



Designation: D5329 – 20

Standard Test Methods for Sealants and Fillers, Hot-Applied, for Joints and Cracks in Asphalt Pavements and Portland Cement Concrete Pavements¹

This standard is issued under the fixed designation D5329; 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 These test methods cover tests for hot-applied types of joint and crack sealants and fillers for portland cement concrete and asphaltic concrete pavements. There are numerous standard material specifications that use these test methods. Refer to the respective standard material specification of interest to determine which of the following test methods to use. For sample melting and concrete block preparation, see their respective standard practices.

1.2 The test methods appear in the following sections:

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1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.4 *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.*

1.5 *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.*

¹ These test methods are under the jurisdiction of ASTM Committee D04 on Road and Paving Materials and are the direct responsibility of Subcommittee D04.33 on Formed In-Place Sealants for Joints and Cracks in Pavements.

Current edition approved May 1, 2020. Published May 2020. Originally approved in 1992. Last previous edition approved in 2016 as D5329 – 16. DOI: 10.1520/D5329-20.

2. Referenced Documents

2.1 *ASTM Standards:*²

- D5/D5M Test Method for Penetration of Bituminous Materials
- D217 Test Methods for Cone Penetration of Lubricating Grease
- D618 Practice for Conditioning Plastics for Testing
- D1074 Test Method for Compressive Strength of Asphalt Mixtures
- D1561/D1561M Practice for Preparation of Bituminous Mixture Test Specimens by Means of California Kneading Compactor
- D1985 Practice for Preparing Concrete Blocks for Testing Sealants, for Joints and Cracks
- D3381/D3381M Specification for Viscosity-Graded Asphalt Binder for Use in Pavement Construction
- D5167 Practice for Melting of Hot-Applied Joint and Crack Sealant and Filler for Evaluation
- D6690 Specification for Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavements
- E145 Specification for Gravity-Convection and Forced-Ventilation Ovens
- E177 Practice for Use of the Terms Precision and Bias in ASTM Test Methods
- E691 Practice for Conducting an Interlaboratory Study to Determine the Precision of a Test Method
- G151 Practice for Exposing Nonmetallic Materials in Accelerated Test Devices that Use Laboratory Light Sources
- G154 Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Nonmetallic Materials
- G155 Practice for Operating Xenon Arc Light Apparatus for Exposure of Non-Metallic Materials

3. Significance and Use

3.1 These test methods describe procedures for determining specification conformance for hot-applied, field-molded joint and crack sealants and fillers.

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.

4. Sample Melting

4.1 See Practice **D5167**.

5. Standard Conditions

5.1 The laboratory atmospheric conditions, hereinafter referred to as standard conditions, shall be in accordance with Practice **D618** (23 ± 2 °C, 50 ± 10 % relative humidity).

6. Cone Penetration, Non-Immersed

6.1 *Scope*—This test method covers determination of cone penetration of bituminous joint and crack sealers and fillers.

6.2 *Significance and Use*—The cone penetration, non-immersed is a measure of consistency. Higher values indicate a softer consistency.

6.3 *Apparatus*—Conduct this test using the apparatus described in Test Method **D5/D5M**, except as specified herein. Use a penetration cone in place of the standard penetration needle. The cone shall conform to the requirements given in Test Methods **D217**, except that the interior construction may be modified as desired. The total moving weight of the cone and attachments shall be 150.0 ± 0.1 g.

6.4 *Specimen Preparation*—Pour a portion of the sample prepared in accordance with Practice **D5167** into a cylindrical, metal, flat-bottom container of essentially 60 to 75 mm in diameter and 45 to 55 mm in depth and fill flush with the rim of the container. Allow the specimen to cure under standard conditions as specified in its respective material specification.

6.5 *Procedure*—Place the specimen in a water bath maintained at 25 ± 0.1 °C for 2 h immediately before testing. Remove the specimen from the bath and dry the surface. Using the apparatus described in **6.3**, make determinations at three locations on approximately 120° radii, and halfway between the center and outside of the specimen. Take care to ensure the cone point is placed on a point in the specimen that is representative of the material itself and is free of dust, water, bubbles, or other foreign material. Clean and dry the cone point after each determination.

6.6 *Report*—Average the three results and record the value as the penetration of the specimen in $1/10$ mm units.

6.7 Precision and Bias:

6.7.1 For Specification **D6690** Type I materials, the following precision statement is based on an interlaboratory study of twelve laboratories that tested five different Specification **D6690** Type I materials.

6.7.1.1 *Within Container*—Single-operator precision (for penetration between 40 and 80): The single-operator deviation has been found to be 0.994. Therefore, results of two properly conducted tests by the same operator should not differ by more than three penetration units.

6.7.1.2 *Within Laboratories*—Single-operator precision (penetrations 40 to 80): The single-operator standard deviation of a single test (test result is defined as the average of three penetrations) has been found to be 0.924. Therefore, the results of two properly conducted tests by the same operator on the same material should not differ by more than three penetration units.

6.7.1.3 *Multilaboratory Precision*—(penetration 40 to 80): The multilaboratory standard deviation of a single test (test result is defined as the average of three penetrations) has been found to be 3.249. Therefore, the results of two properly conducted tests in different laboratories should not differ by more than nine penetration units.

6.7.2 For Specification **D6690** Type II materials, the following precision statement is based on an interlaboratory study of eleven laboratories that tested six different Specification **D6690** Type II materials.

6.7.2.1 *Within Container*—Single-operator precision (for penetration between 55 and 85): The single-operator deviation has been found to be 0.974. Therefore, results of two properly conducted tests by the same operator should not differ by more than three penetration units.

6.7.2.2 *Within Laboratories*—Single-operator precision (penetrations 50 to 70): The single-operator standard deviation of a single test (test result is defined as the average of three penetrations) has been found to be 1.0865. Therefore, the results of two properly conducted tests by the same operator on the same material should not differ by more than three penetration units.

6.7.2.3 *Single-Operator Precision*—(penetrations 71 to 85): The single-operator standard deviation of a single test (test result is defined as the average of three penetrations) has been found to be 2.237. Therefore, the results of two properly conducted tests by the same operator on the same material should not differ by more than six penetration units.

6.7.2.4 *Multilaboratory Precision*—(penetration 50 to 70): The multilaboratory standard deviation of a single test (test result is defined as the average of three penetrations) has been found to be 5.2609. Therefore, the results of two properly conducted tests in different laboratories should not differ by more than 15 penetration units.

6.7.2.5 *Multilaboratory Precision*—(penetration 71 to 85): The multilaboratory standard deviation of a single test (test result is defined as the average of three penetrations) has been found to be 16.8831. Therefore, the results of two properly conducted tests in different laboratories should not differ by more than 48 penetration units.

7. Flow

7.1 *Scope*—This test method measures the amount of flow of bituminous joint and crack sealants when held at a 75° angle at elevated temperatures.

7.2 *Significance and Use*—This test method is a means of measuring the ability of a sealant to resist flow from the joint or crack at high ambient temperatures.

7.3 Apparatus:

7.3.1 *Mold*—Construct a mold (see **Note 1**) 40 mm wide by 60 mm long by 3.2 mm deep and place it on a bright tin panel. The tin plate must be free of dirt, oil, and so forth and be between 0.25 to 0.64 mm in thickness.

NOTE 1—A release agent should be used to coat molds and spacers to prevent them from bonding to the sealants. Extreme care should be exercised to avoid contaminating the area where the joint sealant makes contact with the blocks. A non-toxic release agent is recommended for this purpose. Two examples that have been found suitable for this purpose are

KY jelly (available at drug stores) and a release agent prepared by grinding a mixture of approximately 50 % talc, 35 % glycerine, and 15 % by weight of a water-soluble medical lubricant into a smooth paste.

7.3.2 *Oven*—Forced-draft type conforming to Specification **E145** and capable of controlling its temperature ± 1 °C.

7.4 *Specimen Preparation*—Pour a portion of the sample prepared in accordance with Practice **D5167** for melting samples into the mold described in 7.3. Fill the mold with an excess of material. Allow the test specimen to cool at standard conditions for at least ½ h, then trim the specimen flush with the face of the mold with a heated metal knife or spatula and remove the mold. Allow the specimen to cure under standard conditions as specified in its respective material specification.

7.5 *Procedure*—Mark reference lines on the panel at the bottom edge of the sealant. Then place the panel containing the sample in a forced-draft oven maintained for the time and at the temperature specified in its respective material specification. During the test, mount the panel so that the longitudinal axis of the specimen is at an angle of $75 \pm 1^\circ$ with the horizontal, and the transverse axis is horizontal. After the specified test period, remove the panel from the oven and measure the movement of the specimen below the reference lines in millimetres.

7.6 *Report*—Report the measurement obtained in 7.5 in millimetres.

7.7 *Precision and Bias:*

7.7.1 For Specification **D6690** Type I materials, the following precision statement is based on an interlaboratory study of twelve laboratories that tested five different Specification **D6690** Type I materials.

7.7.1.1 *Single-Operator Precision (flow 0 to 5)*—The single-operator standard deviation has been found to be 0.255. Therefore, the results of two properly conducted tests by the same operator should not differ by more than one flow unit.

7.7.1.2 *Single-Operator Precision (flow 5 to 10)*—The single-operator standard deviation has been found to be 1.024. Therefore, the results of two properly conducted tests by the same operator should not differ by more than three flow units.

7.7.1.3 *Multilaboratory Precision (flow 0 to 5)*—The multi-laboratory standard deviation has been found to be 4.256. Therefore, the results of two properly conducted tests in different laboratories should not differ by more than twelve flow units.

7.7.1.4 *Multilaboratory Precision (flow 5 to 10)*—The multi-laboratory standard deviation has been found to be 5.326. Therefore, the results of two properly conducted tests in different laboratories should not differ by more than 15 flow units.

7.7.2 For Specification **D6690** Type II materials, the following precision statement is based on an interlaboratory study of eleven laboratories that tested six different Specification **D6690** Type II materials.

7.7.2.1 *Single-Operator Precision (flow 0 to 1)*—The single-operator standard deviation has been found to be 0.2494. Therefore, the results of two properly conducted tests by the same operator should not differ by more than one flow unit.

7.7.2.2 *Single-Operator Precision (flow 1.1 to 4)*—The single-operator standard deviation has been found to be 0.7616.

Therefore, the results of two properly conducted tests by the same operator should not differ by more than three flow units.

7.7.2.3 *Multilaboratory Precision (flow 0 to 1)*—The multi-laboratory standard deviation has been found to be 0.5644. Therefore, the results of two properly conducted tests in different laboratories should not differ by more than three flow units.

7.7.2.4 *Multilaboratory Precision (flow 1.1 to 4)*—The multi-laboratory standard deviation has been found to be 2.3508. Therefore, the results of two properly conducted tests in different laboratories should not differ by more than seven flow units.

8. Bond, Non-Immersed

8.1 *Scope*—This test method is used to evaluate the bond to concrete.

8.2 *Significance and Use*—Bond to concrete is necessary for a sealant to maintain proper field performance.

8.3 *Apparatus:*

8.3.1 *Extension Machine*—The extension machine used in the bond test shall be so designed that the specimen can be extended a minimum of 12.5 mm at a uniform rate of 3.1 ± 0.3 mm per hour. It shall consist essentially of one or more screws rotated by an electric motor through suitable gear reductions. Self-aligning plates or grips, one fixed and the other carried by the rotating screw or screws, shall be provided for holding the test specimen in position during the test.³

8.3.2 *Cold Chamber*—The cold chamber shall be capable of maintaining the required cold test temperature within ± 1 °C.

8.4 *Concrete Block Preparation*—The concrete blocks shall be prepared in accordance with Practice **D1985**.

8.5 *Specimen Preparation:*

8.5.1 Prepare three test specimens (three specimens $\times 2 =$ six blocks) as follows: On removal from the storage container, again scrub the 50 by 75 mm saw-cut faces of the blocks under running water. When all blocks are scrubbed, lightly blot them with an oil-free, soft, absorbent cloth or paper towel to remove all free surface water and condition them by air drying on the 25 by 50 mm ends according to the respective material specification.

8.5.2 Take these blocks and mold the test specimen between them as follows (see Fig. 1): Place four treated (see Note 1) brass or TFE-fluorocarbon spacer strips, approximately 6 mm thick, on a treated metal plate base to enclose an open space according to the width specified in the respective material specification by 50 mm long. Place the blocks on the spacer strips and space them the required width ± 0.1 mm apart by means of other treated brass or TFE-fluorocarbon spacer strips, of the required width placed at such distances from the ends that an opening is of the required width by 50.0 ± 0.2 by 50.0 ± 0.2 mm is formed between the blocks with a 6.4-mm opening below the blocks.

³ The sole source of supply of the apparatus known to the committee at this time is Applied Test Systems of Butler, PA. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,¹ which you may attend.

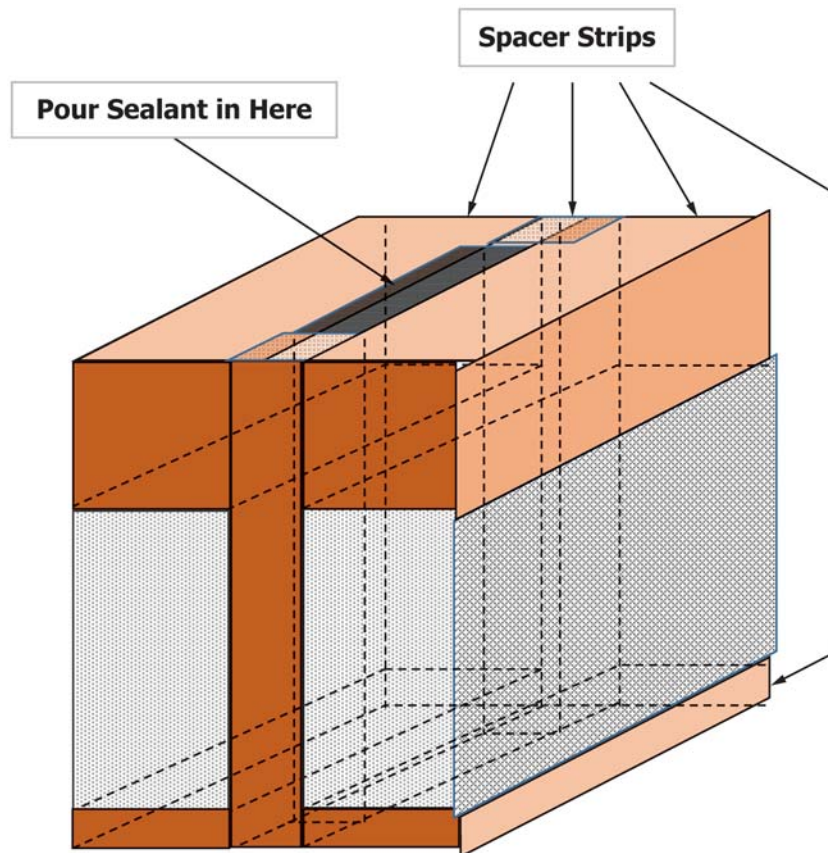


FIG. 1 Concrete Block Mold

8.5.3 Rubber bands, clamps, or similar suitable means may be used to hold the blocks in position. Place treated brass or TFE-fluorocarbon spacer strip side walls 25 mm high on top of the blocks. Pour material prepared in accordance with Practice D5167 into the space between the blocks in sufficient quantity to bring flush with the top of the side walls. After the specimen has cooled for at least 2 h, remove the excess material protruding beyond the top and bottom of the blocks by cutting it off with a heated metal knife or spatula. Use extreme care when removing the spacers so as not to damage the sealant. If this spacer removal causes defects, if shrinkage of the material upon cooling reduces its level below the top of the concrete blocks, or if other casting defects are apparent, the specimen shall be discarded. The finished specimen should resemble Fig. 2.

8.6 *Extension at Low Temperature*—Place test specimens, prepared as described in 8.5, in a cold cabinet at temperature of the respective material specification as described in 8.3.2 for not less than 4 h; then remove the treated spacer blocks and mount the specimens immediately in the self-aligning clamps of the extension machine. Extend the specimens as required by the respective material specification at a uniform rate of 3.0 ± 0.3 mm per hour. During this period, maintain the atmosphere surrounding the test specimens at the temperature specified in the respective material specification. The specimen shall be removed from the test device within 30 min after completing the extension.

8.7 *Recompression*—After extension as described in 8.6, remove the specimens from the extension machine and immediately examine the specimens for obvious separations within the sealant and between the sealant and the blocks, without distorting or manually causing extension of the specimens. After inspection replace the spacer strips, return to storage at room temperature for 2 h, and rest each specimen on one concrete block so that the weight of the top block recompresses the joint sealant.

8.8 *Re-Extension at Low Temperature and Recompression*—After recompression repeat the procedure described in 8.6 and 8.7 to complete the number of cycles of extension and recompression as specified in the respective material specification.

8.9 *Evaluation of Bond Test Results*—Within 30 min after the last required extension, remove the bond test specimens from the extension machine. Immediately examine the specimens, while still frozen, for obvious separations within the sealant and between the sealant and the blocks, without distorting or manually causing extension of the specimens. Determine conformance to the respective material specification.

8.10 *Precision and Bias*—No information is presented about precision or bias of this test method for bond evaluation since the results are nonquantitative.

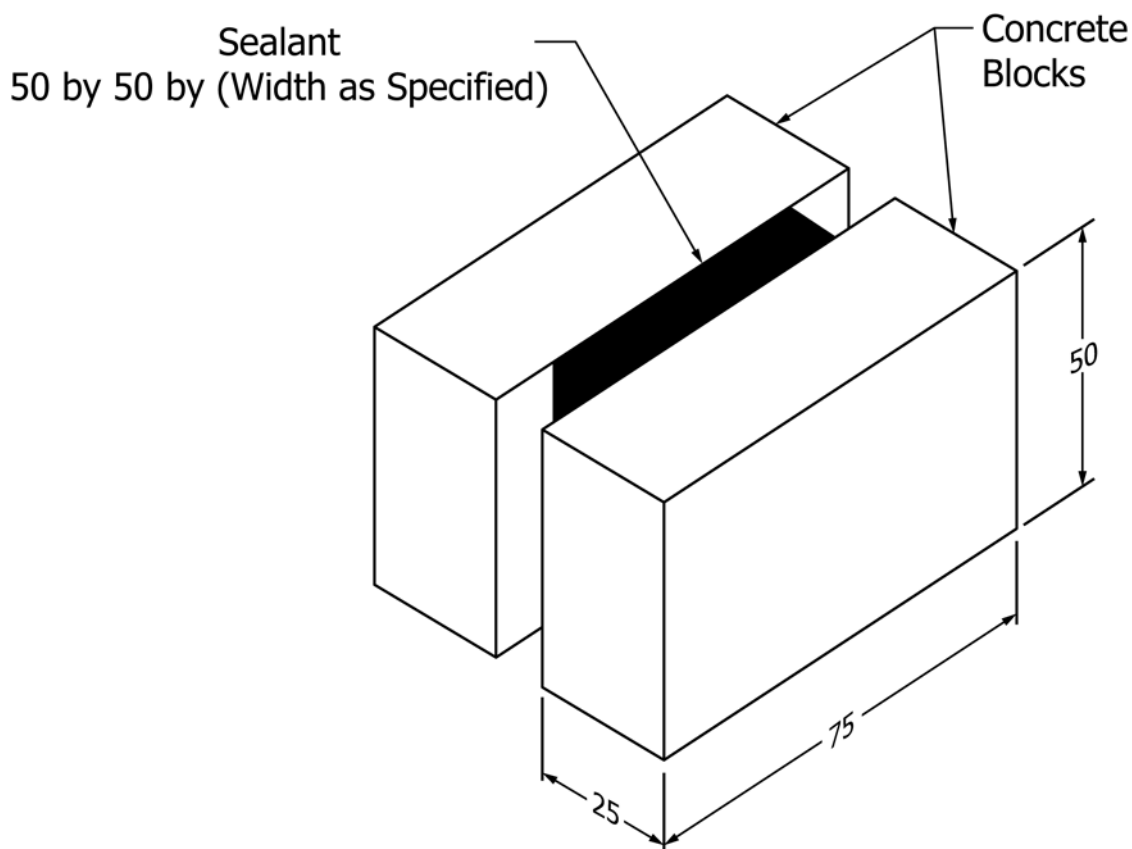


FIG. 2 Concrete Block Test Specimen

9. Bond, Water-Immersed

9.1 *Scope*—This test method evaluates bond to concrete after immersion in water.

9.2 *Significance and Use*—Bond to concrete is necessary for a sealant to maintain for proper field performance. Water immersion can have deleterious effects on the bond to concrete.

9.3 Apparatus:

9.3.1 *Extension Machine*, as described in 8.3.1.

9.3.2 *Cold Chamber*, as described in 8.3.2.

9.4 Concrete Block Preparation:

9.4.1 The concrete blocks shall be prepared in accordance with Practice D1985.

9.5 *Specimen Preparation*—Prepare three specimens as described in 8.5, replacing the thicker brass or TFE-fluorocarbon spacers with thinner spacers between the concrete blocks so that an opening of not less than 6.0 by 12.5 by 50.0 mm will be produced and maintained between the spacers and the sealant. Then immerse the specimens in suitable covered containers to provide at least a 12.5-mm water cover for 96 h in 500 mL of distilled or deionized water per specimen and store under standard conditions. Place the specimens in the containers with the concrete blocks in the horizontal position, resting on the block faces measuring 50 by 75 mm. Three specimens may be placed in one container provided the water to specimen ratio is maintained. At the end of a 96 h water-immersion period, remove the specimens from the water, remove the spacers, and

remove the excess surface water from the specimens with a soft, dry, absorbent material. After the surface water has been removed, proceed as described in 8.6.

9.6 *Extension at Low Temperature*—Same as described in 8.6.

9.7 *Recompression*—Same as described in 8.7.

9.8 *Re-Extension at Low Temperature and Recompression*—Same as described in 8.8.

9.9 *Evaluation of Bond Test Results*—Same as described in 8.9.

9.10 *Precision and Bias*—No information is presented about precision or bias of this test method for bond evaluation since the results are nonquantitative.

10. Resilience

10.1 *Scope*—This test method measures the ability of a sealant to recover after a steel ball has been forced into the surface.

10.2 *Significance and Use*—The ability of a sealant to reject incompressible objects from its surface is important to the functioning of a sealant.

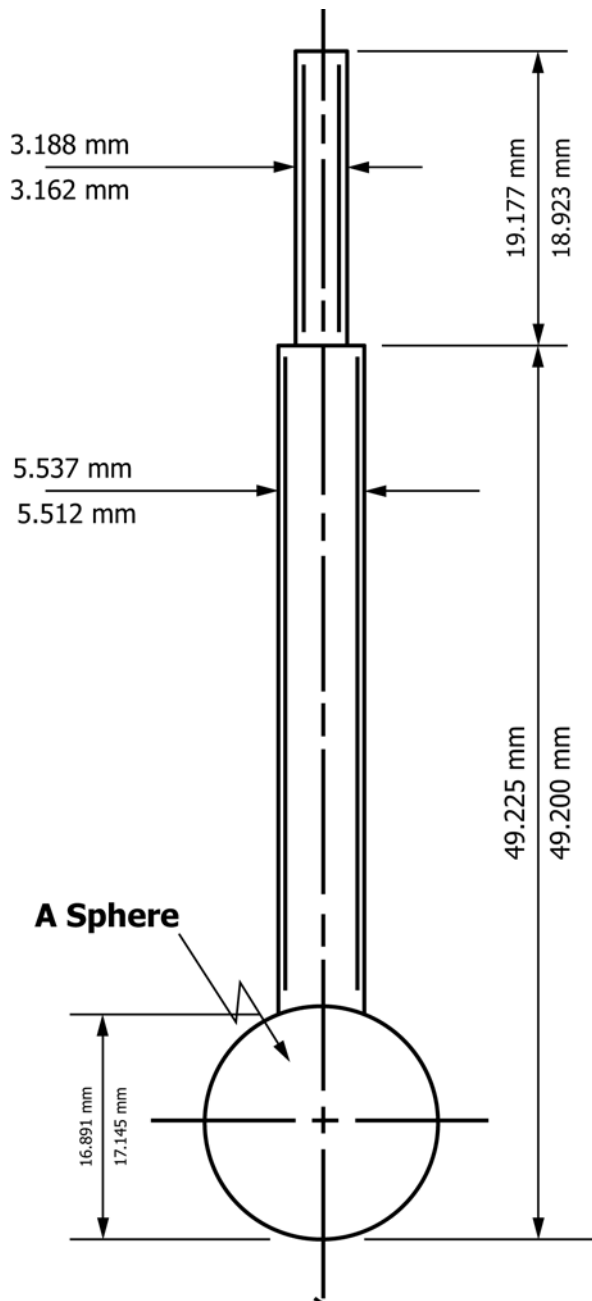
10.3 *Apparatus*—Conduct this test using the standard penetrometer described in Test Method D5/D5M, except replace the needle on this standard penetrometer with a ball penetration

tool shown in Fig. 3 (total weight of the ball penetration tool and penetrometer spindle shall be 75 ± 0.01 g).

10.4 *Specimen Preparation*—Prepare one specimen as specified in Practice D5167 using a cylindrical, flat-bottom, metal container of essentially 60 to 75 mm in diameter and 45 to 55 mm in depth. Cure the specimen at the temperature and for the time specified in the respective material specification under standard laboratory conditions prior to testing.

10.5 *Procedure*—Place the specimen in a water bath maintained at 25 ± 0.1 °C for 2 h immediately before testing. Remove the specimen from the water bath, dry the surface, and prepare the specimen for testing by coating the surface of the

material lightly with talc and blowing off the excess. Do not test under water. Proceed as follows: Set the indicating dial to zero and place the ball penetration tool in contact with the surface of the specimen by using a light source so that initial contact of the ball and surface of the specimen can be readily seen. Release the ball penetration tool, allow it to penetrate the specimen for 5 s, and record the reading as ball penetration, *P*. Without returning the dial pointer to zero, press the ball penetration tool down an additional 100 units (that is, to a reading of *P* + 100) at a uniform rate in 10 s. Re-engage the clutch to hold the tool down for an additional 5 s, and during this time return the dial to zero. Release the clutch, allow the



1. **Material: Steel**
2. **Weight of ball & shaft (shown): 27.5 ± 0.1 g**
3. **Total weight of ball, shaft & penetrometer shaft (not shown): 75 ± 0.1 g**
4. **Ball may be screw attached, brazed on or made with shaft.**
5. **Ball finish must be 63 RMS & diameter profile within 0.051 mm**

FIG. 3 Ball Penetration Tool

specimen to recover for 20 s, and record the final dial reading, F . (If the ball does not release freely from the specimen, disregard the resilience determination and re-talc surface of the specimen and test.) Make determinations at three points equally spaced from each other and not less than 13 mm from the container rim. Compute the recovery (a measure of resilience) as follows:

$$\text{Recovery, \%} = P + 100 - F \quad (1)$$

10.6 *Report*—Record the average of three determinations obtained in 10.5 as the resilience.

10.7 Precision and Bias:

10.7.1 *Within Container*—The single-operator deviation has been found to be 1.254. Therefore, the maximum difference between three values on the same sample should not differ by more than four units.

10.7.2 *Within Laboratories*—Single-operator precision (resiliences 55 to 65). The single-operator standard deviation of a single test (test result is defined as the average of three resiliences) has been found to be 1.0894. Therefore, the results of two properly conducted tests by the same operator on the same material should not differ by more than three resilience units.

10.7.3 *Multilaboratory Precision*—(resilience 55 to 65). The multilaboratory standard deviation of a single test (test result is defined as the average of three resiliences) has been found to be 11.8132. Therefore, the results of two properly conducted tests in different laboratories should not differ by more than 33 resilience units.

11. Resilience, Oven-Aged

11.1 *Scope*—This test method measures the material's ability to rebound a steel ball after being aged in an oven for seven days.

11.2 *Significance and Use*—The sealant is required to have an ability to reject incompressible objects after aging in order to maintain performance.

11.3 *Apparatus*, as described in 10.3.

11.4 *Specimen Preparation*—Same as described in 10.4.

11.5 *Procedure*—Oven-age the specimen in a forced-draft oven at the temperature and for the time specified in the respective material specification, then cool under standard conditions for 1 h and proceed as described in 10.5.

11.6 *Report*—Same as described in 10.6

11.7 *Precision and Bias*—The precision and bias of this test method for measuring oven-aged resilience are as specified in Section 10.

12. Asphalt Compatibility

12.1 *Scope*—This test method covers sealant compatibility with an asphalt pavement.

12.2 *Significance and Use*—Asphalt incompatibilities can lead to oily exudates, which will lead to early failures on the road of the sealants covered in these test methods.

12.3 *Specimen Preparation* (see Note 2):

12.3.1 *Preparation of Asphalt Specimens*—Prepare two test specimens not less than 100 mm in diameter and 63 mm in height of hot-mix asphaltic concrete using an AC-20 viscosity graded asphalt cement as described in Specification D3381/D3381M.

NOTE 2—Specimens prepared in accordance with the section on test specimens of Test Method D1074 or Practice D1561/D1561M are suitable for this purpose. Specimens that are other than circular, but with similar dimensions and properties, are also acceptable. Density and asphalt content of the specimens will be those values which would be specified in an asphaltic concrete pavement mix design using the design method specified by the purchasing agency.

12.3.2 *Grooving Asphalt Blocks*—Allow the test specimen to cool to room temperature, after which cut a groove 100 mm long by 13 ± 3.2 mm wide by 19 ± 3.2 mm deep in the top surface of each specimen by wet sawing with a power-driven masonry saw. Scrub the grooves thus formed with a stiff-bristle brush while holding specimens under running water to remove all residue from sawing. Allow the specimens to dry and return to room temperature, after which securely wrap them with cloth-backed adhesive tape, or otherwise reinforce to prevent slumping or collapse during the ensuing test period. Caulk the ends of the grooves to prevent leaking. Pour joint sealant prepared as described in Practice D5167 into the grooves, overfilling the grooves slightly. However, allow no joint sealant to overflow onto the surface of the asphaltic concrete adjacent to the grooves. After the sealing compound has cooled to room temperature, remove any overflow of sealing compound with a hot knife blade, so that the surface of the sealing compound is even with the surface of the specimens.

12.4 *Procedure*—Place the duplicate specimens in a forced-draft oven maintained at a temperature of 60 ± 3 °C for 72 h.

12.5 *Interpretation of Results*—Immediately after removing from the oven and again after cooling to room temperature, examine the specimens for incompatibility (as required in the respective material specification) of the joint sealant with the asphaltic concrete. Report as required in the respective material specification.

12.6 *Precision and Bias*—No information is presented about precision or bias of this test method for asphalt compatibility evaluation since the results are nonquantitative.

13. Artificial Weathering

13.1 *Scope*—This test method describes a procedure for artificial weathering of sealants.

13.2 *Significance and Use*—A sealant must be able to withstand weathering to perform in its intended use. This test method is a laboratory evaluation of the resistance to weathering.

13.3 *Specimen Preparation*—Prepare three specimens as follows: A treated (see Note 1) brass or TFE-fluorocarbon plastic mold 38 mm wide by 100 mm long by 6.4 mm deep shall be placed on an aluminum panel 76 mm wide by 152 mm long. Fill the mold with an excess of sealant, and allow the specimen to cure for a minimum of 1 h prior to trimming the specimen flush with the mold using a heated knife or spatula.

NOTE 3—Aluminum alloys 6061T6 and 5052H38 are more resistant to

corrosion than other aluminum alloys and are preferable for the aluminum panel on which the sealant specimens are prepared.

13.4 *Artificial Weathering*—Two types of artificial weathering procedures are described, xenon-arc exposure and fluorescent UVA-340 exposure. Because of differences in the emission properties of the light sources and the test conditions in the two types, test results may differ. The two types of artificial weathering cannot be used interchangeably without supporting data that demonstrates equivalency of the test results for the materials tested. The choice of weathering test shall be by mutual agreement of the interested parties.

13.4.1 *Xenon-Arc Exposure*—Use a xenon-arc exposure device operating with daylight type filters that meets the requirements of Practices **G151** and **G155**. For each material, the three test specimens prepared on aluminum panels are randomly placed in the xenon-arc device as recommended in Practice **G151** or are repositioned during exposure as recommended in Practice **G151** to obtain maximum uniformity of radiant exposure among the specimens. In rotating rack devices, fill the empty spaces with blank panels. Use the test parameters in **Table 1**.

13.4.1.1 *Exposure Times for Equivalent Radiant Exposures at Different Irradiance Levels*—The relation between radiant exposure in joules (J) and time in hours of exposure to the radiation source is based on the irradiance level and the equivalency of 1 watt equals 3.6 kJ/hour. The equation relating radiant exposure in kilojoules (kJ) to time in hours is:

$$\text{watts} \times 3.6 \text{ kJ/hr} \times \text{hours of exposure} = \text{kilojoules}$$

For example, at an irradiance level of 0.51 W/(m²·nm) at 340 nm, in 500 h the radiant exposure is 918 kJ/(m²·nm) at 340 nm. At an irradiance level of 0.35 W/(m²·nm) at 340 nm, 918 kJ/(m²·nm) at 340 nm requires 729 h of exposure.

13.4.2 *Fluorescent UV exposure*—As an alternate to exposure in a xenon-arc weathering device, the specimens can be exposed in a fluorescent ultraviolet/condensation device operating with UVA-340 fluorescent lamps that meets the requirements of Practices **G151** and **G154**. For each material, the three

test specimens prepared on aluminum panels are randomly placed in the device as recommended in Practice **G151** or are repositioned during exposure as recommended in Practice **G151** to obtain maximum uniformity of radiant exposure among the specimens. Prior to beginning the exposure, make sure to seal any holes larger than 2 mm in specimens and any opening larger than 1 mm around irregularly shaped specimens to prevent loss of water vapor. Attach porous specimens to a solid backing, such as aluminum, that can act as a vapor barrier. Fill all of the empty spaces using blank panels of corrosion-resistant material. See **Table 2**.

13.5 *Evaluation of Exposure*—The duration of the exposure is given in the material specification. As soon as possible after the exposure is completed, examine the specimens thoroughly while they are approximately at test chamber temperature. Note any changes observed. Requirements for pass/fail criteria are given in the relevant material specification.

13.6 *Referee Exposure*—No accelerated test can be used as a predictor of outdoor durability unless there is evidence to show that the accelerated test produces the same type of degradation and ranks materials in the same way as outdoor exposures. In case of dispute between parties, results from outdoor exposures shall always take precedence over those from either of the artificial accelerated tests described. Use results from the longest outdoor exposure test that is available.

13.7 *Report*—Report the following information about the exposure test used:

13.7.1 The type of artificial weathering test used and the manufacturer and model of the weathering device.

13.7.2 If xenon-arc exposure was used, report the irradiance level used, the type of wetting and water temperature, and whether the chamber air temperature was controlled.

13.7.3 If fluorescent UV exposure was used, report whether the device was the irradiance controlled or non-controlled apparatus.

TABLE 1 Xenon-Arc Exposure

Exposure Cycle ^A	Set Points	Operational Fluctuations ^B
Dry Period: Light only—102 min	Irradiance: 0.51 W/(m ² ·nm) at 340 nm ^C Uninsulated black panel temperature: 70 °C Relative humidity: 50 % Chamber air temperature (if controlled): 45 °C	±0.02 W/(m ² ·nm) at 340 nm ±2.5 °C ±10 % ±2 °C
Wet Period: Light plus water spray on the exposed surface of the specimen or wetting by immersion in water ^D —18 min	Irradiance: 0.51 W/(m ² ·nm) at 340 nm ^C Uninsulated black panel temperature: 70 °C Relative humidity: 50 % Chamber air temperature is not controlled during the wet period.	±0.02 W/(m ² ·nm) at 340 nm ±2.5 °C ±10 %

Repeat the 2 h cycle described above continuously until the desired exposure time is reached.

^A If mutually agreed upon by all parties, the time of the dry and wet periods of the exposure cycle may be adjusted to be 120 min each. This will provide a cycle with longer specimen wet times. In this case, the total cycle time is 4 h, which will be repeated continuously until the desired exposure time is reached.

^B The operational fluctuation is the allowed deviation from the set point of the controlled parameter indicated by the device during equilibrium conditions. If the fluctuation is outside the limits defined by the operational fluctuation, discontinue the test and correct the cause of the problem before continuing.

^C The irradiance level of 0.51 W/(m²·nm) at 340 nm is preferred. However, to accommodate users who are required to operate the machine at 0.35 W/(m²·nm) at 340 nm, the lower irradiance level is an option. The test duration is specified in terms of radiant exposure and the time is adjusted according to the formula in **13.4.1.1** to obtain the same radiant exposure at the different irradiance levels.

^D The spray water temperature is typically 21 ± 5 °C, but may be lower if ambient water temperature is low and a holding tank is not used to store purified water. The immersion water temperature is typically 40 ± 5 °C. For sealants in which moisture has a significant effect on the weathering, the two types of wetting may produce different test results due to differences in water temperature and because water spray and immersion in water are different kinds of moisture exposures.

TABLE 2 Fluorescent UV Exposure

Exposure Cycle ^A	Set Points	Operational Fluctuations ^B
Dry Period: Light only—8 h	Irradiance: 0.89 W/(m ² ·nm) at 340 nm Uninsulated black panel temperature: 70 °C	±0.02 W/(m ² ·nm) at 340 nm ±2.5 °C
Wet Period: Dark with condensation—4 h	Uninsulated black panel temperature: 50 °C	±2.5 °C

Repeat the 12 h cycle described above continuously until the desired exposure time is reached.

^A If mutually agreed upon by all parties, the time of the dry and wet periods of the exposure cycle may be adjusted to be 120 min each. This will provide a cycle with longer specimen wet times. In this case, the total cycle time is 4 h, which will be repeated continuously until the desired exposure time is reached.

^B The operational fluctuation is the allowed deviation from the set point of the controlled parameter indicated by the device during equilibrium conditions. If the reading indicated by the device is outside the limits defined by the operational fluctuation, discontinue the test and correct the cause of the problem before continuing.

13.7.4 Description used for placement of specimens in exposure device or method of test specimen repositioning, if used.

13.7.5 Variations, if any, from the specified test procedure.

13.8 *Precision and Bias*—No information is presented about precision or bias of this test method for weathering evaluation since the results are nonquantitative.

14. Tensile Adhesion

14.1 *Scope*—This is a test method to determine the elongation of a sealant before failure when adhered to concrete blocks.

14.2 *Significance and Use*—This test method gives a determination that the relative adhesive and cohesive strengths of a sealant are in proper balance.

14.3 *Apparatus*—Use a tensile adhesion test apparatus, capable of gripping the concrete blocks parallel to each other and pulling them apart at a separation rate of 12.5 ± 2.5 mm/min through a range of 0 to 200 mm minimum.⁴

14.4 *Specimen Preparation*—Prepare specimens as specified in 8.5 and the blocks will condition for 24 ± 4 h on the 25 by 50 mm end to dry. Condition the poured specimen for 24 ± 4 h at standard lab conditions.

14.5 *Procedure*—Place the test specimens in equipment as specified in 14.3 and pull apart at standard conditions and at a rate of 12.5 ± 2.5 mm/min. Continue the extension until the specimen reaches complete cohesive or adhesive failure. Record and average the elongation of each of the three specimens, and note if the failure was cohesive or adhesive, and the percentage elongation of each.

14.6 *Report*—Report the results as required in the respective material specification.

14.7 *Precision and Bias*:

14.7.1 The precision of this test method is based on an interlaboratory study of ASTM D5329, Test Methods for Sealants and Fillers, Hot-Applied, for Joints and Cracks in Asphalt Pavements and Portland Cement Concrete Pavements, conducted in 2019. Each of eight volunteer laboratories was asked to test three different materials. Every “test result” represents an individual determination, and all participants were instructed to report three replicate test results for each material. Practice E691 was followed for the design and analysis of the data; the details are given in ASTM Research Report No. RR:D04-1045.⁵

14.7.1.1 *Repeatability Limit (r)*—The difference between repetitive results obtained by the same operator in a given laboratory applying the same test method with the same apparatus under constant operating conditions on identical test material within short intervals of time would, in the long run, in the normal and correct operation of the test method, exceed the following values only in one case in 20.

14.7.1.2 Repeatability can be interpreted as the maximum difference between two results, obtained under repeatability conditions, that is accepted as plausible due to random causes under normal and correct operation of the test method.

14.7.1.3 Repeatability limits are listed in Table 3.

14.7.1.4 *Reproducibility Limit (R)*—The difference between two single and independent results obtained by different operators applying the same test method in different laboratories using different apparatus on identical test material would,

⁴ The sole source of supply of the apparatus known to the committee at this time is the Dillon Low Range Multi-Scale Universal Tester, Model M-1, from W. C. Dillon Co., Van Nuys, CA. If you are aware of alternative suppliers, please provide this information to ASTM International Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical committee,¹ which you may attend.

⁵ Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D04-1045. Contact ASTM Customer Service at service@astm.org.

TABLE 3 Average Tensile Elongation (%) Obtained from Tensile Adhesion Test

Material	Number of Laboratories	Average ^A \bar{x}	Repeatability	Reproducibility	Repeatability Limit r	Reproducibility Limit R
			Standard Deviation S_r	Standard Deviation S_R		
Sample A	8	996.16	36.18	83.82	101.30	234.69
Sample B	8	759.56	48.90	70.60	136.91	197.67
Sample C	8	999.91	44.67	65.54	125.08	183.52

^A The average of the laboratories' calculated averages.

in the long run, in the normal and correct operation of the test method, exceed the following values only in one case in 20.

14.7.1.5 Reproducibility can be interpreted as the maximum difference between two results, obtained under reproducibility conditions, that is accepted as plausible due to random causes under normal and correct operation of the test method.

14.7.1.6 Reproducibility limits are listed in **Table 3**.

14.7.1.7 The terms “repeatability limit” and “reproducibility limit” are used as specified in Practice **E177**.

14.7.2 *Bias*—At the time of the study, there was no accepted reference material suitable for determining the bias for this test method; therefore, no statement on bias is being made.

14.7.3 The precision statement was determined through statistical examination of 72 results, from eight laboratories, on three materials.

15. Flexibility

15.1 *Scope*—This test measures the ability of a sealant to be bent around a mandrel after being exposed to heat aging.

15.2 *Significance and Use*—Some materials can harden upon heat aging and become brittle, which will affect the field performance.

15.3 *Specimen Preparation*—Prepare one specimen as specified in **7.4**.

15.4 *Procedure*—Place the specimen in a forced-draft oven maintained at a temperature of 70 ± 1 °C for 72 h. After removal from the oven, maintain at standard conditions for 24 h, and then slowly bend the tin plate with the sample intact over a 6.4 mm diameter mandrel producing a 90° bend in the plate with a maximum radius at the bend of 3.2 mm. Locate the bend so that it is approximately midpoint in the 60 mm dimension of the specimen.

15.5 *Report*—Report the results as required in the respective material specification.

15.6 *Precision and Bias*—No information is presented about precision or bias of this test method for flexibility evaluation since the results are nonquantitative.

16. Keywords

16.1 fillers; formed in place; hot-applied; sealants

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