Standard Method of Test for

Determining Rutting Susceptibility of Asphalt Mixtures Using the Asphalt Pavement Analyzer (APA)

AASHTO Designation: T 340-23[1]

Technically Revised: 2023 **Editorially Revised: 2023**

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

American Association of State Highway and Transportation Officials
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1. SCOPE

1.1. This method describes a procedure for testing the rutting susceptibility of asphalt mixtures using the Asphalt Pavement Analyzer (APA).

1.2. Annex A1 contains procedures for calibration checks for several APA components and related equipment.

1.3. Appendix X1 presents specifications for, and discussion concerning, several options for APA testing parameters often employed by APA users.

1.4. The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.5. *This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all 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.*

1.6. *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*:

- R 18, Establishing and Implementing a Quality Management System for Construction Materials Testing Laboratories
- 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 Standard*:

- E1, Standard Specification for ASTM Liquid-in-Glass Thermometers

3. APPARATUS

3.1. *APA*—A thermostatically controlled device designed to test the rutting susceptibility of asphalt mixtures by applying repetitive linear loads to compacted test specimens through pressurized hoses via wheels.

3.1.1. The APA shall be thermostatically controlled to maintain the test temperature and conditioning chamber at any set point between 4 and 72°C (40 and 160°F) within 1°C (2°F).

3.1.2. The APA shall be capable of independently applying loads up to 578 N (130 lbf) to the wheels. The loads shall be calibrated to the specified test load by an external-force transducer.

3.1.3. The APA shall be capable of adjusting the pressure in the test hoses and maintaining up to 862 kPa (125 psi) in the test hoses.

3.1.4. The APA shall be capable of testing four or six cylindrical specimens using a two-wheel or three-wheel APA, respectively.

3.1.5. The test molds shall be rectangular in shape, be composed of ultra-high-molecular-weight (UHMW) polyethylene, fit snugly within the testing position in the APA testing chamber, and contain two holes in which to insert the specimens. The dimensions of each hole shall be 150 ± 2.0 mm (5.91 ± 0.08 in.) in diameter by 75.0 ± 2.0 mm (2.95 ± 0.08 in.) tall.

3.1.6. The APA shall have a programmable master cycle counter that can be preset to the desired number of cycles for a test. The APA shall be capable of automatically stopping the test at the completion of the programmed number of cycles.

3.1.7. The test hoses shall be composed of a nylon tube with high-tensile textile cord reinforcement and a synthetic rubber cover. The nominal inside diameter of the hoses shall be 19.0 mm (0.75 in.); the nominal outside diameter of the hoses shall be 29.5 mm (1.16 in.). The maximum working pressure (WP) of the hoses shall be 5.17 MPa (750 psi). The hoses should be replaced when any of the outer rubber casing exhibits significant wear. Follow the APA manufacturer's instructions for the technique on replacing hoses.

Note 1—A Gates 77B Paint Spray and Chemical hose has been found to be satisfactory. This hose is available from the Gates Corporation (Product No. 3207-0296).

3.1.8. When electing to manually measure rut depths, a rut depth measurement template is required. This template shall be machined aluminum plate [approximately 31.7 to 38.1 mm (1.25 to 1.50 in.) thick] and have the following dimensions: 400.0 mm (15.75 in.) long by 152.4 mm (6 in.) wide. The rut depth measurement template shall contain five openings, spaced along the length of the template, in which the ruts are measured. The locations of the openings on the template will coincide with the locations utilized by the automatic measurement system. Each of the five openings shall be approximately 11 mm (0.43 in.) wide.

Note 2—Manual rut depth measurements on specimens that are rutted significantly may result in erroneous data. The rut depth measurement template may rest on the displaced material rather than on the test mold. In these cases, the rut depth measurement template should be modified with a

channel removed from the bottom side of the template in order to span the displaced material and ensure that the template rests on the test mold.

3.1.9. The APA shall be calibrated in accordance with Annex A1.

3.2. Ovens for maintaining temperature of plant-produced asphalt mixtures and preheating specimens.

3.3. *Compaction Device and Molds*:

3.3.1. Superpave gyratory compactor (SGC) and compaction molds conforming to T 312, or

3.3.2. Vibratory compactor and compaction molds.

3.3.2.1. *Vibratory Compactor*—A steel-frame device mounted on noise-absorbing isolators and supports that utilizes adjustable vibratory compression forces to consolidate and compact asphalt mixtures to produce cylindrical specimens for further testing. The device shall be timer-controlled and capable of compacting the specimens to a specified height and extracting the specimens after compaction. The vibratory compactor shall have a control panel separate from the compaction unit. The panel shall contain a mode switch to control specimen compaction and extraction and a timer to control the compaction-time cycle.

3.3.2.2. The compaction molds used for specimens produced in the vibratory compactor shall be composed of steel with the following dimensions:

- Inside diameter of 149.9 ± 0.5 mm (5.90 ± 0.02 in.),
- Inside height of 133.4 ± 0.5 mm (5.25 ± 0.02 in.),
- Overall height of 152.7 ± 0.5 mm (6.01 ± 0.02 in.),
- Wall thickness of 7.81 ± 0.5 mm (0.31 ± 0.02 in.), and
- Bottom plate diameter of 149.0 ± 0.5 mm (5.87 ± 0.02 in.).

4. PREPARATION OF TEST SPECIMENS

4.1. *Number and Dimensions of Test Specimens*—Four cylindrical specimens for the two-wheel APA and six cylindrical specimens for the three-wheel APA, 150 mm (5.91 in.) in diameter by 75 ± 2 mm (3.0 ± 0.1 in.) tall.

4.2. *Roadway Core Specimens*:

4.2.1. Roadway core specimens shall be 140 to 152 mm (5.5 to 6.0 in.) in diameter and a minimum of 50 mm (2 in.) tall with all surfaces of the perimeter perpendicular to the surface of the core within 5 mm (0.2 in.). Cores taller than the desired height shall be trimmed with a saw to a height of 75 ± 2 mm (3.0 ± 0.1 in.). For cores with diameters between 140 and 152 mm (5.5 and 6.0 in.) or heights between 50 and 73 mm (2.0 and 2.9 in.), plaster of paris or comparable material may be used to achieve the proper testing height of 75 ± 2 mm (3.0 ± 0.1 in.) and to ensure that specimens with small diameters fit snugly within the testing mold. Testing shall be conducted on the uncut face of the core.

4.3. *Plant-Produced Asphalt Mixtures*:

4.3.1. Samples of plant-produced asphalt mixtures shall be obtained in accordance with R 97. Asphalt mixture samples shall be reduced to the appropriate test size and compacted while the asphalt mixture is within the compaction temperature range as determined by the specifying agency. Reheating of loose plant asphalt mixtures should be avoided.

4.3.2. When using an SGC, compact specimens conforming to the dimensional requirements of Section 4.1 to 7.0 ± 0.5 percent air voids in accordance with T 312.

4.3.3. When using a vibratory compactor, compact specimens conforming to the dimensional requirements of Section 4.1 to 7.0 ± 0.5 percent air voids in accordance with the following procedure:

4.3.3.1. Attach and level the appropriate compaction head to the vibrating assembly in accordance with the manufacturer's instructions. Verify that the compaction head is correctly attached and arranged to produce a specimen of the desired height. Check the position of the compaction head against the specimen mold in accordance with the manufacturer's instructions.

4.3.3.2. Adjust the compaction force and vibration time settings in accordance with the manufacturer's instructions.

4.3.3.3. Heat and charge the specimen mold in accordance with the manufacturer's instructions.

4.3.3.4. Operate the vibratory compactor in order to compact and extrude the specimen in accordance with the manufacturer's instructions.

4.3.4. Compacted specimens should remain at room temperature, approximately 25°C (77°F), to allow the entire specimen to cool, for a minimum of 3 h.

4.4. *Laboratory-Prepared Asphalt Mixtures*:

4.4.1. Prepare the ingredient materials and mix the asphalt mixture specimens in accordance with T 312.

4.4.2. When using an SGC, compact specimens conforming to the dimensional requirements of Section 4.1 to 7.0 ± 0.5 percent air voids in accordance with T 312.

4.4.3. When using a vibratory compactor, compact specimens conforming to the dimensional requirements of Section 4.1 to 7.0 ± 0.5 percent air voids in accordance with the procedure given in Sections 4.3.3.1 through 4.3.3.4.

4.4.4. Compacted specimens should remain at room temperature, approximately 25°C (77°F), to allow the entire specimen to cool, for a minimum of 3 h.

5. DETERMINING THE AIR VOID CONTENT

5.1. Determine the bulk specific gravity of the asphalt mixture specimens in accordance with T 166. In the case of sawn specimens as described in Section 4.2.1, determine the bulk specific gravity of the specimens after sawing.

5.2. Determine the maximum specific gravity of the loose asphalt mixture in accordance with T 209.

5.3. Determine the air void content of the asphalt mixture specimens in accordance with T 269.

6. SELECTING THE TEST TEMPERATURE

6.1. The test temperature shall be set to the high temperature of the standard Superpave performance-graded (PG) binder identified by the specifying agency for the project for which the asphalt mixture is intended. For circumstances where the high-temperature binder grade has been increased, the APA test temperature will remain at the standard PG binder high temperature.

7. SPECIMEN PREHEATING

7.1. Place the specimens in the test molds.

7.2. Specimens shall be preheated at the test temperature in the temperature-calibrated APA test chamber or a separate calibrated oven for a minimum of 6 h. Specimens should not be held at the test temperature for more than 24 h prior to testing.

8. PROCEDURE

8.1. Set the hose pressure gap reading to 690 ± 35 kPa (100 ± 5 psi). Set the load cylinder pressure reading for each wheel to achieve a load of 445 ± 22 N (100 ± 5 lbf).

8.2. Stabilize the testing chamber temperature at the temperature selected in Section 6.

8.3. Secure the preheated, molded specimens in the APA. The preheated APA chamber should not be open for more than 6 min when securing the test specimens into the machine. Close the chamber doors and allow a minimum of 10 min for the temperature to stabilize prior to starting the test.

8.4. *Manual Rut-Depth Measurement*:

8.4.1. Apply 25 cycles to seat the specimens before taking the initial measurements. Make adjustments to the hose pressure as needed during these 25 cycles.

8.4.2. Open the chamber doors; unlock and pull out the sample holding tray.

8.4.3. Place the rut-depth-measurement template conforming to Section 3.1.8 over the specimen. Ensure that the rut-depth-measurement template is properly seated and firmly rests on top of the testing mold.

8.4.4. Zero the measuring gauge. Take initial readings at each of the four outside locations on the template; the center measurement is not used. Measurements shall be determined by placing the measuring gauge in the template slots and sliding the gauge slowly across each slot. Record the smallest measurement for each location to the nearest 0.01 mm (0.0004 in.).

8.4.5. Repeat Sections 8.4.3 and 8.4.4 for each set of cylinders in the testing position. All measurements shall be completed within 6.0 ± 0.5 min.

8.4.6. Push the sample holding tray in and secure it. Close the chamber doors and allow a minimum of 10 min for the temperature to stabilize.

8.4.7. Set the preset counter to 8000 cycles.

8.4.8. Start the test. When the test reaches 8000 cycles, the APA will stop and the load wheels will automatically retract.

8.4.9. Repeat Sections 8.4.2 through 8.4.5 to obtain the final measurements.

8.5. *Automatic Rut-Depth Measurement*:

Note 3—Some APA users have reported significant differences in rut depths between automatic measurements and manual measurements.

8.5.1. Initialize the APA computer software. Using the APA computer software or on the APA as appropriate, enter the applicable test parameters and project information prior to starting the test.

8.5.2. Ensure that the cycle-countdown mechanism is set to a value that will permit the specimens to be seated, a complete test of 8000 cycles to be performed, and the computer program to be disengaged at the end of the test. Normally, this value is between 8050 and 8100 cycles.

8.5.3. Using the APA computer software or on the APA as appropriate, start the test.

8.5.4. The APA will stop when the test is complete, and the wheels will automatically retract. Save the rut-depth data file to the computer. Print the data if desired.

9. CALCULATIONS

9.1. *Determine the average rut depth for each of the two or three test positions*:

9.1.1. When utilizing manual rut-depth measurement, determine the rut depth at each location by subtracting the final measurement from the initial measurement. Use the rut depth for all four locations to calculate the average rut depth for each of the two or three test positions.

9.1.2. When utilizing automatic rut-depth measurement, obtain the rut depths from the test positions as displayed on the APA computer software.

9.2. *Outlier Evaluation*—When three test positions are used, calculate the sample standard deviation for the three test positions. If the sample standard deviation of the three test positions is greater than or equal to 2.0 mm (0.08 in.), then the position with the rut depth farthest from the average may be discarded. The testing procedure, device calibration, and test specimens should be investigated to determine possible causes for the excessive variation.

9.3. The APA rut depth for the asphalt mixture is the overall average rut depth for the two positions from the four cylindrical specimens or the three test positions, less any outliers, from the six cylindrical specimens.

10. REPORT

10.1. *The test report shall include the following information*:

10.1.1. The laboratory name, technician name, and date of the test;

10.1.2. The asphalt mixture type and description;

10.1.3. The type of test specimens (cylinders or cores);

10.1.4. For cylinders, the type of compaction device (SGC or vibratory compactor);

10.1.5. The average air void content of the test specimens;

10.1.6. The test temperature;

10.1.7. The method utilized to measure rut depth (manual or automatic); and

10.1.8. The average rut depth for each of the two or three test positions, and the overall average rut depth for the asphalt mixture, to the nearest 0.1 mm (0.0004 in.).

11. PRECISION AND BIAS

11.1. Work is under way to develop precision and bias statements for this standard.

12. KEYWORDS

12.1. Asphalt mixture; Asphalt Pavement Analyzer (APA); calibration checks.

ANNEX A—CALIBRATION PROCEDURE

(Mandatory Information)

A1. CALIBRATION

A1.1. The following items should be checked for calibration no less than once per year: (1) preheating oven; (2) APA temperature; (3) APA wheel load; and (4) APA hose pressure. Instructions for each of these calibration checks are included in this section. For APAs equipped with the automatic rut-depth-measurement system, calibrate the horizontal and vertical components of the data-acquisition system according to the manufacturer's schedule and instructions.

A1.2. *Temperature Calibration of the Preheating Oven*:

A1.2.1. The preheating oven must be calibrated with a NIST-traceable thermometer [an ASTM No. 65C (65F) calibrated thermometer conforming to ASTM E1 is recommended] and a metal thermometer well to avoid rapid heat loss when checking the temperature.

A1.2.2. *Temperature Stability*:

A1.2.2.1. Set the oven to the chosen temperature [e.g., 64°C (147°F)]. Place the thermometer in the well and place the thermometer and well on the center of the shelf where the samples and molds will be preheated. It usually takes an hour or so for the oven chamber, well, and thermometer to stabilize. After 1 h, open the oven door and read the thermometer without removing it from the well. Record this temperature. Close the oven door.

A1.2.2.2. Thirty minutes after obtaining the first reading, obtain another reading of the thermometer. Record this temperature.

A1.2.2.3. If the readings from Sections A1.2.2.1 and A1.2.2.2 are within 0.4°C (0.8°F), average the readings. If the readings differ by more than 0.4°C (0.8°F), continue to take readings every 30 min until the temperature stabilizes within 0.4°C (0.8°F) on two consecutive readings.

A1.2.3. *Temperature Uniformity*:

A1.2.3.1. To check the uniformity of the temperature in the oven chamber, move the thermometer and well to another location in the oven so that they are on a shelf where the samples and molds will be preheated, but as far as possible from the first location. Take and record readings of the thermometer at the second location every 30 min until two consecutive readings at the second location are within 0.4°C (0.8°F).

A1.2.3.2. Compare the average of the two readings at the first location from Section A1.2.2.3 with the average of the stabilized temperature at the second location. If the average temperatures from the

two locations are within 0.4°C (0.8°F), the oven temperature is relatively uniform, and it is suitable for use in preheating APA samples. If the average of the readings at the two locations differs by more than 0.4°C (0.8°F), another oven that will maintain this level of uniformity and meet calibration must be utilized.

A1.2.4. *Temperature Accuracy*:

A1.2.4.1. Average the temperatures from the two locations (Section A1.2.2.3 and A1.2.3.2.). If that average temperature is within 0.4°C (0.8°F) of the set-point temperature on the oven, the oven is reasonably accurate, and calibration is complete.

A1.2.4.2. If the set point differs from the average temperature by more than 0.4°C (0.8°F), adjust the oven set point appropriately to raise or lower the temperature inside the oven chamber so that the thermometer and well will be at the desired temperature [e.g., 64°C (147°F)].

A1.2.4.3. Place the thermometer and well on the center of the shelf. At 30-min intervals, take readings of the thermometer. When two consecutive readings are within 0.4°C (0.8°F), and the average of the two consecutive readings is within 0.4°C (0.8°F) of the desired test temperature [e.g., 64°C (147°F)], the oven has been properly adjusted and calibration is complete. If these two conditions are not satisfied, repeat Sections A1.2.4.2 and A1.2.4.3.

A1.3. *APA Temperature Calibration*:

A1.3.1. The APA must be calibrated with a NIST-traceable thermometer [an ASTM No. 65C (65F) calibrated thermometer conforming to ASTM E1 is recommended] and a metal thermometer well to avoid rapid heat loss when checking the temperature.

A1.3.2. *Temperature Stability*:

A1.3.2.1. Turn on the APA main power, and set the chamber temperature controller so that the inside of the testing chamber is at the anticipated testing temperature [e.g., 64°C (147°F)]. Also, if applicable, set the water temperature controller to achieve the anticipated testing temperature.

Note A1—Because of possible variability in the APA temperature controller, the thermometer reading should always be considered as the chamber temperature.

A1.3.2.2. Place the thermometer in the well and place the thermometer and well on the left side of the APA where the samples are tested.

Note A2—It may be helpful to remove the hose rack from the APA during the temperature calibration to avoid breaking the thermometer.

A1.3.2.3. It usually takes about 5 h for the APA temperature to stabilize. After the temperature display on the controller has stabilized, open the chamber doors and read the thermometer without removing it from the well. Record this temperature. Close the chamber doors.

A1.3.2.4. Thirty minutes after obtaining the first reading, obtain another reading of the thermometer. Record this temperature.

A1.3.2.5. If the readings from Sections A1.3.2.3 and A1.3.2.4 are within 0.4°C (0.8°F), average the readings. If the readings differ by more than 0.4°C (0.8°F), continue to take readings every 30 min until the temperature stabilizes within 0.4°C (0.8°F) on two consecutive readings.

A1.3.3. *Temperature Uniformity*:

A1.3.3.1. To check the uniformity of the temperature in the APA chamber, move the thermometer and well to the right side of the APA where the samples are tested. Take and record readings of the thermometer at the second location every 30 min until two consecutive readings at the second location are within 0.4°C (0.8°F).

A1.3.3.2. Compare the average of the two consecutive readings obtained in Sections A1.3.2.5 and A1.3.3.1. If the average temperatures from the two locations are within 0.4°C (0.8°F), the APA temperature is relatively uniform, and it is suitable for use. If the average of the readings at the two locations differs by more than 0.4°C (0.8°F), consult the manufacturer on improving the temperature uniformity.

A1.3.4. *Temperature Accuracy*:

A1.3.4.1. Average the temperatures from the two locations (Sections A1.3.2.5 and A1.3.3.2.). If that average temperature is within 0.4°C (0.8°F) of the desired test temperature [e.g., 64°C (147°F)], the APA temperature is reasonably accurate and calibration is complete.

A1.3.4.2. If the average temperature differs from the desired test temperature [e.g., 64°C (147°F)] by more than 0.4°C (0.8°F), adjust the APA temperature controller so that the thermometer and well will be at the desired test temperature.

Note A3—It is advisable to keep the water bath set at the same temperature as the test chamber.

A1.3.4.3. Place the thermometer and well on the center of the shelf. At 30-min intervals, take readings of the thermometer. When two consecutive readings are within 0.4°C (0.8°F), and the average of the two consecutive readings is within 0.4°C (0.8°F) of the desired test temperature [e.g., 64°C (147°F)], the APA temperature has been properly adjusted and calibration at that temperature is complete. Record the current set points on the temperature controllers for later reference. If these two conditions are not satisfied, repeat Sections A1.3.4.2 and A1.3.4.3.

A1.4. APA wheel load calibration of the air cylinders at the two test positions for a two-wheel APA or the three test positions for a three-wheel APA.

A1.4.1. Check the APA wheel loads with the calibrated load cell provided with the APA. Check and adjust the loads one at a time while the other wheels are in the “down” position and bearing on a dummy sample or wooden block of approximately the same height as a test sample. Calibration of the wheel loads should be accomplished with the APA at room temperature.

A1.4.1.1. Remove the hose rack from the APA.

A1.4.1.2. “Jog” the wheel carriage until the wheels are over the center of the sample tray when the wheels are in the “down” position.

A1.4.1.3. Raise and lower the wheels 20 times to heat up the cylinders.

A1.4.1.4. Adjust the bar on top of the load cell until the total height of the load cell/load bar assembly is 105 ± 5 mm (4.1 ± 0.2 in.).

A1.4.1.5. Position the load cell under one of the wheels. Place wooden blocks or dummy samples under the other one wheel for a two-wheel APA or the other two wheels for a three-wheel APA.

A1.4.1.6. Zero the load cell.

A1.4.1.7. Lower all wheels by turning the cylinder switch to “CAL.”

A1.4.1.8. If the load cell is not centered left-to-right beneath the wheel, then raise the wheel and adjust the position of the load cell. To determine if the load cell is centered front-to-back beneath the wheel, unlock the sample tray and move it SLOWLY until the wheel rests in the indentation on the load-cell bar (where the screw is located).

A1.4.1.9. After the load cell has been properly centered, adjust the pressure in the cylinder to obtain 445 ± 5 N (100 ± 1 lbf). Allow 3 min for the load-cell reading to stabilize between adjustments. Record the pressure and load.

A1.4.1.10. With the wheel on the load cell remaining in the "down" position, raise and lower the other wheels one time. Allow 3 min for the load-cell reading to stabilize. Record the pressure and load.

A1.4.1.11. With the other wheels remaining in the "down" position, raise and lower the wheel over the load cell. Allow 3 min for the load-cell reading to stabilize. Record the pressure and load.

A1.4.1.12. Repeat Sections A1.4.1.5 through A1.4.1.11 for each wheel/cylinder.

A1.4.1.13. Return the load cell to the first wheel and repeat Sections A1.4.1.5 through A1.4.1.11.

A1.4.1.14. Place the load cell under the second wheel and repeat Sections A1.4.1.5 through A1.4.1.11. Skip to Section A1.5 if using a two-wheel APA.

A1.4.1.15. Place the load cell under the third wheel for the three-wheel APA and repeat Sections A1.4.1.5 through A1.4.1.11. The current cylinder pressures will be used to set the wheel loads to 445 N (100 lbf).

A1.5. *Replacement of the APA Hoses*:

A1.5.1. New hoses shall be placed in service in accordance with Section 3.1.7.

A1.5.1.1. Remove the hose rack from the APA.

A1.5.1.2. Remove the used hoses from the hose rack. For each position, place the new hose on the barbed nipples and secure it with the hose clamps.

A1.5.1.3. Position each new hose in the rack, ensuring that any curvature in the hose is aligned vertically (concave down toward the specimen) without any curvature in the horizontal direction. Tighten the nuts at the ends of the hoses only until the hoses are secure. Overtightening will affect the contact pressure and hose life.

A1.5.1.4. Place the hose rack back into the APA and ensure that the hoses are aligned beneath the wheels.

A1.5.1.5. Prior to formal testing, "break in" the new hoses by running 8000 cycles on a set of previously tested samples at a temperature of 55°C (131°F) or higher.

A1.6. *APA Hose Pressure Check*:

A1.6.1. The air pressure in the APA test hoses shall be checked with a NIST-traceable test gauge or transducer with a suitable range while the APA is operating. Because the hoses are connected in series, it is satisfactory to connect the test gauge to the end of the rightmost hose. The pressure should not fluctuate outside of the range of 690 ± 35 kPa (100 ± 5 psi) during normal operation. Adjust the pressure as necessary with the hose-pressure regulator.

Note A4—The Ashcroft test gauge, Model 450182As02L200#, has been found to be satisfactory for this purpose. This gauge is available through Grainger (Stock No. 2F008).

APPENDIX

(Nonmandatory Information)

X1. OPTIONAL APA TESTING PARAMETERS

X1.1. The numerous testing parameters involved when utilizing the APA (e.g., hose pressure/wheel load, specimen air void content, specimen height, etc.) present a great opportunity for multiple combinations. Accordingly, very few APA users employ the same set of testing parameters. One reason for this diversity is that the use of the APA predated the development of a standard for the APA. Most users developed their own method based on the manufacturer's instructions, accumulated substantial data with that method, and in some cases, implemented a specification based on those data. Understandably, many APA users are hesitant to modify their testing parameters at this point.

X1.2. This standard establishes a set of APA testing parameters for the sake of consistency and development of precision and bias statements. The parameters specified are based on the general experience of numerous APA users and are widely accepted within the industry. In fact, the specified test conditions represent the majority of APA users. However, the parameters established in this standard do not agree with the recommendations from NCHRP 9-17 (*NCHRP Report 508*) in every case. The NCHRP 9-17 study attempted to identify the APA test parameters that best correlate with field rutting performance.

X1.3. Because of the diversity involved with the APA testing parameters throughout the community of users, this appendix presents specifications for, and discussion concerning, other test-condition options often employed by APA users.

X1.4. *Beam Specimens*:

X1.4.1. Some APA users test asphalt mixture beam specimens, rather than cylindrical specimens, for rut depth. Beam specimens can only be prepared by using the vibratory compactor. NCHRP 9-17 (*NCHRP Report 508*) included beam specimens as part of the research effort. When utilizing beam specimens in the APA, the following additional specifications are recommended:

X1.4.1.1. The APA shall be capable of testing cylindrical or beam specimens.

X1.4.1.2. The test molds for beam specimens shall be rectangular in shape, be composed of UHMW polyethylene, fit snugly within the testing position in the APA testing chamber, and contain one hole in which to insert the specimen. The dimensions of the hole shall be 75.0 ± 2.0 mm (2.95 ± 0.08 in.) tall by 125.0 ± 2.0 mm (4.92 ± 0.08 in.) wide by 300.0 ± 2.0 mm (11.81 ± 0.08 in.) long.

X1.4.1.3. The compaction molds used for beam specimens shall be composed of steel and reinforced with 25.4 mm (1.00 in.) by 28.6 mm (1.13 in.) angle mounted 25.4 mm (1.00 in.) from the top of the mold. The molds shall conform to the following dimensions:

X1.4.1.3.1. Inside length of 299.9 ± 0.5 mm (11.81 ± 0.02 in.),

X1.4.1.3.2. Inside width of 124.5 ± 0.5 mm (4.90 ± 0.02 in.),

X1.4.1.3.3. Inside height of 133.5 ± 0.5 mm (5.26 ± 0.02 in.),

X1.4.1.3.4. Overall height of 152.5 ± 0.5 mm (6.00 ± 0.02 in.),

X1.4.1.3.5. Wall thickness of 6.25 ± 0.5 mm (0.25 ± 0.02 in.),

X1.4.1.3.6. Bottom plate length of 297.4 ± 0.5 mm (11.71 ± 0.02 in.), and

X1.4.1.3.7. Bottom plate width of 122.2 ± 0.5 mm (4.81 ± 0.02 in.).

X1.4.1.4. For either laboratory-prepared or plant-produced asphalt mixtures, compact two beam specimens for the two-wheel APA or three beam specimens for the three-wheel APA per test in accordance with the procedure given in Sections 4.3.3.1 through 4.3.3.4. Ensure that the beam specimens conform to the following dimensions: 75 ± 2 mm (3.0 ± 0.1 in.) tall by 125 mm (4.92 in.) wide by 300 mm (11.81 in.) long.

X1.4.1.5. When performing manual rut-depth measurement for beam specimens, take initial readings at each of the five locations on the rut-depth-measurement template conforming to Section 3.1.8. Otherwise, obtain manual rut-depth measurements in accordance with Section 8.4.

X1.4.1.6. When calculating the rut depth from manual rut-depth measurements for beam specimens, use the rut depth for all five locations to calculate the average rut depth for each of the two or three test positions. The APA rut depth for the asphalt mixture is the overall average rut depth for the two or three test positions, less any outliers as described in Section 9.2, from the three beam specimens.

X1.4.1.7. Report that beam specimens were the type of test specimens utilized to evaluate the asphalt mixture rut depth.

X1.5. *115-mm Cylindrical Specimens*:

X1.5.1. Some APA users test cylindrical specimens with a specimen height of 115 mm, rather than a specimen height of 75 mm, for rut depth. NCHRP 9-17 (*NCHRP Report 508*) did not include cylindrical specimens with a specimen height of 115 mm as part of the research effort. Additional research is needed to compare rut depths between the two sample heights (75 mm and 115 mm) for cylindrical specimens. When utilizing cylindrical specimens with a specimen height of 115 mm in the APA, the following additional specifications are recommended:

X1.5.1.1. The dimensions of each of the two holes in the test molds for cylindrical specimens shall be 150.0 ± 2.0 mm (5.91 ± 0.08 in.) in diameter by 115.0 ± 2.0 mm (4.53 ± 0.08 in.) tall.

X1.5.1.2. The number and dimensions of test specimens shall be as follows: four cylindrical specimens for the two-wheel APA or six cylindrical specimens for the three-wheel APA, 150 mm (5.91 in.) in diameter by 115 ± 2 mm (4.5 ± 0.1 in.) tall.

X1.5.1.3. Report that cylindrical specimens with a specimen height of 115 mm were the type of test specimens utilized to evaluate the asphalt mixture rut depth.

X1.6. *Lower Target Air Void Content*:

X1.6.1. Some APA users test cylindrical specimens compacted to 4.0 percent air voids or beam specimens compacted to 5.0 percent air voids rather than using a target air void content of 7.0 percent. When desiring a lower target air void content, beam specimens are normally compacted to 5.0 percent air voids rather than 4.0 percent because of a frequent inability to compact beam specimens to 4.0 percent.

X1.6.2. NCHRP 9-17 (*NCHRP Report 508*) evaluated these lower air void targets during the course of the research and found that the lower targets more closely related to field rutting performance than cylindrical and beam specimens compacted to 7.0 percent air voids. However, the vast majority of APA users utilize a target air void content of 7.0 percent.

X1.6.3. When utilizing cylindrical specimens compacted to 4.0 percent air voids or beam specimens compacted to 5.0 percent air voids, the following additional specifications are recommended:

X1.6.3.1. When producing either laboratory-prepared or plant-produced asphalt mixture specimens using an SGC, compact cylindrical specimens conforming to the dimensional requirements of Section 4.1 or Section X1.5.1.2 to 4.0 ± 0.5 percent air voids in accordance with T 312.

X1.6.3.2. When producing either laboratory-prepared or plant-produced asphalt mixture specimens using a vibratory compactor, compact cylindrical specimens conforming to the dimensional requirements of Section 4.1 or Section X1.5.1.2 to 4.0 ± 0.5 percent air voids. Alternatively, compact beam specimens conforming to the dimensional requirements of Section X1.4.1.4 to 5.0 ± 0.5 percent air voids. In both cases, compact the specimens in accordance with the procedure given in Sections 4.3.3.1 through 4.3.3.4.

X1.7. *Higher Wheel Load and Hose Pressure*:

X1.7.1. Some APA users test specimens using a wheel load of 534 N (120 lbf) and a hose pressure of 830 kPa (120 psi) rather than 445 N (100 lbf) and 690 kPa (100 psi), respectively. NCHRP 9-17 (*NCHRP Report 508*) evaluated the higher load and pressure during the course of the research. However, the vast majority of APA users utilize a wheel load of 445 N (100 lbf) and a hose pressure of 690 kPa (100 psi) when testing APA specimens. Additional research is needed to compare rut depths between the two loading conditions. When utilizing a wheel load of 534 N (120 lbf) and a hose pressure of 830 kPa (120 psi), the following additional specifications are recommended:

X1.7.1.1. Set the hose pressure gap reading to 830 ± 35 kPa (120 ± 5 psi). Set the load cylinder pressure reading for each wheel to achieve a load of 534 ± 22 N (120 ± 5 lbf).

X1.7.1.2. Report that a wheel load of 534 N (120 lbf) and a hose pressure of 830 kPa (120 psi) were utilized to evaluate the asphalt mixture rut depth.

X1.7.1.3. When calibrating the APA wheel load, after the load cell has been properly centered, adjust the pressure in the cylinder to obtain 534 ± 5 N (120 ± 1 lbf). Otherwise, calibrate the APA wheel load for each test position in accordance with Section A1.4. Use the current cylinder pressures to set the wheel loads to 534 N (120 lbf) as described in Section A1.4.1.15.

X1.7.1.4. When checking the APA hose pressure, ensure that the pressure does not fluctuate outside the range of 830 ± 35 kPa (120 ± 5 psi) during normal operation. If necessary, adjust the pressure with the hose-pressure regulator.

X1.8. *Reference*:

X1.8.1. NCHRP. *National Cooperative Highway Research Program Report 508: Accelerated Laboratory Rutting Tests: Evaluation of the Asphalt Pavement Analyzer*. National Cooperative Highway Research Program, Transportation Research Board, National Research Council, Washington, DC, 2003. Available from https://onlinepubs.trb.org/onlinepubs/nchrp/nchrp_rpt_508.pdf

[1] Formerly AASHTO Provisional Standard TP 63. First published as a full standard in 2010.