

Designation: D8259/D8259M - 21

# Standard Test Method for Rotary Wheel Testing (RWT) of Compacted Asphalt Mixtures<sup>1</sup>

This standard is issued under the fixed designation D8259/D8259M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon ( $\varepsilon$ ) indicates an editorial change since the last revision or reapproval.

## 1. Scope

1.1 This test method describes a procedure for testing the rutting and moisture susceptibility of asphalt specimens using the Rotary Wheel Tester (RWT). Superpave Gyratory Compactor (SGC) specimens (Test Method D6925) are wrapped, conditioned, submerged in water, and confined between three metal wheels in continuous synchronized rotation with each wheel applying a fixed load around the periphery of the specimen. The system records the number of load cycles applied to the specimen, the deformation of the specimen (rut depth), the loading rate, the temperature of the water, and Sigma, which is an indication of specimen roundness.

1.2 The test method is used to determine the premature rutting susceptibility of asphalt mixtures by measuring rut depth as a function of number of load cycles throughout the test.

1.3 This test method also measures the potential for moisture damage effects because the specimens are submerged in temperature-controlled water during preconditioning and for the duration of the test.

1.4 The parameters of the test are shown in Table 1. See an example of the test parameters used in Appendix X1.

Note 1—This test uses a typical specimen produced by a Superpave gyratory compactor.

Note 2—The ruggedness study identified air void content as the most influential factor evaluated and recommended a tolerance of  $\pm 0.25$  % to minimize the effect of air void content on the test results. The precision study evaluated three asphalt mixtures with specimen air void contents ranging from 2.87 % to 3.23 %, from 4.28 % to 4.64 %, and from 5.77 % to 6.19 %. Precision statements covering the air void content ranges of 2.75 % to 4.75 % and 5.75 % to 6.25 % can be found in Section 10. Lemke and Bahia (2019) found that an asphalt mixture with 7 % air void content was more susceptible to rutting than a mixture with 3 % air void content and that the test results for the 7 % AV mixture did not differentiate between control factors such as test temperature and mixture source like the mixture with 3 % air void content did.

NOTE 3—The University of Wisconsin at Madison Modified Asphalt Research Center (2017) reported that the City of LA selected the test temperature of 60 °C [140 °F] because "(1) it approximates the observed high average temperature of most pavements, (2) it is close to the high temperature performance grade classification of the asphalt binder used in most local applications, (3) it allows a test to be performed in an accelerated time frame (about 2 h excluding preconditioning time), and (4) research on rut testing has shown [that] the asphalt binder seems to have the most control over the test results at lower test temperatures." The ruggedness study was completed at 60 °C [140 °F] using PG 64-10 with 50 % RAC asphalt mixture. The precision study was completed at 60 °C [140 °F] using PG 64-10 with 50 % RAC asphalt mixture for two of the mixtures evaluated and using PG 76-22 for the third mixture considered. One may wish to consider lower test temperatures because Lemke and Bahia (2019) reported reducing the test temperature from 60 °C [140 °F] to 52 °C [125.6 °F] when testing PG 58S-28 and PG 58H-28 asphalt because of premature failure. Note 8 includes a suggestion for selecting an alternative test temperature based on the binder if one chooses to do so.

Note 4—The University of Wisconsin at Madison Modified Asphalt Research Center (2017) reported that the City of LA selected 6900 load cycles as the maximum load cycles because "initial observations from tests showed that most samples tested showed their performance well before these values (6900 load cycles and 6.0 mm [0.24 in.]) were attained ... while those that exhibited low rut depth in the field and no moisture susceptibility showed test result curves that behaved as asymptotes to their initial creep slope until the maximum number of cycles (30 000 cycles) of the machine was attained." 6900 load cycles was used in both the ruggedness and precision work as well. The machine has an allowable range of 300 to 30 000 load cycles.

NOTE 5—The University of Wisconsin at Madison Modified Asphalt Research Center (2017) reported that the City of LA selected 6.0 mm [0.24 in.] as the maximum rut depth because "initial observations from tests showed that most samples tested showed their performance well before these values (6900 load cycles and 6.0 mm [0.24 in.]) were attained ... while those that exhibited low rut depth in the field and no moisture susceptibility showed test result curves that behaved as asymptotes to their initial creep slope until the maximum number of cycles (30 000 cycles) of the machine was attained." 6.0 mm [0.24 in.] was used in both the ruggedness and precision work as well.

Note 6—The University of Wisconsin at Madison Modified Asphalt Research Center (2017) reported that the City of LA selected 70 CPM as the loading rate because that is what its RWT was set at by the factory. 70 CPM was used in both the ruggedness and precision work as well. The machine has an allowable range of 60 to 90 CPM.

Note 7—The University of Wisconsin at Madison Modified Asphalt Research Center (2017) reported that the City of LA selected an applied load of 334 N [75 lb] because that is what its RWT was set at by the factory. 334 N [75 lb] was used in both the ruggedness and precision work as well. The machine has an allowable range of 334 to 489 N [75 to 110 lb] in 22-N [5-lb] increments. Applied loads of greater than 334 N [75 lb] are not recommended based on experience.

1.5 Criteria for the evaluation and interpretation of test results shall be developed for local conditions and material

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<sup>&</sup>lt;sup>1</sup> This test method is under the jurisdiction of ASTM Committee D04 on Road and Paving Materials and is the direct responsibility of Subcommittee D04.20 on Mechanical Tests of Asphalt Mixtures.

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**TABLE 1 Test Parameters** 

Test Parameter	Specification
Specimen height	115 ± 5 mm [4.5 ± 0.2 in.] (Note 1)
Specimen diameter	150 mm [5.9 in.] (Note 1)
Specimen air void content	Target $\pm$ 0.25 % (3 % $\leq$ Target $\leq$ 6 %) (Note 2)
Test temperature	60 ± 0.5 °C [140 ± 0.9 °F] (Note 3)
Preconditioning time	120 ± 10 min
Maximum load cycles	6900 load cycles (Note 4)
Maximum rut depth	6.0 mm [0.24 in.] (Note 5)
Loading rate	70 ± 2 load cycles per min (CPM) (Note 6)
Applied load	334 ± 5 N [75 ± 1 lb] (Note 7)

characteristics. Appendix X1 shows an example of how test results are used and interpreted.

1.6 The text of this test method references notes and footnotes which provide explanatory material. These notes and footnotes (excluding those in tables and figures) shall not be considered as requirements of the test method.

1.7 Units—The values stated in either SI units or inchpound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with the standard.

1.8 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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.

1.9 This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.

#### 2. Referenced Documents

- 2.1 ASTM Standards:<sup>2</sup>
- D8 Terminology Relating to Materials for Roads and Pavements
- D1188 Test Method for Bulk Specific Gravity and Density of Compacted Bituminous Mixtures Using Coated Samples
- D2041/D2041M Test Method for Theoretical Maximum Specific Gravity and Density of Asphalt Mixtures
- D2726/D2726M Test Method for Bulk Specific Gravity and Density of Non-Absorptive Compacted Asphalt Mixtures
- D3203/D3203M Test Method for Percent Air Voids in Compacted Asphalt Mixtures
- D3666 Specification for Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials
- D6027/D6027M Practice for Calibrating Linear Displacement Transducers for Geotechnical Purposes

- D6752/D6752M Test Method for Bulk Specific Gravity and Density of Compacted Asphalt Mixtures Using Automatic Vacuum Sealing Method
- D6857/D6857M Test Method for Maximum Specific Gravity and Density of Asphalt Mixtures Using Automatic Vacuum Sealing Method
- D6925 Test Method for Preparation and Determination of the Relative Density of Asphalt Mix Specimens by Means of the Superpave Gyratory Compactor
- E4 Practices for Force Calibration and Verification of Testing Machines

# 3. Terminology

3.1 *Definitions*—For definitions of terms used in this test method, refer to Terminology D8.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 applied load [N], n—the force applied by the top wheel to the specimen.

3.2.1.1 *Discussion*—This force is the combined effect of the weight of the wheel, the load frame, and the dead weight.

3.2.2 *creep slope, CS, n*—the straight line portion of the curve before the SIP.

3.2.2.1 *Discussion*—This portion of the curve is a measure of rutting susceptibility not due to moisture.

3.2.3 *load cycle*, *n*—the application of load to a specimen by one wheel for one rotation of the specimen.

3.2.3.1 *Discussion*—There are three wheels; therefore, each rotation of a specimen generates three (3) load cycles.

3.2.4 *loading rate [CPM]*—the number of load cycles applied to a specimen per minute.

3.2.4.1 *Discussion*—Because three (3) load cycles are applied per specimen revolution, a loading rate of 70 CPM means the specimen is rotating 23.3 times per minute (70 CPM  $\div$  3 load cycles per revolution).

3.2.5 *post-compaction consolidation [mm], n*—the rut depth at the y-intercept of the creep slope.

3.2.5.1 *Discussion*—This represents densification of the specimen during the beginning load cycles of the test.

3.2.6 *rut curve*, *n*—the plot of rut depth versus load cycle.

3.2.7 *rut depth [mm]*, *n*—a depression into the asphalt mixture sample due to loading.

3.2.7.1 *Discussion*—The reported rut depth is the average of the rut depth measurements taken during one (1) revolution of a specimen.

3.2.8 *sigma*, *n*—the roundness parameter of a specimen calculated for each rotation of the specimen using the standard deviation of the rut measurements for that rotation.

3.2.8.1 *Discussion*—A value of 0.0 represents a perfect cylinder. A value of 0.8 is considered to indicate a specimen that is severely out of round and is used as the default value for stopping a test.

3.2.9 *stripping inflection point, SIP, n*—the intersection of the creep slope and the stripping slope.

3.2.10 *stripping slope, SS, n*—the straight line portion of the curve after the SIP.

<sup>&</sup>lt;sup>2</sup> For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.



3.2.10.1 *Discussion*—This portion of the curve is a measure of rutting susceptibility due to moisture damage.

3.2.11 *test temperature* [°C], *n*—the temperature at which specimens are preconditioned and tested.

Note 8—The proposed test procedure is run at 60 °C [140 °F] and the ruggedness and precision work done for the procedure was completed at 60 °C [140 °F]. However, one may wish to use a lower temperature for softer binders. One approach to identifying an appropriate test temperature is to use the PG high temperature corresponding to 50 % reliability for the location of interest at a depth of 20 mm [0.787 in.] and no traffic adjustment determined from the LTPPBind program. The different generations of the LTPPBind program use different algorithms and weather databases for determining the PG high temperature for a location. The choice of which LTPPBind version to use is up to the specifier.

## 4. Significance and Use

4.1 The test method is developed for determining the rutting and moisture susceptibility of asphalt mixtures. The rutting and moisture damage resistance can help differentiate mixtures whose service life might be compromised by permanent deformation or by moisture damage. The test method is valid for specimens that are tested at temperatures of  $60 \pm 0.5$  °C [140  $\pm 0.9$  °F]. Test specimen geometry is a diameter of 150 mm [5.9 in.] and a height of 115  $\pm 5$  mm [4.5  $\pm 0.2$  in.]. Specimens are prepared using a Superpave gyratory compactor.

Note 9—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 Specification D3666 are generally considered capable of competent and objective testing, sampling, inspection, etc. Users of this standard are cautioned that compliance with Specification D3666 alone does not completely ensure reliable results. Reliable results depend on many factors; following the suggestions of Specification D3666 or some similar acceptable guideline provides a means of evaluating and controlling some of those factors.

### 5. Apparatus

5.1 *Rotary Wheel Tester (RWT)*—Capable of testing a cylindrical asphalt specimen for deformation and stripping. The cylindrical specimen is confined between three loaded wheels on its circumference which rotate in synchronization (see Figs. 1 and 2). The lower two wheels are mounted on rotating shafts at fixed positions. The upper wheel is mounted on a shaft fixed to the load frame that is lifted to insert the cylindrical asphalt specimens. The upper wheel applies a force to the specimen while the synchronized rotation of the three wheels continuously rotates the specimen at the specified rate. All three (3) wheels are driven at the same speed. The applied force on the upper wheel may be adjusted using a dead weight system applied to the arm holding the upper wheel. The wheels are made of hardened stainless steel 47  $\pm$  0.1 mm [1.85  $\pm$  0.005 in.] wide by 228.6  $\pm$  0.1 mm [9  $\pm$  0.005 in.] diameter. The top wheel is mounted on a pivot such that the weight of the load frame is applied to the specimen.

5.1.1 *Load Frame*—The upper wheel is mounted on the load frame which, when lowered into the testing position, applies the weight of the load frame to the specimen. Additional weight can be added to the load frame to increase the applied load (see Fig. 2). A lift mechanism raises and lowers the load frame.

5.1.2 *Water Tank*—A water tank sized so that the specimen is completely submerged in water for the duration of the test.

5.1.3 *Rut Depth Measurement System*—Rut depth is measured using a displacement transducer (DT) mounted to the load frame (see Fig. 3). The DT measures the position of the load frame relative to the top surface of the water tank of the device. The position of the load frame is a function of the position of the wheel mounted on the load frame against the surface of the specimen being tested. The deformation of the specimen is determined by the position of the load frame.

5.1.3.1 *Displacement Transducer (DT)*—The DT shall have a range of  $\pm 12.5$  mm [ $\pm 0.5$  in.] and an accuracy of  $\pm 0.5$  % full scale.

5.1.3.2 The DTs are calibrated using calibration rings with nominal diameters of 120 and 150 mm [4.7 and 5.9 in.] The actual diameter of the ring measured to 0.01 mm [0.0004 in.] is entered into the RWT during calibration of the DTs for rut depth.



FIG. 1 Asphalt Mixture Specimen Loading Geometry and Device Chamber of the RWT

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