td>Kilograms, kg</td>
<td>0.0284</td>
</tr>
<tr>
<td>Ounces, oz</td>
<td>Pounds, lb</td>
<td>0.0625</td>
</tr>
<tr>
<td>Pounds, lb</td>
<td>Kilograms, kg</td>
<td>0.4536</td>
</tr>
</tbody>
</table>
*Mass of free water on aggregate*

\[
\frac{C}{C} = \frac{C}{oFF} FFC CCAAAAFFFAA WW fff FFF
\]

\[
1 + (FFF WWWW FFPPPP PPP FFAFF \times 100)
\]

Where:

- Free Water Mass = on coarse or fine aggregate
- FC or CA Aggregate = mass of coarse or fine aggregate
- Free Water Percentage = percent of moisture of coarse or fine aggregate

**Water/Cement Ratio**

\[
WWW fff FFC CaaPP \times FFPP\times FFF
\]

Where:

- Water Content = sum mass of water in the batch
- \(C\) = sum mass of cementitious materials

**Example**

Mass of concrete in measure \((M_m)\) 16.290 kg (36.06 lb)

Volume of measure \((V_m)\) 0.007079 m³ (0.2494 ft³)

From batch ticket:

- Yards batched 4 yd³
- Cement 950 kg (2094 lb)
- Fly ash 180 kg (397 lb)
- Coarse aggregate 3313 kg (7305 lb)
- Fine aggregate 2339 kg (5156 lb)
- Water added at plant 295 L (78 gal)
Other

Water added in transit 0
Water added at jobsite 38 L (10 gal)
Total mass of the batch of concrete (W) 7115 kg (15,686 lb)
Moisture content of coarse aggregate 1.7%
Moisture content of coarse aggregate 5.9%

Density

\[
DD = \frac{MM_m}{V_m}
\]

\[
DD = \frac{16.920 \text{ kg AA}}{0.007079 \text{ m}^3} = 2390 \frac{\text{ kg AA}}{\text{ m}^3}
\]

\[
DD = \frac{36.06 \text{ lb ft}^3}{0.2494 \text{ ft}^3} = 144.6 \frac{\text{ lb ft}^3}{\text{ ft}^3}
\]

Given:

\[
M_m = 16.920 \text{ kg (36.06 lb)}
\]

\[
V_m = 0.007079 \text{ m}^3 (0.2494 \text{ ft}^3) \text{ (Annex A)}
\]

Yield m³

\[
\frac{WW}{D}
\]

\[
\frac{7115 \text{ kg AA}}{2390 \frac{\text{ kg AA}}{\text{ m}^3}} = 2.98 \text{ m}^3
\]

Given:

Total mass of the batch of concrete (W), kg = 7115 kg


Yield \( \text{yd}^3 \)

\[
\begin{align*}
\gamma_{\text{yd}^3} & = \frac{W}{D} \\
\gamma_{\text{yd}^3} & = \frac{W_{\text{fly}}} {27 Y_{\text{yd}^3}^3}
\end{align*}
\]

\[
\begin{align*}
\gamma_{\text{yd}^3} & = \frac{15,686 \text{ lll}} {144.6 \text{ lll/}\text{yd}^3} = 108.48 \text{ lll/}\text{yd}^3 \\
\gamma_{\text{yd}^3} & = \frac{108.48 \text{ lll}^3} {27 \text{ lll}^3 / \text{yd}^3} = 4.02 \text{ yd}^3
\end{align*}
\]

**Given:**

Total mass of the batch of concrete (W), lb = 15,686 lb

**Cement Content**

\[
N = \frac{N_{\text{fly}}} {\gamma_{\text{yd}^3}}
\]

\[
N = \frac{950 \text{ kg} + 180 \text{ kg}^3} {2.98 \text{ m}^3} = 379 \text{ kg/m}^3
\]

\[
N = \frac{2094 \text{ lll} + 397 \text{ lll}^3} {4.02 \text{ yd}^3} = 620 \text{ lll/}\text{yd}^3
\]

**Given:**

\[
\begin{align*}
N_t \text{ (cement)} & = 950 \text{ kg (2094 lb)} \\
N_t \text{ (flyash)} & = 180 \text{ kg (397 lb)} \\
Y & = Y_m \text{ or } Y_{\text{yd}}
\end{align*}
\]

*Note 6: Specifications may require Portland Cement content and supplementary cementitious materials content.*
Free water

\[
\begin{align*}
\text{Free water} & \quad = \frac{\text{CA aggregate}}{1 + (\text{CA moisture content} / 100)} \\
& = \frac{3313 \text{ kg}}{1 + (1.7/100)} = 55 \text{ kg} \\
& = \frac{7305 \text{ lb}}{1 + (1.7/100)} = 122 \text{ lb} \\
& = \frac{2339 \text{ kg}}{1 + (5.9/100)} = 130 \text{ kg} \\
& = \frac{5156 \text{ lb}}{1 + (5.9/100)} = 287 \text{ lb}
\end{align*}
\]

Given:

- CA aggregate = 3313 kg (7305 lb)
- FC aggregate = 2339 kg (5156 lb)
- CA moisture content = 1.7%
- FC moisture content = 5.9%
Water Content

Sum of all water in the mix.

\[ W_W = (78 \text{ AWWu} + 10 \text{ AWWu}) \times 3.785 \frac{kkAA}{AWWu} + 55 \text{ kkAA} + 130 \text{ kkAA} = 518 \text{ kkAA} \]

\[ W_W = (78 \text{ AWWu} + 10 \text{ AWWu}) \times 8.34 \frac{llll}{AWWu} + 130 lll + 287 lll = 1151 lll \]

Given:

- Water added at plant = 295 L (78 gal)
- Water added at the jobsite = 38 L (10 gal)

Water/Cement Ratio

\[ WW/CC = \frac{518 \text{ kkAA}}{950 \text{ kkAA} + 180 \text{ kkAA}} = 0.458 \]

\[ WW/CC = \frac{1151 llll}{2094 llll + 397 ll} = 0.462 \]

Report 0.46

Report

- Results on forms approved by the agency
- Sample ID
- Density (unit weight) to 1 kg/m\(^3\) (0.1 lb/ft\(^3\))
- Yield to 0.01 m\(^3\) (0.01 yd\(^3\))
- Cement content to 1 kg/m\(^3\) (1 lb/yd\(^3\))
- Cementitious material content to 1 kg/m\(^3\) (1 lb/yd\(^3\))
- Water/Cement ratio to 0.01
ANNEX A

STANDARDIZATION OF MEASURE

Standardization is a critical step to ensure accurate test results when using this apparatus. Failure to perform the standardization procedures as described herein will produce inaccurate or unreliable test results.

Apparatus

- Listed in the FOP for AASHTO T 121
  - Measure
  - Balance or scale
  - Strike-off plate

- Thermometer: Standardized liquid-in-glass, or electronic digital total immersion type, accurate to 0.5°C (1°F)

Procedure

1. Determine the mass of the dry measure and strike-off plate.
2. Fill the measure with water at a temperature between 16°C and 29°C (60°F and 85°F) and cover with the strike-off plate in such a way as to eliminate bubbles and excess water.
3. Wipe the outside of the measure and cover plate dry, being careful not to lose any water from the measure.
4. Determine the mass of the measure, strike-off plate, and water in the measure.
5. Determine the mass of the water in the measure by subtracting the mass in Step 1 from the mass in Step 4.
6. Measure the temperature of the water and determine its density from Table A1, interpolating as necessary.
7. Calculate the volume of the measure, $V_m$, by dividing the mass of the water in the measure by the density of the water at the measured temperature.
Calculations

\[ V_m = \frac{MM}{DD} \]

Where:

- \( V_m \) = volume of the mold
- \( M \) = mass of water in the mold
- \( D \) = density of water at the measured temperature

Example

Mass of water in Measure = 7.062 kg (15.53 lb)

Density of water at 23°C (73.4°F) = 997.54 kg/m³ (62.274 lb/ft³)

\[ V_m = \frac{7.062 \text{ kg} \times 1 \text{ m}^3}{997.54 \text{ kg/m}^3} = 0.007079 \text{ m}^3 \]

\[ M_m = \frac{15.53 \text{ lb}}{62.274 \text{ lb/ft}^3} = 0.2494 \text{ ft}^3 \]

Table A1
Unit Mass of Water
15°C to 30°C

<table>
<thead>
<tr>
<th>°C</th>
<th>(°F)</th>
<th>kg/m³</th>
<th>(lb/ft³)</th>
<th>°C</th>
<th>(°F)</th>
<th>kg/m³</th>
<th>(lb/ft³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>(59.0)</td>
<td>999.10</td>
<td>(62.372)</td>
<td>23</td>
<td>(73.4)</td>
<td>997.54</td>
<td>(62.274)</td>
</tr>
<tr>
<td>15.6</td>
<td>(60.0)</td>
<td>999.01</td>
<td>(62.366)</td>
<td>23.9</td>
<td>(75.0)</td>
<td>997.32</td>
<td>(62.261)</td>
</tr>
<tr>
<td>16</td>
<td>(60.8)</td>
<td>998.94</td>
<td>(62.361)</td>
<td>24</td>
<td>(75.2)</td>
<td>997.29</td>
<td>(62.259)</td>
</tr>
<tr>
<td>17</td>
<td>(62.6)</td>
<td>998.77</td>
<td>(62.350)</td>
<td>25</td>
<td>(77.0)</td>
<td>997.03</td>
<td>(62.243)</td>
</tr>
<tr>
<td>18</td>
<td>(64.4)</td>
<td>998.60</td>
<td>(62.340)</td>
<td>26</td>
<td>(78.8)</td>
<td>996.77</td>
<td>(62.227)</td>
</tr>
<tr>
<td>18.3</td>
<td>(65.0)</td>
<td>998.54</td>
<td>(62.336)</td>
<td>26.7</td>
<td>(80.0)</td>
<td>996.59</td>
<td>(62.216)</td>
</tr>
<tr>
<td>19</td>
<td>(66.2)</td>
<td>998.40</td>
<td>(62.328)</td>
<td>27</td>
<td>(80.6)</td>
<td>996.50</td>
<td>(62.209)</td>
</tr>
<tr>
<td>20</td>
<td>(68.0)</td>
<td>998.20</td>
<td>(62.315)</td>
<td>28</td>
<td>(82.4)</td>
<td>996.23</td>
<td>(62.192)</td>
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<tr>
<td>21</td>
<td>(69.8)</td>
<td>997.99</td>
<td>(62.302)</td>
<td>29</td>
<td>(84.2)</td>
<td>995.95</td>
<td>(62.175)</td>
</tr>
<tr>
<td>21.1</td>
<td>(70.0)</td>
<td>997.97</td>
<td>(62.301)</td>
<td>29.4</td>
<td>(85.0)</td>
<td>995.83</td>
<td>(62.166)</td>
</tr>
<tr>
<td>22</td>
<td>(71.6)</td>
<td>997.77</td>
<td>(62.288)</td>
<td>30</td>
<td>(86.0)</td>
<td>995.65</td>
<td>(62.156)</td>
</tr>
</tbody>
</table>
Report

- Measure ID
- Date Standardized
- Temperature of the water
- Volume, $V_m$, of the measure
PERFORMANCE EXAM CHECKLIST

DENSITY (UNIT WEIGHT), YIELD, AND AIR CONTENT (GRAVIMETRIC) OF CONCRETE
FOP FOR AASHTO T 121

Participant Name __________________________ Exam Date _________________

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

**Procedure Element**

<table>
<thead>
<tr>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Mass and volume of empty measure determined?</td>
<td></td>
</tr>
</tbody>
</table>

**First Layer**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2. Dampened measure filled approximately one third full, moving a scoop around the perimeter of the measure to evenly distribute the concrete as discharged?</td>
<td></td>
</tr>
<tr>
<td>3. Layer rodded throughout its depth 25 times, without forcibly striking the bottom of the measure, with hemispherical end of rod, uniformly distributing strokes?</td>
<td></td>
</tr>
<tr>
<td>4. Perimeter of the measure tapped 10 to 15 times with the mallet after rodding?</td>
<td></td>
</tr>
</tbody>
</table>

**Second layer**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>5. Measure filled approximately two thirds full, moving a scoop around the perimeter of the measure to evenly distribute the concrete as discharged?</td>
<td></td>
</tr>
<tr>
<td>6. Layer rodded throughout its depth, just penetrating the previous layer (approximately 25 mm (1 in.) 25 times with hemispherical end of rod, uniformly distributing strokes?</td>
<td></td>
</tr>
<tr>
<td>7. Perimeter of the measure tapped 10 to 15 times with the mallet after rodding?</td>
<td></td>
</tr>
</tbody>
</table>

**Third layer**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>8. Measure slightly overfilled, moving a scoop around the perimeter of the measure to evenly distribute the concrete as discharged?</td>
<td></td>
</tr>
<tr>
<td>9. Layer rodded throughout its depth, just penetrating the previous layer (approximately 25 mm (1 in.) 25 times with hemispherical end of rod, uniformly distributing strokes?</td>
<td></td>
</tr>
<tr>
<td>10. Perimeter of the measure tapped 10 to 15 times with the mallet after rodding each layer?</td>
<td></td>
</tr>
<tr>
<td>11. Any excess concrete removed using a trowel or a scoop, or small quantity of concrete added to correct a deficiency, after consolidation of final layer?</td>
<td></td>
</tr>
</tbody>
</table>

**OVER**
<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>12. Strike-off plate placed flat on the measure covering approximately 2/3 of the surface, then sawing action used to withdraw the strike-off plate across the previously covered surface?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>13. Strike-off plate placed flat on the measure covering approximately 2/3 of the surface, then sawing action used to advance the plate across the entire measure surface?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>14. Strike off completed using the inclined edge of the plate creating a smooth surface?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>15. All excess concrete cleaned off and mass of full measure determined?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>16. Net mass calculated?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>17. Density calculated correctly?</td>
<td>______</td>
<td>______</td>
</tr>
</tbody>
</table>

**Comments:**

First attempt: Pass ______ Fail ______  
Second attempt: Pass ______ Fail ______

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AIR CONTENT OF FRESHLY MIXED CONCRETE BY THE PRESSURE METHOD
FOP for AASHTO T 152

Scope
This procedure covers determination of the air content in freshly mixed Portland Cement Concrete containing dense aggregates in accordance with AASHTO T 152-17, Type B meter. It is not for use with lightweight or highly porous aggregates. This procedure includes standardization of the Type B air meter gauge, Annex A.

Warning—Fresh Hydraulic cementitious mixtures are caustic and may cause chemical burns to skin and tissue upon prolonged exposure.

Apparatus
- Air meter: Type B, as described in AASHTO T 152
- Balance or scale: Accurate to 0.3 percent of the test load at any point within the range of use (for Method 1 standardization only)
- Tamping rod: 16 mm (5/8 in.) diameter and 400 mm (16 in.) to 600 mm (24 in.) long, having a hemispherical tip the same diameter as the rod. (Hemispherical means “half a sphere”; the tip is rounded like half of a ball.)
- Vibrator: 9000 vibrations per minute, 19 to 38 mm (0.75 to 1.50 in.) in diameter, at least 75 mm (3 in.) longer than the section being vibrated for use with low slump concrete
- Scoop: a receptacle of appropriate size so that each representative increment of the concrete sample can be placed in the container without spillage.
- Container for water: rubber syringe (may also be a squeeze bottle)
- Strike-off bar: Approximately 300 mm x 22 mm x 3 mm (12 in. x 3/4 in. x 1/8 in.)
- Strike-off plate: A flat rectangular metal plate at least 6 mm (1/4 in.) thick or a glass or acrylic plate at least 12 mm (1/2 in.) thick, with a length and width at least 50 mm (2 in.) greater than the diameter of the measure with which it is to be used. The edges of the plate shall be straight and smooth within tolerance of 1.5 mm (1/16 in.).
  
  Note 1: Use either the strike-off bar or strike-off plate; both are not required.
- Mallet: With a rubber or rawhide head having a mass of 0.57 ±0.23 kg (1.25 ±0.5 lb)
Procedure Selection

There are two methods of consolidating the concrete – rodding and vibration. If the slump is greater than 75 mm (3 in.), consolidation is by rodding. When the slump is 25 to 75 mm (1 to 3 in.), internal vibration or rodding can be used to consolidate the sample, but the method used must be that required by the agency in order to obtain consistent, comparable results. For concrete with slumps less than 25 mm (1 in.), consolidate the sample by internal vibration. Do not consolidate self-consolidating concrete (SCC).

Procedure – Rodding

1. Obtain the sample in accordance with the FOP for WAQTC TM 2. If the concrete mixture contains aggregate retained on the 37.5mm (1½ in.) sieve, the aggregate must be removed in accordance with the Wet Sieving portion of the FOP for WAQTC TM 2.

   Note 2: Testing shall begin within five minutes of obtaining the sample.

2. Dampen the inside of the air meter measure and place on a firm level surface.

3. Use the scoop to fill the measure approximately 1/3 full with concrete. Evenly distribute the concrete in a circular motion around the inner perimeter of the measure.

4. Consolidate the layer with 25 strokes of the tamping rod, using the rounded end. Distribute the strokes evenly over the entire cross section of the concrete. Rod throughout its depth without hitting the bottom too hard.

5. Tap around the perimeter of the measure smartly 10 to 15 times with the mallet to close voids and release trapped air.

6. Add the second layer, filling the measure about 2/3 full. Evenly distribute the concrete in a circular motion around the inner perimeter of the measure.

7. Consolidate this layer with 25 strokes of the tamping rod, penetrating about 25 mm (1 in.) into the bottom layer.

8. Tap around the perimeter of the measure smartly 10 to 15 times with the mallet.

9. Add the final layer, slightly overfilling the measure. Evenly distribute the concrete in a circular motion around the inner perimeter of the measure.

10. Consolidate this layer with 25 strokes of the tamping rod, penetrating about 25 mm (1 in.) into the second layer.

11. Tap around the perimeter of the measure smartly 10 to 15 times with the mallet.

   Note 3: The measure should be slightly over full, about 3 mm (1/8 in.) above the rim. If there is a great excess of concrete, remove a portion with the trowel or scoop. If the measure is under full, add a small quantity. This adjustment may be done only after consolidating the final layer and before striking off the surface of the concrete.

12. Strike off the surface of the concrete and finish it smoothly with a sawing action of the strike-off bar or plate, using great care to leave the measure just full. The surface should be smooth and free of voids.

13. Clean the top flange of the measure to ensure a proper seal.
14. Moisten the inside of the cover and check to see that both petcocks are open and the main air valve is closed.

15. Clamp the cover on the measure.

16. Inject water through a petcock on the cover until water emerges from the petcock on the other side.

17. Incline slightly and gently rock the air meter until no air bubbles appear to be coming out of the second petcock. The petcock expelling water should be higher than the petcock where water is being injected. Return the air meter to a level position and verify that water is present in both petcocks.

18. Close the air bleeder valve and pump air into the air chamber until the needle goes past the initial pressure determined for the gauge. Allow a few seconds for the compressed air to cool.

19. Tap the gauge gently with one hand while slowly opening the air bleeder valve until the needle rests on the initial pressure. Close the air bleeder valve.

20. Close both petcocks.

21. Open the main air valve.

22. Tap around the perimeter of the measure smartly with the mallet.

23. With the main air valve open, lightly tap the gauge to settle the needle, and then read the air content to the nearest 0.1 percent.

24. Release or close the main air valve.

25. Open both petcocks to release pressure, remove the concrete, and thoroughly clean the cover and measure with clean water.

26. Open the main air valve to relieve the pressure in the air chamber.

**Procedure - Internal Vibration**

1. Obtain the sample in accordance with the FOP for WAQTC TM 2. If any aggregate 37.5mm (1½ in.) or larger is present, aggregate must be removed in accordance with the Wet Sieving portion of the FOP for WAQTC TM 2.

2. Dampen the inside of the air meter measure and place on a firm level surface.

3. Use the scoop to fill the measure approximately 1/2 full with concrete. Evenly distribute the concrete in a circular motion around the inner perimeter of the measure.

4. Insert the vibrator at three different points. Do not let the vibrator touch the bottom or side of the measure. Remove the vibrator slowly, so that no air pockets are left in the material. Continue vibration only long enough to achieve proper consolidation of the concrete. Over vibration may cause segregation and loss of appreciable quantities of intentionally entrained air.

5. Use the scoop to fill the measure a bit over full. Evenly distribute the concrete in a circular motion around the inner perimeter of the measure.
6. Insert the vibrator as in Step 4. Do not let the vibrator touch the side of the measure, and penetrate the first layer approximately 25 mm (1 in.). Remove the vibrator slowly, so that no air pockets are left in the material. Continue vibration only long enough to achieve proper consolidation of the concrete. Over vibration may cause segregation and loss of appreciable quantities of intentionally entrained air.

7. Return to Step 12 of the rodding procedure and continue.

**Procedure – Self Consolidating Concrete**

1. Obtain the sample in accordance with the FOP for WAQTC TM 2.
2. Dampen the inside of the air meter measure and place on a firm level surface.
3. Use the scoop to slightly overfill the measure. Evenly distribute the concrete in a circular motion around the inner perimeter of the measure.

**Report**

- Results on forms approved by the agency
- Sample ID
- Percent of air to the nearest 0.1 percent.
- Some agencies require an aggregate correction factor in order to determine total percent of entrained air.

  Total % entrained air = Gauge reading – aggregate correction factor from mix design

(See AASHTO T 152 for more information.)
ANNEX A—STANDARDIZATION OF AIR METER GAUGE

Standardization is a critical step to ensure accurate test results when using this apparatus. Failure to perform the standardization procedures as described below will produce inaccurate or unreliable test results.

Standardization shall be performed at a minimum of once every three months. Record the date of the standardization, the standardization results, and the name of the technician performing the standardization in the log book kept with each air meter.

There are two methods for standardizing the air meter, mass or volume, both are covered below.

1. Screw the short piece of straight tubing into the threaded petcock hole on the underside of the cover.

2. Determine and record the mass of the dry, empty air meter measure and cover assembly (mass method only).

3. Fill the measure nearly full with water.

4. Clamp the cover on the measure with the tube extending down into the water. Mark the petcock with the tube attached for future reference.

5. Add water through the petcock having the pipe extension below until all air is forced out the other petcock. Rock the meter slightly until all air is expelled through the petcock.

6. Wipe off the air meter measure and cover assembly; determine and record the mass of the filled unit (mass method only).

7. Pump up the air pressure to a little beyond the predetermined initial pressure indicated on the gauge. Wait a few seconds for the compressed air to cool, and then stabilize the gauge hand at the proper initial pressure by pumping up or relieving pressure, as needed.

8. Close both petcocks and immediately open the main air valve exhausting air into the measure. Wait a few seconds until the meter needle stabilizes. The gauge should now read 0 percent. If two or more tests show a consistent variation from 0 percent in the result, change the initial pressure line to compensate for the variation, and use the newly established initial pressure line for subsequent tests.

9. Determine which petcock has the straight tube attached to it. Attach the curved tube to external portion of the same petcock.

10. Pump air into the air chamber. Open the petcock with the curved tube attached to it. Open the main air valve for short periods of time until 5 percent of water by mass or volume has been removed from the air meter. Remember to open both petcocks to release the pressure in the measure and drain the water in the curved tube back into the measure. To determine the mass of the water to be removed, subtract the mass found in Step 1 from the mass found in Step 5. Multiply this value by 0.05. This is the mass of the water that must be removed. To remove 5 percent by volume, remove water until the external standardization vessel is level full.
Note A1: Many air meters are supplied with a standardization vessel(s) of known volume that are used for this purpose. Standardization vessel must be protected from crushing or denting. If an external standardization vessel is used, confirm what percentage volume it represents for the air meter being used. Vessels commonly represent 5 percent volume, but they are for specific size meters. This should be confirmed by mass.

11. Remove the curved tube. Pump up the air pressure to a little beyond the predetermined initial pressure indicated on the gauge. Wait a few seconds for the compressed air to cool, and then stabilize the gauge hand at the proper initial pressure by pumping up or relieving pressure, as needed.

12. Close both petcocks and immediately open the main air valve exhausting air into the measure. Wait a few seconds until the meter needle is stabilized. The gauge should now read 5.0 ±0.1 percent. If the gauge is outside that range, the meter needs adjustment. The adjustment could involve adjusting the starting point so that the gauge reads 5.0 ±0.1 percent when this standardization is run, or could involve moving the gauge needle to read 5.0 percent. Any adjustment should comply with the manufacturer’s recommendations.

13. When the gauge hand reads correctly at 5.0 percent, additional water may be withdrawn in the same manner to check the results at other values such as 10 percent or 15 percent.

14. If an internal standardization vessel is used, follow steps 1 through 8 to set initial reading.

15. Release pressure from the measure and remove cover. Place the internal standardization vessel into the measure. This will displace 5 percent of the water in the measure. (See AASHTO T 152 for more information on internal standardization vessels.)

16. Place the cover back on the measure and add water through the petcock until all the air has been expelled.

17. Pump up the air pressure chamber to the initial pressure. Wait a few seconds for the compressed air to cool, and then stabilize the gauge hand at the proper initial pressure by pumping up or relieving pressure, as needed.

18. Close both petcocks and immediately open the main air valve exhausting air into the measure. Wait a few seconds until the meter needle stabilizes. The gauge should now read 5 percent.

19. Remove the extension tubing from threaded petcock hole in the underside of the cover before starting the test procedure.

Report

- Air Meter ID
- Date Standardized
- Initial Pressure (IP)
PERFORMANCE EXAM CHECKLIST

AIR CONTENT OF FRESHLY MIXED CONCRETE BY THE PRESSURE METHOD
FOP FOR AASHTO T 152

Participant Name ___________________________ Exam Date ____________

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Representative sample selected?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td><strong>First Layer</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Dampered measure filled approximately one third full, moving a scoop around the perimeter of the measure to evenly distribute the concrete as discharged?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>3. Layer rodded throughout its depth 25 times, without forcibly striking the bottom of the measure, with hemispherical end of rod, uniformly distributing strokes?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>4. Perimeter of the measure tapped 10 to 15 times with the mallet after rodding?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td><strong>Second layer</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Measure filled approximately two thirds full, moving a scoop around the perimeter of the measure to evenly distribute the concrete as discharged?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>6. Layer rodded throughout its depth, just penetrating the previous layer (approximately 25 mm (1 in.)) 25 times with hemispherical end of rod, uniformly distributing strokes?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>7. Perimeter of the measure tapped 10 to 15 times with the mallet after rodding?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td><strong>Third layer</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Measure slightly overfilled, moving a scoop around the perimeter of the measure to evenly distribute the concrete as discharged?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>9. Layer rodded throughout its depth, just penetrating the previous layer (approximately 25 mm (1 in.)) 25 times with hemispherical end of rod, uniformly distributing strokes?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>10. Perimeter of the measure tapped 10 to 15 times with the mallet after rodding each layer?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>11. Concrete struck off level with top of the measure using the bar or strike-off plate and rim cleaned off?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>12. Top flange of base cleaned?</td>
<td>______</td>
<td>______</td>
</tr>
</tbody>
</table>

OVER
**Procedure Element**

**Using a Type B Meter:**

13. Both petcocks open?  

14. Air valve closed between air chamber and the measure?  

15. Inside of cover cleaned and moistened before clamping to base?  

16. Water injected through petcock until it flows out the other petcock?  

17. Water injection into the petcock continued while jarring and or rocking the meter to insure all air is expelled?  

18. Air pumped up to just past initial pressure line?  

19. A few seconds allowed for the compressed air to stabilize?  

20. Gauge adjusted to the initial pressure?  

21. Both petcocks closed?  

22. Air valve opened between chamber and measure?  

23. The outside of measure tapped smartly with the mallet?  

24. With the main air valve open, gauge lightly tapped and air percentage read to the nearest 0.1 percent?  

25. Air valve released or closed and then petcocks opened to release pressure before removing the cover?  

26. Aggregate correction factor applied if required?  

27. Air content recorded to 0.1 percent?  

**Comments:**  
First attempt: Pass Fail  
Second attempt: Pass Fail  

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METHOD OF MAKING AND CURING CONCRETE TEST SPECIMENS IN THE FIELD
FOP FOR AASHTO T 23

Scope
This procedure covers the method for making, initially curing, and transporting concrete test specimens in the field in accordance with AASHTO T 23-17.

Warning—Fresh Hydraulic cementitious mixtures are caustic and may cause chemical burns to skin and tissue upon prolonged exposure.

Apparatus and Test Specimens

- Concrete cylinder molds: Conforming to AASHTO M 205 with a length equal to twice the diameter. Standard specimens shall be 150 mm (6 in.) by 300 mm (12 in.) cylinders. Mold diameter must be at least three times the maximum aggregate size unless wet sieving is conducted according to the FOP for WAQTC TM 2. Agency specifications may allow cylinder molds of 100 mm (4 in.) by 200 mm (8 in.) when the nominal maximum aggregate size does not exceed 25 mm (1 in.).

- Beam molds: Rectangular in shape with ends and sides at right angles to each other. Must be sufficiently rigid to resist warpage. Surfaces must be smooth. Molds shall produce length no more than 1.6 mm (1/16 in.) shorter than that required (greater length is allowed). Maximum variation from nominal cross section shall not exceed 3.2 mm (1/8 in.). Ratio of width to depth may not exceed 1:5; the smaller dimension must be at least 3 times the maximum aggregate size. Standard beam molds shall result in specimens having width and depth of not less than 150 mm (6 in.). Agency specifications may allow beam molds of 100 mm (4 in.) by 100 mm (4 in.) when the nominal maximum aggregate size does not exceed 38 mm (1.5 in.). Specimens shall be cast and hardened with the long axes horizontal.

- Standard tamping rod: 16 mm (5/8 in.) in diameter and 400 mm (16 in.) to 600 mm (24 in.) long, having a hemispherical tip of the same diameter as the rod for preparing 150mm (6 in.) x 300 mm (12 in.) cylinders.

- Small tamping rod: 10 mm (3/8 in.) diameter and 305 mm (12 in.) to 600 mm (24 in.) long, having a hemispherical tip of the same diameter as the rod for preparing 100 mm (4 in.) x 200 mm (8 in.) cylinders.

- Vibrator: At least 9000 vibrations per minute, with a diameter no more than ¼ the diameter or width of the mold and at least 75 mm (3 in.) longer than the section being vibrated for use with low slump concrete.

- Scoop: a receptacle of appropriate size so that each representative increment of the concrete sample can be placed in the container without spillage.

  Trowel or float

- Mallet: With a rubber or rawhide head having a mass of 0.57 ±0.23 kg (1.25 ±0.5 lb.).
• Rigid base plates and cover plates: may be metal, glass, or plywood.

• Initial curing facilities: Temperature-controlled curing box or enclosure capable of maintaining the required range of 16 to 27°C (60 to 80°F) during the entire initial curing period (for concrete with compressive strength of 40 Mpa (6000 psi) or more, the temperature shall be 20 to 26°C (68 to 78°F). As an alternative, sand or earth for initial cylinder protection may be used provided that the required temperature range is maintained and the specimens are not damaged.

• Thermometer: Capable of registering both maximum and minimum temperatures during the initial cure.

Procedure – Making Specimens – General
1. Obtain the sample according to the FOP for WAQTC TM 2.
2. Wet Sieving per the FOP for WAQTC TM 2 is required for 150 mm (6 in.) diameter specimens containing aggregate with a nominal maximum size greater than 50 mm (2 in.); screen the sample over the 50 mm (2 in.) sieve.
3. Remix the sample after transporting to testing location.
4. Begin making specimens within 15 minutes of obtaining the sample.
5. Set molds upright on a level, rigid base in a location free from vibration and relatively close to where they will be stored.
6. Fill molds in the required number of layers, attempting to slightly overfill the mold on the final layer. Add or remove concrete prior to completion of consolidation to avoid a deficiency or excess of concrete.
7. There are two methods of consolidating the concrete – rodding and internal vibration. If the slump is greater than 25 mm (1 in.), consolidation may be by rodding or vibration. When the slump is 25 mm (1 in.) or less, consolidate the sample by internal vibration. Agency specifications may dictate when rodding or vibration will be used.

Procedure – Making Cylinders – Self Consolidating Concrete
1. Use the scoop to slightly overfill the mold. Evenly distribute the concrete in a circular motion around the inner perimeter of the mold.
2. Strike off the surface of the molds with tamping rod, straightedge, float, or trowel.
3. Immediately begin initial curing.

Procedure – Making Cylinders – Rodding
1. For the standard 150 mm (6 in.) by 300 mm (12 in.) specimen, fill each mold in three approximately equal layers, moving the scoop or trowel around the perimeter of the mold.
to evenly distribute the concrete. For the 100 mm (4 in.) by 200 mm (8 in.) specimen, fill the mold in two layers. When filling the final layer, slightly overfill the mold.

2. Consolidate each layer with 25 strokes of the appropriate tamping rod, using the rounded end. Distribute strokes evenly over the cross section of the concrete. Rod the first layer throughout its depth without forcibly hitting the bottom. For subsequent layers, rod the layer throughout its depth penetrating approximately 25 mm (1 in.) into the underlying layer.

3. After rodding each layer, tap the sides of each mold 10 to 15 times with the mallet (reusable steel molds) or lightly with the open hand (single-use light-gauge molds).

4. Strike off the surface of the molds with tamping rod, straightedge, float, or trowel.

5. Immediately begin initial curing.

**Procedure – Making Cylinders – Internal Vibration**

1. Fill the mold in two layers.

2. Insert the vibrator at the required number of different points for each layer (two points for 150 mm (6 in.) diameter cylinders; one point for 100 mm (4 in.) diameter cylinders). When vibrating the bottom layer, do not let the vibrator touch the bottom or sides of the mold. When vibrating the top layer, the vibrator shall penetrate into the underlying layer approximately 25 mm (1 in.)

3. Remove the vibrator slowly, so that no large air pockets are left in the material.

   **Note 1:** Continue vibration only long enough to achieve proper consolidation of the concrete. Over vibration may cause segregation and loss of appreciable quantities of intentionally entrained air.

4. After vibrating each layer, tap the sides of each mold 10 to 15 times with the mallet (reusable steel molds) or lightly with the open hand (single-use light-gauge molds).

5. Strike off the surface of the molds with tamping rod, straightedge, float, or trowel.

6. Immediately begin initial curing.

**Procedure – Making Flexural Beams – Rodding**

1. Fill the mold in two approximately equal layers with the second layer slightly overfilling the mold.

2. Consolidate each layer with the tamping rod once for every 1300 mm$^2$ (2 in$^2$) using the rounded end. Rod each layer throughout its depth, taking care to not forcibly strike the bottom of the mold when compacting the first layer. Rod the second layer throughout its depth, penetrating approximately 25 mm (1 in.) into the lower layer.

3. After rodding each layer, strike the mold 10 to 15 times with the mallet and spade along the sides and end using a trowel.

4. Strike off the surface of the molds with tamping rod, straightedge, float, or trowel.

5. Immediately begin initial curing.
Procedure – Making Flexural Beams – Vibration

1. Fill the mold to overflowing in one layer.
2. Consolidate the concrete by inserting the vibrator vertically along the centerline at intervals not exceeding 150 mm (6 in.). Take care to not over-vibrate, and withdraw the vibrator slowly to avoid large voids. Do not contact the bottom or sides of the mold with the vibrator.
3. After vibrating, strike the mold 10 to 15 times with the mallet.
4. Strike off the surface of the molds with tamping rod, straightedge, float, or trowel.
5. Immediately begin initial curing.

Procedure – Initial Curing

- When moving cylinder specimens made with single use molds support the bottom of the mold with trowel, hand, or other device.
- For initial curing of cylinders, there are two methods, use of which depends on the agency. In both methods, the curing place must be firm, within ¼ in. of a level surface, and free from vibrations or other disturbances.
- Maintain initial curing temperature of 16 to 27°C (60 to 80°F) or 20 to 26°C (68 to 78°F) for concrete with strength of 40 Mpa (6000 psi) or more.
- Prevent loss of moisture.

Method 1 – Initial cure in a temperature controlled chest-type curing box

1. Finish the cylinder using the tamping rod, straightedge, float, or trowel. The finished surface shall be flat with no projections or depressions greater than 3.2 mm (1/8 in.).
2. Place the mold in the curing box. When lifting light-gauge molds be careful to avoid distortion (support the bottom, avoid squeezing the sides).
3. Place the lid on the mold to prevent moisture loss.
4. Mark the necessary identification data on the cylinder mold and lid.

Method 2 – Initial cure by burying in earth or by using a curing box over the cylinder

Note 2: This procedure may not be the preferred method of initial curing due to problems in maintaining the required range of temperature.

1. Move the cylinder with excess concrete to the initial curing location.
2. Mark the necessary identification data on the cylinder mold and lid.
3. Place the cylinder on level sand or earth, or on a board, and pile sand or earth around the cylinder to within 50 mm (2 in.) of the top.

4. Finish the cylinder using the tamping rod, straightedge, float, or trowel. Use a sawing motion across the top of the mold. The finished surface shall be flat with no projections or depressions greater than 3.2 mm (1/8 in.).

5. If required by the agency, place a cover plate on top of the cylinder and leave it in place for the duration of the curing period, or place the lid on the mold to prevent moisture loss.

**Procedure – Transporting Specimens**

- Initially cure the specimens for 24 to 48 hours. Transport specimens to the laboratory for final cure. Specimen identity will be noted along with the date and time the specimen was made and the maximum and minimum temperatures registered during the initial cure.
- Protect specimens from jarring, extreme changes in temperature, freezing, or moisture loss during transport.
- Secure cylinders so that the axis is vertical.
- Do not exceed 4 hours transportation time.

**Final Curing**

- Upon receiving cylinders at the laboratory, remove the cylinder from the mold and apply the appropriate identification.
- For all specimens (cylinders or beams), final curing must be started within 30 minutes of mold removal. Temperature shall be maintained at 23° ±2°C (73 ±3°F). Free moisture must be present on the surfaces of the specimens during the entire curing period. Curing may be accomplished in a moist room or water tank conforming to AASHTO M 201.
- For cylinders, during the final 3 hours prior to testing the temperature requirement may be waived, but free moisture must be maintained on specimen surfaces at all times until tested.
- Final curing of beams must include immersion in lime-saturated water for at least 20 hours before testing.
Report

- On forms approved by the agency
- Pertinent placement information for identification of project, element(s) represented, etc.
- Sample ID
- Date and time molded.
- Test ages.
- Slump, air content, and density.
- Temperature (concrete, initial cure max. and min., and ambient).
- Method of initial curing.
- Other information as required by agency, such as: concrete supplier, truck number, invoice number, water added, etc.
PERFORMANCE EXAM CHECKLIST

MAKING AND CURING CONCRETE TEST SPECIMENS IN THE FIELD
FOP FOR AASHTO T 23 (4 X 8)

Participant Name__________________________  Exam Date ______________

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

Procedure Element                        Trial 1 Trial 2

1. Molds placed on a level, rigid, horizontal surface free of vibration?     _____ _____
2. Representative sample selected?                      _____ _____
3. Making of specimens begun within 15 minutes of sampling?   _____ _____

First layer

4. Concrete placed in the mold, moving a scoop or trowel around the perimeter of the mold to evenly distribute the concrete as discharged? _____ _____
5. Mold filled approximately half full?   _____ _____
6. Layer rodded throughout its depth 25 times with hemispherical end of rod, uniformly distributing strokes?       _____ _____
7. Sides of the mold tapped 10-15 times after rodding?
   a. With mallet for reusable steel molds       _____ _____
   b. With the open hand for flexible light-gauge molds       _____ _____

Second layer

8. Concrete placed in the mold, moving a scoop or trowel around the perimeter of the mold to evenly distribute the concrete as discharged?   _____ _____
9. Mold slightly overfilled on the last layer?        _____ _____
10. Layer rodded 25 times with hemispherical end of rod, uniformly distributing strokes and penetrating 25 mm (1 in.) into the underlying layer? _____ _____
11. Sides of the mold tapped 10-15 times after rodding each layer?
   a. With mallet for reusable steel molds       _____ _____
   b. With the open hand for flexible light-gauge molds       _____ _____
12. Concrete struck off with tamping rod, float or trowel?   _____ _____
13. Specimens covered with non-absorptive, non-reactive cap or plate?   _____ _____
14. Initial curing addressed?                       _____ _____

OVER
<table>
<thead>
<tr>
<th>Comments</th>
<th>First attempt: Pass</th>
<th>Fail</th>
<th>Second attempt: Pass</th>
<th>Fail</th>
</tr>
</thead>
</table>

Examiner Signature________________________ WAQTC #:________________

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PERFORMANCE EXAM CHECKLIST

MAKING AND CURING CONCRETE TEST SPECIMENS IN THE FIELD
FOP FOR AASHTO T 23 (6 X 12)

Participant Name_________________________ Exam Date ______________

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Molds placed on a level, rigid, horizontal surface free of vibration?</td>
<td>____</td>
<td>____</td>
</tr>
<tr>
<td>2. Representative sample selected?</td>
<td>____</td>
<td>____</td>
</tr>
<tr>
<td>3. Making of specimens begun within 15 minutes of sampling?</td>
<td>____</td>
<td>____</td>
</tr>
<tr>
<td><strong>First layer</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Concrete placed in the mold, moving a scoop or trowel around the perimeter of the mold to evenly distribute the concrete as discharged?</td>
<td>____</td>
<td>____</td>
</tr>
<tr>
<td>5. Mold filled approximately one third full?</td>
<td>____</td>
<td>____</td>
</tr>
<tr>
<td>6. Layer rodded throughout its depth 25 times with hemispherical end of rod, uniformly distributing strokes?</td>
<td>____</td>
<td>____</td>
</tr>
<tr>
<td>7. Sides of the mold tapped 10-15 times after rodding each layer?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. With mallet for reusable steel molds</td>
<td>____</td>
<td>____</td>
</tr>
<tr>
<td>b. With the open hand for flexible light-gauge molds</td>
<td>____</td>
<td>____</td>
</tr>
<tr>
<td><strong>Second layer</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Concrete placed in the mold, moving a scoop or trowel around the perimeter of the mold to evenly distribute the concrete as discharged?</td>
<td>____</td>
<td>____</td>
</tr>
<tr>
<td>9. Mold filled approximately two thirds full?</td>
<td>____</td>
<td>____</td>
</tr>
<tr>
<td>10. Layer rodded 25 times with hemispherical end of rod, uniformly distributing strokes and penetrating 25 mm (1 in.) into the underlying layer?</td>
<td>____</td>
<td>____</td>
</tr>
<tr>
<td>11. Sides of the mold tapped 10-15 times after rodding?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. With mallet for reusable steel molds</td>
<td>____</td>
<td>____</td>
</tr>
<tr>
<td>b. With the open hand for flexible light-gauge molds</td>
<td>____</td>
<td>____</td>
</tr>
<tr>
<td><strong>Third layer</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Concrete placed in the mold, moving a scoop or trowel around the perimeter of the mold to evenly distribute the concrete as discharged?</td>
<td>____</td>
<td>____</td>
</tr>
</tbody>
</table>

OVER
### Procedure Element

13. Mold slightly overfilled on the last layer?

14. Layer rodded 25 times with hemispherical end of rod, uniformly distributing strokes and penetrating 25 mm (1 in.) into the underlying layer?

15. Sides of the mold tapped 10-15 times after rodding?
   - a. With mallet for reusable steel molds
   - b. With the open hand for flexible light-gauge molds

16. Concrete struck off with tamping rod, straightedge, float, or trowel?

17. Specimens covered with non-absorptive, non-reactive cap or plate?

18. Initial curing addressed?

### Trial 1  Trial 2

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>13. Mold slightly overfilled on the last layer?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. Layer rodded 25 times with hemispherical end of rod, uniformly distributing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>strokes and penetrating 25 mm (1 in.) into the underlying layer?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. Sides of the mold tapped 10-15 times after rodding?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. With mallet for reusable steel molds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. With the open hand for flexible light-gauge molds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16. Concrete struck off with tamping rod, straightedge, float, or trowel?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17. Specimens covered with non-absorptive, non-reactive cap or plate?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18. Initial curing addressed?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Comments:

First attempt: Pass Fail Second attempt: Pass Fail

Examiner Signature ____________________________________________________________________

WAQTC #: ___________________________________________________________________________

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MOISTURE-DENSITY RELATIONS OF SOILS:
USING A 2.5 kg (5.5 lb) RAMMER AND A 305 mm (12 in.) DROP
FOP FOR AASHTO T 99
USING A 4.54 kg (10 lb) RAMMER AND A 457 mm (18 in.) DROP
FOP FOR AASHTO T 180

Scope

This procedure covers the determination of the moisture-density relations of soils and soil-aggregate mixtures in accordance with two similar test methods:

- AASHTO T 99-17: Methods A, B, C, and D
- AASHTO T 180-17: Methods A, B, C, and D

This test method applies to soil mixtures having 40 percent or less retained on the 4.75 mm (No. 4) sieve for methods A or B, or, 30 percent or less retained on the 19 mm (3/4 in.) with methods C or D. The retained material is defined as oversize (coarse) material. If no minimum percentage is specified, 5 percent will be used. Samples that contain oversize (coarse) material that meet percent retained criteria should be corrected by using Annex A, Correction of Maximum Dry Density and Optimum Moisture for Oversized Particles.

Samples of soil or soil-aggregate mixture are prepared at several moisture contents and compacted into molds of specified size, using manual or mechanical rammers that deliver a specified quantity of compactive energy. The moist masses of the compacted samples are multiplied by the appropriate factor to determine wet density values. Moisture contents of the compacted samples are determined and used to obtain the dry density values of the same samples. Maximum dry density and optimum moisture content for the soil or soil-aggregate mixture is determined by plotting the relationship between dry density and moisture content.

Apparatus

- Mold – Cylindrical mold made of metal with the dimensions shown in Table 1 or Table 2. If permitted by the agency, the mold may be of the “split” type, consisting of two half-round sections, which can be securely locked in place to form a cylinder. Determine the mold volume according to Annex B, Standardization of the Mold.
- Mold assembly – Mold, base plate, and a detachable collar.
- Rammer – Manually or mechanically-operated rammers as detailed in Table 1 or Table 2. A manually-operated rammer shall be equipped with a guide sleeve to control the path and height of drop. The guide sleeve shall have at least four vent holes no smaller than 9.5 mm (3/8 in.) in diameter, spaced approximately 90 degrees apart and approximately 19 mm (3/4 in.) from each end. A mechanically-operated rammer will uniformly distribute blows over the sample and will be calibrated with several soil types, and be adjusted, if necessary, to give the same moisture-density results as with the manually operated rammer. For additional information concerning calibration, see the FOP for AASHTO T 99 and T 180.
• Sample extruder – A jack, lever frame, or other device for extruding compacted specimens from the mold quickly and with little disturbance.

• Balance(s) or scale(s) of the capacity and sensitivity required for the procedure used by the agency.

    A balance or scale with a capacity of 11.5 kg (25 lb) and a sensitivity of 1 g for obtaining the sample, meeting the requirements of AASHTO M 231, Class G 5.

    A balance or scale with a capacity of 2 kg and a sensitivity of 0.1 g is used for moisture content determinations done under both procedures, meeting the requirements of AASHTO M 231, Class G 2.

• Drying apparatus – A thermostatically controlled drying oven, capable of maintaining a temperature of 110 ±5°C (230 ±9°F) for drying moisture content samples in accordance with the FOP for AASHTO T 255/T 265.

• Straightedge – A steel straightedge at least 250 mm (10 in.) long, with one beveled edge and at least one surface plane within 0.1 percent of its length, used for final trimming.

• Sieve(s) – 4.75 mm (No. 4) and/or 19.0 mm (3/4 in.), meeting the requirements of FOP for AASHTO T 27/T 11.

• Mixing tools – Miscellaneous tools such as a mixing pan, spoon, trowel, spatula, etc., or a suitable mechanical device, for mixing the sample with water.

• Containers with close-fitting lids to prevent gain or loss of moisture in the sample.
### Table 1
Comparison of Apparatus, Sample, and Procedure – Metric

<table>
<thead>
<tr>
<th></th>
<th>T 99</th>
<th>T 180</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mold Volume, m³</td>
<td>Methods A, C: 0.000943 ± 0.000014</td>
<td>Methods A, C: 0.000943 ± 0.000014</td>
</tr>
<tr>
<td></td>
<td>Methods B, D: 0.002124 ± 0.000025</td>
<td>Methods B, D: 0.002124 ± 0.000025</td>
</tr>
<tr>
<td>Mold Diameter, mm</td>
<td>Methods A, C: 101.60 ± 0.40</td>
<td>Methods A, C: 101.60 ± 0.40</td>
</tr>
<tr>
<td></td>
<td>Methods B, D: 152.40 ± 0.70</td>
<td>Methods B, D: 152.40 ± 0.70</td>
</tr>
<tr>
<td>Mold Height, mm</td>
<td>116.40 ± 0.50</td>
<td>116.40 ± 0.50</td>
</tr>
<tr>
<td>Detachable Collar Height, mm</td>
<td>50.80 ± 0.64</td>
<td>50.80 ± 0.64</td>
</tr>
<tr>
<td>Rammer Diameter, mm</td>
<td>50.80 ± 0.25</td>
<td>50.80 ± 0.25</td>
</tr>
<tr>
<td>Rammer Mass, kg</td>
<td>2.495 ± 0.009</td>
<td>4.536 ± 0.009</td>
</tr>
<tr>
<td>Rammer Drop, mm</td>
<td>305</td>
<td>457</td>
</tr>
<tr>
<td>Layers</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Blows per Layer</td>
<td>Methods A, C: 25</td>
<td>Methods A, C: 25</td>
</tr>
<tr>
<td></td>
<td>Methods B, D: 56</td>
<td>Methods B, D: 56</td>
</tr>
<tr>
<td>Material Size, mm</td>
<td>Methods A, B: 4.75 minus</td>
<td>Methods A, B: 4.75 minus</td>
</tr>
<tr>
<td></td>
<td>Methods C, D: 19.0 minus</td>
<td>Methods C, D: 19.0 minus</td>
</tr>
<tr>
<td>Test Sample Size, kg</td>
<td>Method A: 3 (1)</td>
<td>Method B: 7 (1)</td>
</tr>
<tr>
<td></td>
<td>Method C: 5 (1)</td>
<td>Method D: 11 (1)</td>
</tr>
<tr>
<td>Energy, kN·m/m³</td>
<td>592</td>
<td>2,693</td>
</tr>
</tbody>
</table>

(1) This may not be a large enough sample depending on your nominal maximum size for moisture content samples.

### Table 2
Comparison of Apparatus, Sample, and Procedure – English

<table>
<thead>
<tr>
<th></th>
<th>T 99</th>
<th>T 180</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mold Volume, ft³</td>
<td>Methods A, C: 0.0333 ± 0.0005</td>
<td>Methods A, C: 0.0333 ± 0.0005</td>
</tr>
<tr>
<td></td>
<td>Methods B, D: 0.07500 ± 0.0009</td>
<td>Methods B, D: 0.07500 ± 0.0009</td>
</tr>
<tr>
<td>Mold Diameter, in.</td>
<td>Methods A, C: 4.000 ± 0.016</td>
<td>Methods A, C: 4.000 ± 0.016</td>
</tr>
<tr>
<td></td>
<td>Methods B, D: 6.000 ± 0.026</td>
<td>Methods B, D: 6.000 ± 0.026</td>
</tr>
<tr>
<td>Mold Height, in.</td>
<td>4.584 ± 0.018</td>
<td>4.584 ± 0.018</td>
</tr>
<tr>
<td>Detachable Collar Height, in.</td>
<td>2.000 ± 0.025</td>
<td>2.000 ± 0.025</td>
</tr>
<tr>
<td>Rammer Diameter, in.</td>
<td>2.000 ± 0.025</td>
<td>2.000 ± 0.025</td>
</tr>
<tr>
<td>Rammer Mass, lb</td>
<td>5.5 ± 0.02</td>
<td>10 ± 0.02</td>
</tr>
<tr>
<td>Rammer Drop, in.</td>
<td>12</td>
<td>18</td>
</tr>
<tr>
<td>Layers</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Blows per Layer</td>
<td>Methods A, C: 25</td>
<td>Methods A, C: 25</td>
</tr>
<tr>
<td></td>
<td>Methods B, D: 56</td>
<td>Methods B, D: 56</td>
</tr>
<tr>
<td>Material Size, in.</td>
<td>Methods A, B: No. 4 minus</td>
<td>Methods A, B: No.4 minus</td>
</tr>
<tr>
<td></td>
<td>Methods C, D: 3/4 minus</td>
<td>Methods C, D: 3/4 minus</td>
</tr>
<tr>
<td>Test Sample Size, lb</td>
<td>Method A: 7 (1)</td>
<td>Method B: 16 (1)</td>
</tr>
<tr>
<td></td>
<td>Method C: 12 (1)</td>
<td>Method D: 25 (1)</td>
</tr>
<tr>
<td>Energy, lb·ft/ft³</td>
<td>12.375</td>
<td>56.250</td>
</tr>
</tbody>
</table>

(1) This may not be a large enough sample depending on your nominal maximum size for moisture content samples.
Sample

If the sample is damp, dry it until it becomes friable under a trowel. Drying may be in air or by use of a drying apparatus maintained at a temperature not exceeding 60°C (140°F). Thoroughly break up aggregations in a manner that avoids reducing the natural size of individual particles.

Obtain a representative test sample of the mass required by the agency by passing the material through the sieve required by the agency. See Table 1 or Table 2 for test sample mass and material size requirements.

In instances where the material is prone to degradation, i.e., granular material, a compaction sample with differing moisture contents should be prepared for each point.

Note 1: Both T 99 and T 180 have four methods (A, B, C, D) that require different masses and employ different sieves.

Note 2: If the sample is plastic (clay types), it should stand for a minimum of 12 hours after the addition of water to allow the moisture to be absorbed. In this case, several samples at different moisture contents should be prepared, put in sealed containers and tested the next day.

Procedure

During compaction, rest the mold firmly on a dense, uniform, rigid, and stable foundation or base. This base shall remain stationary during the compaction process.

1. Determine the mass of the clean, dry mold. Include the base plate, but exclude the extension collar. Record the mass to the nearest 1 g (0.005 lb).

2. Thoroughly mix the selected representative sample with sufficient water to dampen it to approximately 4 to 8 percentage points below optimum moisture content. See Note 2. For many materials, this condition can be identified by forming a cast by hand.

3. Form a specimen by compacting the prepared soil in the mold assembly in approximately equal layers. For each layer:
   a. Spread the loose material uniformly in the mold.
   b. Lightly tamp the loose material with the manual rammer or other similar device, this establishes a firm surface.
   c. Compact each layer with uniformly distributed blows from the rammer. See Table 1 for mold size, number of layers, number of blows, and rammer specification for the various test methods. Use the method specified by the agency.
   d. Trim down material that has not been compacted and remains adjacent to the walls of the mold and extends above the compacted surface.
4. Remove the extension collar. Avoid shearing off the sample below the top of the mold. The material compacted in the mold should not be over 6 mm (¼ in.) above the top of the mold once the collar has been removed.

5. Trim the compacted soil even with the top of the mold with the beveled side of the straightedge.

6. Determine and record the mass of the mold, base plate, and wet soil to the nearest 1 g (0.005 lb) or better.

7. Determine and record the wet mass ($M_w$) of the sample by subtracting the mass in Step 1 from the mass in Step 6.

8. Calculate the wet density, in kg/m$^3$ (lb/ft$^3$), by dividing the wet mass by the measured volume ($V_m$).

9. Extrude the material from the mold. For soils and soil-aggregate mixtures, slice vertically through the center and take a representative moisture content sample from one of the cut faces, ensuring that all layers are represented. For granular materials, a vertical face will not exist. Take a representative sample. This sample must meet the sample size requirements of the test method used to determine moisture content.

Note 4: When developing a curve for free-draining soils such as uniform sands and gravels, where seepage occurs at the bottom of the mold and base plate, taking a representative moisture content from the mixing bowl may be preferred in order to determine the amount of moisture available for compaction.

10. Determine and record the moisture content of the sample in accordance with the FOP for AASHTO T 255 / T 265.

11. Thoroughly break up the remaining portion of the molded specimen until it will again pass through the sieve, as judged by eye, and add to the remaining portion of the sample being tested. See Note 2.

12. Add sufficient water to increase the moisture content of the remaining soil by 1 to 2 percentage points and repeat steps 3 through 11.

13. Continue determinations until there is either a decrease or no change in the wet mass. There will be a minimum of three points on the dry side of the curve and two points on the wet side. For non-cohesive, drainable soils, one point on the wet side is sufficient.
**Calculations**

**Wet Density**

\[ D_{w} = \frac{M_w}{V_m} \]

Where:

- \( D_w \) = wet density, kg/m\(^3\) (lb/ft\(^3\))
- \( M_w \) = wet mass
- \( V_m \) = volume of the mold, Annex B

**Dry Density**

\[ D_d = \frac{D_{ww} \times 100}{ww + 100} \]

Where:

- \( D_d \) = dry density, kg/m\(^3\) (lb/ft\(^3\))
- \( w \) = moisture content, as a percentage
Example for 4-inch mold, Methods A or C

- Wet mass, $M_w = 1.944$ kg (4.25 lb)
- Moisture content, $w = 11.3\%$
- Measured volume of the mold, $V_m = 0.000946$ m$^3$ (0.0334 ft$^3$)

**Wet Density**

$$DD_w = \frac{1.944 \text{ kg}}{0.000946 \text{ m}^3} = 2055 \text{ kg/m}^3$$

$$DD_w = \frac{4.25 \text{ lb}}{0.0334 \text{ ft}^3} = 127.2 \text{ lb/ft}^3$$

**Dry Density**

$$DD_d = \frac{2055 \text{ kg/m}^3}{11.3 + 100} \times 100 = 1846 \text{ kg/m}^3$$

$$DD_d = \frac{127.2 \text{ lb/ft}^3}{11.3 + 100} \times 100 = 114.3 \text{ lb/ft}^3$$

Or

$$DD_d = \frac{2055 \text{ kg/m}^3}{\frac{11.3}{100} + 1} \times 1846 \text{ kg/m}^3 = 114.3 \text{ lb/ft}^3$$
Moisture-Density Curve Development

When dry density is plotted on the vertical axis versus moisture content on the horizontal axis and the points are connected with a smooth line, a moisture-density curve is developed. The coordinates of the peak of the curve are the maximum dry density, or just “maximum density,” and the “optimum moisture content” of the soil.

Example

Given the following dry density and corresponding moisture content values develop a moisture-density relations curve and determine maximum dry density and optimum moisture content.

<table>
<thead>
<tr>
<th>Dry Density</th>
<th>Moisture Content, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>kg/m³</td>
<td>lb/ft³</td>
</tr>
<tr>
<td>1846</td>
<td>114.3</td>
</tr>
<tr>
<td>1868</td>
<td>115.7</td>
</tr>
<tr>
<td>1887</td>
<td>116.9</td>
</tr>
<tr>
<td>1884</td>
<td>116.7</td>
</tr>
<tr>
<td>1871</td>
<td>115.9</td>
</tr>
</tbody>
</table>

In this case, the curve has its peak at:

Maximum dry density = 1890 kg/m³ (117.0 lb/ft³)

Optimum moisture content = 13.2%

Note that both values are approximate, since they are based on sketching the curve to fit the points.
Report

- Results on forms approved by the agency
- Sample ID
- Maximum dry density to the closest 1 kg/m$^3$ (0.1 lb/ft$^3$)
- Optimum moisture content to the closest 0.1 percent
ANNEX A

CORRECTION OF MAXIMUM DRY DENSITY AND OPTIMUM MOISTURE FOR OVERSIZED PARTICLES

This section corrects the maximum dry density and moisture content of the material retained on the 4.75 mm (No. 4) sieve, Methods A and B; or the material retained on the 19 mm (¾ in.) sieve, Methods C and D. The maximum dry density, corrected for oversized particles and total moisture content, are compared with the field-dry density and field moisture content.

This correction can be applied to the sample on which the maximum dry density is performed. A correction may not be practical for soils with only a small percentage of oversize material. The agency shall specify a minimum percentage below which the method is not needed. If not specified, this method applies when more than 5 percent by weight of oversize particles is present.

Bulk specific gravity (G_{bs}) of the oversized particles is required to determine the corrected maximum dry density. Use the bulk specific gravity as determined using the FOP for AASHTO T 85 in the calculations. For construction activities, an agency established value or specific gravity of 2.600 may be used.

This correction can also be applied to the sample obtained from the field while performing in-place density.

1. Use the sample from this procedure or a sample obtained according to the FOP for AASHTO T 310.

2. Sieve the sample on the 4.75 mm (No. 4) sieve for Methods A and B or the 19 mm (¾ in.) sieve, Methods C and D.

3. Determine the dry mass of the oversized and fine fractions (M_{DC} and M_{DF}) by one of the following:
   a. Dry the fractions, fine and oversized, in air or by use of a drying apparatus that is maintained at a temperature not exceeding 60ºC (140ºF).
   b. Calculate the dry masses using the moisture samples.

To determine the dry mass of the fractions using moisture samples.

1. Determine the moist mass of both fractions, fine (M_{Mf}) and oversized (M_{Mc}):

2. Obtain moisture samples from the fine and oversized material.
3. Determine the moisture content of the fine particles ($MC_f$) and oversized particles ($MC_c$) of the material by FOP for AASHTO T 255/T 265 or agency approved method.

4. Calculate the dry mass of the oversize and fine particles.

$$MM_0 = \frac{MM_{mm}}{1 + MC}$$

Where:

$M_D$ = mass of dry material (fine or oversize particles)

$M_m$ = mass of moist material (fine or oversize particles)

$MC$ = moisture content of respective fine or oversized, expressed as a decimal

5. Calculate the percentage of the fine ($P_f$) and oversized ($P_c$) particles by dry weight of the total sample as follows: See Note 2.

$$P_{ff} = \frac{100 \times MM_{DDD}}{MM_{DDD} + \frac{100 \times 15.4 \ llll}{15.4 \ lllll + 5.7 \ lll}} = 73\%$$

$$P_{cc} = 100 - P_{ff}$$

And

$$P_{aa} = \frac{100 \times MM_{DDD}}{MM_{DDD} + \frac{100 \times 5.7 \ lll}{15.4 \ lllll + 5.7 \ lll}} = 27\%$$

Or for $P_c$:

$$PP_{cc} = 100 - PP_{ff}$$

Where:

$P_f$ = percent of fine particles, of sieve used, by weight

$P_c$ = percent of oversize particles, of sieve used, by weight

$M_{DF}$ = mass of fine particles

$M_{DC}$ = mass of oversize particles
Optimum Moisture Correction Equation

1. Calculate the corrected moisture content as follows:

\[
MC_T = \frac{MC_F \times PF + (MC_C \times PC)}{100} \quad \frac{(13.2\% \times 73.0\%) + (2.1\% \times 27.0\%)}{100} = 10.2\%
\]

*MC* = corrected moisture content of combined fines and oversized particles, expressed as a % moisture

*MC* = moisture content of fine particles, as a % moisture

*MC* = moisture content of oversized particles, as a % moisture

**Note 1:** Moisture content of oversize material can be assumed to be two (2) percent for most construction applications.

**Note 2:** In some field applications agencies will allow the percentages of oversize and fine materials to be determined with the materials in the wet state.

Density Correction Equation

2. Calculate the corrected dry density of the total sample (combined fine and oversized particles) as follows:

\[
DD_{\text{corr}} = \frac{100\% \times DD_f}{PF + PC \times k}
\]

Where:

* Dd = corrected total dry density (combined fine and oversized particles) kg/m³ (lb/ft³)
* Df = dry density of the fine particles kg/m³ (lb/ft³), determined in the lab
* P = percent of oversize particles, of sieve used, by weight.
* P = percent of fine particles, of sieve used, by weight.
* k = Metric: 1,000 * Bulk Specific Gravity (Gb) (oven dry basis) of coarse particles (kg/m³).
* k = English: 62.4 * Bulk Specific Gravity (Gb) (oven dry basis) of coarse particles (lb/ft³)

**Note 3:** If the specific gravity is known, then this value will be used in the calculation. For most construction activities the specific gravity for aggregate may be assumed to be 2.600.
**Calculation**

**Example**

- Metric:

  Maximum laboratory dry density ($D_l$): 1890 kg/m$^3$
  Percent coarse particles ($P_c$): 27%
  Percent fine particles ($P_f$): 73%
  Mass per volume coarse particles ($k$): $(2.697)(1000) = 2697$ kg/m$^3$

\[
D_D = \frac{100}{P_P} \frac{D_{ff}}{PP_c} \frac{k}{D_{df}}
\]

\[
D_D = \frac{100}{\text{73% 27%}} \frac{1890 \text{ kkg/m}^3}{2697 \text{ kkg/m}^3}
\]

\[
D_D = \frac{100}{[0.03862 \text{ kkg/m}^3 + 0.01001 \text{ kkg/m}^3]}
\]

\[
D_k = 2056.3 \text{ kkg/m}^3 \times 2056 \text{ kkg/m}^3
\]
English:

Maximum laboratory dry density ($D_d$): 117.0 lb/ft$^3$
Percent coarse particles ($P_c$): 27%
Percent fine particles ($P_f$): 73%
Mass per volume of coarse particles ($k$): $(2.697)(62.4) = 168.3$ lb/ft$^3$

\[
D_d = \frac{100\%}{P_f \cdot P_c} \quad (\text{DD}_d)
\]

\[
DD_d = \frac{100\%}{73\% \cdot 27\%} \quad \frac{117.0 \text{ lb/ft}^3}{168.3 \text{ lb/ft}^3}
\]

\[
DD_d = \frac{100\%}{[0.6239 \text{ lb/ft}^3 + 0.1604 \text{ lb/ft}^3]}
\]

\[
DD_d = \frac{100\%}{0.7843 \text{ lb/ft}^3}
\]

\[
D_d = 127.50 \text{ lb/ft}^3 \quad \text{RRrrrrrrooooff 127.5 \text{ lb/ft}^3}
\]

Report

- Results on forms approved by the agency
- Sample ID
- Corrected maximum dry density to the closest 1 kg/m$^3$ (0.1 lb/ft$^3$)
- Corrected optimum moisture to the 0.1 percent
ANNEX B

STANDARDIZATION OF THE MOLD

Standardization is a critical step to ensure accurate test results when using this apparatus. Failure to perform the standardization procedure as described herein will produce inaccurate or unreliable test results.

Apparatus

- Mold and base plate
- Balance or scale – Accurate to within 45 g (0.1 lb) or 0.3 percent of the test load, whichever is greater, at any point within the range of use.
- Cover plate – A piece of plate glass, at least 6 mm (1/4 in.) thick and at least 25 mm (1 in.) larger than the diameter of the mold.
- Thermometers – Standardized liquid-in-glass, or electronic digital total immersion type, accurate to 0.5°C (1°F)

Procedure

1. Create a watertight seal between the mold and base plate.
2. Determine and record the mass of the dry sealed mold, base plate, and cover plate.
3. Fill the mold with water at a temperature between 16°C and 29°C (60°F and 85°F) and cover with the cover plate in such a way as to eliminate bubbles and excess water.
4. Wipe the outside of the mold, base plate, and cover plate dry, being careful not to lose any water from the mold.
5. Determine and record the mass of the filled mold, base plate, cover plate, and water.
6. Determine and record the mass of the water in the mold by subtracting the mass in Step 2 from the mass in Step 5.
7. Measure the temperature of the water and determine its density from Table B1, interpolating as necessary.
8. Calculate the volume of the mold, \( V_m \), by dividing the mass of the water in the mold by the density of the water at the measured temperature.
**Calculations**

\[ V_m = \frac{MM}{DD} \]

Where:

- \( V_m \) = volume of the mold
- \( M \) = mass of water in the mold
- \( D \) = density of water at the measured temperature

**Example**

Mass of water in mold = 0.94061 kg (2.0737 lb)

Density of water at 23°C (73.4°F) = 997.54 kg/m³ (62.274 lb/ft³)

\[ \frac{0.94061}{997.54} = 0.000943 \text{ mm}^3 \]

\[ \frac{2.0737}{62.274} = 0.0333 \text{ ft}^3 \]
Table B1
Unit Mass of Water
15°C to 30°C

<table>
<thead>
<tr>
<th>°C</th>
<th>(°F)</th>
<th>kg/m³</th>
<th>(lb/ft³)</th>
<th>°C</th>
<th>(°F)</th>
<th>kg/m³</th>
<th>(lb/ft³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>15</td>
<td>(59.0)</td>
<td>999.10</td>
<td>(62.372)</td>
<td>23</td>
<td>(73.4)</td>
<td>997.54</td>
<td>(62.274)</td>
</tr>
<tr>
<td>15.6</td>
<td>(60.0)</td>
<td>999.01</td>
<td>(62.366)</td>
<td>23.9</td>
<td>(75.0)</td>
<td>997.32</td>
<td>(62.261)</td>
</tr>
<tr>
<td>16</td>
<td>(60.8)</td>
<td>998.94</td>
<td>(62.361)</td>
<td>24</td>
<td>(75.2)</td>
<td>997.29</td>
<td>(62.259)</td>
</tr>
<tr>
<td>17</td>
<td>(62.6)</td>
<td>998.77</td>
<td>(62.350)</td>
<td>25</td>
<td>(77.0)</td>
<td>997.03</td>
<td>(62.243)</td>
</tr>
<tr>
<td>18</td>
<td>(64.4)</td>
<td>998.60</td>
<td>(62.340)</td>
<td>26</td>
<td>(78.8)</td>
<td>996.77</td>
<td>(62.227)</td>
</tr>
<tr>
<td>18.3</td>
<td>(65.0)</td>
<td>998.54</td>
<td>(62.336)</td>
<td>26.7</td>
<td>(80.0)</td>
<td>996.59</td>
<td>(62.216)</td>
</tr>
<tr>
<td>19</td>
<td>(66.2)</td>
<td>998.40</td>
<td>(62.328)</td>
<td>27</td>
<td>(80.6)</td>
<td>996.50</td>
<td>(62.209)</td>
</tr>
<tr>
<td>20</td>
<td>(68.0)</td>
<td>998.20</td>
<td>(62.315)</td>
<td>28</td>
<td>(82.4)</td>
<td>996.23</td>
<td>(62.192)</td>
</tr>
<tr>
<td>21</td>
<td>(69.8)</td>
<td>997.99</td>
<td>(62.302)</td>
<td>29</td>
<td>(84.2)</td>
<td>995.95</td>
<td>(62.175)</td>
</tr>
<tr>
<td>21.1</td>
<td>(70.0)</td>
<td>997.97</td>
<td>(62.301)</td>
<td>29.4</td>
<td>(85.0)</td>
<td>995.83</td>
<td>(62.166)</td>
</tr>
<tr>
<td>22</td>
<td>(71.6)</td>
<td>997.77</td>
<td>(62.288)</td>
<td>30</td>
<td>(86.0)</td>
<td>995.65</td>
<td>(62.156)</td>
</tr>
</tbody>
</table>

Report

- Mold ID
- Date Standardized
- Temperature of the water
- Volume, $V_m$, of the mold
PERFORMANCE EXAM CHECKLIST

MOISTURE-DENSITY RELATION OF SOILS
FOP FOR AASHTO T 99

Participant Name ___________________________ Exam Date ________________

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. If damp, sample dried in air or drying apparatus, not exceeding 60°C (140°F)?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>2. Sample broken up and an adequate amount sieved over the appropriate sieve (4.75 mm / No. 4 or 19.0 mm / 3/4 in.) to determine oversize (coarse particle) percentage?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>3. Sample passing the sieve has appropriate mass?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>4. If soil is plastic (clay types):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Multiple samples mixed with water varying moisture content by 1 to 2 percent, bracketing the optimum moisture content?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>b. Samples placed in covered containers and allowed to stand for at least 12 hours?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>5. Sample determined to be 4 to 8 percent below expected optimum moisture content?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>6. Mold placed on rigid and stable foundation?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>7. Layer of soil (approximately one third compacted depth) placed in mold with collar attached, loose material lightly tamped?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>8. Soil compacted with appropriate number of blows (25 or 56)?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>9. Material adhering to the inside of the mold trimmed?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>10. Layer of soil (approximately two thirds compacted depth) placed in mold with collar attached, loose material lightly tamped?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>11. Soil compacted with appropriate number of blows (25 or 56)?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>12. Material adhering to the inside of the mold trimmed?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>13. Mold filled with soil such that compacted soil will be above the mold, loose material lightly tamped?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>14. Soil compacted with appropriate number of blows (25 or 56)?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>15. Collar removed without shearing off sample?</td>
<td>______</td>
<td>______</td>
</tr>
</tbody>
</table>

OVER
## Procedure Element

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>16. Approximately 6 mm (1/4 in.) of compacted material above the top of the mold (without the collar)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17. Soil trimmed to top of mold with the beveled side of the straightedge?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18. Mass of mold and contents determined to appropriate precision?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19. Wet density calculated from the wet mass?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20. Soil removed from mold using a sample extruder if needed?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21. Soil sliced vertically through center (non-granular material)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22. Moisture sample removed ensuring all layers are represented?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23. Moist mass determined immediately to 0.1 g?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24. Moisture sample mass of correct size?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25. Sample dried and water content determined according to the FOP for T 255/T 265?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>26. Remainder of material from mold broken up until it will pass through the sieve, as judged by eye, and added to remainder of original test sample?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>27. Water added to increase moisture content of the remaining sample in 1 to 2 percent increments?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>28. Steps 2 through 26 repeated for each increment of water added?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>29. If material is degradable: Multiple samples mixed with water varying moisture content by 1 to 2 percent, bracketing the optimum moisture content?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30. Process continued until wet density either decreases or stabilizes?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>31. Moisture content and dry density calculated for each sample?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>32. Dry density plotted on vertical axis, moisture content plotted on horizontal axis, and points connected with a smooth curve?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>33. Moisture content at peak of curve recorded as optimum water content and recorded to nearest 0.1 percent?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>34. Dry density at optimum moisture content reported as maximum density to nearest 1 kg/m³ (0.1 lb/ft³)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>35. Corrected for coarse particles if applicable?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Comments:**

First attempt: Pass____ Fail____

Second attempt: Pass____ Fail____

Examiner Signature______________________________ WAQTC #:______________
PERFORMANCE EXAM CHECKLIST

MOISTURE-DENSITY RELATION OF SOILS
FOP FOR AASHTO T 180

Participant Name __________________________________________________________________ Exam Date __________

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Trial 1</th>
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<tbody>
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<td>1. If damp, sample dried in air or drying apparatus, not exceeding 60°C (140°F)?</td>
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</tr>
<tr>
<td>3. Sample passing the sieve has appropriate mass?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. If soil is plastic (clay types):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Multiple samples mixed with water varying moisture content by 1 to 2 percent, bracketing the optimum moisture content?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Samples placed in covered containers and allowed to stand for at least 12 hours?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Sample determined to be 4 to 8 percent below expected optimum moisture content?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Mold placed on rigid and stable foundation?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Layer of soil (approximately one fifth compacted depth) placed in mold with collar attached, loose material lightly tamped?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Soil compacted with appropriate number of blows (25 or 56)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Material adhering to the inside of the mold trimmed?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Layer of soil (approximately two fifths compacted depth) placed in mold with collar attached, loose material lightly tamped?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Soil compacted with appropriate number of blows (25 or 56)?</td>
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<td></td>
</tr>
<tr>
<td>12. Material adhering to the inside of the mold trimmed?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Layer of soil (approximately three fifths compacted depth) placed in mold with collar attached, loose material lightly tamped?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. Soil compacted with appropriate number of blows (25 or 56)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. Material adhering to the inside of the mold trimmed?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

OVER
Procedure Element

16. Layer of soil (approximately four fifths compacted depth) placed in mold with collar attached, loose material lightly tamped?  
17. Soil compacted with appropriate number of blows (25 or 56)?  
18. Material adhering to the inside of the mold trimmed?  
19. Mold filled with soil such that compacted soil will be above the mold, loose material lightly tamped?  
20. Soil compacted with appropriate number of blows (25 or 56)?  
21. Collar removed without shearing off sample?  
22. Approximately 6 mm (1/4 in.) of compacted material above the top of the mold (without the collar)?  
23. Soil trimmed to top of mold with the beveled side of the straightedge?  
24. Mass of mold and contents determined to appropriate precision?  
25. Wet density calculated from the wet mass?  
26. Soil removed from mold using a sample extruder if needed?  
27. Soil sliced vertically through center (non-granular material)?  
28. Moisture sample removed ensuring all layers are represented?  
29. Moist mass determined immediately to 0.1 g?  
30. Moisture sample mass of correct size?  
31. Sample dried and water content determined according to the FOP for T 255/T 265?  
32. Remainder of material from mold broken up until it will pass through the sieve, as judged by eye, and added to remainder of original test sample?  
33. Water added to increase moisture content of the remaining sample in 1 to 2 percent increments?  
34. Steps 2 through 20 repeated for each increment of water added?  
35. If soil is plastic (clay types):  
a. Samples mixed with water varying moisture content by 1 to 2 percent, bracketing the optimum moisture content?  
b. Samples placed in covered containers and allowed to stand for at least 12 hours?  
36. If material is degradable:  
   Multiple samples mixed with water varying moisture content by 1 to 2 percent, bracketing the optimum moisture content?  

OVER
**Procedure Element**

<table>
<thead>
<tr>
<th>Procedure Element</th>
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<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>37. Process continued until wet density either decreases or stabilizes?</td>
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<td></td>
</tr>
<tr>
<td>41. Dry density at optimum moisture content reported as maximum density to nearest 1 kg/m³ (0.1 lb/ft³)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>42. Corrected for coarse particles if applicable?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Comments:**  
First attempt: Pass Fail  
Second attempt: Pass Fail  

Examiner Signature________________________  WAQTC #: ____________
FOP for AASHTO T 99 & T 180

MOISTURE-DENSITY RELATIONS OF SOILS:
USING A 2.5 kg (5.5 lb) RAMMER AND A 305 mm (12 in.) DROP
FOP FOR AASHTO T 99 (15)
USING A 4.54 kg (10 lb) RAMMER AND A 457 mm (18 in.) DROP
FOP FOR AASHTO T 180 (15)

ANNEX.

Add the following to the second paragraph:

Correct for coarse particles if more than 10% of the material is retained on the 3/4 inch sieve.
DEVELOPING A FAMILY OF CURVES
FOP FOR AASHTO R 75

Scope

This procedure provides a method to develop a family of curves in accordance with AASHTO R 75-16 using multiple moisture density relationships developed using the same method, A, B, C, or D, from the FOP for AASHTO T 99/T 180.

All curves used in a family must be developed using a single Method: A, B, C, or D of a procedure for AASHTO T 99 or T 180. See the FOP for AASHTO T 99/T 180.

Terminology

family of curves — a group of soil moisture-density relationships (curves) determined using AASHTO T 99 or T 180, which reveal certain similarities and trends characteristic of the soil type and source.

spine — smooth line extending through the point of maximum density/optimum moisture content of a family of moisture-density curves.

Procedure

1. Sort the curves by Method (A, B, C, or D of the FOP for T 99/T 180). At least three curves are required to develop a family.

2. Select the highest and lowest maximum dry densities from those selected to assist in determining the desired scale of the subsequent graph.

3. Plot the maximum density and optimum moisture points of the selected curves on the graph.

4. Draw a smooth, “best fit,” curved line through the points creating the spine of the family of curves.

5. Remove maximum density and optimum moisture points that were not used to establish the spine.

6. Add the moisture/density curves associated with the points that were used to establish the spine. It is not necessary to include the portion of the curves over optimum moisture.

Note 1—Intermediate template curves using slopes similar to those of the original moisture-density curves may be included when maximum density points are more than 2.0 lb/ft³ apart. Template curves are indicated by a dashed line.
7. Plot the 80 percent of optimum moisture range when desired:

   a. Using the optimum moisture of an existing curve, calculate 80 percent of optimum moisture and plot this value on the curve. Repeat for each curve in the family.

   b. Draw a smooth, “best fit,” curved line connecting the 80 percent of optimum moisture points plotted on the curves that parallel the spine.

**Calculations**

Calculate 80 percent of optimum moisture of each curve:

Example:

Optimum moisture of the highest density curve = 14.6%

\[
80\% \text{ Moisture} = \frac{80}{100} \times 14.6\% = 11.7\%
\]
PERFORMANCE EXAM CHECKLIST

DEVELOPING A FAMILY OF CURVES
FOP FOR AASHTO R 75

Participant Name ___________________________ Exam Date ______________

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Curves sorted by method and procedure (A, B, C, or D of the FOP for T 99/T 180)?</td>
<td>________</td>
<td>________</td>
</tr>
<tr>
<td>a. At least three curves per family?</td>
<td>________</td>
<td>________</td>
</tr>
<tr>
<td>2. Maximum density and optimum moisture points plotted on the graph?</td>
<td>________</td>
<td>________</td>
</tr>
<tr>
<td>3. Spine drawn correctly?</td>
<td>________</td>
<td>________</td>
</tr>
<tr>
<td>4. Maximum density and optimum moisture points removed that were not used for the spine?</td>
<td>________</td>
<td>________</td>
</tr>
<tr>
<td>5. Moisture/density curves added?</td>
<td>________</td>
<td>________</td>
</tr>
<tr>
<td>6. Optimum moisture range?</td>
<td>________</td>
<td>________</td>
</tr>
<tr>
<td>a. 80 percent of optimum moisture calculated for each curve?</td>
<td>________</td>
<td>________</td>
</tr>
<tr>
<td>b. Curved line through 80 percent of optimum moisture drawn correctly?</td>
<td>________</td>
<td>________</td>
</tr>
</tbody>
</table>

Comments: First attempt: Pass____Fail_____ Second attempt: Pass____Fail_____

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Examiner Signature_____________________________ WAQTC #: ______________
TOTAL EVAPORABLE MOISTURE CONTENT OF AGGREGATE BY DRYING
FOP FOR AASHTO T 255
LABORATORY DETERMINATION OF MOISTURE CONTENT OF SOILS
FOP FOR AASHTO T 265

Scope

This procedure covers the determination of moisture content of aggregate and soil in accordance with AASHTO T 255-00 and AASHTO T 265-15. It may also be used for other construction materials.

Overview

Moisture content is determined by comparing the wet mass of a sample and the mass of the sample after drying to constant mass. The term constant mass is used to define when a sample is dry.

Constant mass – the state at which a mass does not change more than a given percent, after additional drying for a defined time interval, at a required temperature.

Apparatus

- Balance or scale: capacity sufficient for the principle sample mass, accurate to 0.1 percent of sample mass or readable to 0.1 g, and meeting the requirements of AASHTO M 231
- Containers, clean, dry and capable of being sealed
- Suitable drying containers
- Microwave safe container with ventilated lid
- Heat source, controlled:
  - Forced draft oven
  - Ventilated oven
  - Convection oven
- Heat source, uncontrolled:
  - Infrared heater/heat lamp, hot plate, fry pan, or any other device/method that will dry the sample without altering the material being dried
- Microwave oven (900 watts minimum)

- Utensils such as spoons

- Hot pads or gloves

**Sample Preparation**

In accordance with the FOP for AASHTO T 2 obtain a representative sample in its existing condition.

For aggregates the representative sample size is based on Table 1 or other information that may be specified by the agency.

### TABLE 1

**Sample Sizes for Moisture Content of Aggregate**

<table>
<thead>
<tr>
<th>Nominal Maximum Size* mm (in.)</th>
<th>Minimum Sample Mass g (lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.75 (No. 4)</td>
<td>500 (1.1)</td>
</tr>
<tr>
<td>9.5 (3/8)</td>
<td>1500 (3.3)</td>
</tr>
<tr>
<td>12.5 (1/2)</td>
<td>2000 (4)</td>
</tr>
<tr>
<td>19.0 (3/4)</td>
<td>3000 (7)</td>
</tr>
<tr>
<td>25.0 (1)</td>
<td>4000 (9)</td>
</tr>
<tr>
<td>37.5 (1 1/2)</td>
<td>6000 (13)</td>
</tr>
<tr>
<td>50 (2)</td>
<td>8000 (18)</td>
</tr>
<tr>
<td>63 (2 1/2)</td>
<td>10,000 (22)</td>
</tr>
<tr>
<td>75 (3)</td>
<td>13,000 (29)</td>
</tr>
<tr>
<td>90 (3 1/2)</td>
<td>16,000 (35)</td>
</tr>
<tr>
<td>100 (4)</td>
<td>25,000 (55)</td>
</tr>
<tr>
<td>150 (6)</td>
<td>50,000 (110)</td>
</tr>
</tbody>
</table>

* One sieve larger than the first sieve to retain more than 10 percent of the material using an agency specified set of sieves based on cumulative percent retained. Where large gaps in specification sieves exist, intermediate sieve(s) may be inserted to determine nominal maximum.
For soils the representative sample size is based on Table 2 or other information that may be specified by the agency.

### TABLE 2

**Sample Sizes for Moisture Content of Soil**

<table>
<thead>
<tr>
<th>Maximum Particle Size mm (in)</th>
<th>Minimum Sample Mass g</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.425 (No. 40)</td>
<td>10</td>
</tr>
<tr>
<td>4.75 (No. 4)</td>
<td>100</td>
</tr>
<tr>
<td>12.5 (1/2)</td>
<td>300</td>
</tr>
<tr>
<td>25.0 (1)</td>
<td>500</td>
</tr>
<tr>
<td>50 (2)</td>
<td>1000</td>
</tr>
</tbody>
</table>

Immediately seal or cover samples to prevent any change in moisture content or follow the steps in “Procedure.”

### Procedure

Determine and record the sample mass as follows:

- For aggregate, determine and record all masses to the nearest 0.1 percent of the sample mass or to the nearest 0.1 g.
- For soil, determine and record all masses to the nearest 0.1 g.

When determining the mass of hot samples or containers or both, place and tare a buffer between the sample container and the balance. This will eliminate damage to or interference with the operation of the balance or scale.

1. Determine and record the mass of the container (and lid for microwave drying).
2. Place the wet sample in the container.
   a. For oven(s), hot plates, infrared heaters, etc.: Spread the sample in the container.
   b. For microwave oven: Heap sample in the container; cover with ventilated lid.
3. Determine and record the total mass of the container and wet sample.
4. Determine and record the wet mass of the sample by subtracting the container mass determined in Step 1 from the mass of the container and sample determined in Step 3.
5. Place the sample in one of the following drying apparatus:
   
a. For aggregate –
   
   i. Controlled heat source (oven): at 110 ±5°C (230 ±9°F).
   
   ii. Uncontrolled heat source (Hot plate, infrared heater, etc.): Stir frequently to avoid localized overheating.
   
   b. For soil – controlled heat source (oven): at 110 ±5°C (230 ±9°F).

*Note 1*: Soils containing gypsum or significant amounts of organic material require special drying. For reliable moisture contents dry these soils at 60°C (140°F). For more information see AASHTO T 265, Note 2.

6. Dry until sample appears moisture free.

7. Determine mass of sample and container.

8. Determine and record the mass of the sample by subtracting the container mass determined in Step 1 from the mass of the container and sample determined in Step 7.

9. Return sample and container to the heat source for additional drying.
   
a. For aggregate –
   
   i. Controlled heat source (oven): 30 minutes
   
   ii. Uncontrolled heat source (Hot plate, infrared heater, etc.): 10 minutes
   
   iii. Uncontrolled heat source (Microwave oven): 2 minutes

*Caution*: Some minerals in the sample may cause the aggregate to overheat, altering the aggregate gradation.

b. For soil – controlled heat source (oven): 1 hour

10. Determine mass of sample and container.

11. Determine and record the mass of the sample by subtracting the container mass determined in Step 1 from the mass of the container and sample determined in Step 10.
12. Determine percent change by subtracting the new mass determination ($M_n$) from the previous mass determination ($M_p$) divide by the previous mass determination ($M_p$) multiply by 100.

13. Continue drying, performing steps 9 through 12, until there is less than a 0.10 percent change after additional drying time.

14. Constant mass has been achieved, sample is defined as dry.

15. Allow the sample to cool. Immediately determine and record the total mass of the container and dry sample.

16. Determine and record the dry mass of the sample by subtracting the mass of the container determined in Step 1 from the mass of the container and sample determined in Step 15.

17. Determine and record percent moisture by subtracting the final dry mass determination ($M_D$) from the initial wet mass determination ($M_W$) divide by the final dry mass determination ($M_D$) multiply by 100.

### Table 3
**Methods of Drying**

<table>
<thead>
<tr>
<th>Aggregate</th>
<th>Heat Source</th>
<th>Specific Instructions</th>
<th>Drying intervals to achieve constant mass (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Controlled:</strong></td>
<td>Forced draft (preferred), ventilated, or convection oven</td>
<td>110 ±5°C (230 ±9°F)</td>
<td>30</td>
</tr>
<tr>
<td><strong>Uncontrolled:</strong></td>
<td>Hot plate, infrared heater, etc.</td>
<td>Stir frequently</td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>Microwave</td>
<td>Heap sample and cover with ventilated lid</td>
<td>2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Soil</th>
<th>Heat Source</th>
<th>Specific Instructions</th>
<th>Drying increments (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Controlled:</strong></td>
<td>Forced draft (preferred), ventilated, or convection oven</td>
<td>110 ±5°C (230 ±9°F)</td>
<td>1 hour</td>
</tr>
</tbody>
</table>
Calculation

**Constant Mass:**

Calculate constant mass using the following formula:

\[
\frac{MM_p - MM_n}{MM_p} \times 100 = \% \text{ Change}
\]

Where:
- \( M_p \) = previous mass measurement
- \( M_n \) = new mass measurement

Example:

Mass of container: 1232.1 g

Mass of container and sample after first drying cycle: 2637.2 g

Mass, \( M_p \), of possibly dry sample: 2637.2 g - 1232.1 g = 1405.1 g

Mass of container and dry sample after second drying cycle: 2634.1 g

Mass, \( M_n \), of dry sample: 2634.1 g - 1232.1 g = 1402.0 g

\[
\frac{1405.1 \text{ g} - 1402.0 \text{ g}}{1405.1 \text{ g}} \times 100 = 0.22\%
\]

0.22 percent is not less than 0.10 percent, so continue drying

Mass of container and dry sample after third drying cycle: 2633.0 g

Mass, \( M_n \), of dry sample: 2633.0 g - 1232.1 g = 1400.9 g

\[
\frac{1402.0 \text{ g} - 1400.9 \text{ g}}{1402.0 \text{ g}} \times 100 = 0.08\%
\]

0.08 percent is less than 0.10 percent, so constant mass has been reached.
Moisture Content:

Calculate the moisture content, as a percent, using the following formula:

\[ w = \frac{M_{W} - M_{D}}{M_{D}} \times 100 \]

Where:
- \( w \) = moisture content, percent
- \( M_{W} \) = wet mass
- \( M_{D} \) = dry mass

Example:

Mass of container: 1232.1 g
Mass of container and wet sample: 2764.7 g
Mass, \( M_{W} \), of wet sample: 2764.7 g - 1232.1 g = 1532.6 g
Mass of container and dry sample (COOLED): 2633.5 g
Mass, \( M_{D} \), of dry sample: 2633.5 g - 1232.1 g = 1401.4 g

\[ w = \frac{1532.6 \text{ g} - 1401.4 \text{ g}}{1401.4 \text{ g}} \times 100 = \frac{1312 \text{ g}}{1401.4 \text{ g}} \times 100 = 9.36\% \]

Report

- Results on forms approved by the agency
- Sample ID
- \( M_{W} \), wet mass
- \( M_{D} \), dry mass
- \( w \), moisture content to nearest 0.1 percent
PERFORMANCE EXAM CHECKLIST

TOTAL EVAPORABLE MOISTURE CONTENT OF AGGREGATE BY DRYING
FOP FOR AASHTO T 255
LABORATORY DETERMINATION OF MOISTURE CONTENT OF SOILS
FOP FOR AASHTO T 265

Participant Name ___________________________ Exam Date ____________

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.</td>
<td></td>
<td></td>
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<tr>
<td>8.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Comments: First attempt: Pass ____ Fail ____ Second attempt: Pass ____ Fail ____

Examiner Signature ___________________________ WAQTC #: ____________

3_T255_T265_pr_16.docx   E&B/ID 3-9   Pub. October 2017
SPECIFIC GRAVITY AND ABSORPTION OF COARSE AGGREGATE
FOP FOR AASHTO T 85

Scope

This procedure covers the determination of specific gravity and absorption of coarse aggregate in accordance with AASHTO T 85-14. Specific gravity may be expressed as bulk specific gravity ($G_{sb}$), bulk specific gravity, saturated surface dry ($G_{sb\ SSD}$), or apparent specific gravity ($G_{sa}$). $G_{sb}$ and absorption are based on aggregate after soaking in water. This procedure is not intended to be used with lightweight aggregates.

Terminology

Absorption – the increase in the mass of aggregate due to water being absorbed into the pores of the material, but not including water adhering to the outside surface of the particles, expressed as a percentage of the dry mass. The aggregate is considered “dry” when it has been maintained at a temperature of 110 ±5°C (230 ±9°F) for sufficient time to remove all uncombined water.

Saturated Surface Dry (SSD) – condition of an aggregate particle when the permeable voids are filled with water, but no water is present on exposed surfaces.

Specific Gravity – the ratio of the mass, in air, of a volume of a material to the mass of the same volume of gas-free distilled water at a stated temperature.

Apparent Specific Gravity ($G_{sa}$)– the ratio of the mass, in air, of a volume of the impermeable portion of aggregate to the mass of an equal volume of gas-free distilled water at a stated temperature.

Bulk Specific Gravity ($G_{sb}$) – the ratio of the mass, in air, of a volume of aggregate (including the permeable and impermeable voids in the particles, but not including the voids between particles) to the mass of an equal volume of gas-free distilled water at a stated temperature.

Bulk Specific Gravity (SSD) ($G_{sb\ SSD}$) – the ratio of the mass, in air, of a volume of aggregate, including the mass of water within the voids filled to the extent achieved by submerging in water for 15 to 19 hours (but not including the voids between particles), to the mass of an equal volume of gas-free distilled water at a stated temperature.

Apparatus

- Balance or scale: with a capacity of 5 kg, sensitive to 1 g. Meeting the requirements of AASHTO M 231.

- Sample container: a wire basket of 3.35 mm (No. 6) or smaller mesh, with a capacity of 4 to 7 L (1 to 2 gal) to contain aggregate with a nominal maximum size of 37.5 mm (1 1/2 in.) or smaller; or a larger basket for larger aggregates, or both.
• Water tank: watertight and large enough to completely immerse aggregate and basket, equipped with an overflow valve to keep water level constant.

• Suspension apparatus: wire used to suspend apparatus shall be of the smallest practical diameter.

• Sieves 4.75 mm (No. 4) or other sizes as needed, meeting the requirements of FOP for AASHTO T 27/T 11.

• Large absorbent towel

**Sample Preparation**

1. Obtain the sample in accordance with the FOP for AASHTO T 2 (see Note 1).

2. Mix the sample thoroughly and reduce it to the approximate sample size required by Table 1 in accordance with the FOP for AASHTO R 76.

3. Reject all material passing the appropriate sieve by dry sieving.

4. Thoroughly wash sample to remove dust or other coatings from the surface.

5. Dry the test sample to constant mass at a temperature of 110 ±5°C (230 ±9°F) and cool in air at room temperature for 1 to 3 hours.

   *Note 1:* Where the absorption and specific gravity values are to be used in proportioning concrete mixtures in which the aggregates will be in their naturally moist condition, the requirement for initial drying to constant mass may be eliminated, and, if the surfaces of the particles in the sample have been kept continuously wet until test, the 15-to-19 hour soaking may also be eliminated.

6. Re-screen the sample over the appropriate sieve. Reject all material passing that sieve.

7. The sample shall meet or exceed the minimum mass given in Table 1.

   *Note 2:* If this procedure is used only to determine the $G_{sb}$ of oversized material for the FOP for AASHTO T 99 / T 180, the material can be rejected over the appropriate sieve. For T 99 / T 180 Methods A and B, use the 4.75 mm (No. 4) sieve; T 99 / T 180 Methods C and D use the 19 mm (3/4 in).
Table 1

<table>
<thead>
<tr>
<th>Nominal Maximum Size*</th>
<th>Minimum Mass of Test Sample, g (lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>12.5 (1/2) or less</td>
<td>2000 (4.4)</td>
</tr>
<tr>
<td>19.0 (3/4)</td>
<td>3000 (6.6)</td>
</tr>
<tr>
<td>25.0 (1)</td>
<td>4000 (8.8)</td>
</tr>
<tr>
<td>37.5 (1 1/2)</td>
<td>5000 (11)</td>
</tr>
<tr>
<td>50 (2)</td>
<td>8000 (18)</td>
</tr>
<tr>
<td>63 (2 1/2)</td>
<td>12,000 (26)</td>
</tr>
<tr>
<td>75 (3)</td>
<td>18,000 (40)</td>
</tr>
</tbody>
</table>

* One sieve larger than the first sieve to retain more than 10 percent of the material using an agency specified set of sieves based on cumulative percent retained. Where large gaps in specification sieves exist, intermediate sieve(s) may be inserted to determine nominal maximum size.

**Procedure**

1. Immerse the aggregate in water at room temperature for a period of 15 to 19 hours.

   **Note 3:** When testing coarse aggregate of large nominal maximum size requiring large test samples, it may be more convenient to perform the test on two or more subsamples, and then combine the values obtained.

2. Place the empty basket into the water bath and attach to the balance. Inspect the immersion tank to ensure the water level is at the overflow outlet height. Tare the balance with the empty basket attached in the water bath.

3. Remove the test sample from the water and roll it in a large absorbent cloth until all visible films of water are removed. Wipe the larger particles individually. If the test sample dries past the SSD condition, immerse in water for 30 min, and then resume the process of surface-drying.

   **Note 4:** A moving stream of air may be used to assist in the drying operation, but take care to avoid evaporation of water from aggregate pores.

4. Determine the SSD mass of the sample, and record this and all subsequent masses to the nearest 0.1 g or 0.1 percent of the sample mass, whichever is greater. Designate this mass as “B.”

5. Immediately place the SSD test sample in the sample container and weigh it in water maintained at 23.0 ±1.7°C (73.4 ±3°F). Shake the container to release entrapped air before recording the weight. Re-inspect the immersion tank to insure the water level is at the overflow outlet height. Designate this submerged weight as “C.”

   **Note 5:** The container should be immersed to a depth sufficient to cover it and the test sample during mass determination. Wire suspending the container should be of the smallest practical size to minimize any possible effects of a variable immersed length.

6. Remove the sample from the basket. Ensure all material has been removed. Place in a container of known mass.
7. Dry the test sample to constant mass in accordance with the FOP for AASHTO T 255 / T 265 (Aggregate section) and cool in air at room temperature for 1 to 3 hours. Designate this mass as “A.”

**Calculations**

Perform calculations and determine values using the appropriate formula below.

**Bulk specific gravity (G\textsubscript{sb})**

\[
G_{sb} = \frac{AA}{BB - CC}
\]

**Bulk specific gravity, SSD (G\textsubscript{sb SSD})**

\[
G_{sb\ SSD} = \frac{BB}{BB - CC}
\]

**Apparent specific gravity (G\textsubscript{sa})**

\[
G_{sa} = \frac{AA}{AA - CC}
\]

**Absorption**

\[
\text{Absorption} = \frac{BB - AA}{AA} \times 100
\]

Where:

- A = oven dry mass, g
- B = SSD mass, g
- C = weight in water, g

**Sample Calculations**

<table>
<thead>
<tr>
<th>Sample</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>B - C</th>
<th>A - C</th>
<th>B - A</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2030.9</td>
<td>2044.9</td>
<td>1304.3</td>
<td>740.6</td>
<td>726.6</td>
<td>14.0</td>
</tr>
<tr>
<td>2</td>
<td>1820.0</td>
<td>1832.5</td>
<td>1168.1</td>
<td>664.4</td>
<td>651.9</td>
<td>12.5</td>
</tr>
<tr>
<td>3</td>
<td>2035.2</td>
<td>2049.4</td>
<td>1303.9</td>
<td>745.5</td>
<td>731.3</td>
<td>14.2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sample</th>
<th>G\textsubscript{sb}</th>
<th>G\textsubscript{sb SSD}</th>
<th>G\textsubscript{sa}</th>
<th>Absorption</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.742</td>
<td>2.761</td>
<td>2.795</td>
<td>0.7</td>
</tr>
<tr>
<td>2</td>
<td>2.739</td>
<td>2.758</td>
<td>2.792</td>
<td>0.7</td>
</tr>
<tr>
<td>3</td>
<td>2.730</td>
<td>2.749</td>
<td>2.783</td>
<td>0.7</td>
</tr>
</tbody>
</table>
These calculations demonstrate the relationship between $G_{sb}$, $G_{sb\ SSD}$, and $G_{sa}$. $G_{sb}$ is always lowest, since the volume includes voids permeable to water. $G_{sb\ SSD}$ is always intermediate. $G_{sa}$ is always highest, since the volume does not include voids permeable to water. When running this test, check to make sure the values calculated make sense in relation to one another.

**Report**

- Results on forms approved by the agency
- Sample ID
- Specific gravity values to 3 decimal places
- Absorption to 0.1 percent
PERFORMANCE EXAM CHECKLIST

SPECIFIC GRAVITY AND ABSORPTION OF COARSE AGGREGATE
FOP FOR AASHTO T 85

Participant Name ___________________________ Exam Date ____________

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Sample obtained by FOP for AASHTO T 2 and reduced by FOP for AASHTO R 76 or from FOP for AASHTO T 99 / T 180?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>2. Screened on the appropriate size sieve?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>3. Sample mass appropriate?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>4. Particle surfaces clean?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>5. Dried to constant mass 110 ±5°C (230 ±9°F) and cooled to room temperature?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>6. Re-screen over appropriate sieve?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>7. Covered with water for 15 to 19 hours?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>8. Basket placed into immersion tank and attached to balance?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>9. Immersion tank inspected for proper water height?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>10. Balance tared with basket in tank and temperature checked 23.0 ±1.7°C (73.4 ±3°F)?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>11. Sample removed from water and rolled in cloth to remove visible films of water?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>12. Larger particles wiped individually?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>13. Evaporation avoided?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>14. Sample mass determined to 0.1 g?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>15. Sample immediately placed in basket, in immersion tank?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>16. Entrapped air removed before weighing by shaking basket while immersed?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>17. Immersion tank inspected for proper water height?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>18. Immersed sample weight determined to 0.1 g?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>19. All the sample removed from basket?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>20. Sample dried to constant mass and cooled to room temperature?</td>
<td>______</td>
<td>______</td>
</tr>
</tbody>
</table>

OVER
Procedure Element

21. Sample mass determined to 0.1 g?

Trial 1 Trial 2

22. Proper formulas used in calculations?

Comments: First attempt: Pass____Fail____ Second attempt: Pass____Fail____

Examiner Signature________________________ WAQTC #:______________
ONE-POINT METHOD FOR DETERMINING MAXIMUM DRY DENSITY AND OPTIMUM MOISTURE FOP FOR AASHTO T 272

Scope

This procedure provides for a rapid determination of the maximum dry density and optimum moisture content of a soil sample, using a one-point determination in accordance with AASHTO T 272-16. This procedure is related to the FOPs for AASHTO T 99/T 180 and R 75.

One-point determinations are made by compacting the soil in a mold of a given size with a specified rammer dropped from a specified height and then compared to an individual moisture/density curve (FOP for AASHTO T 99 or T 180) or a family of curves (FOP for AASHTO R 75). Four alternate methods – A, B, C, and D – are used and correspond to the methods described in the FOP for AASHTO T 99/T 180. The method used in AASHTO T 272 must match the method used for the reference curve or to establish the family of curves. For example, when moisture-density relationships as determined by T 99 - Method C are used to form the family of curves or an individual moisture density curve, then T 99 - Method C must be used to for the one-point determination.

Apparatus

See the FOP for AASHTO T 99/T 180. Use the method matching the individual curve or Family of Curves. Refer to Table 1 of the FOP for AASHTO T 99 / T 180 for corresponding mold size, number of layers, number of blows, and rammer specification for the various test methods.

Sample

Sample size determined according to the FOP for AASHTO T 310. In cases where the existing individual curve or family cannot be used a completely new curve will need to be developed and the sample size will be determined by the FOP for AASHTO T 99/T 180.

If the sample is damp, dry it until it becomes friable under a trowel. Drying may be in air or by use of a drying apparatus maintained at a temperature not exceeding 60°C (140°F). Thoroughly break up aggregations in a manner that avoids reducing the natural size of individual particles.

Procedure

1. Determine the mass of the clean, dry mold. Include the base plate, but exclude the extension collar. Record the mass to the nearest 1 g (0.005 lb).

2. Thoroughly mix the sample with sufficient water to adjust moisture content to 80 to 100 percent of the anticipated optimum moisture.
3. Form a specimen by compacting the prepared soil in the mold (with collar attached) in approximately equal layers. For each layer:
   a. Spread the loose material uniformly in the mold.
   
   **Note 1:** It is recommended to cover the remaining material with a non-absorbent sheet or damp cloth to minimize loss of moisture.
   
   b. Lightly tamp the loose material with the manual rammer or other similar device, this establishes a firm surface.
   
   c. Compact each layer with uniformly distributed blows from the rammer.
   
   d. Trim down material that has not been compacted and remains adjacent to the walls of the mold and extends above the compacted surface.

4. Remove the extension collar. Avoid shearing off the sample below the top of the mold. The material compacted in the mold should not be over 6 mm (¼ in.) above the top of the mold once the collar has been removed.

5. Trim the compacted soil even with the top of the mold with the beveled side of the straightedge.

6. Determine the mass of the mold and wet soil to the nearest 1 g (0.005 lb) or better.

7. Determine the wet mass of the sample by subtracting the mass in Step 1 from the mass in Step 6.

8. Calculate the wet density as indicated below under “Calculations.”

9. Extrude the material from the mold. For soils and soil-aggregate mixtures, slice vertically through the center and take a representative moisture content sample from one of the cut faces, ensuring that all layers are represented. For granular materials, a vertical face will not exist. Take a representative sample. This sample must meet the sample size requirements of the test method used to determine moisture content.

10. Determine the moisture content of the sample in accordance with the FOP for AASHTO T 255 / T 265.
Calculations

1. Calculate the wet density, in kg/m\(^3\) (lb/ft\(^3\)), by dividing the wet mass by the measured volume of the mold (T 19).

Example – Methods A or C mold:

Wet mass = 2.0055 kg (4.42 lb)

Measured volume of the mold = 0.0009469 m\(^3\) (0.03344 ft\(^3\))

\[
\rho_w = \frac{2.0055 \text{ kg}}{0.0009469 \text{ m}^3} = 2118 \frac{\text{kg}}{\text{m}^3} = 2118 \frac{\text{lb}}{\text{ft}^3}
\]

\[
\rho_w = \frac{4.42 \text{ lb}}{0.03344 \text{ ft}^3} = 132.2 \frac{\text{lb}}{\text{ft}^3}
\]

2. Calculate the dry density as follows.

\[
\rho_d = \frac{\rho_w \times 100}{\rho_w + 100}
\]

Where:

\(\rho_d\) = Dry density, kg/m\(^3\) (lb/ft\(^3\))

\(\rho_w\) = Wet density, kg/m\(^3\) (lb/ft\(^3\))

\(w\) = Moisture content, as a percentage

Example:

\(\rho_w = 2118 \text{ kg/m}^3 \) (132.2 lb/ft\(^3\))

\(w = 13.5\%\)

\[
\rho_d = \frac{2118 \text{ kg/m}^3 \times 100}{13.5 + 100} = 1866 \frac{\text{kg}}{\text{m}^3} = 132.2 \frac{\text{lb}}{\text{ft}^3}
\]

or

\[
\rho_d = \frac{2118 \text{ kg/m}^3}{13.5 + 1} = 1866 \frac{\text{kg}}{\text{m}^3} = 132.2 \frac{\text{lb}}{\text{ft}^3}
\]
Maximum Dry Density and Optimum Moisture Content Determination Using an Individual Moisture / Density Curve

1. The moisture content must be within 80 to 100 percent of optimum moisture of the reference curve. Compact another specimen, using the same material, at an adjusted moisture content if the one-point does not fall in the 80 to 100 percent of optimum moisture range.

2. If the moisture content of the one-point determination is not within 80 to 100 percent of the optimum moisture content, compact another specimen, using the same material, at adjusted moisture content.

3. Plot the one-point, dry density on the vertical axis and moisture content on the horizontal axis, on the reference curve graph.

4. If the one-point falls on the reference curve or within ±2.0 lbs/ft³, then the maximum dry density and optimum moisture content determined by the curve can be used.

5. Perform a full moisture-density relationship if the one-point does not fall on or within ±2.0 lbs/ft³ of the reference curve at 80 to 100 percent optimum moisture.
The results of a one-point determination were 116.5 lb/ft$^3$ at 13.5 percent moisture. The point was plotted on the reference curve graph. The one-point determination is within 2.0 lb/ft$^3$ of the point on the curve that corresponds with the moisture content.
Maximum Dry Density and Optimum Moisture Content Determination Using a Family of Curves

1. If the moisture-density one-point falls on one of the curves in the family of curves, the maximum dry density and optimum moisture content defined by that curve is used.

2. If the moisture-density one-point falls within the family of curves but not on an existing curve, draw a new curve through the plotted single point, parallel and in character with the nearest existing curve in the family of curves. Use the maximum dry density and optimum moisture content as defined by the new curve.

3. The one-point must fall either between or on the highest or lowest curves in the family. If it does not, then a full curve must be developed.

4. If the one-point plotted within or on the family of curves does not fall in the 80 to 100 percent of optimum moisture content, compact another specimen, using the same material, at an adjusted moisture content that will place the one point within this range.

5. If the new curve through a one-point is not well defined or is in any way questionable, perform a full moisture-density relationship to correctly define the new curve and verify the applicability of the family of curves.

Note 2: New curves drawn through plotted single point determinations shall not become a permanent part of the family of curves until verified by a full moisture-density procedure following the FOP for AASHTO T 99/T 180.
The results of a one-point determination were 116.5 lb/ft$^3$ at 13.5 percent moisture. The point was plotted on the reference curve graph. The point was plotted on the appropriate family between two previously developed curves near and intermediate curve.

The “dotted” curve through the moisture-density one-point was sketched between the existing curves. A maximum dry density of 119.3 lb/ft$^3$ and a corresponding optimum moisture content of 15.9 percent were estimated.
Report

- Results on forms approved by the agency
- Sample ID
- Maximum dry density to the closest 1 kg/m³ (0.1 lb/ft³)
- Optimum moisture content to the closest 0.1 percent
- Reference curve or Family of Curves used
**PERFORMANCE EXAM CHECKLIST**

**ONE-POINT METHOD**  
**FOP FOR AASHTO T 272 (T 99)**

Participant Name_________________________ Exam Date ________________

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. One-point determination of dry density and corresponding moisture content made in accordance with the FOP for AASHTO T 99?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Correct size (4.75 mm / No. 4 or 19.0 mm / 3/4 in.) material used?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. If necessary, sample dried until friable in air or drying apparatus, not exceeding 60°C (140°F)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Sample broken up and an adequate amount sieved over the appropriate sieve (4.75 mm / No. 4 or 19.0 mm / 3/4 in.) to determine oversize (coarse particle) percentage?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Sample passing the sieve has appropriate mass?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Layer of soil (approximately one third compacted depth) placed in mold with collar attached, loose material lightly tamped?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Soil compacted with appropriate number of blows (25 or 56)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Material adhering to the inside of the mold trimmed?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Layer of soil (approximately two thirds compacted depth) placed in mold with collar attached, loose material lightly tamped?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Soil compacted with appropriate number of blows (25 or 56)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Material adhering to the inside of the mold trimmed?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Mold filled with soil such that compacted soil will be above the mold, loose material lightly tamped?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Soil compacted with appropriate number of blows (25 or 56)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Collar removed without shearing off sample?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. Approximately 6 mm (1/4 in.) of compacted material above the top of the mold (without the collar)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. Soil trimmed to top of mold with the beveled side of the straightedge?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16. Mass of mold and contents determined to appropriate precision?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17. Wet density calculated from the wet mass?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18. Soil removed from mold using a sample extruder if needed?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19. Soil sliced vertically through center (non-granular material)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20. Moisture sample removed ensuring all layers are represented?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

OVER
# Procedure Element

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>21. Moist mass determined immediately to 0.1 g?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22. Moisture sample mass of correct size?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23. Sample dried and water content determined according to the FOP for T 255/T 265?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24. One-point plotted on family of curves supplied?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25. One-point falls within 80 to 100 percent of optimum moisture content in order to be valid?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>26. If one-point does not fall within 80 to 100 percent of optimum moisture content, another one-point determination with an adjusted water content is made?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>27. Maximum dry density and corresponding optimum moisture content correctly estimated?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Comments:** First attempt: Pass Fail Second attempt: Pass Fail

Examiner Signature_________________________ WAQTC #:_________________
PERFORMANCE EXAM CHECKLIST

ONE-POINT METHOD
FOP FOR AASHTO T 272 (T 180)

Participant Name_____________________________ Exam Date ________________

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. One-point determination of dry density and corresponding moisture content made</td>
<td></td>
<td></td>
</tr>
<tr>
<td>in accordance with the FOP for AASHTO T 180?</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>a. Correct size (4.75 mm / No. 4 or 19.0 mm / 3/4 in.) material used?</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>2. If necessary, sample dried until friable in air or drying apparatus,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>not exceeding 60°C (140°F)?</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>3. Sample broken up and an adequate amount sieved over the appropriate sieve</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(4.75 mm / No. 4 or 19.0 mm / 3/4 in.) to determine oversize (coarse particle)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>percentage?</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>4. Sample passing the sieve has appropriate mass?</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>5. Mold placed on rigid and stable foundation?</td>
<td>_____</td>
<td></td>
</tr>
<tr>
<td>6. Layer of soil (approximately one fifth compacted depth) placed in mold</td>
<td></td>
<td></td>
</tr>
<tr>
<td>with collar attached, loose material lightly tamped?</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>7. Soil compacted with appropriate number of blows (25 or 56)?</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>8. Material adhering to the inside of the mold trimmed?</td>
<td>_____</td>
<td></td>
</tr>
<tr>
<td>9. Layer of soil (approximately two fifths compacted depth) placed in mold</td>
<td></td>
<td></td>
</tr>
<tr>
<td>with collar attached, loose material lightly tamped?</td>
<td></td>
<td>_____</td>
</tr>
<tr>
<td>10. Soil compacted with appropriate number of blows (25 or 56)?</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>12. Material adhering to the inside of the mold trimmed?</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>13. Layer of soil (approximately three fifths compacted depth) placed in mold</td>
<td></td>
<td></td>
</tr>
<tr>
<td>with collar attached, loose material lightly tamped?</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>14. Soil compacted with appropriate number of blows (25 or 56)?</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>15. Material adhering to the inside of the mold trimmed?</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>16. Layer of soil (approximately four fifths compacted depth) placed in mold</td>
<td></td>
<td></td>
</tr>
<tr>
<td>with collar attached, loose material lightly tamped?</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>17. Soil compacted with appropriate number of blows (25 or 56)?</td>
<td>_____</td>
<td>_____</td>
</tr>
<tr>
<td>18. Material adhering to the inside of the mold trimmed?</td>
<td>_____</td>
<td>_____</td>
</tr>
</tbody>
</table>

OVER
**Procedure Element**  
<table>
<thead>
<tr>
<th></th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>19. Mold filled with soil such that compacted soil will be above the mold, loose material lightly tamped?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20. Soil compacted with appropriate number of blows (25 or 56)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>21. Collar removed without shearing off sample?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>22. Approximately 6 mm (1/4 in.) of compacted material above the top of the mold (without the collar)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23. Soil trimmed to top of mold with the beveled side of the straightedge?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24. Mass of mold and contents determined to appropriate precision?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>25. Wet density calculated from the wet mass?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>26. Soil removed from mold using a sample extruder if needed?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>27. Soil sliced vertically through center (non-granular material)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>28. Moisture sample removed ensuring all layers are represented?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>29. Moist mass determined immediately to 0.1 g?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>30. Moisture sample mass of correct size?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>31. Sample dried and water content determined according to the FOP for T 255/T 265?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>32. One-point plotted on family of curves supplied?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>33. One-point falls within 80 to 100 percent of optimum moisture content in order to be valid?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>34. If one-point does not fall within 80 to 100 percent of optimum moisture content, another one-point determination with an adjusted water content is made?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>35. Maximum dry density and corresponding optimum moisture content correctly estimated?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Comments:** First attempt: Pass Fail  Second attempt: Pass Fail

Examiner Signature_________________________ WAQTC #: __________

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5_T272_pr_180_16.docx   E&B/ID 5-12   Pub. October 2017
TOTAL EVAPORABLE MOISTURE CONTENT OF AGGREGATE BY DRYING
FOP FOR AASHTO T 255
LABORATORY DETERMINATION OF MOISTURE CONTENT OF SOILS
FOP FOR AASHTO T 265

Scope

This procedure covers the determination of moisture content of aggregate and soil in accordance with AASHTO T 255-00 and AASHTO T 265-15. It may also be used for other construction materials.

Overview

Moisture content is determined by comparing the wet mass of a sample and the mass of the sample after drying to constant mass. The term constant mass is used to define when a sample is dry.

*Constant mass* – the state at which a mass does not change more than a given percent, after additional drying for a defined time interval, at a required temperature.

Apparatus

- Balance or scale: capacity sufficient for the principle sample mass, accurate to 0.1 percent of sample mass or readable to 0.1 g, and meeting the requirements of AASHTO M 231
- Containers, clean, dry and capable of being sealed
- Suitable drying containers
- Microwave safe container with ventilated lid
- Heat source, controlled:
  - Forced draft oven
  - Ventilated oven
  - Convection oven
- Heat source, uncontrolled:
  - Infrared heater/heat lamp, hot plate, fry pan, or any other device/method that will dry the sample without altering the material being dried
– Microwave oven (900 watts minimum)

- Utensils such as spoons
- Hot pads or gloves

**Sample Preparation**

In accordance with the FOP for AASHTO T 2 obtain a representative sample in its existing condition.

For aggregates the representative sample size is based on Table 1 or other information that may be specified by the agency.

<table>
<thead>
<tr>
<th>Nominal Maximum Size* mm (in.)</th>
<th>Minimum Sample Mass g (lb)</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.75 (No. 4)</td>
<td>500 (1.1)</td>
</tr>
<tr>
<td>9.5 (3/8)</td>
<td>1500 (3.3)</td>
</tr>
<tr>
<td>12.5 (1/2)</td>
<td>2000 (4)</td>
</tr>
<tr>
<td>19.0 (3/4)</td>
<td>3000 (7)</td>
</tr>
<tr>
<td>25.0 (1)</td>
<td>4000 (9)</td>
</tr>
<tr>
<td>37.5 (1 1/2)</td>
<td>6000 (13)</td>
</tr>
<tr>
<td>50 (2)</td>
<td>8000 (18)</td>
</tr>
<tr>
<td>63 (2 1/2)</td>
<td>10,000 (22)</td>
</tr>
<tr>
<td>75 (3)</td>
<td>13,000 (29)</td>
</tr>
<tr>
<td>90 (3 1/2)</td>
<td>16,000 (35)</td>
</tr>
<tr>
<td>100 (4)</td>
<td>25,000 (55)</td>
</tr>
<tr>
<td>150 (6)</td>
<td>50,000 (110)</td>
</tr>
</tbody>
</table>

* One sieve larger than the first sieve to retain more than 10 percent of the material using an agency specified set of sieves based on cumulative percent retained. Where large gaps in specification sieves exist, intermediate sieve(s) may be inserted to determine nominal maximum.
For soils the representative sample size is based on Table 2 or other information that may be specified by the agency.

### TABLE 2
Sample Sizes for Moisture Content of Soil

<table>
<thead>
<tr>
<th>Maximum Particle Size mm (in)</th>
<th>Minimum Sample Mass g</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.425 (No. 40)</td>
<td>10</td>
</tr>
<tr>
<td>4.75 (No. 4)</td>
<td>100</td>
</tr>
<tr>
<td>12.5 (1/2)</td>
<td>300</td>
</tr>
<tr>
<td>25.0 (1)</td>
<td>500</td>
</tr>
<tr>
<td>50 (2)</td>
<td>1000</td>
</tr>
</tbody>
</table>

Immediately seal or cover samples to prevent any change in moisture content or follow the steps in “Procedure.”

### Procedure

Determine and record the sample mass as follows:

- For aggregate, determine and record all masses to the nearest 0.1 percent of the sample mass or to the nearest 0.1 g.

- For soil, determine and record all masses to the nearest 0.1 g.

When determining the mass of hot samples or containers or both, place and tare a buffer between the sample container and the balance. This will eliminate damage to or interference with the operation of the balance or scale.

1. Determine and record the mass of the container (and lid for microwave drying).

2. Place the wet sample in the container.
   a. For oven(s), hot plates, infrared heaters, etc.: Spread the sample in the container.
   b. For microwave oven: Heap sample in the container; cover with ventilated lid.

3. Determine and record the total mass of the container and wet sample.

4. Determine and record the wet mass of the sample by subtracting the container mass determined in Step 1 from the mass of the container and sample determined in Step 3.
5. Place the sample in one of the following drying apparatus:
   a. For aggregate –
      i. Controlled heat source (oven): at 110 ±5°C (230 ±9°F).
      ii. Uncontrolled heat source (Hot plate, infrared heater, etc.): Stir frequently to avoid localized overheating.
   b. For soil – controlled heat source (oven): at 110 ±5°C (230 ±9°F).

   *Note 1:* Soils containing gypsum or significant amounts of organic material require special drying. For reliable moisture contents dry these soils at 60°C (140°F). For more information see AASHTO T 265, Note 2.

6. Dry until sample appears moisture free.

7. Determine mass of sample and container.

8. Determine and record the mass of the sample by subtracting the container mass determined in Step 1 from the mass of the container and sample determined in Step 7.

9. Return sample and container to the heat source for additional drying.
   a. For aggregate –
      i. Controlled heat source (oven): 30 minutes
      ii. Uncontrolled heat source (Hot plate, infrared heater, etc.): 10 minutes
      iii. Uncontrolled heat source (Microwave oven): 2 minutes

   *Caution:* Some minerals in the sample may cause the aggregate to overheat, altering the aggregate gradation.
   b. For soil – controlled heat source (oven): 1 hour

10. Determine mass of sample and container.

11. Determine and record the mass of the sample by subtracting the container mass determined in Step 1 from the mass of the container and sample determined in Step 10.
12. Determine percent change by subtracting the new mass determination ($M_n$) from the previous mass determination ($M_p$) divide by the previous mass determination ($M_p$) multiply by 100.

13. Continue drying, performing steps 9 through 12, until there is less than a 0.10 percent change after additional drying time.

14. Constant mass has been achieved, sample is defined as dry.

15. Allow the sample to cool. Immediately determine and record the total mass of the container and dry sample.

16. Determine and record the dry mass of the sample by subtracting the mass of the container determined in Step 1 from the mass of the container and sample determined in Step 15.

17. Determine and record percent moisture by subtracting the final dry mass determination ($M_D$) from the initial wet mass determination ($M_W$) divide by the final dry mass determination ($M_D$) multiply by 100.

<table>
<thead>
<tr>
<th>Table 3</th>
<th>Methods of Drying</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aggregate</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Heat Source</strong></td>
<td><strong>Specific Instructions</strong></td>
</tr>
<tr>
<td>Controlled:</td>
<td></td>
</tr>
<tr>
<td>Forced draft (preferred), ventilated, or convection oven</td>
<td>110 ±5°C (230 ±9°F)</td>
</tr>
<tr>
<td>Uncontrolled:</td>
<td></td>
</tr>
<tr>
<td>Hot plate, infrared heater, etc.</td>
<td>Stir frequently</td>
</tr>
<tr>
<td>Microwave</td>
<td>Heap sample and cover with ventilated lid</td>
</tr>
<tr>
<td><strong>Soil</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Heat Source</strong></td>
<td><strong>Specific Instructions</strong></td>
</tr>
<tr>
<td>Controlled:</td>
<td></td>
</tr>
<tr>
<td>Forced draft (preferred), ventilated, or convection oven</td>
<td>110 ±5°C (230 ±9°F)</td>
</tr>
</tbody>
</table>
Calculation

Constant Mass:

Calculate constant mass using the following formula:

\[
\frac{MM_p - MM_n}{MM_p} \times 100 = \% \text{ Change}
\]

Where:  
\( M_p \) = previous mass measurement  
\( M_n \) = new mass measurement

Example:

Mass of container: 1232.1 g  
Mass of container and sample after first drying cycle: 2637.2 g  
Mass, \( M_p \), of possibly dry sample: 2637.2 g - 1232.1 g = 1405.1 g  
Mass of container and dry sample after second drying cycle: 2634.1 g  
Mass, \( M_n \), of dry sample: 2634.1 g - 1232.1 g = 1402.0 g

\[
\frac{1405.1 \, gg - 1402.0 \, gg}{1405.1 \, gg} \times 100 = 0.22\% 
\]

0.22 percent is not less than 0.10 percent, so continue drying

Mass of container and dry sample after third drying cycle: 2633.0 g  
Mass, \( M_n \), of dry sample: 2633.0 g - 1232.1 g = 1400.9 g

\[
\frac{1402.0 \, gg - 1400.9 \, gg}{1402.0 \, gg} \times 100 = 0.08\% 
\]

0.08 percent is less than 0.10 percent, so constant mass has been reached.
Moisture Content:

Calculate the moisture content, as a percent, using the following formula:

\[ w = \frac{MM_{WW} - MM_{DD}}{MM_{DD}} \times 100 \]

Where:
- \( w \) = moisture content, percent
- \( MM_{WW} \) = wet mass
- \( MM_{DD} \) = dry mass

Example:

Mass of container: 1232.1 g
Mass of container and wet sample: 2764.7 g
Mass, \( MM_{WW} \), of wet sample: 2764.7 g - 1232.1 g = 1532.6 g
Mass of container and dry sample (COOLED): 2633.5 g
Mass, \( MM_{DD} \), of dry sample: 2633.5 g - 1232.1 g = 1401.4 g

\[ w = \frac{1532.6 \text{ g} - 1401.4 \text{ g}}{1401.4 \text{ g}} \times 100 = \frac{1312\text{ g}}{1401.4 \text{ g}} \times 100 = 9.36\% \text{ nearest } 9.4\% \]

Report

- Results on forms approved by the agency
- Sample ID
- \( MM_{WW} \), wet mass
- \( MM_{DD} \), dry mass
- \( w \), moisture content to nearest 0.1 percent
PERFORMANCE EXAM CHECKLIST

TOTAL EVAPORABLE MOISTURE CONTENT OF AGGREGATE BY DRYING
FOP FOR AASHTO T 255
LABORATORY DETERMINATION OF MOISTURE CONTENT OF SOILS
FOP FOR AASHTO T 265

Participant Name ___________________________ Exam Date __________

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Representative sample of appropriate mass obtained?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>2. Mass of container determined to 0.1 g?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>3. Sample placed in container and mass determined to 0.1 g?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>4. Test sample mass conforms to the required mass?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>5. Wet sample mass determined to 0.1 g?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>6. Loss of moisture avoided prior to mass determination?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>7. Sample dried by a suitable heat source?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>8. If aggregate heated by means other than a controlled oven, is sample stirred to avoid localized overheating?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>9. For aggregate: Is aggregate heated for the additional, specified time (forced draft, ventilated, convection – 30 minutes; microwave – 2 minutes; other 10 minutes) and then mass determined and compared to previous mass showing less than 0.10 percent loss?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>10. For soil: Is soil heated for at least 1 hour additional drying time and then mass determined and compared to previous mass - showing less than 0.10 percent loss?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>11. Sample cooled, dry mass determined and recorded to the nearest 0.1 percent?</td>
<td>______</td>
<td>______</td>
</tr>
<tr>
<td>12. Moisture content calculated correctly and recorded to the nearest 0.1 percent?</td>
<td>______</td>
<td>______</td>
</tr>
</tbody>
</table>

Comments: First attempt: Pass _____ Fail _____ Second attempt: Pass _____ Fail _____

Examiner Signature _______________________________ WAQTC #: __________

6_T255_T265_pr_16.docx E&B/ID 6-9 Pub. October 2017
IN-PLACE DENSITY AND MOISTURE CONTENT OF SOIL AND SOIL-AGGREGATE BY NUCLEAR METHODS (SHALLOW DEPTH)
FOP FOR AASHTO T 310

Scope

This procedure covers the determination of density, moisture content, and relative compaction of soil, aggregate, and soil-aggregate mixes in accordance with AASHTO T 310-13. This field operating procedure is derived from AASHTO T 310. The nuclear moisture-density gauge is used in the direct transmission mode.

Apparatus

- Nuclear density gauge with the factory matched standard reference block.
- Drive pin, guide/scaper plate, and hammer for testing in direct transmission mode.
- Transport case for properly shipping and housing the gauge and tools.
- Instruction manual for the specific make and model of gauge.
- Radioactive materials information and calibration packet containing:
  - Daily Standard Count Log.
  - Factory and Laboratory Calibration Data Sheet.
  - Leak Test Certificate.
  - Shippers Declaration for Dangerous Goods.
  - Procedure Memo for Storing, Transporting and Handling Nuclear Testing Equipment.
  - Other radioactive materials documentation as required by local regulatory requirements.
- Sealable containers and utensils for moisture content determinations.

Radiation Safety

This method does not purport to address all of the safety problems associated with its use. This test method involves potentially hazardous materials. The gauge utilizes radioactive materials that may be hazardous to the health of the user unless proper precautions are taken. Users of this gauge must become familiar with the applicable safety procedures and governmental regulations. All operators will be trained in radiation safety prior to operating.
nuclear density gauges. Some agencies require the use of personal monitoring devices such as a thermoluminescent dosimeter or film badge. Effective instructions together with routine safety procedures such as source leak tests, recording and evaluation of personal monitoring device data, etc., are a recommended part of the operation and storage of this gauge.

**Calibration**

Calibrate the nuclear gauge as required by the agency. This calibration may be performed by the agency using manufacturer’s recommended procedures or by other facilities approved by the agency. Verify or re-establish calibration curves, tables, or equivalent coefficients every 12 months.

**Standardization**

1. Turn the gauge on and allow it to stabilize (approximately 10 to 20 minutes) prior to standardization. Leave the power on during the day’s testing.

2. Standardize the nuclear gauge at the construction site at the start of each day’s work and as often as deemed necessary by the operator or agency. Daily variations in standard count shall not exceed the daily variations established by the manufacturer of the gauge. If the daily variations are exceeded after repeating the standardization procedure, the gauge should be repaired and/or recalibrated.

3. Record the standard count for both density and moisture in the Daily Standard Count Log. The exact procedure for standard count is listed in the manufacturer’s Operator’s Manual.

*Note 1:* New standard counts may be necessary more than once a day. See agency requirements.

**Overview**

There are two methods for determining in-place density of soil / soil aggregate mixtures. See agency requirements for method selection.

- Method A Single Direction
- Method B Two Direction

**Procedure**

1. Select a test location(s) randomly and in accordance with agency requirements. Test sites should be relatively smooth and flat and meet the following conditions:
   a. At least 10 m (30 ft) away from other sources of radioactivity
   b. At least 3 m (10 ft) away from large objects
c. The test site should be at least 150 mm (6 in.) away from any vertical projection, unless the gauge is corrected for trench wall effect.

2. Remove all loose and disturbed material, and remove additional material as necessary to expose the top of the material to be tested.

3. Prepare a flat area sufficient in size to accommodate the gauge. Plane the area to a smooth condition so as to obtain maximum contact between the gauge and the material being tested. For Method B, the flat area must be sufficient to permit rotating the gauge 90 or 180 degrees about the source rod.

4. Fill in surface voids beneath the gauge with fines of the material being tested passing the 4.75 mm (No. 4) sieve or finer. Smooth the surface with the guide plate or other suitable tool. The depth of the filler should not exceed approximately 3 mm (1/8 in.).

5. Make a hole perpendicular to the prepared surface using the guide plate and drive pin. The hole shall be at least 50 mm (2 in.) deeper than the desired probe depth, and shall be aligned such that insertion of the probe will not cause the gauge to tilt from the plane of the prepared area. Remove the drive pin by pulling straight up and twisting the extraction tool.

6. Place the gauge on the prepared surface so the source rod can enter the hole without disturbing loose material.

7. Insert the probe in the hole and lower the source rod to the desired test depth using the handle and trigger mechanism.

8. Seat the gauge firmly by partially rotating it back and forth about the source rod. Ensure the gauge is seated flush against the surface by pressing down on the gauge corners, and making sure that the gauge does not rock.

9. Pull gently on the gauge to bring the side of the source rod nearest to the scaler/detector firmly against the side of the hole.

10. Perform one of the following methods, per agency requirements:

   a. Method A Single Direction: Take a test consisting of the average of two, one-minute readings, and record both density and moisture data. The two wet density readings should be within 32 kg/m$^3$ (2.0 lb/ft$^3$) of each other. The average of the two wet densities and moisture contents will be used to compute dry density.

   b. Method B Two Direction: Take a one-minute reading and record both density and moisture data. Rotate the gauge 90 or 180 degrees, pivoting it around the source rod. Reseat the gauge by pulling gently on the gauge to bring the side of the source rod nearest to the scaler/detector firmly against the side of the hole.
hole and take a one-minute reading. (In trench locations, rotate the gauge 180 degrees for the second test.) Some agencies require multiple one-minute readings in both directions. Analyze the density and moisture data. A valid test consists of wet density readings in both gauge positions that are within 50 kg/m³ (3.0 lb/ft³). If the tests do not agree within this limit, move to a new location. The average of the wet density and moisture contents will be used to compute dry density.

11. If required by the agency, obtain a representative sample of the material, 4 kg (9 lb) minimum, from directly beneath the gauge full depth of material tested. This sample will be used to verify moisture content and / or identify the correct density standard. Immediately seal the material to prevent loss of moisture.

The material tested by direct transmission can be approximated by a cylinder of soil approximately 300 mm (12 in.) in diameter directly beneath the centerline of the radioactive source and detector. The height of the cylinder will be approximately the depth of measurement. When organic material or large aggregate is removed during this operation, disregard the test information and move to a new test site.

12. To verify the moisture content from the nuclear gauge, determine the moisture content with a representative portion of the material using the FOP for AASHTO T 255/T 265 or other agency approved methods. If the moisture content from the nuclear gauge is within ±1 percent, the nuclear gauge readings can be accepted. Moisture content verification is gauge and material specific. Retain the remainder of the sample at its original moisture content for a one-point compaction test under the FOP for AASHTO T 272, or for gradation, if required.

Note 2: Example: A gauge reading of 16.8 percent moisture and an oven dry of 17.7 percent are within the ±1 percent requirements. Moisture correlation curves will be developed according to agency guidelines. These curves should be reviewed and possibly redeveloped every 90 days.

13. Determine the dry density by one of the following.

   a. From nuclear gauge readings, compute by subtracting the mass (weight) of the water (kg/m³ or lb/ft³) from the wet density (kg/m³ or lb/ft³) or compute using the percent moisture by dividing wet density from the nuclear gauge by 1 + moisture content expressed as a decimal.

   b. When verification is required and the nuclear gauge readings cannot be accepted, the moisture content is determined by the FOP for AASHTO T 255/T 265 or other agency approved methods. Compute dry density by dividing wet density from the nuclear gauge by 1 + moisture content expressed as a decimal.

**Percent Compaction**

- Percent compaction is determined by comparing the in-place dry density as determined by this procedure to the appropriate agency density standard. For soil or soil-aggregate
mixes, these are moisture-density curves developed using the FOP for AASHTO T 99/T 180. When using maximum dry densities from the FOP for AASHTO T 99/T 180 or FOP for AASHTO T 272, it may be necessary to use the Annex in the FOP for T 99/T 180 to determine corrected maximum dry density and optimum moisture content.

For coarse granular materials, the density standard may be density-gradation curves developed using a vibratory method such as AKDOT&PF’s ATM 212, ITD’s T 74, WSDOT’s TM 606, or WFLHD’s Humphres.

See appropriate agency policies for use of density standards.

**Calculation**

Wet density readings from gauge: 1963 kg/m$^3$ (121.6 lb/ft$^3$)  
1993 kg/m$^3$ (123.4 lb/ft$^3$)  
Avg: 1978 kg/m$^3$ (122.5 lb/ft$^3$)

**Moisture readings from gauge: 14.2% and 15.4% = Avg 14.8%**

Moisture content from the FOP’s for AASHTO T 255/ T 265: 15.9%

**Moisture content is greater than 1 percent different so the gauge moisture cannot be used.**

Calculate the dry density as follows:

\[
p_d = \frac{\rho_d}{\rho_{ww}} \times 100 \frac{\rho_{ww}}{100 + 1}
\]

Where:

\[
\rho_d = \text{Dry density, kg/m}^3 (\text{lb/ft}^3) \\
\rho_{ww} = \text{Wet density, kg/m}^3 (\text{lb/ft}^3) \\
w = \text{Moisture content from the FOP’s for AASHTO T 255 / T 265, as a percentage}
\]

\[
\rho_{dd} = \frac{1978 \text{ kg/m}^3}{15.9 + 100} \times 100 \frac{15.9}{100 + 1}
\]

Corrected for moisture Dry Density: 1707 kg/m$^3$ (105.7 lb/ft$^3$)
Calculate percent compaction as follows:

\[
\% \text{ Compaction} = \frac{\rho d}{\text{Agency density standard}} \times 100
\]

Example:

\[
\% \text{ Compaction} = \frac{105.7 \text{ lb/ft}^3}{111.3 \text{ lb/ft}^3} \times 100 = 95\%
\]

Where:
- \(\rho_d\) = Dry density, kg/m\(^3\) (lb/ft\(^3\))
- Agency density standard = Corrected maximum dry density from the FOP from T 99/T 180 Annex

**Report**

- Results on forms approved by the agency
- Sample ID
- Location of test, elevation of surface, and thickness of layer tested.
- Visual description of material tested.
- Make, model and serial number of the nuclear moisture-density gauge.
- Wet density to 0.1 lb/ft\(^3\).
- Moisture content as a percent, by mass, of dry soil mass to 0.1 percent.
- Dry density to 0.1 lb/ft\(^3\).
- Density standard to 0.1 lb/ft\(^3\).
- Percent compaction.
- Name and signature of operator.
PERFORMANCE EXAM CHECKLIST

IN-PLACE DENSITY AND MOISTURE CONTENT OF SOIL AND SOIL-AGGREGATE BY NUCLEAR METHODS (SHALLOW DEPTH)
FOP FOR AASHTO T 310

Participant Name___________________________ Exam Date ______________

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Gauge turned on 10 to 20 minutes before use?</td>
<td>_______</td>
<td>_______</td>
</tr>
<tr>
<td>2. Calibration verified?</td>
<td>_______</td>
<td>_______</td>
</tr>
<tr>
<td>3. Standard count taken and recorded in accordance with manufacturer’s instructions?</td>
<td>_______</td>
<td>_______</td>
</tr>
<tr>
<td>4. Test location selected appropriately 10 m (30 ft.) from other radioactive sources, 3 m (10 ft.) from large objects, 150 mm (6 in.) away from vertical projections?</td>
<td>_______</td>
<td>_______</td>
</tr>
<tr>
<td>5. Loose, disturbed material removed?</td>
<td>_______</td>
<td>_______</td>
</tr>
<tr>
<td>6. Flat, smooth area prepared?</td>
<td>_______</td>
<td>_______</td>
</tr>
<tr>
<td>7. Surface voids filled with native fines (-No. 4) to 3 mm (1/8 in.) maximum thickness?</td>
<td>_______</td>
<td>_______</td>
</tr>
<tr>
<td>8. Hole driven 50 mm (2 in.) deeper than probe depth?</td>
<td>_______</td>
<td>_______</td>
</tr>
<tr>
<td>9. Gauge placed, probe placed, and source rod lowered without disturbing loose material?</td>
<td>_______</td>
<td>_______</td>
</tr>
<tr>
<td>10. Method A:</td>
<td>_______</td>
<td>_______</td>
</tr>
<tr>
<td>a. Gauge firmly seated, and gently pulled back so that the source rod is against the side of the hole toward the scaler / detectors?</td>
<td>_______</td>
<td>_______</td>
</tr>
<tr>
<td>b. Two, one-minute reading taken; wet density within 32 kg/m$^3$ (2.0 lb/ft$^3$)?</td>
<td>_______</td>
<td>_______</td>
</tr>
<tr>
<td>c. Density and moisture data averaged?</td>
<td>_______</td>
<td>_______</td>
</tr>
<tr>
<td>11. Method B:</td>
<td>_______</td>
<td>_______</td>
</tr>
<tr>
<td>a. Gauge firmly seated, and gently pulled back so that the source rod is against the side of the hole toward the scaler / detectors?</td>
<td>_______</td>
<td>_______</td>
</tr>
<tr>
<td>b. A minimum of a one-minute reading taken; density and moisture data recorded?</td>
<td>_______</td>
<td>_______</td>
</tr>
<tr>
<td>c. Gauge turned 90° or 180° (180° in trench)?</td>
<td>_______</td>
<td>_______</td>
</tr>
</tbody>
</table>

OVER
### Procedure Element

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>d. Gauge firmly seated, and gently pulled back so that the source rod is against</td>
<td></td>
<td></td>
</tr>
<tr>
<td>the side of the hole toward the scaler / detectors?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. A minimum of a one-minute reading taken; density and moisture data recorded?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>f. Wet densities within 50 kg/m³ (3.0 lb/ft³)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>g. Density and moisture data averaged?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Representative sample (4 kg or 9 lb) obtained from test location?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Sample sealed immediately to prevent moisture loss?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. Moisture content correctly determined using other means than the nuclear</td>
<td></td>
<td></td>
</tr>
<tr>
<td>density gauge reading?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. Dry Density calculated using proper moisture content?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16. Percent compaction calculated correctly?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Comments:

First attempt: Pass Fail  
Second attempt: Pass Fail

Examiner Signature________________________ WAQTC #: ________________
FOP for AASHTO T 310

In-Place Density and Moisture Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

Procedure.

**Add** the following to Step 12:

For each soil or material type, the average moisture content of at least seven (7) consecutive tests is calculated to indicate the density gauge is reading the moisture content within a tolerance of 1% moisture content of the actual AASHTO T 255/265 test results. If the average moisture content exceeds the 1% tolerance, a moisture correction is applied. If less than seven density tests are required for a specific material type, then the percent moisture is determined by performing AASHTO T 255/265.

Percent Compaction.

Delete the entire section and substitute the following:

- Percent compaction is determined by comparing the in-place dry density as determined by this procedure to the appropriate density standard. For soil or soil-aggregate mixes, these are moisture-density curves developed using the FOP for AASHTO T 99/ FOP for AASHTO T 180. When using curves developed by the FOP for AASHTO T 99 / FOP for AASHTO T 180, it may be necessary to use the Annex of FOP for AASHTO T 99 / FOP for AASHTO T 180 and FOP for AASHTO T 272 to determine maximum density and moisture determinations.

- When the maximum density standard is from AASHTO T 99 or AASHTO T 180, a one-point determination per AASHTO T 272 is performed for every AASHTO T 310 compaction test to select the proper individual moisture-density curve or family of curves, including correction for coarse aggregate when necessary.

- A family of curves developed per AASHTO R75 may be used to determine the maximum density standard only if the moisture density curves were developed with material from the same geologic source area with concurrence from the District Materials Engineer.

- For coarse granular materials, the maximum density standard may be density-gradation curve developed using a vibratory method such as AKDOT&PF’s ATM 212, ITD’s T 74, WSDOT’s TM 606, or WFLHD’s Humphres.

Granular Materials and Processed Aggregates above Subgrade

- For Idaho T 74 curve, the standard density is the maximum dry density corresponding to the percent passing the No. 4 sieve. A laboratory density curve is used (produced) that represents the granular material or processed aggregate.

- Obtain a representative sample directly beneath the gauge. The sample size will be determined by the nominal maximum aggregate size from the table in AASHTO T255.

- Determine moisture content in accordance with AASHTO T255.
- Perform a field gradation test using the representative dry sample. Shake the sample over the No. 4 sieve. Hand shaking must continue until not more than 0.5 percent by mass of the total sample passes the sieve during one minute of continuous shaking. No wash is required.
  - When large aggregate is present, use a 1 inch buffer sieve.
  - Do not overload the No. 4 sieve.
- Use the IT 74 laboratory curve to find the maximum dry density at the percent passing No. 4 sieve. Divide the in place dry density by the maximum dry density to determine the compaction percent.
- A new Idaho T 74 curve must be provided annually for existing stockpiles or for new stockpiles of processed material.
- A field gradation test is not required for each density test if the nuclear density gauge has been calibrated for moisture correction and the gauge in place dry density reading is equal to or greater than 95% (94.6 rounded) at the peak point of the Idaho T 74 curve.
- A compaction test result over 105% is not considered valid. The material and calculations must be evaluated to resolve the cause of this type of test result.
IN-PLACE DENSITY OF ASPHALT MIXTURES BY NUCLEAR METHOD
FOP FOR AASHTO T 355

Scope

This test method describes a procedure for determining the density of asphalt mixtures by means of a nuclear gauge using the backscatter method in accordance with AASHTO T 355-16. Correlation with densities determined under the FOP for AASHTO T 166 is required by some agencies.

Apparatus

- Nuclear density gauge with the factory-matched standard reference block.
- Transport case for properly shipping and housing the gauge and tools.
- Instruction manual for the specific make and model of gauge.
- Radioactive materials information and calibration packet containing:
  - Daily standard count log
  - Factory and laboratory calibration data sheet
  - Leak test certificate
  - Shippers’ declaration for dangerous goods
  - Procedure memo for storing, transporting and handling nuclear testing equipment
  - Other radioactive materials documentation as required by local regulatory requirements

Material

- Filler material: Fine-graded sand from the source used to produce the asphalt pavement or other agency approved materials.

Radiation Safety

This method does not purport to address all of the safety problems associated with its use. This test method involves potentially hazardous materials. The gauge utilizes radioactive materials that may be hazardous to the health of the user unless proper precautions are taken. Users of this gauge must become familiar with the applicable safety procedures and governmental regulations. All operators will be trained in radiation safety prior to operating nuclear density gauges. Some agencies require the use of personal monitoring devices such
as a thermoluminescent dosimeter or film badge. Effective instructions, together with routine safety procedures such as source leak tests, recording and evaluation of personal monitoring device data, etc., are a recommended part of the operation and storage of this gauge.

**Calibration**

Calibrate the nuclear gauge as required by the agency. This calibration may be performed by the agency using the manufacturer’s recommended procedures or by other facilities approved by the agency. Verify or re-establish calibration curves, tables, or equivalent coefficients every 12 months.

**Standardization**

1. Turn the gauge on and allow it to stabilize (approximately 10 to 20 minutes) prior to standardization. Leave the power on during the day’s testing.

2. Standardize the nuclear gauge at the construction site at the start of each day’s work and as often as deemed necessary by the operator or agency. Daily variations in standard count shall not exceed the daily variations established by the manufacturer of the gauge. If the daily variations are exceeded after repeating the standardization procedure, the gauge should be repaired, recalibrated, or both.

3. Record the standard count for both density and moisture in the daily standard count log. The exact procedure for standard count is listed in the manufacturer’s Operator’s Manual.

*Note 1:* New standard counts may be necessary more than once a day. See agency requirements.

**Test Site Location**

1. Select a test location(s) randomly and in accordance with agency requirements. Test sites should be relatively smooth and flat and meet the following conditions:
   
   a. At least 10 m (30 ft.) away from other sources of radioactivity.
   
   b. At least 3 m (10 ft.) away from large objects.
   
   c. If the gauge will be closer than 600 mm (24 in.) to any vertical mass, or less than 300 mm (12 in.) from a vertical pavement edge, use the gauge manufacturer’s correction procedure.
Procedure

1. Maintain maximum contact between the base of the gauge and the surface of the material under test. Use filler material to fill surface voids. Spread a small amount of filler material over the test site surface and distribute it evenly. Strike off the surface with a straightedge (such as a lathe or flat-bar steel) to remove excess material.

2. Place the gauge on the test site, perpendicular to the roller passes. Using a crayon (not spray paint), mark the outline or footprint of the gauge. Extend the probe to the backscatter position.

3. Take a one-minute test and record the wet density reading.

4. Rotate the gauge 90 degrees centered over the original footprint. Mark the outline or footprint of the gauge.

5. Take another one-minute test and record the wet density reading.

6. If the difference between the two one-minute tests is greater than 40 kg/m$^3$ (2.5 lb/ft$^3$), retest in both directions. If the difference of the retests is still greater than 40 kg/m$^3$ (2.5 lb/ft$^3$) test at 180 and 270 degrees.

7. The density reported for each test site shall be the average of the two individual one-minute wet density readings.
Calculation of Results

Percent compaction is determined by comparing the in-place wet density as determined by this method to the appropriate agency density standard. See appropriate agency policy for use of density standards.

Example:

Reading #1: 141.5 lb/ft³
Reading #2: 140.1 lb/ft³  Are the two readings within the tolerance? (YES)
Reading average: 140.8 lb/ft³
Core correction : +2.1 lb/ft³
Corrected reading: 142.9 lb/ft³

From the FOP for AASHTO T 209:

\[ G_{mm} = 2.466 \]

\[ \frac{142.9 \text{ lb/ft}^3}{153.5 \text{ lb/ft}^3} \times 100 = 93.1\% \]

Report

- Results on forms approved by the agency
- Test ID
- Location of test and thickness of layer tested
- Mixture type
- Make, model and serial number of the nuclear moisture-density gauge
- Calculated wet density of each measurement and any adjustment data
- Density standard
- Compaction 0.1 percent
- Name and signature of operator
APPENDIX – CORRELATION WITH CORES

(Nonmandatory Information)

The Bulk Specific Gravity ($G_{mb}$) of the core is a physical measurement of the in-place HMA and can be compared with the nuclear density gauge readings. Comparing the core value to the corresponding gauge values, a correlation can be established.

The correlation can then be used to adjust the gauge readings to the in-place density of the cores. The core correlation is gauge specific and must be determined without traffic allowed on the pavement between nuclear density gauge readings and obtaining the core. When using multiple nuclear density gauges each gauge should be correlated to the core locations prior to removal of the core.

When density correlation with the FOP for AASHTO T 166 is required, correlation of the nuclear gauge with pavement cores shall be made on the first day’s paving (within 24 hours) or from a test strip constructed prior to the start of paving. Cores must be taken before traffic is allowed on the pavement.

Correlation with Cores

1. Determine the number of cores required for correlation from the agency’s specifications. Cores shall be located on the first day’s paving or on the test strip. Locate the test sites in accordance with the agency’s specifications. Follow the “Procedure” section above to establish test sites and obtain densities using the nuclear gauge.

2. Obtain a pavement core from each of the test sites according to AASHTO R 67. The core should be taken from the center of the nuclear gauge footprint.

Footprint of the gauge test site. Core location in the center of the footprint.
3. Determine the density of the cores by the FOP for AASHTO T 166, Bulk Specific Gravity of Compacted Asphalt Mixtures Using Saturated Surface Dry Specimens.

4. Calculate a correlation factor for the nuclear gauge reading as follows:

   a. Calculate the difference between the core density and the average nuclear gauge density at each test site to the nearest 1 kg/m$^3$ (0.1 lb/ft$^3$). Calculate the average difference and standard deviation of the differences for the entire data set to the nearest 1 kg/m$^3$ (0.1 lb/ft$^3$).

   b. If the standard deviation of the differences is equal to or less than 40 kg/m$^3$ (2.5 lb/ft$^3$), the correlation factor applied to the average nuclear gauge density shall be the average difference calculated above in 4.a.

   c. If the standard deviation of the differences is greater than 40 kg/m$^3$ (2.5 lb/ft$^3$), the test site with the greatest variation from the average difference shall be eliminated from the data set and the data set properties and correlation factor recalculated following 4.a and 4.b.

   d. If the standard deviation of the modified data set still exceeds the maximum specified in 4.b, additional test sites will be eliminated from the data set and the data set properties and correlation factor recalculated following 4.a and 4.b. If the data set consists of less than five test sites, additional test sites shall be established.

   Note A1: The exact method used in calculating the nuclear gauge correlation factor shall be defined by agency policy.

   Note A2: The above correlation procedure must be repeated if there is a new job mix formula. Adjustments to the job mix formula beyond tolerances established in the contract documents will constitute a new job mix formula. A correlation factor established using this procedure is only valid for the particular gauge and at the probe depth used in the correlation procedure. If another gauge is brought onto the project, it shall be correlated using the same procedure. Multiple gauges may be correlated from the same series of cores if done at the same time.

   Note A3: For the purpose of this procedure, a job mix formula is defined as the percent and grade of paving asphalt used with a specified gradation of aggregate from a designated aggregate source. A new job mix formula may be required whenever compaction of the wearing surface exceeds the agency’s specified maximum density or minimum air voids.
### Core Correlation Example:

<table>
<thead>
<tr>
<th>Core results from T 166:</th>
<th>Average Gauge reading:</th>
<th>Difference:</th>
<th>X</th>
<th>X²</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 144.9 lb/ft³</td>
<td>142.1 lb/ft³</td>
<td>2.8 lb/ft³</td>
<td>-0.7</td>
<td>0.49</td>
</tr>
<tr>
<td>2 142.8 lb/ft³</td>
<td>140.9 lb/ft³</td>
<td>1.9 lb/ft³</td>
<td>0.2</td>
<td>0.04</td>
</tr>
<tr>
<td>3 143.1 lb/ft³</td>
<td>140.7 lb/ft³</td>
<td>2.4 lb/ft³</td>
<td>-0.3</td>
<td>0.09</td>
</tr>
<tr>
<td>4 140.7 lb/ft³</td>
<td>138.9 lb/ft³</td>
<td>1.8 lb/ft³</td>
<td>0.3</td>
<td>0.09</td>
</tr>
<tr>
<td>5 145.1 lb/ft³</td>
<td>143.6 lb/ft³</td>
<td>1.5 lb/ft³</td>
<td>0.6</td>
<td>0.36</td>
</tr>
<tr>
<td>6 144.2 lb/ft³</td>
<td>142.4 lb/ft³</td>
<td>1.8 lb/ft³</td>
<td>0.3</td>
<td>0.09</td>
</tr>
<tr>
<td>7 143.8 lb/ft³</td>
<td>141.3 lb/ft³</td>
<td>2.5 lb/ft³</td>
<td>-0.4</td>
<td>0.16</td>
</tr>
<tr>
<td>8 142.8 lb/ft³</td>
<td>139.8 lb/ft³</td>
<td>3.0 lb/ft³</td>
<td>0.9</td>
<td>0.81</td>
</tr>
<tr>
<td>9 144.8 lb/ft³</td>
<td>143.3 lb/ft³</td>
<td>1.5 lb/ft³</td>
<td>-0.6</td>
<td>0.36</td>
</tr>
<tr>
<td>10 143.0 lb/ft³</td>
<td>141.0 lb/ft³</td>
<td>2.0 lb/ft³</td>
<td>-0.1</td>
<td>0.01</td>
</tr>
</tbody>
</table>

Average Difference: +2.1 lb/ft³

\[ \frac{\sum x^2}{n-1} \]

Where:
- \( \sum \) = Sum
- \( x \) = Difference from the average Difference
- \( n-1 \) = number of data sets minus 1

Example: 10 – 1 = 9

\[ \frac{2.5}{9} = 0.53 \]

X1.1.1. The Sum of \( X^2 = 2.5 \) and the number of data sets = 9 for a computed standard deviation of 0.53. This is within the allowable 2.5 therefore no cores are eliminated, use the average difference from all ten cores.
# PERFORMANCE EXAM CHECKLIST

**IN-PLACE DENSITY OF ASPHALT MIXTURES BY NUCLEAR METHOD**

**FOP FOR AASHTO T 355**

Participant Name_________________________  Exam Date ______________

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Gauge turned on approximately 10 to 20 minutes before use?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Gauge calibrated and standard count recorded?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Test location selected appropriately [600 mm (24 in.) from vertical projections or 10 m (30 ft.) from any other radioactive sources]?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Procedure:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Filler spread evenly over test site?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Excess filler material removed by striking off the surface?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Gauge placed on pavement surface and footprint of gauge marked?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. Probe extended to backscatter position?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. One-minute count taken; gauge rotated 90°, reseated, and another one-minute count taken?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>f. Densities averaged?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>g. If difference of the wet densities is greater than 40 kg/m³ (2.5 lb/ft³), retest conducted in both directions?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Core correlation applied if required?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Percent compaction calculated correctly?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Comments:**

First attempt: Pass_____ Fail_____  Second attempt: Pass_____ Fail_____

__________________________________________________________________________
__________________________________________________________________________
__________________________________________________________________________

Examiner Signature_________________________  WAQTC #:____________________

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**FOP for AASHTO T 355**

In-Place Density of Asphalt Mixtures Using the Nuclear Moisture-Density Gauge

**Scope**

Add the following

Asphalt mixtures when no acceptance test strip is required See [Section 270.00](#), Minimum Testing Requirements for 405 SUPERPAVE Hot Mix Asphalt.
USE OF AKDOT & PF ATM 212, ITD IT 74, WSDOT T 606, OR WFLHD HUMPHRES CURVES

Background

Coarse-grained granular soils are free-draining and have little or no cohesion. These soils are, therefore, not particularly well suited for the moisture-density relations procedures of AASHTO T 99 or AASHTO T 180. Transportation agencies have developed specialized test methods that are hybrids of those moisture-density procedures and methods that employ compaction under load with vibration. Those methods include:

- AKDOT & PF’s ATM 212
- ITD’s IT 74
- WSDOT’s T 606
- WFLHD’s Humphres

Description of Procedure

In these tests, material is compacted in a mold and in a manner similar to those used in a moisture / density relationship, after which the material is further compacted through a combination of applied loads and vibration. A laboratory maximum dry density is determined, as is the percent of material passing a certain sieve such as the 4.75 mm (No. 4). A number of determinations are made for different percentages passing the specified sieve. A graph is developed in which dry density is plotted versus the percentage of material passing that sieve. These tests are conducted in the agency’s central lab, and the curve developed is a central lab function. Figure 1 is an example of such a curve.

Construction specifications will call out a percent of maximum dry density required for the granular materials used on the job. These specified values will be based on ATM 212, IT 74, T 606, or Humphres, depending on the agency.

In the field, the dry density of the granular material will be determined in accordance with the FOP for AASHTO 310. The percent of material passing the specified sieve will be determined for a sample obtained at the site of the density test. The dry density and percent passing values will then be compared with the curve developed in the lab for that particular granular material to determine conformance with the project specifications.
### Maximum Density Chart

#### Density Curves

<table>
<thead>
<tr>
<th>Pass #4</th>
<th>Maximum</th>
<th>Pass #4</th>
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</tr>
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#### Density Curves

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<th>Pass #4</th>
<th>Maximum</th>
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</tr>
<tr>
<td>18.0</td>
<td>130.0</td>
<td>100.0</td>
<td>126.9</td>
</tr>
<tr>
<td>19.0</td>
<td>129.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>20.0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21.0</td>
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<td></td>
<td></td>
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<tr>
<td>22.0</td>
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<tr>
<td>23.0</td>
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<tr>
<td>24.0</td>
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<tr>
<td>25.0</td>
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<td></td>
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<tr>
<td>26.0</td>
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<tr>
<td>27.0</td>
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<td>28.0</td>
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<td></td>
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<td>29.0</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>30.0</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Control Points for Density Curves

<table>
<thead>
<tr>
<th>Pass #4</th>
<th>Maximum</th>
<th>Loose</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>104.8</td>
<td>87.6</td>
</tr>
<tr>
<td>20.5</td>
<td>122.8</td>
<td>99.6</td>
</tr>
<tr>
<td>27.4</td>
<td>130.4</td>
<td>103.8</td>
</tr>
<tr>
<td>42.5</td>
<td>139.1</td>
<td>105.4</td>
</tr>
<tr>
<td>61.1</td>
<td>134.9</td>
<td>96.7</td>
</tr>
<tr>
<td>100.0</td>
<td>126.9</td>
<td>81.9</td>
</tr>
</tbody>
</table>
Example:

A compaction test was taken and a sample was removed from the test site per the FOP for AASHTO T 310. The sample was graded over a 4.75 mm (No. 4) sieve. The following results were reported.

Dry density from the FOP for AASHTO T 310 = 136.0 lb/ft$^3$

Percent passing 4.75 mm (No. 4) sieve = 49%

Maximum density = 138.8 lb/ft$^3$

\[
\frac{136.0 \text{ lb/ft}^3}{138.8 \text{ lb/ft}^3} \times 100 = 98\%
\]
Idaho Field Operating Procedure for

FLAT AND ELONGATED PARTICLES IN COARSE AGGREGATE

FOP FOR ASTM D4791

1. **SCOPE**

1.1. This Idaho Field Operating Procedure (FOP) covers the determination of the percentage, by mass, of flat and elongated particles in coarse aggregates for comparison with specification limits.

1.2. This FOP can be performed in conjunction with AASHTO T 27/T 11.

2. **SUMMARY AND SIGNIFICANCE OF METHOD**

2.1. Flat and elongated particles of aggregates, for some construction applications, may interfere with consolidation and result in harsh, difficult to place materials and a potentially unstable mixture.

3. **REFERENCE DOCUMENTS**

3.1. *AASHTO Standards*

   - M 231, Weighing Devices Used in the Testing of Materials
   - R 76, Standard Practice for Reducing Samples of Aggregate to Testing Size
   - T 2, Sampling of Aggregates
   - T 27, Sieve Analysis of Coarse and Fine Aggregates
   - T 11, Materials Finer Than 75-μm (No. 200) Sieve in Material Aggregates by Washing

3.2. *ASTM Standards*

   - D4791, Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
   - E11, Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves

3.3. *OTHER Standards*

   - Standard Specifications for Highway Construction, Subsection 703.

4. **APPARATUS**

4.1. *Balance or Scale:* Meets the requirements of AASHTO M 231 Class G 2. Capacity sufficient for the principal sample mass, accurate to 0.1 percent of the sample mass or readable to 0.1 g.

4.2. *Sieves:* Meeting requirements of ASTM E11.

4.3. *Proportional Caliper Device:* Meeting the requirements of ASTM D4791.
4.3.1. The device typically consists of a base plate with two fixed posts and a swinging arm mounted between them so that the openings between the arm and the posts maintain a constant ratio.

4.3.2. The numbers on the arm represent the ratios for which the apparatus can be set. For example, the number 5 represents the 5:1 ratio.

5. TERMINOLOGY

5.1. Flat and elongated particles are defined as those coarse aggregate particles that have a ratio of length to thickness equal to or greater than a specified value such as 5:1.

6. SAMPLE AND SAMPLE PREPARATION

6.1. Sample the aggregate in accordance with the FOP for AASHTO T 2.

6.2. Mix the sample and reduce to sample size in accordance with the FOP for AASHTO R 76. See Table 1 for minimum required sample mass.

<table>
<thead>
<tr>
<th>Nominal Maximum Size</th>
<th>Sample Mass, min.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>kg</td>
</tr>
<tr>
<td>3/8”</td>
<td>1</td>
</tr>
<tr>
<td>1/2”</td>
<td>2</td>
</tr>
<tr>
<td>3/4”</td>
<td>5</td>
</tr>
<tr>
<td>1”</td>
<td>10</td>
</tr>
<tr>
<td>1 1/2”</td>
<td>15</td>
</tr>
</tbody>
</table>

6.3. Dry the sample to constant mass.

6.4. Sieve the aggregate according to the FOP for AASHTO T 27/11.

6.4.1. If an individual sieve size fraction is not represented by at least 10% of the +No. 4 aggregate material, combine that sieve size fraction with the next smaller fraction for all sieves except the 3/8” sieve.

6.4.2. If the 3/8” sieve is not represented by at least 10% of the +No. 4, combine the 3/8” sieve material with the next larger sieve size material.

6.5. Reduce each individual sieve size fraction through and including the 3/8” sieve to approximately 100 particles per R 76 (Reduction to an exact amount is not permitted).

7. PROCEDURE

7.1. From Step 6.5, perform the following for each sieve size fraction:

7.1.1. Determine the total dry mass of each fraction to the nearest 0.1 g. This mass is designated as T in the calculation.

7.1.2. Set the proportional caliper device to the ratio required in the contract specifications: (2:1, 3:1, or 5:1).
7.1.3. Expedite testing through preliminary visual separation of all material which obviously is not flat and elongated.

7.1.4. Test each questionable particle by setting the larger opening of the proportional caliper device equal to the maximum dimension of the particle’s length. Determine the dimension which represents the particle thickness (the smallest dimension). Pull the particle horizontally through the smaller opening without rotating, maintaining contact of the particle with the fixed post at all times. If the entire particle thickness can be pulled through the smaller opening, the particle is flat and elongated. Develop two categories of aggregate for each size fraction, flat and elongated and not flat and elongated.

7.1.5. Determine the dry mass of the flat and elongated particles in each size fraction to the nearest 0.1 g. This mass is designated as $F$ in the calculation.

8. CALCULATIONS

8.1. Calculate the percentage of flat and elongated particles in each size fraction to the nearest 0.1% according to the equation shown below:

$$PP_{ii} = \frac{FF}{TT} \times 100$$

Where:

- $P_i$ = percent flat & elongated of individual size fraction
- $F$ = mass of flat and elongated particles in fraction
- $T$ = total mass of particles in fraction

**Example** –

Individual Percent Flat & Elongated for 3/4” Sieve Size Fraction:

$$PP_{i} = \frac{196.4}{1178.0} \times 100 = 16.7, RRRRRRRRRRRR 17\%$$

9. REPORT

9.1. Sample Report

<table>
<thead>
<tr>
<th>Sieve Size</th>
<th>Total Mass in Size Fraction (Mass)</th>
<th>Mass of Flat &amp; Elongated Particles (Mass)</th>
<th>Flat &amp; Elongated (Percent) *</th>
</tr>
</thead>
<tbody>
<tr>
<td>1”</td>
<td>1640.9</td>
<td>589.2</td>
<td>36</td>
</tr>
<tr>
<td>3/4”</td>
<td>1178.0</td>
<td>196.4</td>
<td>17</td>
</tr>
<tr>
<td>1/2”</td>
<td>825.7</td>
<td>70.1</td>
<td>8</td>
</tr>
<tr>
<td>3/8”</td>
<td>277.0</td>
<td>23.3</td>
<td>8</td>
</tr>
</tbody>
</table>

* Report to the nearest 1 percent.
**PERFORMANCE EXAM CHECKLIST**

**FLAT PARTICLES, ELONGATED PARTICLES, OR FLAT AND ELONGATED PARTICLES IN COARSE AGGREGATE FOP FOR IDAHO FOP FOR ASTM D 4791**

Participant Name: ___________________________  Exam Date: _______

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sample Preparation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Sample obtained, mixed and reduced in accordance with AASHTO T 2 and AASHTO R 76 to approximately the amount required for testing? For combined samples fine portion (- # 4) removed?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Minimum dry sample mass meets requirements of Table 1?</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Procedure</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. If determination by mass, sample oven-dried to constant mass at 230 ±9° F? <strong>Note:</strong> If determination is by particle count drying is not necessary.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Sample sieved according to AASHTO T 27?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Each coarse aggregate size fraction present in amount of 10% or more of original coarse sample reduced according to R 76 until approximately 100 particles obtained?</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Flat and Elongated Particle Test:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Each particle in each size fraction tested and placed into one of two groups: (1) flat and elongated or (2) not flat and elongated?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Proportional caliper device positioned at proper ratio?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Larger opening set equal to particle length?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Particle is flat and elongated if the thickness can be placed in the smaller opening?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Proportion of sample in each group determined by count or by mass, as required?</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Calculation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Percentage of flat and elongated particles calculated to nearest 1% for each sieve size greater than No. 4?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. When weighted average for sample is required, sieve sizes not tested (those representing less than 10% of sample) assumed to have same percentage of flat particles, elongated particles, or flat and elongated particles as the next smaller or the next larger size? <strong>Or if both are present, is average for next smaller and larger sizes used?</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

First Attempt:  Pass [ ]  Fail [ ]  Second Attempt:  Pass [ ]  Fail [ ]

Comments: ____________________________________________________________

Testing Technician’s Signature: ___________________________  WAQTC #:  ___________  Date: ___________

Examiner’s Name: ___________________________  Signature: ___________  WAQTC #: ___________
Idaho Field Operating Procedure for

SAMPLING AND FABRICATION OF 2-IN. (50-MM) CUBE SPECIMENS USING GROUT (NON-SHRINK) OR MORTAR

FOP FOR AASHTO R 64

1. SCOPE

1.1. This method covers field sampling and fabrication and initial curing of 2-in. (50-mm) cube specimens of non-shrink grout and/or mortar materials.

1.2. The values stated in either SI or inch-pound units shall be regarded separately as standard. The SI units are shown in brackets. The values stated might not be exact equivalents; therefore, each system must be used independently of the other.

Note 1—Unit weight was the previous terminology used to describe the property determined by this test method, which is mass per unit volume.

1.3. The text of this test method references notes and footnotes that provide explanatory information. These notes and footnotes (excluding those in tables) shall not be considered as requirements of this test method.

1.4. This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

Warning—Fresh hydraulic cementitious mixtures are caustic and may cause chemical burns to skin and tissue upon prolonged exposure.

2. REFERENCE DOCUMENTS

2.1 AASHTO Standards

- T 106, Test method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or 50-mm Cube Specimens.)

2.2 ASTM Standards

- C 1107 Standard Specification for Packaged Dry, Hydraulic-Cement Grout (Non-shrink)
- D 2240, Standard Test Method for Rubber Property—Durometer Hardness

2.3 WAQTC Method

- TM 2, Sampling Freshly Mixed Concrete
3. TERMINOLOGY

3.1. Definitions

3.1.1. Plastic mix – material viscous enough that an indentation will be left in the surface of the grout after tamping.

3.1.2. Fluid mix – material fluid enough that little or no indentation will be left in the surface after puddling.

4. APPARATUS

4.1. Specimen Molds including cover plate (s): The 2 in. (50 mm) cube specimen molds shall be tight fitting and made of brass or other suitable material. This material shall not be susceptible to attack by the cement mortar. The molds shall have not more than three (3) cube compartments and shall be separable into not more than two (2) parts. The parts of the molds, when assembled, shall be positively held together. The cover plate(s) working surface shall be plane and shall be positively attached to the side walls of the mold. The interior faces of the molds shall conform to the tolerances of Table 1.

4.2. Tamper: A non-absorptive, nonabrasive, non-brittle material such as a hard rubber compound having a Shore A durometer hardness of 80 ± 10. The tamper shall have a cross section of about 1/2 in. x 1 in. (13 mm x 25 mm) and a length of 5 in. to 6 in. (125 mm to 150 mm). The tamping face shall be flat and at right angles to the length of the tamper.

4.3. Trowel: Steel bladed, 4 in. to 6 in. (100 to 150 mm) in length, with straight edges.

4.4. Water tight container: a 6 in. x 12 in. (150 mm x 300 mm) concrete cylinder mold with lid

4.5. Other Equipment: Rubber gloves, scoop, clamps to secure the cover plate, light release oil for oiling the molds, small brush or lint-free cloth for applying and removing excess release oil, burlap or wrapping cloth capable of retaining moisture.

5. SAMPLING

5.1. Samples shall be obtained in accordance with WAQTC TM 2 when the batch equals or exceeds 1 cy (1 m³). When the batch is less than 1 cy (1 m³) sample from the batch after discharge. If remixing is required, sample after remixing. Begin molding the specimen within an elapsed time of not more than 2 1/2 minutes from completion of mixing.
Note 2—This test is to be used only for grouts with 100 percent passing the 3/8- in. (9.5-mm) sieve.

5.2. Obtain a representative sample of the mix. Samples shall be a minimum size of 4 lb. (2000 g) for each set of three (3) cubes to be fabricated.

6. **PROCEDURE**

6.1. Assemble both portions of the mold and the bottom cover plate. All joints shall be watertight. If not water tight, seal the surfaces where the halves of the mold join by applying a coating of light cup grease (non water soluble). The amount should be sufficient to extrude slightly when the halves are tightened together. Repeat this process for attaching the mold to the bottom cover plate. Remove any excess grease. Apply a thin coating of release agent to the interior faces of the mold and the bottom cover plate. Wipe the mold faces and base plate as necessary to remove any excess release agent and to achieve a thin, even coating on the interior surfaces. Adequate coating is that which is just sufficient to allow a distinct fingerprint to remain following light finger pressure.

6.2. Place a layer of grout about 1 in. (25 mm) (approximately one-half of the depth of the mold) in all of the cube compartments. Consolidated according to the consistency (plastic or fluid) of the mix.

6.2.1. For plastic mixes, tamp the lift in four rounds of 8 tamps for a total of 32 tamps with the rubber tamper in 10 seconds. See Figure 1 for tamping sequence of each round. Rounds 1 and 3; and 2 and 4 shall be the same.

**Figure #1**

![Tamping Sequence](image)

6.2.2. For fluid mixes, puddle the lift 5 times with a gloved finger. See Figure 2 for tamping sequence.

**Figure #2**

![Puddling Sequence](image)
6.3. Place the second lift in each of the cube compartments, slightly over-filling each compartment. Consolidate the material in the same fashion as the first lift with the additional requirement that during consolidation of the second lift any grout forced out onto the top of the mold after each round will be pushed back onto the compartment by means of the tamper and/or gloved fingers before the next consolidation round. When consolidation of the grout is completed, material should extend slightly above the top of the mold. Push any grout forced out onto the top of the mold after the last round back onto the compartment with the trowel.

6.4. Smooth off the cubes by drawing the flat side of the trowel (with the leading edge slightly raised) once across the top of each cube at right angles to the length of the mold. Then, for the purpose of leveling the mortar and making the mortar that protrudes above the top of the mold of more uniform thickness, draw the flat trailing edge of the trowel (with leading edge slightly raised) once lightly along the length of the mold. Cut off the mortar to a plane surface flush with the top of the mold by drawing the straight edge of the trowel (held nearly perpendicular to the mold) with a sawing motion over the length of the mold. The material shall be flush with the top of the mold.

6.5. Immediately secure the top cover plate to the cube mold.

6.6. Place the molds in a secure location away from vibration and as close as possible to the structure for initial curing. Cover with wet burlap, towels, or rags, seal it in a plastic sack in a level location out of direct sunlight, and record the time. These samples shall remain undisturbed and protected from freezing or overheating for a period of 24 ± 4 hours.

6.7. At the end of the initial curing period as required by the agency either.

6.7.1. Place the sealed plastic sack into a water tight container. Transport the cube samples immediately to the location of final curing. During transport, the cube samples shall be protected from jarring, freezing, and moisture loss.

6.7.2. Disassemble the mold and carefully remove the cube samples. Using a permanent marker, identify the cube samples. Handling the cube samples very carefully, wrap them in wet burlap or wet towels and place them into a water tight container. Transport the cube samples immediately to the location of final curing. During transport, the cube samples shall be protected from jarring, freezing, and moisture loss.

6.8. Final curing shall consist of immersing the cube samples in a lime-saturated water storage tank. They are to remain in the storage tank until time of test. (Curing cube samples of material other than hydraulic cement shall be in conformance with the manufacturer’s recommendations.) The storage tank shall be made of non-corroding materials.
PERFORMANCE EXAM CHECKLIST

SAMPLING & FABRICATION OF 2" (50 – MM) CUBE SPECIMENS USING GROUT (NON-SHRINK) MORTAR
IDAHO FOP FOR AASHTO R 64

Participant Name: ___________________________ Exam Date: _________________

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

Procedure Elements:  

1. **Obtain Sample.** Use WAQTC TM 2 for 1 yd$^3$ or more or for less than 1 yd$^3$ sample from discharge after remixing takes place.

2. **Inspect and adjust test apparatus.** Apparatus includes mold assembly, tamper, trowel, watertight container.

3. **Mold portion attached to bottom plate and joints are water tight.** Use of a light coating of non water-soluble grease is allowed.

4. **Place a 1" (approximately 1/2 the depth of the mold) layer of Grout or non-shrink mortar into the mold.** Grout or mortar shall be placed in all compartments.

5. **Consolidate the mix.** The mix shall be consolidated depending on the consistency, either plastic or fluid.

6. **Plastic mixes:** tamp lift in 4 rounds, 8 tamps per round, for a total of 32 tamps in 10 seconds with rubber tamper. Rounds 1 and 3 and 2 and 4 shall be the same.

7. **Fluid Mixes:** puddle the lift 5 times with gloved finger.
8. **Place the second lift into all of the mold compartments and consolidate:**
   Slightly overfill. Consolidate in same fashion as first lift. After consolidation material should extend slightly above the top of the mold. Push any grout forced out onto the top of the mold back onto the compartment with a trowel.

9. **Strike off the surface.** Using the trowel draw the flat side with the leading edge slightly raised once across the top of each cube at right angles to the length of the mold. Then draw the flat trailing edge of the trowel, with leading edge slightly raised, once lightly along the length of the mold. Cut off the mortar to a plane surface flush with the top of the mold by drawing the straight edge of the trowel (held nearly perpendicular to the mold) with a sawing motion over the length of the mold. The material shall be flush with the top of the mold.

10. **Immediately secure the top plate to the molds.**

11. **Molds properly stored:** Cover with wet burlap, towels, or rags, seal it in a plastic sack in a level location out of direct sunlight, and record the time. These samples shall remain undisturbed and protected from freezing or overheating for a period of 24 ± 4 hours.

First Attempt:  Pass   ☐  Fail   ☐  Second Attempt:  Pass   ☐  Fail   ☐

Comments: ____________________________________________________________
                                                     ____________________________________________________________
                                                     ____________________________________________________________
                                                     ____________________________________________________________

Testing Technician’s Signature: ___________________________ WAQTC #: __________ Date: __________

Examiner’s Name: ___________________________ Signature: ___________________________ WAQTC #: __________
Idaho Field Operating Procedure for

UNCOMPACTED VOID CONTENT OF FINE AGGREGATE

FOP FOR AASHTO T 304

1. SCOPE

1.1. This Idaho Field Operating Procedure (FOP) covers a method for determining the loose uncompacted void content of a sample of fine aggregate.

1.2. Three procedures are included for the measurement of void content:

1.2.1. Standard Graded Sample (Method A)

1.2.2. Individual Size Fractions (Method B)

1.2.3. As-Received Grading (Method C)

1.3. For Method A or C, the percent void content is determined directly and the average value of two test runs is reported.

1.4. For Method B, the mean percent void content is calculated using the results from each of the three individual size fractions.

2. REFERENCE DOCUMENTS

2.1. IDAHO Test Methods

- IT-144, Specific Gravity and Absorption of Fine Aggregate Using Automatic Vacuum Sealing (CoreLok) Method

2.2. AASHTO Standards

- M 231, Weighing Devices Used in the Testing of Materials
- R 76, Reducing Samples of Aggregate to Testing Size
- T 2, Sampling of Aggregates
- T 11, Materials Finer Than 75-μm (No. 200) Sieve in Mineral Aggregate
- T 27, Sieve Analysis of Fine and Coarse Aggregate
- T 304, Uncompacted Void Content of Fine Aggregate.
- T 308, Determining Asphalt Binder Content of Hot Mix Asphalt (HMA) by the Ignition Method

3. SUMMARY AND SIGNIFICANCE OF METHOD

3.1. Methods A and B provide percent void content determined under standardized conditions which depend on the particle shape and texture of a fine aggregate. An increase in void content by these
procedures indicates greater angularity, less sphericity, rougher surface texture, or some combination of these three factors.

3.2. Method C measures the uncompacted void content of the minus No. 4 portion of the as-received material. This void content depends on grading as well as particle shape and texture.

3.3. The standard graded sample (Method A) is most useful as a quick test that indicates the particle shape properties of a graded fine aggregate. Typically, the material used to make up the standard graded sample can be obtained from the remaining size fractions after performing a single sieve analysis of the fine aggregate.

3.4. Obtaining and testing individual size fractions (Method B) is more time-consuming and requires a larger initial sample than using the graded sample. However, Method B provides additional information concerning the shape and texture characteristics of individual size fractions.

3.5. Testing samples in the as-received grading (Method C) may be useful in selecting proportions of the components used in a variety of mixtures. In general, high void content suggests that the material could be improved by providing additional fine aggregate or more binder may be needed to fill the voids between particles.

3.6. The bulk dry specific gravity of the fine aggregate ($G_{sb}$) is used to calculate the void content. The effectiveness of these methods of determining void content and its relationship to particle shape and texture depend on the bulk specific gravity of the various size fractions being equal (or nearly so).

3.7. Void content information from Methods A, B, and C may be a useful indicator of properties such as:

3.7.1. Mixing water demand of hydraulic cement concrete.

3.7.2. Flowability, pumpability, or workability of grouts and mortars.

3.7.3. The effect of fine aggregate on stability, strength and VMA in asphalt mixtures.

3.7.4. Stability and strength of base course material.

4. **APPARATUS**

4.1. **Cylindrical Measure:** A right cylinder of approximately 100 mL capacity having an inside diameter of approximately 1.5 inches and an inside height of approximately 3.4 inches made of drawn copper water tube. The bottom of the measure shall be at least 0.25 inches thick, shall be firmly sealed to the tubing, and shall be provided with the means for aligning the axis of the cylinder with that of the funnel. Determine the volume of the measure to the nearest 0.1 mL.

4.2. **Funnel:** A funnel such that the lateral surface of the right frustum of the cone is sloped 60°±4° from the horizontal with an opening 0.5±0.02 inches diameter. The funnel section shall be a piece of metal, smooth on the inside, and at least 1.5 inches high. It shall have a volume of at least 200 mL, or shall be provided with a supplemental container to provide the required volume.

4.3. **Funnel Stand:** A three or four-legged support capable of holding the funnel firmly in position with the axis of the funnel collinear (within 4° angle and a displacement of 0.07 inches) with the axis of the cylinder measure. The funnel opening shall be 4.5 inches above the top of the cylinder.

4.4. **Glass Plate:** A square glass plate approximately 2.3 by 2.3 inches with a minimum 0.15-inch thickness.
4.5.  *Pan:* A metal or plastic pan of sufficient size to contain the funnel stand and prevent loss of material.

4.6.  *Spatula:* A metal spatula with a blade approximately 4 inches long and at least 0.75 inches wide, with straight edges. The end shall be cut at a right angle to the edges.

4.7.  *Balance:* Meets the requirements of AASHTO M 231 Class G 2. A balance with a capacity of 1000 g and sensitive to 0.1 g.

5. **SAMPLE**

5.1. The samples used for this test shall be obtained using AASHTO T 2 and AASHTO R 76, or from sieve analysis samples used for AASHTO T 27, or from an extracted asphalt mixture sample using AASHTO T 308.

5.2. For Methods A and B, the sample is washed over a No. 100 or No. 200 sieve in accordance with AASHTO T 11 and then dried and sieved into separate size fractions according to AASHTO T 27. Maintain the necessary size fractions obtained from one or more sieve analyses in a dry condition in separate containers for each size.

5.3. For Method C, dry a split of the as-received sample in accordance with the drying provisions of AASHTO T 27.

6. **SAMPLE PREPARATION**

6.1.  *Method A – Standard Graded Sample*

6.1.1. Weigh out and combine the following quantities of fine aggregate that has been dried and sieved in accordance with AASHTO T 27.

<table>
<thead>
<tr>
<th>Individual Size Fraction</th>
<th>Mass, g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passing No. 8 to Retained on No. 16</td>
<td>44 ±0.2</td>
</tr>
<tr>
<td>Passing No. 16 to Retained on No. 30</td>
<td>57 ±0.2</td>
</tr>
<tr>
<td>Passing No. 30 to Retained on No. 50</td>
<td>72 ±0.2</td>
</tr>
<tr>
<td>Passing No. 50 to Retained on No. 100</td>
<td>17 ±0.2</td>
</tr>
<tr>
<td></td>
<td>190 ±0.2</td>
</tr>
</tbody>
</table>

6.2.  *Method B – Individual Size Fractions*

6.2.1. Prepare a separate 190 g sample of fine aggregate, dried and sieved in accordance with AASHTO T 27 for each of the following size fractions:

<table>
<thead>
<tr>
<th>Individual Size Fraction</th>
<th>Mass, g</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passing No. 8 to Retained on No. 16</td>
<td>190 ±1</td>
</tr>
<tr>
<td>Passing No. 16 to Retained on No. 30</td>
<td>190 ±1</td>
</tr>
<tr>
<td>Passing No. 30 to Retained on No. 50</td>
<td>190 ±1</td>
</tr>
</tbody>
</table>

Do not mix fractions together. Each size is tested separately.
6.3.  *Method C – As-received Grading*

6.3.1.  Pass the sample (dried in accordance with AASHTO T 27) through a No. 4 sieve. Obtain a 190 ± 1 g sample of this material for the test.

6.4.  *Specific Gravity of Fine Aggregate*

6.4.1.  If the bulk specific gravity (\(G_{sb}\)) of the fine aggregate sample is unknown, determine it according to Idaho IT-144.

7.  **PROCEDURE**

7.1.  Record all masses to the nearest 0.1 g.

7.2.  Record the mass of the empty measure.

7.3.  Mix each test sample with the spatula until it appears to be homogeneous.

7.4.  Position the jar and funnel section in the stand and center the cylindrical measure with the axis of the funnel. Use a finger to block the opening of the funnel.

7.5.  Pour the test sample into the funnel. Level the material in the funnel with the spatula.

7.6.  Remove the finger and allow the sample to freely flow into the cylindrical measure.

7.7.  After the funnel empties, strike off excess from the top of the cylindrical measure by a single pass of the spatula with the width of the blade vertical, using the straight part of its edge in light contact with the top of the measure.

7.7.1.  Until this operation is complete, avoid vibration or disturbance that could cause compaction of the fine aggregate in the measure (see note).

**Note:** After strike off, the cylindrical measure may be tapped lightly to compact the sample to make it easier to transfer the container to the scale or balance without spilling any of the sample.

7.8.  Brush adhering grains from the outside of the cylindrical measure. Determine the mass of the measure and its contents to the nearest 0.1 g.

7.9.  Recombine the sample from the retaining pan and cylindrical measure, repeat the procedure, and average the results of the two test runs.

8.  **CALCULATIONS**

8.1.  Calculate the uncompacted voids for each determination according to the following formula:

\[
UU = \frac{VV - \frac{FE}{G \times G}}{VV} \times 100
\]
Where:

\[ U = \text{uncompacted voids, percent, in the material}; \]
\[ V = \text{volume of cylindrical measure, mL}; \]
\[ F = \text{net mass of fine aggregate in measure, g}; \]
\[ G = \text{bulk specific gravity (} G_{sb} \text{) of aggregate} \]

8.1.1. **For Methods A and C:** Calculate the average uncompacted voids for the two determinations.

8.2. **For Method B:** First determine the uncompacted void content for each of the individual size fractions; then calculate the mean uncompacted void content as follows:

\[ UU_{mn} = \frac{UU_1 + UU_2 + UU_3}{3} \]

Where:

\[ U = \text{Mean uncompacted void content, \%} \]
\[ U_1, U_2, U_3 = \text{Uncompacted void content of individual size fractions} \]

8.3. **Calculation Examples**

\[ UU = \frac{99.8 - 146.2}{2.636} \times 100 = 44.3, \text{say 44.4\%} \]

Where:

\[ U = \text{Uncompacted void content, \%}; \]
\[ V = 99.8 \text{ mL} \]
\[ F = 146.2 \text{ g.} \]
\[ G = 2.636 \]

\[ UU_{mn} = \frac{48.7+49.9+47.0}{3} = 48.53, \text{say 48.5\%} \]

Where:

\[ U_m = \text{Mean uncompacted void content, \%} \]
\[ U_1 = 48.7\% \]
\[ U_2 = 49.9\% \]
\[ U_3 = 47.0\% \]

9. **REPORT**

9.1. Results shall be reported on Form ITD-1046 to the nearest 0.1 percent.
PERFORMANCE EXAM CHECKLIST
UNCOMPACTED VOID CONTENT OF FINE AGGREGATE
FOP FOR AASHTO T 304

Participant Name: ________________________________ Exam Date: ___

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

Procedure Element: (all test methods are AASHTO unless otherwise shown) Trial 1 Trial 2

Sampling

1. Sample obtained by one of the following:
   
   (a) T 2 & R 76 (sampling, splitting and quartering)? or;

   (b) From sieve analysis samples used for T 27? or;

   (c) From aggregate extracted from a bituminous concrete specimen (T 308)?

2. Methods A

   (a) Sample washed over No. 100 or No. 200 sieve in accordance with T 11?

   (b) Sample dried and sieved into separate size fractions in accordance with T 27?

   (c) Necessary size fractions obtained from sieve analysis maintained in a dry condition in separate containers for each size?

Sample Preparation

Method A- Standard Graded Sample

1. Following quantities of aggregate that has been dried and sieved in accordance with T 27 weighed out and combined?

<table>
<thead>
<tr>
<th>Individual Size Fractions</th>
<th>Mass, g</th>
<th>OK?</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 8 to No. 16</td>
<td>44 ± 0.2</td>
<td></td>
</tr>
<tr>
<td>No. 16 to No. 30</td>
<td>57 ± 0.2</td>
<td></td>
</tr>
<tr>
<td>No. 30 to No. 50</td>
<td>72 ± 0.2</td>
<td></td>
</tr>
<tr>
<td>No. 50 to No. 100</td>
<td>17 ± 0.2</td>
<td></td>
</tr>
<tr>
<td>Total:</td>
<td>190 ± 0.2</td>
<td></td>
</tr>
</tbody>
</table>

Specific Gravity of Fine Aggregate

If bulk dry specific gravity of aggregate from the source is unknown, specific gravity determined on material passing No. 4 sieve in accordance with IT 144.
Procedure

1. Each test sample mixed with spatula until it appears to be homogeneous?

2. Funnel stand apparatus with cylindrical measure, positioned in retaining pan?

3. Finger used to block opening of funnel?

4. Test sample poured into funnel?

5. Material in funnel leveled with spatula?

6. After funnel empties, excess heaped aggregate struck off from cylindrical measure by single pass of spatula, with blade width vertical and using straight part of its edge in light contact with top of measure?

7. Care exercised to avoid vibration or any disturbance that could cause compaction of aggregate into cylindrical measure?

*Note:* After strike-off, measure may be tapped lightly to compact sample to make it easier to transfer container to scale or balance without spilling any of the sample.

8. Adhering grains brushed from outside of container?

9. Mass of cylindrical measure and contents determined to nearest 0.1 g?

10. All aggregate particles retained for second test run?

11. Sample from retaining pan and cylindrical measure recombined and procedure repeated?

12. Mass of empty measure recorded?

13. Calculations performed properly?

**Formula for Calculation of Uncompacted Voids, percent**

\[
UU = \frac{V - \frac{F}{G}}{V} \times 100
\]

Where:

- \(U\) = uncompacted voids, percent;
- \(V\) = volume of cylindrical measure to nearest 0.1 mL;
- \(F\) = net mass, g, of fine aggregate in measure; and,
- \(G\) = bulk dry specific gravity of fine aggregate \((G_{sb})\)

First Attempt: Pass [ ] Fail [ ] Second Attempt: Pass [ ] Fail [ ]

Comments

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

Testing Technician’s Signature: ___________________________ WAQTC #: ___________ Date: ___________

Examiner’s Name: ___________________________ Signature: ___________________________ WAQTC #: ___________
Idaho Field Operating Procedure for

Pavement Thickness by Magnetic Pulse Induction
Fop for AASHTO T 359

1. SCOPE

1.1. This procedure covers the determination of the pavement thickness by using magnetic pulse induction in accordance with AASHTO T 359. This field operating procedure is derived from AASHTO T 359.

1.1.1. This procedure is intended for use with plain jointed concrete pavements, asphalt pavements, bases with binders and unbound aggregate layers. It is not applicable for continuously reinforced, mesh reinforced or fiber reinforced pavement where the reinforcement would interfere with the magnetic field.

1.2. The values stated in SI units are to be regarded as the standard.

1.3. This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. REFERENCE DOCUMENTS

2.1. AASHTO Standards

- T 359, Pavement Thickness by Magnetic Pulse Induction
- T 148, Measuring Length of Drilled Concrete Cores

2.2. ASTM Standards

- A653, Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process

3. SUMMARY OF TEST METHOD

3.1.1. The method uses magnetic pulse induction technology to measure the thickness of one or several layers above a metal reflector. While scanning, the device generates a variant magnetic field that creates an eddy current in the reflector. The eddy current will generate an induced magnetic field inside the reflector, the intensity of which is detected by sensors from the device. For a given type of reflector, the intensity of the induced magnetic field is determined primarily by the distance from the device to the target. A calibration file, recording the relationship between the induced magnetic field intensity and the distance, is developed for each unique type of reflector produced by the manufacturer. Reflectors are usually either round or square galvanized sheet steel about 0.6 mm thick. They usually range in size depending on the anticipated thickness of the pavement to be measured. For pavements up to 350 mm thick, round 300-mm diameter reflectors are adequate. Square 355-mm reflectors are adequate for pavements up to 500 mm thick.
4. **INTERFERENCES**

4.1. This test method can produce misleading results when metal is nearby. Steel-toe shoes can also affect the results if the operator steps too close to the gauge head during the measurement process.

5. **APPARATUS**

5.1. An electromagnetic pulse induction device that generates a variant magnetic field that creates an eddy current in a reflector capable of measuring pavement thickness.

5.2. A metal reflector that can be detected by the sensors of the pulse induction device. The type of metal and size of the reflector depends on the type and thickness of the pavement that is being measured.

5.2.1. For deeper sections larger reflectors are needed since they create larger magnetic fields. For pavements between 6 and 14 inches thick use 12 inch diameter reflectors.

5.2.2. For pavements less than 6 inches thick use 6 inch diameter reflector.

5.3. Use the manufacturer’s reflectors or 24 gauge sheet metal meeting ASTM A653, CS Type B, G90.

*Note 1*—The metal reflectors should conform to the manufacturer’s specifications.

6. **PROCEDURE**

6.1. Place targets at required locations prior to paving.

6.1.1. It is usually necessary to fasten the reflectors to the base or subbase to prevent movement during the paving operation.

6.1.2. Place the reflector at least 3 feet from any steel or dowel bars.

6.1.3. Record the approximate location reference for ease of locating after paving.

6.2. *Note*—Fasten reflectors with nails. Bright common, galvanized, and coated nails as well as masonry nails up to 3-1/2 inch have worked well. Use of more than three nails per the reflector could affect the accuracy of the readings and therefore is not recommended.

6.3. Thickness measurements are normally made within 2 feet of each edge and across the driving lane.

6.3.1. When adjacent lanes are placed simultaneously, plates across the width of the pavement will represent both lanes.

6.3.2. When pavements include shoulders, measurements may be made in the shoulder area within 3 feet of the lane line, unless special circumstances dictate otherwise.

6.4. At a minimum, place reflectors at twice the number of stations required for each 0.1 mile section.

6.4.1. Reflectors are to be placed at random locations within the section.

6.4.2. The minimum number of measurements per 0.1 mile is as follows in Table 1:
Table 1 Minimum Number of Reflectors per 0.1 Mile

<table>
<thead>
<tr>
<th>Placement Type</th>
<th>Minimum No. of Measurements</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 lane no, no shoulders</td>
<td>3</td>
</tr>
<tr>
<td>1 lane, 1 shoulder</td>
<td>3</td>
</tr>
<tr>
<td>2 lanes, no shoulder</td>
<td>5</td>
</tr>
<tr>
<td>2 lanes, 2 shoulders</td>
<td>5</td>
</tr>
</tbody>
</table>

6.4.3. In cases where a tapered or an unusual pavement width is being placed, use engineering judgment to determine where thickness measurements are made.

6.5. Once the pavement is sufficiently cured to support foot traffic, use the gauge search mode to locate the reflector center.

6.5.1. This is done by holding the gauge head 2 to 3 inches above the pavement and moving it side to side and forward and backward.

6.5.2. When the gauge search function is showing the strongest signal, mark directly above the reflector on the pavement.

6.6. Remove all debris from the surface where the gauge wheels will pass.

6.7. With the gauge switched to the measurement mode, place the front wheel approximately 1-1/2 feet before the mark.

6.7.1. Press the measurement button and then slowly push the gauge over the reflector.

6.7.2. After the gauge has traveled approximately 6 feet, the gauge processor will calculate the thickness of the pavement above the reflector.

6.8. Repeat step 6.7 two more times and record the results.

6.8.1. No single result at a single location should be more than 0.125 inch different than the other 2 readings.

6.8.2. If an individual reading exceeds 0.125 inches, repeat the three readings.

6.8.3. If an individual reading is more than 0.125 different with the second set of readings, record the thickness at that location could not be determined and move to another reflector.

6.9. Repeat 6.5 to 6.8 to obtain the required number of measurements.

7. **CALCULATION AND INTERPRETATION OF RESULTS**

7.1. Average the 3 readings for a location and record the average to the nearest 0.05 inch.

7.2. Average the readings for a section and record the average to the nearest 0.1 inch.

8. **REPORT**

8.1. Report the metal target type used, date, test locations, all thickness measurements and averages.
Section 590.00 – Idaho Transportation Department (ITD) Sampler / Tester Qualification Program (STQP)

Information found in this section can also be found in the Laboratory Operations Manual, Section 250.

Qualifications are granted by ITD through the STQP. The purpose of the ITD STQP is for conformance to State and Federal requirements. All individuals shall be qualified who sample or test on ITD projects. Valid sampler / tester qualification for ITD projects is only available through this program.

The ITD STQP includes Six (6) Western Alliance for Quality Transportation Construction (WAQTC) modules, two (2) ITD STQP modules, and nineteen (19) individual test method qualifications.

Details on the five WAQTC and three ITD STQP modules are located in the Registration Policies and Information Hand book (RP &IH) which can be downloaded from the Sampler Tester qualification web page. [http://itd.idaho.gov/highways/ops/materials/techqual/techqual.asp](http://itd.idaho.gov/highways/ops/materials/techqual/techqual.asp). Details on individual test method qualifications are found in Section 590.10.

QUALIFICATION(S) ARE VALID WHEN POSTED ON THE ITD’S WEB PAGE UNDER “INSPECTOR AND SAMPLER / TESTER QUALIFICATION (WAQTC).”

590.10 Individual Test Method Qualifications. Table 590.10.1 below lists the individual test methods that require qualification. Prerequisite Sampler / Tester (WAQTC) qualifications are required before any performance examination can occur. Performance exam documentation (Registration Form, Rights and Responsibilities form, and completed Performance Exam Checklist) shall be submitted to HQ Central Laboratory. The Individual Qualification certificate is form ITD-949 for all test methods.

The following performance exam checklists in Table 590.10.1 at to be used along with the appropriate AASHTO Test and Idaho Test methods.

QUALIFICATION(S) ARE VALID WHEN POSTED ON ITD WEB PAGE UNDER “IDAHO INDIVIDUAL QUALIFICATIONS.”

The individual qualification is valid for five (5) years.

The District Independent Assurance Inspector (I.A.I.) or an I.A.I. assigned ITD qualified person with 5 years experience will provide individual qualifications unless otherwise specified. Performance exam checklist must be used.

590.10.01 Non-ITD Personnel. The Laboratory Manager will notify the ITD representative who qualifies the laboratory or the District I.A.I. which testing personnel will require individual qualification. Notification shall be made a minimum of 14 calendar days in advance.
Table 590.10.1: Individual Test Methods & Performance Exam Check Lists

<table>
<thead>
<tr>
<th>Test Method</th>
<th>Test Reference</th>
<th>Notes For Pre-Qualification</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Aggregates</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cleanness Value</td>
<td>Idaho IT 72</td>
<td>AgTT Qualification is required.</td>
</tr>
<tr>
<td>Specific Gravity and Absorption of Fine Aggregate</td>
<td>Idaho IT 144</td>
<td>AgTT Qualification is required.</td>
</tr>
<tr>
<td>Bulk Density (&quot;Unit Weight&quot;) and Voids in Aggregate</td>
<td>AASHTO T 19</td>
<td>AgTT Qualification is required.</td>
</tr>
<tr>
<td>Specific Gravity and Absorption of Fine Aggregate</td>
<td>AASHTO T 84</td>
<td>AgTT Qualification is required.</td>
</tr>
<tr>
<td>Uncompacted Void Content Of Fine Aggregate</td>
<td>AASHTO T 304</td>
<td>AgTT Qualification is required.</td>
</tr>
<tr>
<td>Flat and Elongated Particles in Coarse Aggregate</td>
<td>ASTM D4791</td>
<td>AgTT Qualification is required.</td>
</tr>
<tr>
<td><strong>Bituminous Materials</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saybolt Viscosity</td>
<td>Idaho IT 61</td>
<td>AsTT or AsTT II Qualification is required.</td>
</tr>
<tr>
<td>Anti-strip Detection</td>
<td>Idaho IT 99</td>
<td></td>
</tr>
<tr>
<td>Effect of Water on Compressive Strength of Compacted Bituminous Mixtures</td>
<td>AASHTO T 165/ASTM D1075</td>
<td>AsTT or AsTT II Qualification is required. Performance exam administered by HQ Central Laboratory</td>
</tr>
<tr>
<td>Density of In-place HMA Pavement by Electronic Surface Contact Device</td>
<td>AASHTO T 343</td>
<td>AsTT or AsTT II Qualification is required.</td>
</tr>
<tr>
<td>Bulk Specific Gravity and Density of Compacted Hot Mix Asphalt (HMA) using Automatic Vacuum Sealing Method (CoreLok)</td>
<td>AASHTO T 331</td>
<td>AsTT or AsTT II Qualification is required.</td>
</tr>
<tr>
<td>Field Sampling Asphalt Mixtures after Compaction (Obtaining Cores)</td>
<td>AASHTO R 67</td>
<td></td>
</tr>
<tr>
<td><strong>Soils</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Determining the Plastic Limit and Plasticity Index of Soils</td>
<td>AASHTO T 90</td>
<td>EbTT Qualification is required.</td>
</tr>
<tr>
<td>Determining the Liquid Limit of Soils</td>
<td>AASHTO T 89</td>
<td>EbTT Qualification is required.</td>
</tr>
<tr>
<td>Specific Gravity of Soils</td>
<td>AASHTO T 100</td>
<td>EbTT Qualification is required.</td>
</tr>
<tr>
<td><strong>Concrete</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sampling &amp; Fabrication of 2&quot; Cube Specimens using Grout or Mortar</td>
<td>AASHTO R 64</td>
<td>CTT Qualification is required.</td>
</tr>
</tbody>
</table>
PERFORMANCE EXAM CHECKLIST

CLEANNESS VALUE
IDAHO IT-72

Participant Name:_________________________ Exam Date:__

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

**Procedure Element:**

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. The sample was maintained moist in sealed container.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. The sample is equal to 1000 ± 50 grams.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. There is 7 ml of SE solution in SE tube.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. The graduate assembly including sieves, funnel and 500 ml graduate cylinder is properly put together.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. CCM sample was placed in washing vessel or jar and water was added just</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Mechanical Method</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. The vessel was secure in the shaker.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Agitation was started after one (1) minute.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. The vessel was agitated for two minutes.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Hand Method</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Agitation was started after one (1) minute.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. The vessel was properly rotated with 150mm radius.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Vessel was agitated 3 complete rotations per second.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Vessel was agitated for one (1) full minute.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Measure for Cleanness</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. All contents of vessel or jar were washed over sieves into the 500 ml graduate</td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. Cylinder was rapidly turned upside down at 180º, ten (10) times.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. Mixture was poured into SE cylinder to 15 inch mark.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16. SE Cylinder was rotated at least ten (10) complete cycles. Bubble traveled full</td>
<td></td>
<td></td>
</tr>
<tr>
<td>17. Cylinder was allowed to stand 20 minutes on work table free from vibrations.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18. The sediment reading was to the nearest 0.1 inch.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>19. Calculations were accurate to the nearest whole number.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

First Attempt: Pass [ ] Fail [ ] Second Attempt: Pass [ ] Fail [ ]

Comments:________________________________________________________________________

________________________________________________________________________

Testing Technician’s Signature:_________________________ WAQTC #:_________________ Date:____________

Examiner’s Name:_________________________ Signature:_________________________ WAQTC #:_________________
PERFORMANCE EXAM CHECKLIST
SPECIFIC GRAVITY AND ABSORPTION OF FINE AGGREGATE USING AUTOMATIC VACUUM SEALING (CORELOK) METHOD
IDaho IT-144-08

Participant Name: _____________________________  Exam Date: _____________________________

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

Verification Element:

1. Pycnometer and lid placed inside a bucket of water at 25 ± 1°C (77 ± 2°F)? ________ ________
2. Pycnometer and lid removed from water dried well and placed on clamping device until it makes contact with stops? ________ ________
3. Pycnometer filled with 25 ± 1°C (77 ± 2°F) water to 10mm (3/8”) of top, sprayed with Isopropyl alcohol to remove air? ________ ________
4. Lid gently placed on Pycnometer and clamped? ________ ________
5. A syringe filled with 25 ± 1°C (77 ± 2°F) inserted in top of lid and gently added until water is expelled through the 3mm (1/8") hole? ________ ________
6. Water wiped from lid, device water and pycnometer weighed and recorded to 0.1 g? ________ ________
7. Procedure repeated two additional times (no greater than 0.5 g difference) recorded to work sheet and averaged? ________ ________

Procedure Element

8. Representative samples obtained per FOP for AASHTO T 2? ________ ________
9. Reduced per FOP for AASHTO R 76? ________ ________
10. Dried per FOP for AASHTO T 255? ________ ________
11. Samples cooled to 25 ±1°C (77 ± 2°F)? ________ ________
12. Three samples obtained @ 500g ±1g and one @ 1000g ± 1g? ________ ________
13. Pycnometer and lid removed from water, dried and pycnometer placed on clamping device until it makes contact with stops? ________ ________
14. Water added to pycnometer (at 25 ± 1C, 77 ± 2F) to approximately half full? ________ ________
15. Sample at 500 g ± 1g slowly added to pycnometer? ________ ________
16. Metal spatula inserted against side of pycnometer and slowly pushed to center removed, repeated in eight equal increments? ________ ________
17. Water added at 25 ± 1C (77 ± 2F) to within 10mm (3/8”) of rim? ________ ________
18. Sprayed with isopropyl alcohol to remove air? ________ ________
19. Lid gently placed on pycnometer with 3mm (1/8”) hole to the front and clamped? ________ ________
20. Syringe filled with 25 ± 1C (77 ± 2F) water inserted in top of lid and water slowly added until it is expelled through 3mm (1/8”) hole? ________ ________
21. Excess water wiped from lid?  
22. Clamping device, pycnometer and sample mass recorded to 0.1 g?  
23. Clamping device, pycnometer and sample mass determined no more than 2 minutes from time sample was submerged?  
24. Second 500 g ± 1 g sample tested and mass recorded?  
25. If recorded mass of first and second sample greater than 1 g, was a third 500 g ± 1 g sample tested?  
26. Vacuum device set at manufacture’s recommended setting?  
27. Small plastic bag inspected and mass determined to 0.1 g and recorded?  
28. 1000 g ± 1 g sample mass determined and recorded?  
29. 1000 g ± 1 g sample placed in the bag, supported by a smooth surface to prevent punctures?  
30. Sample placed in vacuum device and spread flat by grasping both sides of bag and gently shaking?  
31. Open end of bag placed over seal bar and closed?  
32. Sample removed from vacuum chamber when door opens and submerged in 25 ± 1°C (77 ± 2°F) water bath within 5 seconds?  
33. Bag maintained at a minimum depth of two inches?  
34. A small cut made at corner of bag approximately 25 to 50 mm (1" to 2")?  
35. Submerged bag held open until water flows freely into bag (approximately 45 seconds)  
36. A second cut approximately 25 to 50 mm (1" to 2") made to opposite side of bag?  
37. Residual air removed from bag by running fingers across top of submerged bag?  
38. Bag placed in weighing basket and water allowed to flow freely into bag?  
39. Sample mass determined and recorded after 15 minutes but not more than 20 minutes and recorded to 0.1 g?  
40. Test data entered into manufacture’s software to obtain test results?  

First Attempt:  Pass ☐  Fail ☐  Second Attempt:  Pass ☐  Fail ☐  
Comments:  

Testing Technicians Signature:  ______________________________  WAQTC #  ___________  Date:  ___________

Examiner’s Name:  ______________________________  Signature:  ______________________________  WAQTC #  ___________
PERFORMANCE EXAM CHECKLIST

BULK DENSITY (UNIT WEIGHT) AND VOIDS IN AGGREGATE
AASHTO T 19

Participant Name: ________________________  Exam Date: ________

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

Procedure Elements:  

1. **Obtain Sample.** Use the FOP for AASHTO T 2.  
   Trial 1 Trial 2

2. **Aggregate dried to constant mass per the FOP for AASHTO T 255.**  
   Trial 1 Trial 2

3. **Reduce Sample to required size.** Use the FOP for AASHTO T 248. Sample shall be 125% to 200% of the quantity needed to fill the measure.  
   Trial 1 Trial 2

4. **Inspect measure and other apparatus.** Measure must be calibrated within the last 12 months; balance conforms to M 231, scoop/ shovel, & tamping rod in good working order.  
   Trial 1 Trial 2

5. **Rodding** aggregate NMS 1 1/2” (37.5 mm) or less
   a. **Measure filled 1/3 full, leveled by hand, and rodded 25 times evenly distributed.** The rod shall not strike the bottom of the measure forcibly.  
      Trial 1 Trial 2
   
   b. **Measure filled 2/3 full, leveled by hand, and rodded 25 times evenly distributed.** The rod shall not penetrate into the first layer.  
      Trial 1 Trial 2

   c. **Measure filled to overflowing, and rodded 25 times evenly distributed.** The rod shall only penetrate the top lift. The surface shall be leveled in such a way either by hand or straightedge that the number of slight projections equals the voids.  
      Trial 1 Trial 2

6. **Jigging:** aggregates NMS greater than 1 ½” (37.5 mm) but not exceeding 5” (125mm)
   a. **Measure filled 1/3 full.**  
      Trial 1 Trial 2

   b. **Measure placed on concrete floor with opposite side lifted 2” (50mm) and allowed to drop freely, continue this process for 25 times then drip it 25 more times from the opposite side for a total of 50 drops and leveled by hand.**  
      Trial 1 Trial 2

   c. **Measure filled 2/3 full and placed on concrete floor with opposite side lifted 2” (50mm) and allowed to drop freely, continue this process for 25 times then drip it 25 more times from the opposite side for a total of 50 drops and leveled by hand**  
      Trial 1 Trial 2
d. Measure filled to overflowing, and placed on concrete floor with opposite side lifted 2" (50mm) and allowed to drop freely, continue this process for 25 times then drip it 25 more times from the opposite side for a total of 50 drops and leveled. The surface shall be leveled in such a way either by hand or straightedge that the number of slight projections equals the voids.

7. Shoveling: only when specified

   a. Measure filled to overflowing with shovel or scoop. Material placed into measure from a height not to exceed 2" (50mm) above the top of the measure minimizing segregation while filling.

   b. Measure leveled by hand or straightedge. The surface shall be leveled in such a way either by hand or straightedge that the number of slight projections equals the voids.

8. Determine mass of the measure and aggregate and mass of the measure alone to 0.1lb (0.05 kg).

9. Determined & record the mass of Aggregate 0.1lb (0.05 kg).

10. Calculate the bulk density to 1 lb/ft³ (10 kg/m³).

First Attempt: Pass ☐ Fail ☐ Second Attempt: Pass ☐ Fail ☐

Comments: ________________________________
PERFORMANCE EXAM CHECKLIST

BULK DENSITY (UNIT WEIGHT) AND VOIDS IN AGGREGATE
AASHTO T 19

Participant Name: ____________________________  Exam Date: _______

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

**Procedure Elements:**

**Sample Preparation**

1. Sampled according to AASHTO T 2?

2. Sample reduced according to AASHTO R 76 to approximately 2000 g?

3. Dried to a constant mass at 230 ±9º F, cooled to a comfortable handling temperature?

4. Addition of 6% moisture to sample?

5. Allowed to stand 15 – 19 hours?

6. Uniformly dried by a current of warm air, with frequent stirring?

7. Mold placed on flat, non-absorbent surface and filled to over-flowing?

8. Sample compacted with 25 light drops of tamper from 0.2” above top of sample?

9. Tamper allowed to fall freely under gravitational attraction?

10. Loose sand removed from around bases and mold lifted vertically?

11. Sample fails to slump on the first test?

12. If it does slump, is water added, sample covered and allowed to stand 30 minutes?

13. Drying continued, and test repeated at frequent intervals until sample slumps slightly? Slight slump is when there is some evidence of slumping around the circumference of the cone?

**Testing Procedure**

1. Split out two 500 gram samples that weigh within 0.2 grams of each other.

2. 1000 ml Pycnometer partially filled with water and first sample added?

3. Second sample dried back to constant mass?

4. Pycnometer filled to 90 % of calibrated capacity and agitated to eliminate air bubbles?

5. Temperature adjusted to 73.4 ±3º F.?
<table>
<thead>
<tr>
<th>Quality Assurance</th>
<th>ITD STQP</th>
<th>590.00</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>6.</strong> Water level brought to calibrated capacity and agitated to eliminate air bubbles?</td>
<td>Pass □ Fail □</td>
<td>Pass □ Fail □</td>
</tr>
<tr>
<td><strong>7.</strong> Second sample cooled in air at room temperature for 1.0 ±0.5 hr. and weighed?</td>
<td>Pass □ Fail □</td>
<td>Pass □ Fail □</td>
</tr>
<tr>
<td><strong>8.</strong> Pycnometer calibrated mass determined?</td>
<td>Pass □ Fail □</td>
<td>Pass □ Fail □</td>
</tr>
<tr>
<td><strong>9.</strong> All masses determined to nearest 0.1 g?</td>
<td>Pass □ Fail □</td>
<td>Pass □ Fail □</td>
</tr>
<tr>
<td><strong>10.</strong> Calculations performed and values rounded correctly?</td>
<td>Pass □ Fail □</td>
<td>Pass □ Fail □</td>
</tr>
</tbody>
</table>

**Formulas for Specific Gravities and Absorption**

**Bulk Specific Gravity**

\[
\frac{AA}{BB + SS - CC}
\]

**Bulk Specific Gravity (SSD)**

\[
\frac{SS}{BB + SS - CC}
\]

**Apparent Specific Gravity**

\[
\frac{AA}{BB + AA - CC}
\]

**Absorption, Percent**

\[
\frac{(SS - AA)}{AA} \times 100
\]

Where:

- A = mass of oven-dry specimen (second sample) in air, g;
- B = mass of pycnometer filled with water, g;
- C = mass of pycnometer with specimen and water to calibration mark, g; and
- S = mass of saturated surface-dry specimen (weight of first sample), g.

First Attempt: Pass □ Fail □ Second Attempt: Pass □ Fail □

Comments:

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

Testing Technician’s Signature: ___________________________ WAQTC # _______ Date: _______

Examiner’s Name: ___________________________ Signature: ___________________________ WAQTC # _______
PERFORMANCE EXAM CHECKLIST

UNCOMPACTED VOID CONTENT OF FINE AGGREGATE
FOP FOR AASHTO T 304

Participant Name: ________________________ Exam Date: ___

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

Procedure Element: (all test methods are AASHTO unless otherwise shown) Trial 1 Trial 2

Sampling

1. Sample obtained by one of the following:
   (a) T 2 & R 76 (sampling, splitting and quartering)? or; _______ _______
   (b) From sieve analysis samples used for T 27? or; _______ _______
   (c) From aggregate extracted from a bituminous concrete specimen (T 308)? _______ _______

2. Methods A
   (a) Sample washed over No. 100 or No. 200 sieve in accordance with T 11? _______ _______
   (b) Sample dried and sieved into separate size fractions in accordance with T 27? _______ _______
   (c) Necessary size fractions obtained from sieve analysis maintained in a dry condition in separate containers for each size? _______ _______

Sample Preparation

Method A- Standard Graded Sample

1. Following quantities of aggregate that has been dried and sieved in accordance with T 27 weighed out and combined? _______ _______

<table>
<thead>
<tr>
<th>Individual Size Fractions</th>
<th>Mass, g</th>
<th>OK?</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 8 to No. 16</td>
<td>44 ± 0.2</td>
<td></td>
</tr>
<tr>
<td>No. 16 to No. 30</td>
<td>57 ± 0.2</td>
<td></td>
</tr>
<tr>
<td>No. 30 to No. 50</td>
<td>72 ± 0.2</td>
<td></td>
</tr>
<tr>
<td>No. 50 to No. 100</td>
<td>17 ± 0.2</td>
<td></td>
</tr>
<tr>
<td>Total:</td>
<td>190 ± 0.2</td>
<td></td>
</tr>
</tbody>
</table>

Specific Gravity of Fine Aggregate

If bulk dry specific gravity of aggregate from the source is unknown, specific gravity determined on material passing No. 4 sieve in accordance with IT 144. _______ _______
Procedure

1. Each test sample mixed with spatula until it appears to be homogeneous?

2. Funnel stand apparatus with cylindrical measure, positioned in retaining pan?

3. Finger used to block opening of funnel?

4. Test sample poured into funnel?

5. Material in funnel leveled with spatula?

6. After funnel empties, excess heaped aggregate struck off from cylindrical measure by single pass of spatula, with blade width vertical and using straight part of its edge in light contact with top of measure?

7. Care exercised to avoid vibration or any disturbance that could cause compaction of aggregate into cylindrical measure?

   Note: After strike-off, measure may be tapped lightly to compact sample to make it easier to transfer container to scale or balance without spilling any of the sample.

8. Adhering grains brushed from outside of container?

9. Mass of cylindrical measure and contents determined to nearest 0.1 g?

10. All aggregate particles retained for second test run?

11. Sample from retaining pan and cylindrical measure recombined and procedure repeated?

12. Mass of empty measure recorded?

13. Calculations performed properly?

Formula for Calculation of Uncompacted Voids, percent

\[ UU = \frac{VV - FF \times GG}{VV} \times 100 \]

Where:

\( U = \) uncompacted voids, percent;
\( V = \) volume of cylindrical measure to nearest 0.1 mL;
\( F = \) net mass, g, of fine aggregate in measure; and,
\( G = \) bulk dry specific gravity of fine aggregate (\( G_{sb} \))

First Attempt: Pass [ ] Fail [ ] Second Attempt: Pass [ ] Fail [ ]
PERFORMANCE EXAM CHECKLIST

FLAT PARTICLES, ELONGATED PARTICLES, OR FLAT AND ELONGATED PARTICLES IN COARSE AGGREGATE FOP FOR IDAHO FOP FOR ASTM D 4791

Participant Name:_________________________ Exam Date:_______

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

<table>
<thead>
<tr>
<th>Procedure Element:</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sample Preparation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Sample obtained, mixed and reduced in accordance with AASHTO T 2 and AASHTO R 76 to approximately the amount required for testing? For combined samples fine portion (- # 4) removed?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Minimum dry sample mass meets requirements of Table 1?</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Procedure</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. If determination by mass, sample oven-dried to constant mass at 230 ±9° F? <strong>Note:</strong> If determination is by particle count drying is not necessary.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Sample sieved according to AASHTO T 27?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Each coarse aggregate size fraction present in amount of 10% or more of original coarse sample reduced according to R 76 until approximately 100 particles obtained?</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Flat and Elongated Particle Test:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Each particle in each size fraction tested and placed into one of two groups: (1) flat and elongated or (2) not flat and elongated?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Proportional caliper device positioned at proper ratio?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Larger opening set equal to particle length?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Particle is flat and elongated if the thickness can be placed in the smaller opening?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Proportion of sample in each group determined by count or by mass, as required?</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Calculation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Percentage of flat and elongated particles calculated to nearest 1% for each sieve size greater than No. 4?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. When weighted average for sample is required, sieve sizes not tested (those representing less than 10% of sample) assumed to have same percentage of flat particles, elongated particles, or flat and elongated particles as the next smaller or the next larger size? <strong>Or if both are present, is average for next smaller and larger sizes used?</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

First Attempt: Pass [ ] Fail [ ] Second Attempt: Pass [ ] Fail [ ]

Comments:

Testing Technician’s Signature: ___________________ WAQTC #: __________ Date: __________

Examiner’s Name: ___________________ Signature: ___________________ WAQTC #: __________

1/18 FOP for ASTM D4791
PERFORMANCE EXAM CHECKLIST

FIELD VISCOSITY
IDAHO IT 61

Participant Name: ___________________________ Exam Date: __

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sampling</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Sample taken using a valve:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Minimum of 4 L (1gal) allowed to flow before sample taken?</td>
<td>________</td>
<td>________</td>
</tr>
<tr>
<td>b. Sample taken in clean 1 L (1 quart) wide mouth jar?</td>
<td>________</td>
<td>________</td>
</tr>
<tr>
<td>2. Sample taken with Thief device.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>a. Sample can immersed approximately to middle of tanker?</td>
<td>________</td>
<td>________</td>
</tr>
<tr>
<td>b. Rubber stopper removed from can and sample taken from the middle of the tanker/tank?</td>
<td>________</td>
<td>________</td>
</tr>
<tr>
<td>3. A portion of the sample transferred to a one (1) half pint plastic bottle and sealed with a stopper having a thermometer in the center?</td>
<td>________</td>
<td>________</td>
</tr>
<tr>
<td><strong>Equipment</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Temperature of the viscometer bath at 50°C (122°F)?</td>
<td>________</td>
<td>________</td>
</tr>
<tr>
<td>5. Viscosity tube clean and dry and cork installed?</td>
<td>________</td>
<td>________</td>
</tr>
<tr>
<td><strong>Testing</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Sample cooled to 51.7 ±0.3°C (125 ±0.5°F)?</td>
<td>________</td>
<td>________</td>
</tr>
<tr>
<td>7. Sample poured through a #20 sieve prior to entering the brass viscosity tube?</td>
<td>________</td>
<td>________</td>
</tr>
<tr>
<td>8. Enough sample poured into the tube to allow overflow into gallery?</td>
<td>________</td>
<td>________</td>
</tr>
<tr>
<td>9. Thermometer placed into tube and sample stirred slowly until testing</td>
<td>________</td>
<td>________</td>
</tr>
<tr>
<td>10. Thermometer withdrawn and excess in the overflow gallery siphoned out using a pipette without touching overflow rim?</td>
<td>________</td>
<td>________</td>
</tr>
<tr>
<td>11. Emulsified asphalt sample in viscometer immediately covered?</td>
<td>________</td>
<td>________</td>
</tr>
<tr>
<td>12. Cork pulled allowing the sample roll down the inside lip of the receiving flask?</td>
<td>________</td>
<td>________</td>
</tr>
<tr>
<td>13. Timer immediately started when cork is pulled?</td>
<td>________</td>
<td>________</td>
</tr>
<tr>
<td>14. Timer stopped when bottom of sample meniscus reaches graduation mark?</td>
<td>________</td>
<td>________</td>
</tr>
<tr>
<td>15. Test results reported to nearest 1 second on ITD-1045 form?</td>
<td>________</td>
<td>________</td>
</tr>
</tbody>
</table>

First Attempt: Pass ☐ Fail ☐ Second Attempt: Pass ☐ Fail ☐

Comments

Testing Technician’s Signature: ___________________________ WAQTC #: __________ Date: __________

Examiner’s Name: ___________________________ Signature: ___________________________ WAQTC #: _________
PERFORMANCE EXAM CHECKLIST

DETECTION OF ANTI-STRIP ADDITIVE IN ASPHALT
IDAHO T 99

Participant Name: ________________________  Exam Date: __

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>General</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. All containers and or stir sticks were clean and chemical solutions were fresh.</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Detection Test by Color Method Only</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. A control blank was performed.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. 40 ml of Reagent Isopropyl Alcohol or equivalent was used.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. The asphalt mixture was heated on a hot plate.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Heating of sample was stopped before mixture became too dark.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. The same amount of Bromophenol Blue Indicator was added to both mixtures.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Test results were accurately interpreted and recorded on the proper ITD Form.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

First Attempt: Pass ☐  Fail ☐  Second Attempt: Pass ☐  Fail ☐

Comments ________________________________

________________________________________
________________________________________

Testing Technician’s Signature: ________________________  WAQTC #: __________  Date: __________

Examiner’s Name: ________________________  Signature: ________________________  WAQTC #: __________
PERFORMANCE EXAM CHECKLIST

EFFECT OF WATER ON COMPRESSION STRENGTH OF COMPACTED BITUMINOUS MIXTURES
ASTM D1075

Participant Name: ___________________________ Exam Date: ____________

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

### Procedure Element: Test Specimen

1. Six 4 by 4 in. (101.6 by 101.6 mm) cylindrical specimens made in accordance with AASHTO T 167

### Determination of Bulk Specific Gravity of Test Specimen

1. Each set of specimens cooled for at least 2 hours after removal from curing oven described in test method AASHTO T 167
2. Bulk specific gravity of each specimen was performed and calculated correctly

### Procedure

1. Each set of six test specimens into two groups of three by average bulk specific gravity
2. Group 1 – Specimen temperature was at 25 ± 1°C (77 ± 1.8°F) by storing in an air bath maintained at temperature for no less than 4 hours
3. Group 1 – Compressive Strength of Specimen was determined by T 167
4. Group 2 – Specimens were immersed in water for 24 hours at 60 ± 1°C (140 ± 1.8°F)
5. Group 2 – Specimens were transferred to the water bath maintained at a temperature of 25 ± 1°C (77 ± 1.8°F) for 2 hours
6. Group 2 – Compressive Strength of Specimen was determined by T 167
7. Carefully transfer individual specimens from water bath to compression machine, one at a time, on a non-absorbent (glass, plastic, or metal) transfer plates and immediately perform compressive strength test per T 167. Do not jar or shake specimen during transfer to compression machine.
8. Compressive Strength calculated correctly by T 167
Index of retained strength, % \( = \frac{S_2}{S_1} \times 100 \)

Where:
- \( S_1 \) = Compressive strength of dry specimens (group 1) and
- \( S_2 \) = Compressive strength of immersed specimens (group 2)
PERFORMANCE EXAM CHECKLIST

COMPRESSIVE STRENGTH OF HOT MIX ASPHALT
AASHTO T 167

Participant Name: ___________________________  Exam Date: __

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

<table>
<thead>
<tr>
<th>Procedure Elements:</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preparation of Test Mixtures and Apparatus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. Aggregate ingredient samples obtained in accordance with T 2 and reduced by R 76</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Desired fractions separated in accordance with T 27</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. The job mix formula used to combine appropriate weight of each size from ingredient aggregate to obtain appropriate gradation and batch weights</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4. Correct mixing and compaction temperature supplied by the binder supplier</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Molding Cylinder heated to a compaction temperature for a minimum 1 hour</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laboratory-Mixed Material</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Bowl and batch of aggregate preheated in oven meeting temperature requirements for mixing. Aggregate is heated to no hotter than 28°C(50°F) above mixing temperature to allow for dry mixing prior to adding asphalt binder</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Butter Batch produced and equipment properly coated prior to mixing individual points.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8. Mass of dry aggregate recorded and appropriate weight of asphalt binder determined</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. With the aggregate and bowl resting on the balance, hot asphalt binder quickly poured to the prescribed weight and mixed immediately. If mixing by hand, aggregate and binder mixed with a large spoon by rolling the material from perimeter toward the center to maximize aggregate and asphalt contact and minimize asphalt contact with the bowl</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Mixing completed within 90 to 120 seconds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Mixture temperature at least 3°C (5°F) above compaction temperature, if not, discard and repeat mixing procedures</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Plant Mixed Material

12. R 47, quartering method, used for size reduction

13. Weight adjusted by the reduction of the sample to the required weight by removing and discarding small amounts of both fine and coarse material

14. Care exercised in order to maintain proper gradation

15. Sample is placed into appropriate container and in an oven to mixing temperature

16. Compacting commenced immediately or placed in the oven for a short period of time but no more than 1 hour

17. Molding cylinder, top and bottom plunger preheated 1h in water bath just under boiling point, or in an oven for at least 2 h at 135°C (200-275°)

18. Bottom plunger in place and molding cylinder temporarily supported by two steel 1 inch support bars

19. First half of the mixture poured into the molding cylinder and received spading action of 15 blows around the perimeter and 10 randomly located blows in the center with a heated spade

20. Second half of material poured into the molding cylinder and received spading action of 15 blows around the perimeter and 10 randomly located blows penetrating the mixture as deep as possible with a heated spade

21. The top of the mixture slightly rounded or cone-shaped to aid in firm seating of upper plunger

Compaction and curing of Test Specimens

22. Mixture pre-compacted at 150 psi

23. Remove support bars and fully compact specimen at 3000 psi for 2 minutes

24. Remove specimen from mold with ejection device with smooth uniform rate of travel

25. Specimen oven-cured for 24 hours at 60°C (140°F)

Test Specimens

26. Specimens 101.6 mm (4 in.) in diameter and 101.6 ± 2.5 mm (4.0 ± 0.1 in.) in height

27. If specimen is something other than 4 inches, height shall be equal to the diameter within ±2.5 percent

28. Diameter not less than four times the nominal diameter of the largest aggregate particle

29. Diameter is not less than 50.8 mm (2 in.)
Procedure

30. Test specimen cooled at room temperature for at least 2 hours after removal from the curing oven

31. Bulk specific gravity determined for each specimen in accordance with T 166

32. Test specimens stored at a test temperature of 25 ± 1°C (77 ± 1.8°F) in an air bath for at least 4 hours

33. Specimen tested in axial compression without lateral support at a uniform rate of vertical deformation of 0.05 mm/min-mm or (0.05 in./min-in) for height

34. 101.6 mm (4 in.) specimens in height use a rate of 5.08 mm/min (0.2 in./min)

35. Maximum load experience by specimen during compression process recorded

36. Theoretical specific gravity and density determined by T 209 provided by mix confirmation sample

37. Calculate the percent Air Voids according to T 269

38. Calculate the compressive strength

Technician Calculations:

First Attempt: Pass ☐ Fail ☐ Second Attempt: Pass ☐ Fail ☐

Comments: ____________________________________________________________

_____________________________________________________________________

Testing Technician’s Signature: ___________________________ WAQTC #: __________ Date: __________

Examiner’s Name: _______________________ Signature: ___________________ WAQTC #: __________________
PERFORMANCE EXAM CHECKLIST

BULK SPECIFIC GRAVITY AND DENSITY OF COMPACTED HOT MIX ASPHALT (HMA) USING AUTOMATIC VACUUM SEALING METHOD FOP FOR AASHTO T 331

Participant Name: ________________________ Exam Date: ________________

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

Procedure Element: 

1. Mass of dry sample in air determined?
   a. Dried overnight at 125°F and at successive 2-hour intervals to constant mass?
   b. Cooled in air to 77°± 9°F?
   c. Dry mass determined to 0.1g?
   d. Record initial dry mass as (A)?

2. Bag mass recorded?
   a. Bag inspected for holes or irregularities?
   b. Bag mass recorded?

3. Bag placed in vacuum chamber?

4. Specimen placed in bag 1 inch from end of bag?

5. Check that there are no wrinkles in the bag along the seal bar.

6. Lid closed and lid retaining latch engaged?

7. Once sealed remove the specimen carefully from chamber?

8. Specimen mass in bag in air?
   a. Determine mass to 0.1g?
   b. Record mass as (B).

9. Sealed puck quickly placed in water bath at 77°± 1.8°F?
   a. From time vacuum lid opens to being submerged in water, not to exceed 1 min?
   b. Specimen fully submerged?
   c. Specimen not touching edges of water bath?
   d. Once scale stabilizes, record mass as (E).

10. Bag removed from water bath?

11. Sample removed from bag?
12. Sample Mass determined and designated as (C)?
   a. Verify mass (A) is no more than 5g from mass specimen (C)?
   b. If more than 5g different, oven dry to constant mass and retest?

\[ G_{mb} = \frac{AA}{C + (BB - AA) - EE - \frac{BB - AA}{FF}} \]

Where:

- \( G_{mb} \) = Specimen bulk specific gravity;
- \( A \) = Initial mass of the dried specimen in air, g;
- \( B \) = Calculated mass of the dry, sealed specimen, g;
- \( C \) = Final mass of the specimen after removal from the sealed bag, g;
- \( E \) = Mass of the sealed specimen underwater, g; and
- \( F \) = Apparent specific gravity of the plastic sealing material at 77°F, provided by the Manufacturer.

First Attempt: Pass [ ] Fail [ ] Second Attempt: Pass [ ] Fail [ ]

Comments:

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

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________________________________________________________________________

Testing Technician’s Signature: ___________________________ WAQTC #: ______ Date: ______

Examiner’s Name: ___________________________ Signature: ___________________________ WAQTC #: ______
PERFORMANCE EXAM CHECKLIST

SAMPLING ASPHALT MIXTURES AFTER COMPACTION (OBTAINING CORES)
FOP FOR AASHTO R 67

Participant Name: ___________________________  Exam Date: __

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

Procedure Element:  

1. Core location determined by Agency? __________  __________
2. Asphalt mixture sufficiently cool or cooled with water, ice dry ice or liquid nitrogen? __________  __________
3. Core machine correctly positioned over location? __________  __________
4. Water or air used to remove cuttings and minimize friction? __________  __________
5. Constant pressure applied to bit while keeping it perpendicular to HMA surface? __________  __________
6. Coring stopped a desired depth? __________  __________
7. Retrieval device used to obtain object? __________  __________
8. Core labeled? __________  __________
9. Core placed for transport in a manner that prevents damage from jarring, rolling, impact with any object, or extreme temperatures? __________  __________
10. Core hole filled with agency suitable material and compacted when necessary? __________  __________
11. Thickness determined to 1/8 in., 0.01 ft., or 3 mm? __________  __________

First Attempt:  Pass ☐  Fail ☐  Second Attempt:  Pass ☐  Fail ☐

Comments: ____________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

Testing Technician’s Signature: ___________________________  WAQTC #: __________
Date: __________

Examiner’s Name: ___________________________  Signature: ___________________________  WAQTC #: __________
PERFORMANCE EXAM CHECKLIST

DETERMINING THE PLASTIC LIMIT AND PLASTICITY INDEX OF SOILS
AASHTO T-90

Participant Name: ______________________ Exam Date: ____________

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

Procedure Elements:                                                                 Trial 1                      Trial 2

1. **Inspect and clean apparatus.** Apparatus include mixing dish, spatula, rolling surface, moisture containers with lids, balance readable to 0.01g and a drying oven. All apparatus should be clean dry and within specifications. Moisture containers and their lids will be weighed and recorded before each test.

2. **Prepare sample.** As per AASHTO T-87 or AASHTO T-146. This test requires approximately 20g of material. Material for this test can be obtained from material used for AASHTO T-89.

3. **Adjustment of moisture content.** Moisture content shall be such that the material can be shaped into a ball and is not sticky. Use distilled or demineralized water only.

4. **Roll sample to 3.0 mm (approx. 1/8").** Take approximately 8g of the 20g sample and separate into 1.5–2.0 gram increments. Roll on a ground surface with just enough pressure to make a thread of uniform diameter for its entire length. A rolling rate of 80 to 90 strokes/minute shall be used. When the diameter of the thread becomes 3.0 mm (approx. 1/8") break thread into 6 to 8 pieces then make a ball and repeat process. There is a 2 minute time to get from a ball down to 3.0 mm (approx. 1/8").

5. **Re-roll until thread breaks or crumbles.** Repeat step #4 until thread breaks into a series of segments 6.4 mm (1/4") to 9.5 mm (3/8") in length. The sample must be rolled to 3.0 mm (1/8") at least once before it breaks or crumbles, if failure occurs on the first try add moisture and repeat steps. Do not attempt to produce failure at 3.0 mm (1/8") in diameter.

6. **Collect crumbled particles.** Using the spatula, gather all portions of the crumbled particles into a suitable container; **cover immediately** and determine the mass to the nearest 0.01g.

7. **Remove cover and place in oven at 110±5°C (230±9°F) and dry to constant mass.** When removing sample from the drying oven **cover immediately.**

8. **Determine moisture content.** After drying to a constant mass, cool and determine the mass to the nearest 0.01g and calculate moisture content to the nearest 0.1%.

10. Determine Plasticity Index (PI). Calculate the Plasticity Index of the soil as the difference between its Liquid Limit and its Plastic Limit.

Example: \( LLL - PPL = PPP \)

The result is reported to the nearest whole number.

First Attempt: Pass ☐ Fail ☐ Second Attempt: Pass ☐ Fail ☐

Comments: 

__________________________________________________________________
__________________________________________________________________
__________________________________________________________________

Testing Technician’s Signature: _______________ WAQTC #: __________ Date: __________
Examiner’s Name: __________________________ Signature: __________________________ WAQTC #: __________
PERFORMANCE EXAM CHECKLIST

DETERMINING THE LIQUID LIMIT OF SOILS
(METHOD “B” ONE POINT)
AASHTO T-89

Participant Name:__________________________ Exam Date:__

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

Procedure Elements:  

<table>
<thead>
<tr>
<th>Procedure Step</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Prepare sample. Using AASHTO T 87 or AASHTO T 146. This test requires a minimum of 50g of minus # 40 (0.425 mm) material.</td>
<td>___________</td>
<td>___________</td>
</tr>
<tr>
<td>2. Inspect and adjust test apparatus. Apparatus includes liquid limit device, porcelain mixing dish, spatula, grooving tool, gauge for cup height drop, containers with lids, balance readable to the hundredth and a drying oven. All apparatus shall be clean, dry and within specifications. Moisture containers and lids will be weighed and recorded before each test. Check the drop height on the liquid limit device using the gauge and a piece of tape and adjust as necessary.</td>
<td>___________</td>
<td>___________</td>
</tr>
<tr>
<td>3. Adjust sample moisture and mix. Use distilled or demineralized water only. Add 8 to 10 ml of water to material and mix thoroughly, approximately 5 to 10 minutes. Moisture may then be adjusted by adding increments of 1 to 3 ml of water and mixing thoroughly, approximately 1 minute, or by air drying while mixing and kneading. Moisture may not be adjusted by adding dry soil to the moistened sample. Cover the sample and allow to season for 30 minutes.</td>
<td>___________</td>
<td>___________</td>
</tr>
<tr>
<td>4. Spread sample into cup of device. Remix sample and spread above the spot where cup rests on the base. The top surface should be as level as possible and 10 mm in thickness at its maximum depth. Use as few strokes as possible; do not entrap air into the sample. Return excess material to the mixing dish.</td>
<td>___________</td>
<td>___________</td>
</tr>
<tr>
<td>5. Cut groove into the sample. Cut groove through the center of the sample, perpendicular to the hinge pin of the cup. Use as few strokes as possible. Up to 6 strokes may be used, only the last stroke should touch the bottom of the cup.</td>
<td>___________</td>
<td>___________</td>
</tr>
<tr>
<td>6. Turn the device on and count the taps. Count the number of taps required to close the groove for a length of approx. ½” (13 mm). If sample slides instead of flowing, add water, remix and repeat test. If problem re-occurs discontinue test and note.</td>
<td>___________</td>
<td>___________</td>
</tr>
<tr>
<td>7. Repeat steps 3 through 6 until the groove closes with a range of 22 and 28 taps. Return remaining soil in the brass cup to the mixing dish with something other than the spatula. Apparatus shall be cleaned and dried between tests. Adjustment of moisture shall follow the guidelines in step 3.</td>
<td>___________</td>
<td>___________</td>
</tr>
</tbody>
</table>
8. **Take sample for moisture content determination.** Using the spatula, take a slice of the sample the width of the spatula at the point of closure. The slice shall extend from edge to edge of the soil and perpendicular to the groove for the full depth of the sample. Place the moisture sample in a suitable container, **cover immediately, determine the mass** to the nearest 0.01g and record immediately.

9. **Remove cover, place in oven at 110±5° C (230±9° F) and dry to a constant mass.** When removing the sample from the oven to determine constant mass **cover immediately.**

10. **Complete moisture content determination on samples.** After drying to a constant mass; cool to room temperature and determine the mass to a 0.01g and record. Calculate moisture content to the nearest 0.1%

11. **Calculate the Liquid Limit.** Using the formula:

   \[
   \text{LLLL} = \left(\frac{\text{WWNN}}{\text{NN}}\right)^{0.121} \times 25
   \]

   Calculate the corrected Liquid Limit for 25 taps to the nearest 0.1%

12. **Report the Liquid Limit.** The Liquid Limit is the nearest whole number.

---

First Attempt:  Pass [ ]  Fail [ ]  Second Attempt:  Pass [ ]  Fail [ ]

Comments:

____________________________________________________

Testing Technician’s Signature: ___________________________ WAQTC #: _______ Date: ____________

Examiner’s Name: ___________________________ Signature: ___________________________ WAQTC #: _______
# PERFORMANCE EXAM CHECKLIST

**DETERMINING THE SPECIFIC GRAVITY OF SOILS**

**AASHTO T 100**

<table>
<thead>
<tr>
<th>Participant Name: ___________________________</th>
<th>Exam Date: __________</th>
</tr>
</thead>
</table>

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

<table>
<thead>
<tr>
<th>Procedure Element</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Sample obtained?</td>
<td>__________</td>
<td>__________</td>
</tr>
<tr>
<td>2. Flask filled three quarters with distilled water?</td>
<td>__________</td>
<td>__________</td>
</tr>
<tr>
<td>3. Entrapped air removed?</td>
<td>__________</td>
<td>__________</td>
</tr>
<tr>
<td>4. Vacuum 100mm or less?</td>
<td>__________</td>
<td>__________</td>
</tr>
<tr>
<td>5. Flask agitated gently for the allowed amount of time?</td>
<td>__________</td>
<td>__________</td>
</tr>
<tr>
<td>a. Oven dried sample 2 – 4 hours</td>
<td>__________</td>
<td>__________</td>
</tr>
<tr>
<td>b. Low plasticity 4 – 6 hours</td>
<td>__________</td>
<td>__________</td>
</tr>
<tr>
<td>c. High plasticity containing moisture 6 -8 hours</td>
<td>__________</td>
<td>__________</td>
</tr>
<tr>
<td>6. Pycnometer filled to calibration mark?</td>
<td>__________</td>
<td>__________</td>
</tr>
<tr>
<td>7. Pycnometer mass determined?</td>
<td>__________</td>
<td>__________</td>
</tr>
<tr>
<td>8. Temperature determined?</td>
<td>__________</td>
<td>__________</td>
</tr>
</tbody>
</table>

\[
\sigma = \frac{W_0}{W_a - (W_b - W_0)} \times K
\]

Where:

- \( T_x \) = temperature of the contents of the Pycnometer when mass \( W_b \) was determined, in degrees Celsius;
- \( W_0 \) = mass of sample of oven-dried soil in grams
- \( W_a \) = mass of pycnometer filled with water at temperature \( T_x \) in grams
- \( W_b \) = mass of pycnometer filled with water and soil at temperature \( T_x \), in grams
- \( K \) = Correction Factor = (Rel. Density of Water at \( T \) / Rel. Density of Water at 20°C)

First Attempt:  Pass [ ]  Fail [ ]  Second Attempt:  Pass [ ]  Fail [ ]

Comments: ______________________________________________________

______________________________________________________________

Testing Technicians Signature: __________________________  WAQTC #: __________  Date: __________

Examiner Name: __________________________  Signature: __________________________  WAQTC #: __________
PERFORMANCE EXAM CHECKLIST

SAMPLING & FABRICATION OF 2” (50 – MM) CUBE SPECIMENS USING 
GROUT (NON-SHRINK) MORTAR
IDaho FOP for AASHTO R 64

Participant Name: ___________________________  Exam Date: ___________________________

Record the symbols “P” for passing or “F” for failing on each step of the checklist.

Procedure Elements:

1. **Obtain Sample.** Use WAQTC TM 2 for 1 yd$^3$ or more or for less than 1 yd$^3$ sample from discharge after remixing takes place.

2. **Inspect and adjust test apparatus.** Apparatus includes mold assembly, tamper, trowel, watertight container.

3. **Mold portion attached to bottom plate and joints are water tight.** Use of a light coating of non water-soluble grease is allowed.

4. **Place a 1” (approximately 1/2 the depth of the mold) layer of Grout or non-shrink mortar into the mold.** Grout or mortar shall be placed in all compartments.

5. **Consolidate the mix.** The mix shall be consolidated depending on the consistency, either plastic or fluid.

6. **Plastic mixes:** tamp lift in 4 rounds, 8 tamps per round, for a total of 32 tamps in 10 seconds with rubber tamper. Rounds 1 and 3 and 2 and 4 shall be the same.

7. **Fluid Mixes:** puddle the lift 5 times with gloved finger.

<table>
<thead>
<tr>
<th>Procedure</th>
<th>Trial 1</th>
<th>Trial 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obtain Sample</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Inspect and adjust test apparatus</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Mold portion attached to bottom plate and joints are water tight</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Place a 1” layer of Grout or non-shrink mortar into the mold</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Consolidate the mix</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Plastic mixes</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Fluid Mixes</td>
<td>✔️</td>
<td>✔️</td>
</tr>
</tbody>
</table>
8. **Place the second lift into all of the mold compartments and consolidate:**
   Slightly overfill. Consolidate in same fashion as first lift. After consolidation material should extend slightly above the top of the mold. Push any grout forced out onto the top of the mold back onto the compartment with a trowel.

9. **Strike off the surface.** Using the trowel draw the flat side with the leading edge slightly raised once across the top of each cube at right angles to the length of the mold. Then draw the flat trailing edge of the trowel, with leading edge slightly raised,) once lightly along the length of the mold. Cut off the mortar to a plane surface flush with the top of the mold by drawing the straight edge of the trowel (held nearly perpendicular to the mold) with a sawing motion over the length of the mold. The material shall be flush with the top of the mold.

10. **Immediately secure the top plate to the molds.**

11. **Molds properly stored:** Cover with wet burlap, towels, or rags, seal it in a plastic sack in a level location out of direct sunlight, and record the time. These samples shall remain undisturbed and protected from freezing or overheating for a period of 24 ± 4 hours.