Standard Method of Test for

Resistance of Compacted Asphalt Mixtures to Moisture-Induced Damage

AASHTO Designation: T 283-22

Technically Revised: 2022 **Editorially Revised: 2022**

Technical Subcommittee: 2d, Proportioning of Asphalt–Aggregate Mixtures

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1. SCOPE

1.1. This method covers preparation of specimens and the measurement of the change of diametral tensile strength resulting from the effects of water saturation and accelerated water conditioning, with a freeze–thaw cycle, of compacted asphalt mixtures. The results may be used to predict long-term stripping susceptibility of the asphalt mixture and evaluate liquid antistripping additives that are added to the asphalt binder or pulverulent solids, such as hydrated lime or portland cement, which are added to the mineral aggregate.

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

1.3. *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety 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.*

1.4. *The quality of the results produced by this standard are dependent on the competence of the personnel performing the procedure and the capability, calibration, and maintenance of the equipment used. Agencies that meet the criteria of R 18 are generally considered capable of competent and objective testing/sampling/inspection/etc. Users of this standard are cautioned that compliance with R 18 alone does not completely assure reliable results. Reliable results depend on many factors; following the suggestions of R 18 or some similar acceptable guideline provides a means of evaluating and controlling some of those factors.*

2. REFERENCED DOCUMENTS

2.1. *AASHTO Standards*:

- M 339M/M 339, Thermometers Used in the Testing of Construction Materials
- R 18, Establishing and Implementing a Quality Management System for Construction Materials Testing Laboratories
- R 30, Laboratory Conditioning of Asphalt Mixtures
- R 47, Reducing Samples of Asphalt Mixtures to Testing Size
- R 67, Sampling Asphalt Mixtures after Compaction (Obtaining Cores)
- R 68, Preparation of Asphalt Mixtures by Means of the Marshall Apparatus
- R 97, Sampling Asphalt Mixtures
- T 166, Bulk Specific Gravity (G_{mb}) of Compacted Asphalt Mixtures Using Saturated Surface-Dry Specimens

- T 167, Compressive Strength of Hot Mix Asphalt
- T 209, Theoretical Maximum Specific Gravity (G_{mm}) and Density of Asphalt Mixtures
- T 245, Resistance to Plastic Flow of Asphalt Mixtures Using Marshall Apparatus
- T 247, Preparation of Test Specimens of Hot Mix Asphalt (HMA) by Means of California Kneading Compactor
- T 312, Preparing and Determining the Density of Asphalt Mixture Specimens by Means of the Superpave Gyratory Compactor

2.2. *ASTM Standards*:

- D3387, Standard Test Method for Compaction and Shear Properties of Bituminous Mixtures by Means of the U.S. Corps of Engineers Gyratory Testing Machine (GTM) (withdrawn 2020; no replacement)
- E1, Standard Specification for ASTM Liquid-in-Glass Thermometers
- E230/E230M, Standard Specification for Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples
- E879, Standard Specification for Thermistor Sensors for General Purpose and Laboratory Temperature Measurements
- E1137/E1137M, Standard Specification for Industrial Platinum Resistance Thermometers
- E2877, Standard Guide for Digital Contact Thermometers

2.3. *International Electrotechnical Commission Standards*:

- IEC 60584-1: 2013 Thermocouples - Part 1: EMF Specifications and Tolerances
- IEC 60751: 2008 Industrial Platinum Resistance Thermometers and Platinum Temperature Sensors

3. SIGNIFICANCE AND USE

3.1. This method is intended to evaluate the effects of saturation and accelerated water conditioning, with a freeze–thaw cycle, of compacted asphalt mixtures. This method can be used to test: (a) asphalt mixtures in conjunction with mixture design testing (lab-mixed, lab-compacted); (b) asphalt mixtures produced at mixing plants (field-mixed, lab-compacted); and (c) asphalt mixture cores obtained from completed pavements of any age (field-mixed, field-compacted).

3.2. Numerical indices of retained indirect-tensile properties are obtained by comparing the properties of laboratory specimens subjected to moisture and freeze–thaw conditioning with the similar properties of dry specimens.

4. SUMMARY OF METHOD

4.1. Test specimens for each set of mix conditions, such as those prepared with untreated asphalt binder, asphalt binder treated with antistripping agent, or aggregate treated with lime, are prepared. Each set of specimens is divided into subsets. One subset is tested in dry condition for indirect-tensile strength. The other subset is subjected to vacuum saturation and a freeze cycle, followed by a warm-water soaking cycle, before being tested for indirect-tensile strength. Numerical indices of retained indirect-tensile strength properties are calculated from the test data obtained by the two subsets: dry and conditioned.

5. APPARATUS

5.1. Equipment for preparing and compacting specimens from one of the following: R 68, T 167, T 247, T 312, or ASTM D3387.

5.2. Equipment for determining the theoretical maximum specific gravity (G_{mm}) of the asphalt mixture from T 209.

5.3. Balance and water bath from T 166.

5.4. Water baths shall be capable of maintaining a temperature as required.

5.4.1. Water bath of sufficient size, capable of maintaining a uniform temperature of 60 ± 1°C (140 ± 2°F). The thermometer for measuring the temperature of the water bath shall meet the requirements of M 339M/M 339 with a temperature range of at least 55 to 65°C (131 to 149°F) with an accuracy of ±0.25°C (±0.45°F) (see Note 1).

Note 1—Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E879 thermistor thermometer; ASTM E1137/E1137M Pt-100 RTD platinum resistance thermometer, Class A; or IEC 60751: 2008 Pt-100 RTD platinum resistance thermometer, Class AA.

5.4.2. Water bath of sufficient size, capable of maintaining a uniform temperature of 25 ± 0.5°C (77 ± 0.9°F). The thermometer for measuring the temperature of the water bath shall meet the requirements of M 339M/M 339 with a temperature range of at least 20 to 30°C (68 to 86°F) with an accuracy of ±0.13°C (±0.22°F) (see Note 2).

Note 2—Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E879 thermistor thermometer; ASTM E1137/E1137M Pt-100 RTD platinum resistance thermometer, Special order; or IEC 60751: 2008 Pt-100 RTD platinum resistance thermometer, Special order.

5.5. Freezer maintained at –18 ± 3°C (0 ± 5°F). The thermometer for measuring the temperature of the freezer shall meet the requirements of M 339M/M 339 with a temperature range of at least –25 to –10°C (–13 to 14°F) with an accuracy of ±0.75°C (±1.35°F) (see Note 3).

Note 3—Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E2877 digital metal stem thermometer; ASTM E230/E230M thermocouple thermometer, Type T, Special Class; or IEC 60584 thermocouple thermometer, Type T, Class 1.

5.6. A supply of plastic film for wrapping specimens; heavy-duty, leakproof plastic bags to enclose the saturated specimens; and masking tape.

5.7. 10-mL graduated cylinder.

5.8. Pans having a surface area of 48 400 to 129 000 mm^2 (75 to 200 in.^{2}) in the bottom and a depth of at least 25 mm (1 in.).

5.9. A tape, rule or calipers for measuring specimen thickness.

5.10. Forced-draft oven, properly standardized, thermostatically controlled, and capable of maintaining any desired temperature setting from room temperature to 176°C (350°F) within ±3°C (±5°F). More than one oven may be used, provided each is used within its proper operating temperature range. Thermometer for measuring the temperature of materials shall meet the requirements of M 339M/M 339 with a temperature range of at least 25 to 185°C (77 to 365°F), and an accuracy of ±0.75°C (see Note 4).

Note 4—Thermometer types suitable for use include ASTM E1 mercury thermometers; ASTM E230/E230M thermocouple thermometer, Type T, Special Class; or IEC 60584 thermocouple thermometer, Type T, Class 1.

5.11. Loading jack and ring dynamometer from T 245, or a mechanical or hydraulic testing machine from T 167, to provide a range of accurately controllable rates of vertical deformation, including 50 mm/min (2 in./min).

5.12. Steel loading strips with a concave surface having a radius of curvature equal to the nominal radius of the test specimen. For specimens 100 mm (4 in.) in diameter, the loading strips shall be 12.7 mm (0.5 in.) wide, and for specimens 150 mm (6 in.) in diameter, the loading strips shall be 19.05 mm (0.75 in.) wide. The length of the loading strips shall exceed the thickness of the specimens. The edges of the loading strips shall be rounded to the appropriate radius of curvature by grinding.

6. PREPARATION OF LABORATORY-MIXED, LABORATORY-COMPACTED SPECIMENS

6.1. Prepare mixture for at least six specimens for each test, half to be tested dry and the other half to be tested after partial saturation and moisture conditioning with a freeze–thaw cycle (Note 5).

Note 5—It is recommended that mixture for at least two additional specimens for each set be prepared. These specimens can then be used to establish compaction procedures for specimen void content as given in Section 6.2 and the vacuum saturation technique as given in Section 10.4.

6.1.1. If G_{mm} is unknown, prepare additional mixture according to R 30 Section 7.1, and determine the G_{mm} according to T 209.

6.1.2. Prepare mixtures in batches large enough to make at least three specimens or, alternatively, prepare a batch large enough to just make one specimen at a time. If preparing a multispecimen batch, split the batch into single-specimen quantities before placing in the oven.

6.2. Prepared compacted specimens shall be 7.0 ± 0.5 percent air voids. This level of voids can be obtained by adjusting the mass of the mixture; the number of blows in R 68; adjusting foot pressure, number of tamps, leveling load, or some combination in T 247; or adjusting the number of gyrations or specimen height in T 312 or ASTM D3387. The effective adjustment must be determined experimentally for each mixture before compacting the specimens for each set. (Note 5).

6.3. Specimens 100 mm (4 in.) in diameter by 63.5 ± 2.5 mm (2.5 ± 0.1 in.) thick, or 150 mm (6 in.) in diameter by 95 ± 5 mm (3.75 ± 0.20 in.) thick are used. Specimens 150 mm (6 in.) in diameter by 95 ± 5 mm (3.75 ± 0.20 in.) thick should be used if aggregate larger than 25 mm (1 in.) is present in the mixture.

6.4. Place the mixture in a pan and cool at room temperature for 2 ± 0.5 h.

6.5. Place the cooled mixture in a 60 ± 3°C (140 ± 5°F) oven for 16 ± 1 h for curing. The pans should be placed on spacers to allow air circulation under the pan if the shelves are not perforated.

6.6. Place the mixture in an oven for 2 h ± 10 min at the compaction temperature ±3°C (5°F). Determine compaction temperature according to R 30.

6.7. Compact the specimens according to one of the following methods: R 68, T 167, T 247, T 312, or ASTM D3387 to 7.0 ± 0.5 percent air voids.

6.8. Remove the specimens from the molds (Note 6).

Note 6—Due to the elevated air void content and potential instability of the specimens, ensure that each specimen is adequately cool and stable before removing from the mold.

6.9. Determine air voids according to Sections 9.3 and 9.4. The air void content must be within 7.0 ± 0.5 percent.

7. PREPARATION OF FIELD-MIXED, LABORATORY-COMPACTED SPECIMENS

7.1. Obtain field-mixed asphalt mixture sample in accordance with R 97 of sufficient size to determine G_{mm} and make at least six specimens.

Note 7—It is recommended that mixture for at least two additional specimens for each set be obtained. These specimens can then be used to establish compaction procedures for specimen void content as given in Section 7.3.1 and the vacuum saturation technique as given in Section 10.4.

7.2. Determine G_{mm} by T 209.

7.3. Make at least six specimens for each test, half to be tested dry and the other half to be tested after partial saturation and moisture conditioning with a freeze–thaw cycle (Note 7).

7.3.1. Prepared compacted specimens shall be 7.0 ±0.5 percent air voids. This level of voids can be obtained by adjusting the mass of the mixture, the number of blows in R 68; adjusting foot pressure, number of tamps, leveling load, or some combination in T 247; or adjusting the number of revolutions in T 312 or ASTM D3387. The exact procedure must be determined experimentally for each mixture before compacting the specimens for each set. (Note 7)

7.4. Specimens 100 mm (4 in.) in diameter by 63.5 ± 2.5 mm (2.5 ± 0.1 in.) thick, or 150 mm (6 in.) in diameter by 95 ± 5 mm (3.75 ± 0.20 in.) thick are used. Specimens 150 mm (6 in.) in diameter by 95 ± 5 mm (3.75 ± 0.20 in.) thick should be used if aggregate larger than 25 mm (1 in.) is present in the mixture.

7.5. No loose-mix curing as described in Section 6.5 shall be performed on the field-mixed samples. After sampling, divide the sample to obtain the desired size in accordance with R 47. Next, place the mixture in an oven until it reaches the compaction temperature ±3°C (5°F). Then compact the specimen according to one of the following methods: R 68, T 167, T 247, T 312, or ASTM D3387 to 7.0 ± 0.5 percent air voids.

7.6. Remove the specimens from the molds (Note 6).

7.7. Determine air voids according to Sections 9.3 and 9.4. The air void content must be within 7.0 ± 0.5 percent.

8. PREPARATION OF FIELD-MIXED, FIELD-COMPACTED SPECIMENS (CORES)

8.1. Select locations on the completed pavement to be sampled, and obtain cores according to R 67. When testing pavement layers with a thickness less than or equal to 63.5 mm (2.5 in.), use 100-mm (4-in.) diameter cores. Otherwise, use either 100-mm (4-in.) or 150-mm (6-in.) diameter cores.

8.2. Obtain at least six cores for each set of mix conditions. Additional cores may be required to determine G_{mm} by T 209.

8.3. Separate the core layers as necessary by sawing them or by other suitable means, and store the layers to be tested at room temperature until they are dry.

8.4. No loose-mix curing (Section 6.5) or compacted-mix curing (Section 6.6) shall be performed on the field-mixed, field-compacted specimens (cores).

9. EVALUATION AND GROUPING OF SPECIMENS

9.1. Determine each specimen thickness (t) by measuring to 1mm ($^1/_{16}$ in.) in four locations around the specimen and averaging or, if the specimen is prepared by T 312, use the final height from the Superpave Gyratory Compactor.

9.2. Record each specimen diameter (D) as defined in Section 6.3, 7.4, or 8.1, as appropriate.

9.3. Determine each bulk specific gravity (G_{mb}) by Method A of T 166. Express the volume (E) of the specimens, or the saturated, surface-dry mass minus the mass in water, in cubic centimeters.

9.4. Calculate the percentage of air voids (P_a).

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

where:

G_{mb} = the bulk specific gravity; and;

G_{mm} = the theoretical maximum specific gravity.

9.5. Separate the specimens into two subsets, of at least three specimens each, so that the average air voids of the two subsets are approximately equal.

9.6. For those specimens to be subjected to vacuum saturation, a freeze cycle, and a warm-water soaking cycle, calculate the volume of air voids (V_a) in cubic centimeters using the following equation:

$$V_a = \frac{P_a E}{100} \quad (2)$$

where:

V_a = volume of air voids, cm^3;

P_a = air voids, percent; and

E = volume of the specimen, cm^3.

Note 8—A data sheet that is convenient for use with this test method is shown as Table 1.

10. PRECONDITIONING OF TEST SPECIMENS

10.1. One subset will be tested dry, and the other will be partially vacuum saturated, subjected to freezing, and soaked in warm water before testing.

10.2. Wrap the dry subset with plastic or place in a heavy-duty, leakproof plastic bag.

10.3. Place the specimens in a water bath with the conditioned subset according to Section 10.4.11.

10.4. *The other subset shall be conditioned as follows*:

10.4.1. Place the specimen in the vacuum container supported a minimum of 25 mm (1 in.) above the container bottom by a perforated spacer. Fill the container with potable water at room temperature so that the specimens have at least 25 mm (1 in.) of water above their surface.

10.4.2. Saturate the specimen to 70 to 80 percent by applying a vacuum (Note 9).

Note 9—Apply a vacuum for approximately 5 to 10 min. at approximately 13 to 67 kPa absolute pressure (10 to 26 in.Hg partial pressure). The time required for some specimens to achieve 70 and 80 percent may be less than 5 min. In addition, some specimens may require the use of an absolute pressure of greater than 67 kPa (26 in.Hg partial pressure) or less than 13 kPa (10 in.Hg partial pressure).

10.4.3. Remove the vacuum and leave the specimen submerged in water for approximately 5 to 10 min.

10.4.4. Damp-dry the specimen by blotting it with a damp towel, and determine the surface-dry mass (B') as quickly as possible (the entire operation is not to exceed 15 s). Any water that seeps from the specimen during the weighing operation is considered part of the saturated specimen. Each specimen shall be immersed and weighed individually.

Note 10—Terry cloth has been found to work well for an absorbent cloth. Damp is considered to be when no water can be wrung from the towel.

10.4.5. Calculate the volume of absorbed water (J') in cubic centimeters by use of the following equation:

$$J' = B' - A \qquad (3)$$

where:

J' = volume of absorbed water, cm^3;

B' = mass of the saturated, surface-dry specimen after partial vacuum saturation, g; and

A = mass of the dry specimen in air, g (Section 9.3).

10.4.6. Determine the degree of saturation (S') by comparing the volume of absorbed water (J') with the volume of air voids (V_a) from Section 9.6 using the following equation:

$$S' = \frac{100J'}{V_a} \qquad (4)$$

where:

S' = degree of saturation, percent.

10.4.7. If the degree of saturation is between 70 and 80 percent, proceed to Section 10.4.9.

10.4.8. If the degree of saturation is less than 70 percent, repeat the procedure beginning with Section 10.4.1 using more vacuum and/or time. If the degree of saturation is more than 80 percent, the specimen has been damaged and must be discarded. In this case, repeat the procedure on the next specimen beginning with Section 10.4.1 using less vacuum and/or time.

10.4.9. Cover each of the vacuum-saturated specimens tightly with a plastic film (Saran Wrap® brand or equivalent). Place each wrapped specimen in a plastic bag containing 10 ± 0. 5 mL of water and seal the bag. Place the plastic bags containing the specimens in a freezer at a temperature of –18 ± 3°C (0 ± 5°F) for a minimum of 16 h. Remove the specimens from the freezer.

10.4.10. Place the specimens in a bath containing potable water at 60 ± 1°C (140 ± 2°F) for 24 ± 1 h. The specimens should have a minimum of 25 mm (1 in.) of water above their surface. As soon as possible after placement in the water bath, remove the plastic bag and film from each specimen.

10.4.11. After 24 ± 1 h in the 60 ± 1°C (140 ± 2°F) water bath, remove the specimens and place them and the dry subset in a water bath at 25 ± 0.5°C (77 ± 1°F) for 2 h ± 10 min. The specimens should

have a minimum of 25 mm (1 in.) of water above their surface. It may be necessary to add ice to the water bath to prevent the water temperature from rising above 25°C (77°F). Not more than 15 min should be required for the water bath to reach 25 ± 0.5°C (77 ± 1°F).

10.4.12. Remove the specimens from the water bath, and test them as described in Section 11.

11. TESTING

11.1. Determine the indirect-tensile strength of dry and conditioned specimens at 25 ± 0.5°C (77 ± 1°F).

11.1.1. Remove the specimen from 25 ± 0.5°C (77 ± 1°F) water bath, and determine the thickness (t') according to Section 9.1. Place it between the steel loading strips and then place the specimen and loading strips between the two bearing plates in the testing machine. Care must be taken so that the load will be applied along the diameter of the specimen. Apply the load to the specimen, by means of the constant rate of movement of the testing machine head, at 50 mm/min (2 in./min).

11.1.2. Record the maximum compressive strength noted on the testing machine, and continue loading until a vertical crack appears. Remove the specimen from the machine, and pull it apart at the crack. Inspect the interior surface for evidence of cracked or broken aggregate; visually estimate the approximate degree of moisture damage on a scale from "0" to "5" (with "5" being the most stripped), and record the observations in Table 1.

Table 1—Moisture Damage Laboratory Data Sheet (Nonmandatory Information)

Project _____

Additive _____ Dosage _____

Compaction Method _____ Effort _____

Date Tested _____ By _____

Sample identification									
Diameter, mm (in.)	D								
Thickness, mm (in.)	t								
Dry mass in air, g	A								
SSD mass, g	B								
Mass in water, g	C								
Volume ($B - C$), cm^3	E								
Bulk specific gravity (A/E)	G_{mb}								
Maximum specific gravity	G_{mm}								
% air voids [$100(G_{mm} - G_{mb})/G_{mm}$]	P_a								
Volume of air voids ($P_aE/100$), cm^3	V_a								
Load, N (lbf)	P								
Saturated min @	kPa (psi) or	mmHg (in.Hg)							
Thickness, mm (in.)	t'								
SSD mass, g	B'								
Volume of absorbed water ($B' - A$), cm^3	J'								
% saturation ($100J'/V_a$)	S'								
Load, N (lbf)	P'								
Dry strength [$2000P/\pi tD$ ($2P/\pi tD$)], kPa (psi)	S_1								
Wet strength [$2000P'/\pi t'D$ ($2P/\pi t'D$)], kPa (psi)	S_2								
Visual moisture damage (0 to 5 rating)									
Cracked/broken aggregate?									
TSR (S_2/S_1)									

12. CALCULATIONS

12.1. *Calculate the tensile strength as follows*:

SI units:

$$S_t = \frac{2000P}{\pi t D} \quad (5)$$

where:

S_t = tensile strength, kPa;
P = maximum load, N;
t = specimen thickness, mm; and
D = specimen diameter, mm.

U.S. Customary units:

$$S_t = \frac{2P}{\pi t D} \quad (6)$$

where:

S_t = tensile strength, psi;
P = maximum load, lbf;
t = specimen thickness, in.; and
D = specimen diameter, in.

12.2. Express the numerical index of resistance of asphalt mixtures to the detrimental effect of water as the ratio of the original strength that is retained after the moisture and freeze–thaw conditioning. Calculate the tensile strength ratio to two decimal places as follows:

$$\text{tensile strength ratio (TSR)} = \frac{S_2}{S_1} \quad (7)$$

where:

S_1 = average tensile strength of the dry subset, kPa (psi); and
S_2 = average tensile strength of the conditioned subset, kPa (psi).

13. REPORT

13.1. *Report the following information*:

13.1.1. Number of specimens in each subset;

13.1.2. Average air voids of each subset;

13.1.3. Tensile strength of each specimen in each subset;

13.1.4. Tensile strength ratio;

13.1.5. Results of visually estimated moisture damage observed when the specimen fractures; and

13.1.6. Results of observations of cracked or broken aggregate.

14. KEYWORDS

14.1. Accelerated water conditioning; diametral tensile strength; freeze–thaw cycle; liquid antistripping additives; long-term stripping; portland cement; pulverulent solids; water saturation.

15. REFERENCE

15.1. ASTM. D979/D979M, Standard Practice for Sampling Bituminous Paving Mixtures.