Washington State
Department of Transportation

WSDOT Test Method T 606

Method of Test for Compaction Control of Granular Materials

1. Scope

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

2. Reference Documents

2.1 AASHTO Standards

T 99	Moisture-Density Relations of Soils Using a 5.5 lb (2.5 kg) Rammer and a 12 in (305 mm) Drop (Method A only)
M 92	Standard Specification for Wire-Cloth Sieves for Testing Purposes
M 231	Standard Specification for Weighing Devices Used in the Testing of Materials

2.2 WSDOT Standards

T 2	FOP for AASHTO Standard Practice for Sampling Aggregates
R 76	FOP for AASHTO Reducing Samples of Aggregate to Testing Size
T 255	FOP for AASHTO Total Moisture Content of Aggregate by Drying

3. Definitions

3.1 Fine Aggregate Portion – Material passing the No. 4 Sieve.

3.2 Coarse Aggregate Portion – Material retained on the No. 4 Sieve.

4. Significance and Use

This test method consists of three separate tests which present a method for establishing the proper theoretical maximum density values to be used for controlling the compaction of granular materials. In general, this test method is applicable to granular materials having 30 to 70 percent of the material passing the No. 4 (4.75 mm) sieve. These methods account for variations of maximum obtainable density of a given material for a given compactive effort, due to fluctuations in gradation.

5. Apparatus

5.1 A vibratory spring-loaded compactor. Information on where to obtain this equipment will be provided by the State Materials Laboratory.

5.2 Small Mold height = 8 in ± 0.1 internal diameter = 6 in ± 0.15, a piston to fit inside the mold with a maximum 1⁄16 in clearance between piston and mold.

5.3 Large Mold- Approximately ½ ft^3 (internal height 85-150 percent of diameter) with a piston to fit inside mold having a maximum 1⁄16 in clearance between piston and mold.

5.3.1 The molds and pistons will be constructed of metal of such dimensions as to remain rigid and inflexible under test conditions.

5.4 Spacer blocks of varying heights compatible with the compactor and pistons.

5.5 Measuring device, accurate and readable to 0.01 in with a minimum 6 in length.

5.6 Pycnometer calibrated at the test temperature having a capacity of at least 1 quart (100 ml). Glass pycnometers shall be used to determine the specific gravity of the fine particles. The glass pycnometer shall have a companion glass plate large enough to cover the jar's opening when calibrating or weighing the pycnometer.

5.7 Absolute pressure gauge or vacuum gauge, used for annual standardization and traceable to NIST (mandatory) to be connected directly to the vacuum vessel and to be capable of measuring residual pressure down to 30 mm Hg (4.0 kPa), or less (preferably to zero). It is to be connected at the end of the vacuum line using an appropriate tube and either a "T" connector on the top of the vessel or by using a separate opening (from the vacuum line) in the top of the vessel to attach the hose.

Note 2: A residual pressure of 30 mm Hg (4.0 kPa) absolute pressure is approximately equivalent to 730 mm Hg (97 kPa) reading on vacuum gauge at sea level.

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

5.9 One balance accurate to 0.1 g.

5.10 3 in (75 mm), ¾ in (19 mm), and a No. 4 (4.75 mm) sieve conforming to ASTM E11 requirements.

5.11 Balance or Scale – Capacity sufficient for the principle sample mass, readable to 0.1 percent or 0.1 g, and meeting the requirements of AASHTO M 231.

5.12 Manually Operated Metal Rammer – As specified in AASHTO T 99, Apparatus.

5.13 Tamping rod of straight steel, ⅝ in (16 mm) in diameter and approximately 24 in (400 mm) long having at least one end rounded to a hemispherical tip.

5.14 Graduated cylinder.

5.15 A stopwatch or timer readable to 1 second.

6. Selection of T 606 Test and Procedure

To select the proper method for determining the maximum density of the fine aggregate portion of the sample, refer to the Fine Aggregate Split of Original Sample section of Table 1.

To select the proper procedure in Test 2 for determining the maximum density of the coarse aggregate portion of the sample, refer to the Coarse Aggregate Split of Original Sample section of Table 1.

Fine Aggregate Split of Original Sample	
Soil Type	**Test Method**
Sandy, non-plastic, permeable soils or non-cohesive soils.	T 606, Test 1
Silt, some plasticity, low permeability.	T 99, Method A
Sandy/silt, some plasticity, permeable.	T 606, Test 1/T 99, Method A (use highest results)
Coarse Aggregate Split of Original Sample	
No more than 15 percent by weight of the original aggregate specimen exceeds ¾ in	T 606, Test 2, Procedure 1
15 percent or more by weight of the original aggregate specimen is greater than ¾ in (19 mm), but does not exceed 3 in (76 mm).	T 606, Test 2, Procedure 2

Test Selection
Table 1

7. Sampling Material

7.1 Sample the material in accordance with WSDOT FOP for AASHTO T 2.

7.2 Native soils within the contract limits to be used for embankment construction and/or backfill material do not require sampling by a qualified tester.

7.3 For material that requires gradation testing such as but not limited to manufactured aggregates and gravel borrow, sampling shall be performed by a qualified testers.

8. Sample Preparation

8.1 Prepare the field sample by splitting out a representative portion in accordance with WSDOT FOP for AASHTO R 76.

8.2 Dry the compaction sample in accordance with WSDOT FOP for AASHTO T 255.

8.3 Scalp the plus 75 mm (3 in) material from the compaction sample and discard, if not required for other tests.

8.4 Separate the remainder of the compaction sample into coarse and fine aggregate fractions as follows:

8.4.1 Fine Aggregate (No. 4 minus) – Minimum of three portions approximately 13 lb (6 kg) each.

8.4.2 Coarse Aggregate

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

8.4.2.2 Procedure 2 (Aggregate Size: No. 4 to 3 in (76 mm) – Separate a representative specimen of 45 lbs (20 kg) and weigh to 0.1 lbs (50 g) or less if using a balance that is more accurate than 0.1 lbs.

9. Procedure

9.1 Test No. 1 – Compaction Test of the Fine Fraction (No. 4 Minus Material)

9.1.1 Assemble the small mold and determine its mass, along with the piston, to the nearest 0.01 lb (5 g). Record this as the Mass of Mold Assembly.

9.1.2 Using one of the fine aggregate portions, add an amount of water estimated to produce a saturated sample (see Note 1). Mix the water and aggregate until the sample is homogenous.

Note 1: The sample is considered saturated when one to two drops of free water are visible at the base of the mold at the end of the first 2-minute cycle. Do not over saturate the material.

9.1.3 Set the piston aside and place the sample in the mold in three approximately equal layers. Consolidate each lift by 25 strokes of the tamping rod followed by 25 blows of the manually operated metal rammer. The surface of the top lift should be finished as level as possible.

9.1.4 Place the piston on top of the sample and mount the mold on the jack platform in the compactor. Spacers between the load spring and piston must be used to adjust the elevation of the mold so the hammers strike the mold in the center of the lift area.

9.1.5 Elevate the mold until the loading head seats on top of the piston. Apply an initial seating load of approximately 100 lbs on the sample.

9.1.6 Start the compactor hammers and, by elevating the jack, begin the loading procedure. The load is gradually applied over the time stated in the table below.

Load Application Rate	
Load	**Time**
0 to 500 lb	1 minute
500 lb to 1,000 lb	30 sec
1000 lb to 2,000 lb	30 sec

9.1.7 Upon reaching the 2,000 lb load at the end of the 2-minute cycle, stop the hammers, release the load on the jack, return to zero pressure, and check for free water.

Note 2: If dirty water is flooding off the base of the mold or excessive material is pumping around the sides of the top piston, the sample is beyond the saturation point. Stop the test, remove the material from the mold, prepare a new sample at lower moisture content, and begin the test again.

9.1.8 Repeat Steps 9.1.5 through 9.1.7 four additional times (excluding check for free water). After the last run, remove the mold from the compactor.

9.1.9 Measure the height of the compacted sample to the nearest 0.01 in (0.1 mm) and record as the “Depth.”

9.1.10 Determine the mass of the specimen in the mold to the nearest 0.01 lb (5 g). Record this as: Mass of Mold + Sample.

9.1.11 Remove the specimen from the mold and determine the moisture content in accordance with WSDOT FOP for AASHTO T 255.

9.1.12 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, dry in accordance with AASHTO T 255 to determine the moisture content, and record the results.

9.1.13 Calculate and record the dry density of fine fraction.

9.2 Test No. 2 – Compaction Test of the Coarse Fraction

9.2.1 Procedure 1 – ¾ in (19 mm) to No. 4 (4.75 mm) Aggregates

9.2.1.1 Determine the mass of the coarse aggregate to the nearest 0.01 lb (5 g).

9.2.1.2 Add 2.5 percent moisture to the sample, mix thoroughly.

9.2.1.3 Place in 0.1 ft^3 (0.0028 m^3) mold in approximately three equal lifts. Tamp each lift lightly to consolidate material and achieve a level surface. Avoid the loss of any material during placement.

9.2.1.4 Follow steps 9.1.5 through 9.1.8.

9.2.1.5 Measure the height of the compacted sample to the nearest 0.01 in (0.1 mm) and record as the "Depth."

9.2.1.6 Calculate and record the dry density of coarse fraction.

9.2.2 Procedure 2 – 3 in (76 mm) to No. 4 Aggregates

9.2.2.1 Determine the mass of the coarse aggregate to the nearest 0.01 lb (5 g) or better.

9.2.2.2 Divide the sample into five representative, approximately equal portions.

9.2.2.3 Place one of the portions into the ½ ft^3 (0.014 m^3) mold and level the surface.

9.2.2.4 Position the piston on the material, mount the mold in the compactor, and compact as described in steps 9.1.5 through 9.1.7.

Note 3: Spacers may be needed between the load spring and piston to adjust the elevation of the mold to the height of the lift being compacted.

9.2.2.5 Repeat 9.2.2.3 and 9.2.2.4 for the remaining four portions of material.

9.2.2.6 After the final portion is compacted, determine the height of the compacted sample to the nearest 0.01 in (0.1 mm) and record as the "Depth."

9.2.2.7 Calculate and record the dry density of coarse fraction (see Calculations section).

9.3 Test No. 3 – Specific Gravity Determination for Maximum Density Test

9.3.1 Material

9.3.1.1 Fine fraction No. 4 (4.75 mm) minus 1.1 lbs (500 g) minimum.

9.3.1.2 Coarse fraction No. 4 (4.75 mm) plus 2.2 lbs (1,000 g) minimum.

9.3.2 Procedure

9.3.2.1 Place dry materials, either fine or coarse fraction, in pycnometer.

9.3.2.2 Fill the pycnometer approximately ¾ full with 68°F (20°C) water.

9.3.2.3 Connect the pycnometer to the vacuum system. Apply a partial vacuum of 30 mm Hg or less absolute pressure for a period of 20 minutes.

9.3.2.4 Agitate container either continuously by mechanical device or manually by vigorous shaking at 2-minute intervals.

9.3.2.5 Release vacuum and disconnect the hoses.

9.3.2.6 Fill pycnometer with water. Water temperature during test should be maintained as close to 68° ± 1°F (20° ± 0.5°C) as possible.

Note 4: It may be necessary to place the pycnometer in a water bath for 10 minutes, after release of vacuum, to bring the water temperature back to 68° ± 1°F (20° ± 0.5°C).

9.3.2.6.1 Metal Pycnometer (Coarse Specific Gravity Only) – Fill the vessel, according to the manufacturer's instructions, with 68° ± 1°F (20° ± 0.5°C) water. Dry the outside of the vessel and weigh to the nearest 0.1g. Record the weight.

9.3.2.6.2 Glass Pynometer (Fine or Coarse Specific Gravity) – Completely fill the pycnometer with 68° ± 1°F (20° ± 0.5°C) water, then slide the calibrated glass plate over the mouth of the jar making sure air bubbles are not trapped under the glass plate. Dry the outside of the pycnometer and glass plate and weigh to the nearest 0.1g. Record the weight.

Calculations

10. Determine the dry density of each of the fine aggregate points as follows:

10.1 Calculate Specific Gravity as follows:

$$\text{Sp. Gr.} = = \frac{a}{(a + b - c)}$$

Where:

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

10.2 Calculate the wet sample weight:

$$e = c - d$$

Where:

e = Wet sample weight, g
c = mold and wet sample weight
d = Tare of mold assembly

10.3 Calculate the wet density by:

$$g = \frac{e}{b \times f}$$

Where:

g = wet density, lb/ft^3
e = wet sample weight, lbs
b = mold constant, ft^3/in
f = height of sample, in (height constant-depth)

10.4 Calculate the dry density of each of the fine fraction specimens as follows:

$$h = \frac{g}{1 + n}$$

Where:

h = dry density, lb/ft^3
g = wet density, lb/ft^3
n = moisture content, expressed as a decimal

11. Reports

11.1 Enter information into the WSDOT Materials Testing System (MATS) or other form approved in writing by the State Materials Engineer to obtain the theoretical maximum density curve.

Performance Exam Checklist

WSDOT Test Method T 606
Method of Test for Compaction Control of Granular Materials

Participant Name _____ Exam Date _____

Procedure Element	**Yes**	**No**
1. The tester has a copy of the current procedure on hand?	☐	☐
2. All equipment is functioning according to the test procedure, and if required, has the current calibration/verification tags present?	☐	☐
Fine Fraction – 100% Passing the No. 4 (4.75 mm) Sieve		
Specimen Preparation		
1. Has the specimen been oven-dried?	☐	☐
2. Has the specimen been separated on the No. 4 (4.75 mm) sieve?	☐	☐
3. Is the specimen weight approximately 13 lbs?	☐	☐
Procedure		
1. Is specimen saturated when compacted?	☐	☐
2. Has specimen been placed in three layers, rodded 25, and tamped 25 times, each layer?	☐	☐
3. Is the hammer blow approximately a 12 in free fall to prevent severe displacement of the specimen?	☐	☐
4. The specimen is as level as possible?	☐	☐
5. Has piston been placed on top of the specimen?	☐	☐
6. Has the mold been mounted on the jack in the compactor?	☐	☐
7. Has the mold been elevated until the load-spring retainer sits on top of the piston?	☐	☐
8. Has the initial load been set at 100 lbs?	☐	☐
9. Is the loading rate applied as specified in the test procedure?	☐	☐
10. Has the hammer been stopped, jack released, and pressure returned to zero when 2,000 lbs pressure was reached?	☐	☐
11. Are one to two drops of free water visible at the base of the mold at the end of the first 2-minute cycle?	☐	☐
12. Steps 7 through 10 repeated four additional times?	☐	☐
13. The mold removed from the compactor?	☐	☐
14. Has the height of the specimen been determined?	☐	☐
15. Has specimen been weighed?	☐	☐
16. Has specimen been removed from mold and a representative portion immediately weighted and the moisture percentage determined?	☐	☐
17. Moisture content, dry density determined and entered on the testing sheet?	☐	☐
18. Theoretical maximum density determined by testing fresh specimens, as necessary, at different moisture contents and entered on the testing sheets?	☐	☐

Procedure Element	Yes	No
Aggregate Size: No. 4 to ¾ in (19 mm)		
Specimen Preparation		
1. Has the specimen been oven-dried?	☐	☐
2. Has the specimen been separated on the No. 4 (4.75 mm) sieve?	☐	☐
3. Does more than 85 percent of the material pass the ¾ in (19 mm) sieve?	☐	☐
Procedure		
1. Weight and record specimen weight?	☐	☐
2. Has the specimen been dampened to 2½ percent and placed in three lifts in a 0.1 ft^3 mold?	☐	☐
3. Specimen lightly tamped to archive a level surface?	☐	☐
4. Piston placed on top of specimen and mold mounted on jack in compactor?	☐	☐
5. Mold elevated until the load-spring retainer sits on top of the piston?	☐	☐
6. Initial load of 100 lbs set prior to starting machine?	☐	☐
7. Is the load rate applied as specified in the test procedure?	☐	☐
8. Hammers stopped, jack released, and pressure returned to zero when 2,000 lb load has been reached?	☐	☐
9. Steps 5 through 8 repeated four additional times?	☐	☐
10. The mold removed from the compactor and the height measured?	☐	☐
11. Dry density calculated and entered on the testing sheets?	☐	☐
Aggregate Size: No. 4 to 3 in		
Specimen Preparation		
1. Has the specimen been oven-dried?	☐	☐
2. Has the specimen been separated on the No. 4 (4.75 mm) sieve?	☐	☐
3. Is the specimen weight approximately 45 lbs?	☐	☐
4. Does the specimen contain 15 percent or more ¾ + material?	☐	☐
5. Has material greater than 3 in (76 mm) been removed?	☐	☐
6. Specimen separated into five approximately equal parts?	☐	☐
Procedure		
1. Specimen placed in the mold in five separate lifts?	☐	☐
2. The specimen is as level as possible?	☐	☐
3. After each lift, mold placed in compactor and compacted according to test procedure?	☐	☐
4. After compacting final lift, specimen removed from compactor and volume determined?	☐	☐
5. Dry density determined calculated and entered onto testing sheet?	☐	☐

Procedure Element	**Yes**	**No**
Specific Gravity Determination for Theoretical Maximum Density Test		
Specimen Preparation		
1. Has the specimen been oven-dried?	☐	☐
2. Has the specimen been separated on the No. 4 (4.75 mm) sieve?	☐	☐
3. Weight of fine fraction approximately 500 g?	☐	☐
4. Weight of coarse fraction approximately 1000 g?	☐	☐
Procedure		
1. Material placed in pycnometer and 68°F water added?	☐	☐
2. Vacuum applied for at least 20 minutes?	☐	☐
3. Container and contents agitated manually by shaking at intervals of 2 minutes?	☐	☐
4. Pycnometer filled with water at 68°F?	☐	☐
5. Pycnometer dried, weighted, and recorded on testing sheet?	☐	☐
6. Specific Gravity calculated and entered onto testing sheet?	☐	☐

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

Signature of Examiner _____

Comments: