INTERNATIONAL

**Designation: D8259/D8259M − 21**

# Standard Test Method for Rotary Wheel Testing (RWT) of Compacted Asphalt Mixtures[1]

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 (ε) 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 ±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



[1] 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 ± 0.25 % (3 % ≤ Target ≤ 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 inch-pound 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:*[2]

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 ÷ 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.



[2] 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 ± 0.5 °C [140 ± 0.9 °F]. Test specimen geometry is a diameter of 150 mm [5.9 in.] and a height of 115 ± 5 mm [4.5 ± 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 ± 0.1 mm [1.85 ± 0.005 in.] wide by 228.6 ± 0.1 mm [9 ± 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 ±12.5 mm [±0.5 in.] and an accuracy of ±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.



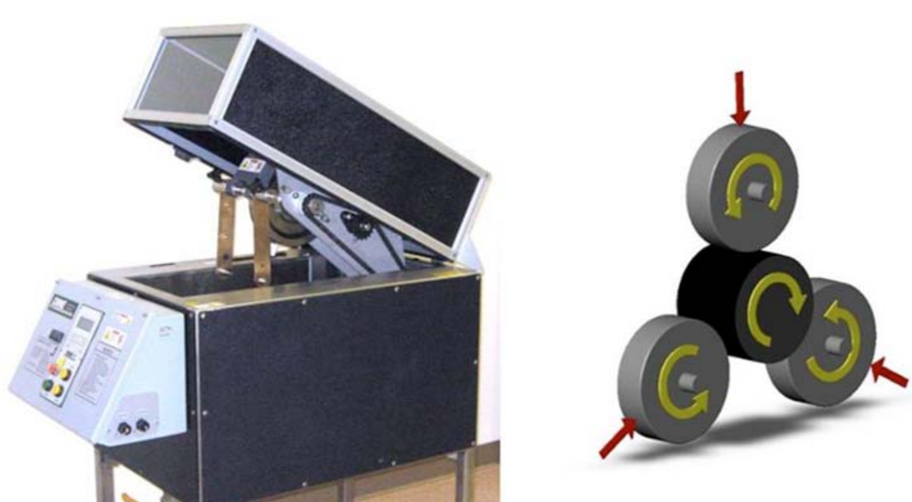

FIG. 1 Asphalt Mixture Specimen Loading Geometry and Device Chamber of the RWT

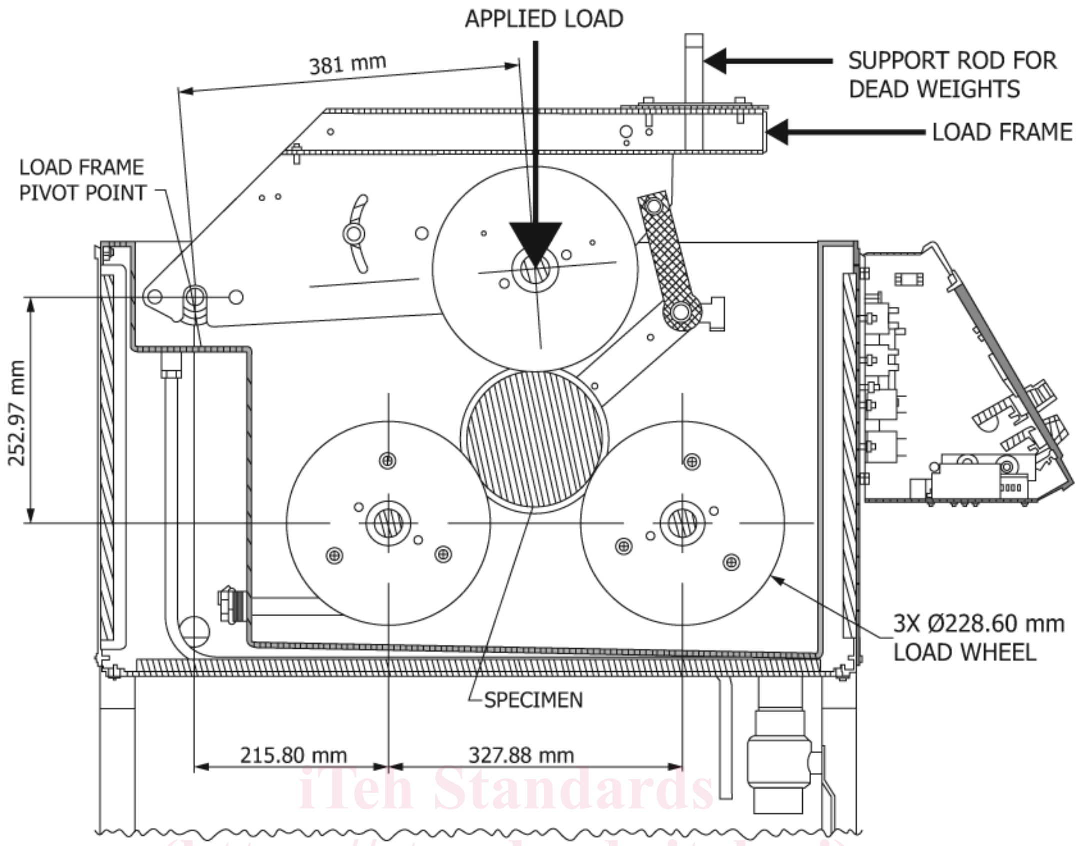


FIG. 2 RWT Section



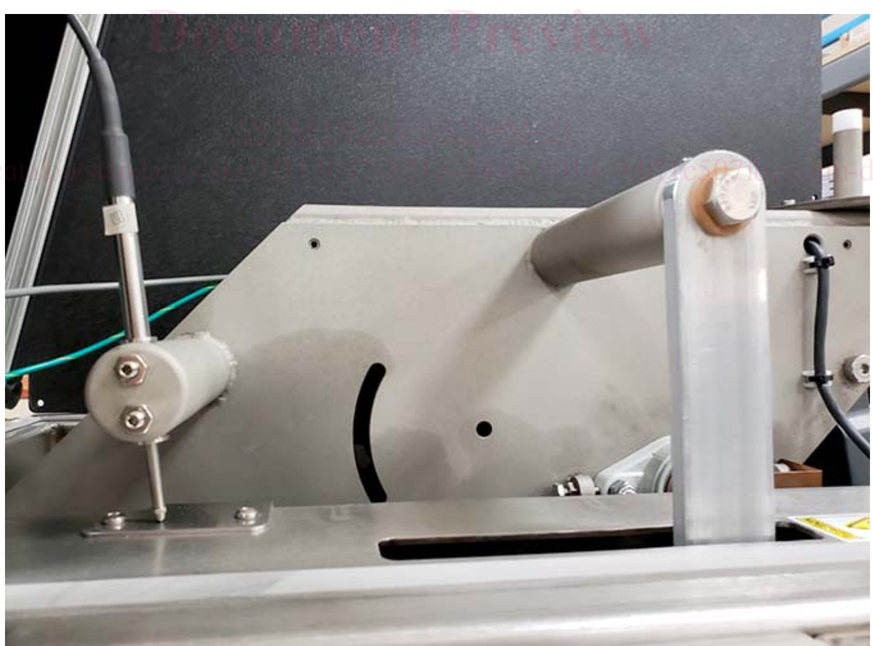

FIG. 3 Rut Measurement with DT, Loading Frame, and Water Tank Surface

5.1.3.3 Calibration of rut depth is verified to within ±0.2 mm [±0.008 in.].

5.1.3.4 Rut depth is measured to the nearest 0.01 mm [0.0004 in.].

5.1.3.5 A rut depth measurement is recorded every 50 ms.

5.1.3.6 Rut depth is calculated using the average of the rut depth measurements recorded during one revolution of the specimen, reported to 0.01 mm [0.0004 in.] for each revolution (see Eq 1).

$$\text{Rut Depth}_i = \text{Specimen Radius}_{\text{Initial}} - \text{Specimen Radius}_i \quad (1)$$

where:

Rut Depth$_i$ = rut depth on revolution $i$,
Specimen Radius$_{\text{Initial}}$ = specimen radius on revolution #4, and
Specimen Radius$_i$ = specimen radius on revolution $i$ (see Eq 2).

$$\text{Specimen Radius}_i = CF \times \frac{\sum_{h=1}^{n} DT_h}{2n} \quad (2)$$

where:

$i$ = the specimen revolution number,
$CF$ = calibration factor (mm/count) (see Note 10),
$DT_h$ = DT readings taken every 50 ms in specimen revolution $i$ (counts), and
$n$ = the number of DT readings recorded in specimen revolution $i$.

NOTE 10—The manufacturer calibrates the DT on the rotary wheel tester using rings of 120 and 150 mm [4.7 and 5.9 in.] nominal diameter. The DT readings are recorded in counts. The calibration process leads to a calibration factor in units of millimeters per count.

5.1.3.7 The roundness of the specimen is monitored throughout the test using the rut depth variation during each cycle of rotation to calculate Sigma (see Eq 3).

$$\text{Sigma}_i = CF \times \sqrt{\frac{(n \times B) - A^2}{n^2}} \quad (3)$$

where:

Sigma$_i$ = Sigma for specimen revolution $i$,
$CF$ = calibration factor (mm/count) (see Note 10),
$n$ = the number of DT readings recorded in specimen revolution $i$,
$A$ = $\Sigma^n_{h=1} DT_h$ (counts),
$B$ = $\Sigma^n_{h=1} (DT_h)^2$ (counts$^2$), and
$DT_h$ = DT readings taken every 50 ms in specimen revolution $i$ (counts).

NOTE 11—Example for Sigma Calculation: Assume the asphalt specimen is rotating 20 times per minute. This means that one revolution of the specimen takes 3 s. The machine is recording a rut depth measurement every 50 ms, therefore the machine records 60 rut depth measurements in 3 s. In Eq 3, $n$ is 60, $A$ is the sum of the 60 rut depth measurements, and $B$ is the sum of the square of each of the 60 rut depth measurements.

5.1.3.8 If Sigma reaches the programmed limit, the test is stopped.

5.1.4 *Specimen Rotation Counter*—The actual rotation of the specimen is measured so the system can maintain the programmed loading rate in load cycles per minute to within ±2 CPM.

5.1.5 *End Caps*—Two end caps are required for each test (Fig. 4), one on each end of the specimen being tested. The end caps fit snuggly on each end of a specimen.

5.1.6 *Temperature Control System*—The specimen and wheels are submerged in a water tank that is of sufficient size and depth to allow total immersion of the specimen and capable of maintaining constant bath temperature accurate to within ±0.5 °C [±0.9 °F] of the specified test temperature for the duration of the test. Water temperature is measured continuously with a single temperature probe.

5.1.7 *Data Acquisition*—The data acquisition system shall have the ability to acquire the data of load cycles, rut depth,



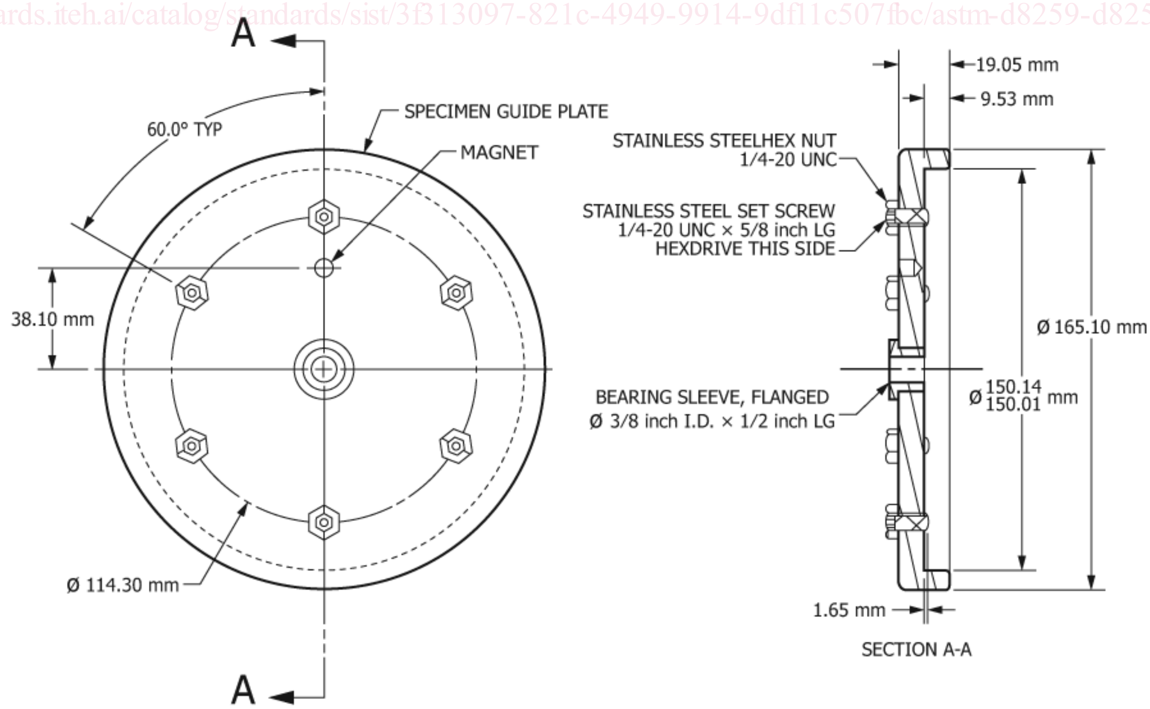


FIG. 4 End Cap

water temperature, loading rate, and Sigma. Data is stored every ten specimen revolutions (30 load cycles) at minimum.

5.2 *Water Bath*—The water bath is used to precondition the specimen to the test temperature before testing the specimen in the RWT. The water bath shall be deep enough to maintain the water level a minimum of 30 mm [1.25 in.] above the top of the specimen. The bath shall maintain the water at the specified test temperature ±0.5 °C [±0.9 °F] at any point in the tank. The tank shall have a perforated false bottom or be equipped with a shelf for supporting specimens 50 mm [2 in.] above the bottom of the bath and shall be equipped with a mechanical water circulator.

5.3 *Stretch Wrap*—A clear polyethylene stretch wrap with a width of 152 mm [6 in.] and a thickness of 0.015 mm [0.00059 in.].

NOTE 12—McMaster-Carr Catalog No. 2008T21 in 12-in. wide rolls that are cut into 6-in. rolls have been found suitable.

5.4 *Balance*—A balance of 12 000-g [26.5-lb] capacity, accurate to 0.1 g [0.0002 lb].

5.5 *Ovens*—Ovens for heating aggregate and asphalt binders.

5.6 *Superpave Gyratory Compactor*—Superpave gyratory compactor (SGC) and molds conforming to Test Method D6925.

5.7 *Caliper*—Measure the diameter of the asphalt specimen to the nearest 0.5 mm [0.02 in.].

5.8 *Miscellaneous*—Miscellaneous equipment may include flat bottom metal pans, waterproof gloves, eye protection, lubricants for moving parts, bowls, spoons, spatulas, brushes, timers, and mechanical mixers.



## 6. Test Specimens

6.1 *Specimen Characteristics*—Manufacture specimens to the characteristics listed below using one of the approaches in 6.2 or 6.3.

6.1.1 Height: 115 ± 5 mm [4.5 ± 0.2 in.].

6.1.2 Diameter: 150 mm [5.91 in.]. Use a 150-mm mold to make the specimen.

6.1.3 Air void content: Target ± 0.25 % where 3 % ≤ Target ≤ 6 %.

NOTE 13—The ruggedness study indicated that air void content has a significant impact on test results. Therefore, as determined by the ruggedness work, if one is going to evaluate asphalt mixtures using this method and wishes to minimize the impact of air void content on the test results, the specimens tested should have an air void content tolerance of ±0.25 %. Furthermore, the work done on precision indicated that the variability of test results increases with increased air void content. See the precision statement in Section 10. This should be considered in the evaluation and interpretation of test results.

6.2 *Laboratory-Produced Asphalt Mixture*—Laboratory mixed laboratory compacted (LMLC) specimens shall be prepared according to Test Method D6925.

6.2.1 Allow compacted specimens to cool at normal room temperature for at least 12 h and then clean them by brushing off loose debris. Mark the top of the specimen for identification.

6.3 *Plant-Produced Asphalt Mixture*—Plant mixed laboratory compacted (PMLC) specimens shall be prepared according to Test Method D6925.

6.3.1 Allow compacted specimens to cool at normal room temperature for at least 12 h and then clean them by brushing off loose debris. Mark the top of the specimen for identification.

6.4 Determine the bulk specific gravity of the specimens in accordance with Test Method D1188, Test Method D2726/D2726M, or Test Method D6752/D6752M.

6.5 Determine the maximum specific gravity of the mixture in accordance with Test Method D2041/D2041M or Test Method D6857/D6857M.

6.6 Determine the air void content of the specimens in accordance with Test Method D3203/D3203M.

6.7 Measure the maximum diameter of the specimen to the nearest 0.5 mm [0.02 in.].

6.8 *Wrap the Specimen*—The circumference of the specimen is wrapped with five layers of stretch wrap. The stretch wrap is cut and the end wrapped tightly around the specimen. Cut off the wrap extending over the top and bottom of the specimen at the top and bottom edges (see Fig. 5).

NOTE 14—The sole purpose of the stretch wrap is to maintain the specimen in a cylindrical shape and to prevent excess raveling during testing. Experience has shown this practice to be necessary to generate consistent test results.

NOTE 15—Stretch wrap has been found not to have an effect on the saturation of the specimen. An experiment comparing the saturation of three (3) pairs of wrapped and unwrapped specimens of the same mix with the same air void content, 7.0 %, after completing preconditioning for

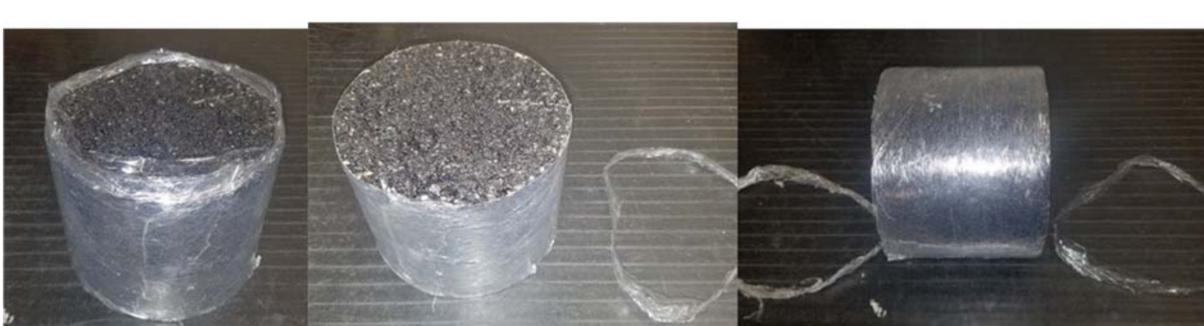

**FIG. 5 Trimming the Wrapped Specimens**

120 min at 60 °C [140 °F] found the percent saturation of each pair to be consistent.

## 7. Procedure

7.1 Check the equipment and maintain it as recommended by the manufacturer.

7.2 Prepare the device for testing according to the manufacturer's recommendations.

7.3 Ensure the applied load is 334 ± 5 N [75 ± 1 lb].

NOTE 16—Applied loads greater than 334 N [75 lb] are not recommended.

7.4 Set the test parameters.

7.4.1 Maximum load cycles: 6900 load cycles. The test will be stopped when this number of load cycles has been applied to the specimen, assuming a maximum rut depth of 6.0 mm [0.24 in.] has not been reached.

7.4.2 Maximum rut depth: 6.0 mm [0.24 in.]. The test will be stopped when the rut depth reaches this depth, assuming a maximum load cycles of 6900 load cycles has not been reached.

7.4.3 Loading rate: 70 CPM. This defines how many load cycles will be applied to the specimen per minute.

7.4.4 Test temperature: 60 °C [140 °F]. This is the temperature of the water at which specimens are conditioned and tested. (See Note 8 regarding alternative test temperatures.)

7.5 Prepare the water tank of the device according to the manufacturer's recommendations.

NOTE 17—Allow enough time for the water to reach testing temperature before a specimen is mounted in the device. Although the device has the capacity to precondition specimens, it is important to precondition specimens in a separate water bath without the end caps installed to allow the specimen to absorb water.

7.6 *Precondition the Specimen*—Precondition the wrapped specimen for 120 ± 10 min in a separate water bath set to the test temperature specified (see Fig. 6).

7.7 *Install End Caps*—Upon completion of preconditioning, remove the specimen from the water bath and immediately install both end caps by firmly pressing one on each end of the specimen. The end caps should fit snuggly (see Fig. 7).

7.8 Immediately after installing the end caps on the specimen (7.7), mount the preconditioned, wrapped specimen in the test device so that the wrap will not be stripped by the rotation of the specimen against the metal wheels. A properly mounted specimen should swing and rotate freely under the loading frame. Care should be taken to make sure the specimen is centered with respect to the load rollers (Fig. 8). Steps in 7.7 and 7.8 should be completed within 60 s of removing the specimen from the preconditioning water bath.

NOTE 18—Experience shows that it takes no longer than 30 s to complete 7.7 and 7.8.

7.9 Lower the load frame and begin the test.

NOTE 19—The DT is automatically zeroed at the start of each test. The software will display a zero at the start of the test.

7.9.1 The test is completed when the maximum load cycles, maximum rut depth, or Sigma reaches its respective limit.

NOTE 20—If a USB flash drive is in the USB port at the completion of a test, the results will automatically be saved to the USB flash drive. Otherwise, the data is saved on the machine and can be saved to a USB flash drive at a future time. Test results may also be sent to a PC through a serial cable during the test.

7.10 Remove the specimen from the device.

NOTE 21—Experience shows that the best way to remove the specimen from the device is by supporting it from underneath with one hand while loosening the right support clamp, sliding it to the right, and applying a slight rotating motion until the axle peg is clear of the end cap. The specimen will be hot and should be handled carefully. Severely rutted specimens may fall apart.

## 8. Calculations



8.1 Plot the rut depth versus number of load cycles for each test. Fig. 9 shows a typical rut curve.

8.2 Fit a six-order polynomial to the rut depth versus load cycles curve as shown in Eq 4.

$$RD(N) = P_1N^6 + P_2N^5 + P_3N^4 + P_4N^3 + P_5N^2 + P_6N + P_7 \quad (4)$$

where:

$RD(N)$ = the fitted rutting depth,
$N$ = the number of loading passes, and
$P_i$ = regression constants.

8.3 Calculate the first derivative of the six-order polynomial (Fig. 10).

8.4 Identify the point near the end of the test where the first derivative calculated in 8.3 is the minimum.

8.5 Define a line that is tangent to the rut depth versus load cycles curve at the point identified in 8.4 (minimum value). The slope of the line will be the first derivative identified in 8.4, which is referred to as the stripping slope (SS).

8.6 Determine the point near the beginning of the test where the first derivative calculated in 8.3 is the maximum.

FIG. 6 Preconditioning Specimens