

**Standard Practice for
Accelerated Aging of Asphalt Binder
Using a Pressurized Aging Vessel (PAV)**

AASHTO Designation: PP1-98^{1,2}

1. Scope

1.1 This practice covers the accelerated aging (oxidation) of asphalt binders by means of pressurized air and elevated temperature. The test method is intended to simulate in-service oxidative aging of asphalt binders and is intended for use with residue from T240 (RTFOT).

1.2 The aging of asphalt binders during service is affected by mixture-associated variables such as the volumetric proportions of the mix, the permeability of the mix, properties of the aggregates, and possibly other factors. This test is intended to provide an evaluation of the relative resistance of different asphalt binders to oxidative aging at selected temperatures and cannot account for mixture variables.

1.3 This standard may involve hazardous materials, operations, and equipment. This standard does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this procedure to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.

2. Referenced Documents

2.1 AASHTO Standards:

- M231 Specification for Standard Masses and Balances Used in the Testing of Highway Materials
- MP1 Specification for Performance-Graded Asphalt Binder
- T240 Effect of Heat and Air on Rolling Film of Asphalt (Rolling Thin-Film Oven Test)

2.2 ASTM Standards:

E220 Method for Calibration of Thermocouples by Comparison Techniques

2.3 Deutsche Industrie Norm (DIN) Standards:

43760 Standardization for Calibration of Thermocouples

3. Terminology

3.1 Definitions

3.1.1 asphalt binder — an asphalt-based cement that is produced from petroleum residue either with or without the addition of non-particulate organic modifiers.

3.1.2 in-service — refers to aging of the asphalt binder that occurs in the pavement as a result of the combined effects of time, traffic and the environment.

4. Summary of Test Method

4.1 Asphalt binder is first aged using T240 (RTFOT). A specified thickness of residue, from the RTFOT, is then placed in standard TFOT (T179) stainless steel pans and aged at the specified aging temperature for 20 hours in a vessel pressurized with air to 2.10 MPa. Aging temperature is selected according to the grade of the asphalt binder. At completion of the PAV process the asphalt binder residue is then vacuum degassed.

5. Significance and Use

5.1 This method is designed to simulate the in-service oxidative aging that occurs in asphalt binders during pavement service. Residue from this test may be used to estimate the physical or chemical properties of

¹ This standard is based on SHRP Product 1003.

² Approved in November 1993, this provisional standard was first published in January 1994.

asphalt binders after five to ten years of in-service aging in the field.

5.2 Asphalt binders aged using PP1 are used to determine specification properties in accordance with MP1. The asphalt binder is aged with the RTFO test prior to this conditioning step. Tank asphalt binders, as well as RTFOT and residue from this test are used to determine specification properties in accordance with MP1.

5.3 For asphalt binders of different grades or from different sources, there is no unique correlation between the aging time and temperature in this test and in-service pavement age and temperature. Therefore, for a given set of in-service climatic conditions, it is not possible to select a single PAV aging time and temperature that will predict the properties of all asphalt binders after a specific set of in-service exposure conditions.

5.4 The relative degree of hardening of different asphalt binders varies at different aging temperatures in the PAV. Therefore, two asphalt binders may age similarly at one temperature, but age differently at another temperature.

6. Apparatus

6.1 A test system consisting of a pressure vessel, pressure controlling devices, temperature controlling devices, pressure and temperature measuring devices, and a temperature recording device (Figure 1).

6.1.1 Pressure Vessel - A stainless steel pressure vessel designed to operate at 2.1 ± 0.1 MPa between 90 and 110°C with interior dimensions adequate to hold 10 TFOT pans and pan holder. The pressure vessel shall contain a pan holder capable of holding ten TFOT stainless steel pans in a horizontal (level) position such that the asphalt binder film thickness in the bottom of the pans does not vary by more than 0.5 mm across any diameter of the pan. The holder shall be designed for easy insertion and removal from the vessel when the holder, pans, and asphalt binder are at the test temperature. A schematic showing the vessel, pan holder and pans and specifying dimensional requirements is shown in Figure 2.

Note 1 -- The vessel may be a separate unit to be placed in a forced draft oven for conditioning the asphalt binders or an integral part of the temperature control system (for example by direct heating of the vessel or by

surrounding the vessel with a permanently affixed heating unit, forced air oven, or liquid bath).

6.1.2 Pressure Controlling Devices

6.1.2.1 A pressure release valve that prevents pressure in the vessel from exceeding 2.2 MPa during the aging procedure.

6.1.2.2 A pressure regulator capable of controlling the pressure within the vessel to ± 1 percent, and with a capacity adequate to reduce the pressure from the source of compressed air so that the pressure within the loaded pressure vessel is maintained at 2.1 ± 0.1 MPa during the test.

6.1.2.3 A slow release bleed valve that allows the pressure in the vessel at the completion of the conditioning procedure to be reduced at an approximately linear rate from 2.1 MPa to local atmospheric pressure within 9 ± 1 minutes.

6.1.3 Temperature Controlling Devices - A temperature control device as described in Section 6.1.3.1 or 6.1.3.2 for maintaining the temperature during the aging procedure at all points within the pressure vessel at the aging temperature $\pm 0.5^\circ\text{C}$ and a digital proportional controller for maintaining the specified temperature control.

6.1.3.1 A forced-draft oven or fluid bath capable of (1) bringing the loaded unpressurized vessel to the desired conditioning temperature $\pm 0.5^\circ\text{C}$, as recorded by the Resistance Thermal Detector (RTD) inside the vessel, within 2 hrs., and (2) maintaining the temperature at all points within the pressure vessel at the aging temperature $\pm 0.5^\circ\text{C}$. The oven shall have sufficiently large interior dimensions to allow forced air to freely circulate within the oven and around the pressure vessel when the vessel is placed in the oven. The oven shall contain a stand or shelf which supports the loaded pressure vessel in a level position above the lower surface of the oven (i.e. maintains the film thickness in the aging pans within the specified tolerance).

6.1.3.2 A pressure vessel with integral temperature control system that is capable of (1) bringing the loaded pressure vessel to the desired conditioning temperature $\pm 0.5^\circ\text{C}$ within 2 hrs., as recorded by the RTD inside the loaded pressure vessel, and (2) maintaining the temperature at all points within the pressure vessel at the aging temperature $\pm 0.5^\circ\text{C}$.

6.1.4 Temperature and Pressure Measuring Devices:

6.1.4.1 A platinum RTD accurate to the nearest 0.1°C and meeting DIN Standard 43760 (Class A), or equal, for measuring temperature inside the pressure vessel. The RTD shall be calibrated as an integral unit with its respective meter or electronic circuitry.

Note 2 -- The RTD or thermistor and its meter may be calibrated by the manufacturer or a commercial vendor. Verification can be obtained by comparing the output from the RTD with a NIST traceable ASTM 94C mercury in glass thermometer in accordance with ASTM E220. A stirred fluid bath is suitable for calibrating the thermal detector. Select a partial immersion mercury-in-glass thermometer with an appropriate range and place the thermal detector and the thermometer in the stirred water bath. Fasten the detector to the glass thermometer with a rubber band or rubber O-ring. Allow the bath, detector, and thermometer to come to thermal equilibrium and record the temperature of the glass thermometer and the readout from the thermal detector. The temperature in the bath shall not change by more than 0.1°C per minute during the calibration process.

6.1.4.2 Temperature Recording Device - A strip chart recorder or other data acquisition system capable of recording temperature throughout the test to 0.1°C . As an alternative, an electronic device capable of reporting maximum and minimum temperatures (accurate to $\pm 0.1^{\circ}\text{C}$) may be used.

6.1.4.3 A pressure gauge capable of measuring the pressure in the pressure vessel to within ± 1 percent during the test.

6.2 Stainless Steel Pans - Ten standard stainless steel TFOT pans meeting the requirements of T179.

6.3 Balance - A balance conforming to the requirements of M231, Class G2.

6.4 Vacuum Oven - A vacuum oven capable of maintaining a temperature up to 180°C with an accuracy of $\pm 5.0^{\circ}\text{C}$ and a vacuum of 1.0 kPa absolute.

6.5 Vacuum system - A vacuum system capable of generating and maintaining pressures below 15 kPa

absolute. Suitable vacuum systems include a vacuum pump, air aspirator, or house vacuum system.

7. Materials - Commercial bottled air or equivalent.

8. Hazards - Use standard laboratory safety procedures in handling the hot asphalt binder when preparing test specimens and removing the residue from the pressure vessel. Use special precaution when lifting the pressure vessel.

9. Calibration and Standardization

9.1 Temperature Detector - Verify the calibration of the RTD to 0.1°C at least every 6 months using a calibrated thermometer.

9.2 Pressure gauge - Calibrate the pressure gauge to an accuracy of 1 percent at least every 6 months.

Note 3 -- The pressure gauge is usually calibrated by the manufacturer or a commercial calibration service. Verification of the continued stability of the pressure gauge within the specified requirements should be done periodically by checking against another certified pressure measurement device.

9.3 To determine the optimum temperature at which to apply pressure to the pressure vessel several tests should be made. With the vessel loaded with pan rack and empty pans increase the temperature to aging temperature. When the temperature inside the pressure vessel is within 10°C of the aging temperature apply an air pressure of 2.1 ± 0.1 MPa. Record the temperature increase when the pressure is applied. Perform the procedure at least three times and use the average temperature increase to establish the temperature at which to apply pressure to the vessel for performing the aging procedure.

10. Procedure

10.1 Condition the asphalt binder and determine the mass change during conditioning in accordance with T240 (RTFOT).

10.2 Combine the hot residue from the RTFOT into a single container, stir to blend, then transfer into (or leave in) TFOT pans for PAV conditioning or allow