
Standard Method of Test for

Hamburg Wheel-Track Testing of Compacted Asphalt Mixtures

AASHTO Designation: T 324-23

Technically Revised: 2023

Editorially Revised: 2023

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



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1. SCOPE

- 1.1. This test method describes a procedure for testing the rutting and moisture-susceptibility of asphalt mixture pavement samples in the Hamburg wheel-tracking device.
- 1.2. The method describes the testing of a submerged, compacted asphalt mixture in a reciprocating rolling-wheel device. This test provides information about the rate of permanent deformation from a moving, concentrated load. A laboratory compactor has been designed to prepare slab specimens. Also, the Superpave Gyratory Compactor (SGC) has been designed to compact specimens in the laboratory. Alternatively, field cores having a diameter of 150 mm (6 in.), 250 mm (10 in.), or 300 mm (12 in.), or saw-cut slab specimens may be tested.
- 1.3. The test method is used to determine the premature failure susceptibility of asphalt mixture due to weakness in the aggregate structure, inadequate binder stiffness, or moisture damage. This test method measures the rut depth and number of passes to failure.
- 1.4. This test method measures the potential for moisture damage effects because the specimens are submerged in temperature-controlled water during loading.
- 1.5. This test method is intended to be the standard; however, agencies may require deviations for various reasons, including test temperature, maximum rut depth calculation, equipment, or others. Deviations must be documented and made available to any accreditation or certifying entities or stakeholders, such as contractors and material producers, upon request.
- 1.6. *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety concerns 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.*
- 1.7. *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, Mixture Conditioning of Asphalt Mixtures
 - < R 97, Sampling Asphalt Mixtures
 - < T 166, Bulk Specific Gravity (G_{mb}) of Compacted Asphalt Mixtures Using Saturated Surface-Dry Specimens
 - < T 209, Theoretical Maximum Specific Gravity (G_{mm}) and Density of Asphalt Mixtures
 - < T 269, Percent Air Voids in Compacted Dense and Open Asphalt Mixtures
 - < T 312, Preparing and Determining the Density of Asphalt Mixture Specimens by Means of the Superpave Gyratory Compactor
- 2.2. *ASTM Standards:*
- < D6027/D6027M, Standard Practice for Calibrating Linear Displacement Transducers for Geotechnical Purposes
 - < D8079, Standard Practice for Preparation of Compacted Slab Asphalt Mix Samples Using a Segmented Rolling Compactor
 - < 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
- 2.4. *National Cooperative Highway Research Program:*
- < NCHRP Web-Only Document 219, *Hamburg Wheel-Track Test Equipment Requirements and Improvements to AASHTO T 324*. NCHRP Project 20-07/Task 361. National Cooperative Highway Research Program, Transportation Research Board, Washington, DC, 2016. Available from <https://www.trb.org/Publications/Blurbs/173895.aspx>; login required.

3. SIGNIFICANCE AND USE

- 3.1. This test measures the rutting and moisture susceptibility of an asphalt mixture specimen.

4. SUMMARY OF METHOD

- 4.1. A laboratory-compacted specimen of asphalt mixture, a saw-cut slab specimen, or a core taken from a compacted pavement is repetitively loaded using a reciprocating steel wheel. The specimen is submerged in a temperature-controlled water bath at a temperature specified by the agency. The deformation of the specimen, caused by the wheel loading, is measured.

- 4.2. The impression is plotted as a function of the number of wheel passes. An abrupt increase in the rate of deformation may coincide with stripping of the asphalt binder from the aggregate in the asphalt mixture specimen.

5. APPARATUS

- 5.1. *Hamburg Wheel-Tracking Device*—An electrically powered machine capable of moving a 203.2 ± 2.0 -mm (8 ± 0.08 -in.) diameter, 47 ± 0.5 -mm (1.85 ± 0.02 -in.) wide steel wheel over the center (x and y axes) of the test specimen. The load on the wheel is 703 ± 4.5 N (158.0 ± 1.0 lb). The wheel reciprocates over the specimen, with the position varying sinusoidally over time. A maximum level of deviation from a perfectly sinusoidal wave is defined through the root mean square error (RMSE), which is calculated as follows:

$$\text{RMSE} = \sqrt{\frac{\sum e_i^2}{n}} \quad (1)$$

where:

e_i = deviation from a pure sinusoidal curve, and

n = number of data points.

The maximum allowable deviation from a sinusoidal wave through the entire track length is set at an RMSE of 2.54 mm (0.1 in.) unless otherwise specified by the agency. The wheel makes 52 ± 2 passes across the specimen per minute. The maximum speed of the wheel, reached at the midpoint of the specimen, is 0.305 ± 0.02 m/s (1 ± 0.066 ft/s).

Note 1—Verify the sinusoidal wave requirement of the Hamburg wheel-tracking device using a Hamburg wheel-tracking device verification/calibration kit.

- 5.2. *Temperature Control System*—A water bath capable of controlling the temperature within $\pm 1.0^\circ\text{C}$ (1.8°F) over a range of 25 to 70°C (77 to 158°F) with a mechanical circulating system stabilizing the temperature within the specimen tank. 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 75°C (68 to 167°F), and an accuracy of $\pm 0.25^\circ\text{C}$ ($\pm 0.45^\circ\text{F}$) (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, Class A; or IEC 60751: 2008 Pt-100 RTD platinum resistance thermometer, Class AA.

- 5.3. *Impression Measurement System:*

- 5.3.1. A linear displacement transducer (LDT) device capable of measuring the depth of the impression (rut) of the wheel to within 0.15 mm (0.006 in.), over a minimum range of 0 to 20 mm (0 to 0.8 in.).

- 5.3.2. The system shall measure the depth of the impression at a minimum at the following locations along the track length: -114 (-4.5), -91 (-3.6), -69 (-2.7), -46 (-1.8), -23 (-0.9), 0 (0), $+23$ ($+0.9$), $+46$ ($+1.8$), $+69$ ($+2.7$), $+91$ ($+3.6$), and $+114$ ($+4.5$) mm (in.) with zero being the midpoint of the track unless otherwise specified by the agency. The midpoint of the track shall be marked by the manufacturer.

- 5.3.3. The system measures the rut depth, without stopping the wheel, at least every 20 passes. Rut depth is expressed as a function of the wheel passes. The device will also disengage if the average LDT displacement (read from the micro-control unit, not the screen) is 40.90 mm (1.6 in.) or greater for an individual specimen. Note that the screen readout subtracts the initial LDT reading from the total displacement.

- 5.3.4. The maximum level of deviation from the 11 preset locations is defined through the RMSE, which is calculated as follows:

$$\text{RMSE} = \sqrt{\frac{\sum e_i^2}{n}} \quad (2)$$

where:

- e_i = deviation from the preset location after considering the effect of curvature of the aluminum apparatus (Table A1.1); and
 n = number of data points.

- 5.3.5. The maximum allowable RMSE at the 11 preset locations after considering the effect of curvature of the aluminum apparatus (Table A1.1), discussed in the NCHRP Web-Only Document 219, is 1.27 mm (0.05 in.).

Note 3—The locations of the deformation readings should be verified using the aluminum apparatus presented in Section A6.4.

- 5.4. *Wheel Pass Counter*—A non-contacting solenoid that counts each wheel pass over the specimen. The signal from this counter is coupled to the wheel impression measurement, allowing for the rut depth to be expressed as a function of the wheel passes.
- 5.5. *Slab Specimen Mounting System*—A stainless steel tray that is mounted rigidly to the machine. The mounting system must restrict shifting of the specimen to within 0.5 mm (0.02 in.) during testing and must suspend the specimen to provide a minimum of 20 mm (0.8 in.) of free circulating water on all sides of the mounting system.
- 5.6. *Cylindrical Specimen Mounting System*—An assembly consisting of two high-density polyethylene (HDPE) molds or plaster of Paris, in accordance with Section 8 to secure the specimen (as shown in Figures 1 and 2), placed on a stainless steel tray that is mounted rigidly to the machine. This mounting system must restrict shifting of the specimen to within 0.5 mm (0.02 in.) during testing and must suspend the specimen to provide a minimum of 20 mm (0.8 in.) of free circulating water on all sides of the mounting system.



Figure 1—Cylindrical Specimen Mounting System