Designation: D545 – 14

Standard Test Methods for Preformed Expansion Joint Fillers for Concrete Construction (Nonextruding and Resilient Types)[1]

This standard is issued under the fixed designation D545; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope

1.1 These test methods cover the physical properties associated with preformed expansion joint fillers. The test methods include:

Property	Section
Expansion in Boiling Water	7.1
Recovery and Compression	7.2
Extrusion	7.3
Boiling in Hydrochloric Acid	7.4
Asphalt Content	7.5
Water Absorption	7.6
Density	7.7

NOTE 1—Specific test methods are applicable only to certain types of joint fillers, as stated herein.

1.2 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.3 *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 consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D1037 Test Methods for Evaluating Properties of Wood-Base Fiber and Particle Panel Materials

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

3. Significance and Use

3.1 The compression resistance perpendicular to the faces, the resistance to the extrusion during compression, and the ability to recover after release of the load are indicative of a joint filler's ability to fill continuously a concrete expansion joint and thereby prevent damage that might otherwise occur during thermal expansion. The asphalt content is a measure of the fiber-type joint filler's durability and life expectancy. In the case of cork-type fillers, the resistance to water absorption and resistance to boiling hydrochloric acid are relative measures of durability and life expectancy.

4. Apparatus

4.1 *Balance,* for weighing joint fillers capable of weighing test specimens within 0.01 g.

4.2 *Mechanical Convection Oven,* capable of maintaining 220 ± 5.0°F (104 ± 3°C).

4.3 *Desiccator,* of sufficient size to accommodate the test specimens.

4.4 *Vernier Caliper,* for measuring length and width of specimens with accuracy within ±0.01 in. (0.25 mm).

4.5 *Dial Micrometer,* or other measuring device, graduated to read in 0.001-in. (0.02-mm) units.

4.6 *Extrusion Mold*—Three-sided steel mold to confine lateral movement of specimens under compression to one side only. Interior dimensions shall be 4 by 4 in. (102 by 102 mm) with permissible variations in length and width of ±0.015 in. (0.38 mm). Mold sides shall be of such height as to extend at least 0.5 in. (13 mm) above the test specimens. A typical mold can be made from a steel base ½ by 4 by 4 ± 0.015 in. (13 by 102 by 102 ± 0.3 mm) and three bolted steel side plates ¼ in. (6.35 mm) thick, extending approximately 1½ in. (38 mm) above the base plate, thus forming a three-sided open-top box.

4.7 *Template*—One steel template 4 by 4 in. (102 by 102 mm), machined from ½-in. (6.4-mm) steel plate to fit the extrusion mold. The template shall fit the mold within −0.005 in. (0.13 mm) in length and width.

[1] These methods are under the jurisdiction of ASTM Committee D04 on Road and Paving Materials and are the direct responsibility of Subcommittee D04.34 on Preformed Joint Fillers, Sealers and Sealing Systems.

Current edition approved June 1, 2014. Published August 2014. Originally approved in 1939. Last previous edition approved in 2008 as D545 – 08. DOI: 10.1520/D0545-14.

[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.

4.8 *Metal Plate,* 4½ by 4½ in. ± 0.1 in. (114 by 114 ± 2.5 mm) with parallel faces machined from ½-in. (6.4-mm) steel plate.

4.9 *Compression Tester,* either hydraulic- or screw-type equipment with sufficient opening between upper- and lower-bearing surfaces to permit the use of verifying apparatus. The load applied to the test specimen shall be indicated with an accuracy of ±1.0 %. The upper-bearing device shall be a spherically seated, hardened metal block firmly attached at the center of the upper head of the machine. The center of the sphere shall lie at the center of the surface of the block in contact with the specimen. The block shall be closely held in its spherical seat, but free to tilt in any direction. Load shall be applied without shock at 0.05 in. (1.3 mm) per min.

4.10 *Extractor Apparatus,* Soxhlet Extractor with thermostatically controlled heating element.

5. Sampling

5.1 One representative sample approximately 2 ft^2/1000 ft^2 of joint filler shall be obtained and properly packaged for safe transporting to the testing agency.

5.2 For self-expanding cork joint filler, a minimum of five 4½ by 4½-in. (114 by 114-mm) square specimens properly banded and plastic wrapped at point of manufacture shall be submitted for testing.

6. Preparation of Test Specimens

6.1 For the joint fillers made of cork, sponge rubber, bituminous cork, or fiber, cut five specimens 4 by 4 in. (102 by 102 mm). Each specimen shall be freshly and squarely cut using a metal plate as a cutting template, as described in 4.7.

6.2 For self-expanding cork only, after boiling the specimens in water as described in 7.1.1, air dry in ambient air 24 h. Then cut specimens to the size described in 6.1.

6.3 Determine the thickness of each specimen to the nearest 0.001 in. (0.03 mm).

7. Procedures

7.1 *Expansion in Boiling Water:*

7.1.1 For self-expanding cork joint filler only, use five of the test specimens supplied by the manufacture as described in 5.2. Determine the thickness of each specimen to the nearest 0.001 in. (0.03 mm). Immerse the specimens in boiling water for 1 h; remove and allow to cool to room temperature for 15 min. Measure the final thickness of each specimen to the nearest 0.001 in. Calculate the expansion as follows:

$$\text{Expansion, \%, of original thickness} = \frac{A}{B} \times 100 \quad (1)$$

where:

A = thickness in inches after boiling in water, and
B = thickness in inches before boiling in water.

7.1.2 Prepare the test specimens for testing as described in 6.2.

7.2 *Recovery and Compression:*

7.2.1 *Test Specimen*—For these tests use one of the specimens prepared and described in 6.1 and 6.2. For the cork, sponge rubber, bituminous cork, and fiber joint fillers; make these tests on material as received. If the cork filler fails to meet the specified requirements, make check tests on specimens that have been immersed in water for 24 h and then air-dried at ambient conditions for 24 h. Acceptance is based on the results of the check tests.

7.2.2 *Mounting*—Place the test specimen on a flat metal plate and center a 4½ by 4½ by ½-in. (114 by 114 by 13-mm) metal plate, ground to have plane parallel faces, on the top surface of the specimen. Use a simple U-shaped bridge to support a dial gage or other suitable measuring device reading to the nearest 0.001 in. (0.03 mm) above the center of the specimen. Place a hollow metal load transfer cylinder with slots for inserting the U-shape bridge and an opening for reading the measuring device between the moving head of the testing machine and the plate covering the specimen. A typical mounting is shown in Fig. 1, but other suitable devices may be used. Mount a spherical bearing block between the upper end of the cylinder and the moving head of the testing machine. Center accurately both the hollow metal cylinder or other device and the spherical bearing block so that the load will be applied uniformly to the test specimen.

7.2.3 *Measurement of Thickness*—When the specimen has been mounted as described in 7.2.2 and is subjected only to the pressure of the dead weight of the 4½ by 4½ by ½-in. (114 by 114 by 13-mm) metal plate, determine its thickness by means of the measuring device. When the load-transferring apparatus and spherical bearing block are placed on the test specimen, some compression may result. Consider this reduction in thickness as part of the 50 % reduction in thickness to be applied.

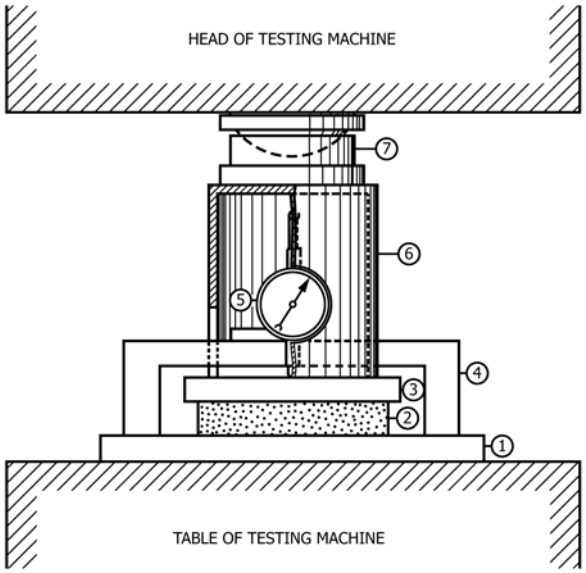
7.2.4 *Recovery*—For the determination of the percentage of recovery, give the specimen a single application of a load sufficient to compress it to 50 % of its thickness before test. Apply the load without shock and at such a rate that the specimen will be compressed approximately 0.05 in. (1.3 mm)/min. Record this applied load. Immediately release the load after application and permit to recover 10 min, after which measure the thickness. Remove the load-transferring apparatus and spherical bearing block from the test specimen following the load application. Calculate the percentage of recovery as follows:

$$\text{Recovery, \%} = \frac{t_1}{t} \times 100 \quad (2)$$

where:

t = thickness of the specimen before test, and
t_1 = thickness 10 min after completion of the application of load.

7.2.4.1 *Retest Provision*—In case the specimen fails to comply with requirements of the specification, test a specimen in accordance with the following procedure. Give the test specimen three applications of a load sufficient to compress it to 50 % of its thickness before test. Apply the load without shock and at such a rate that the specimen will be compressed approximately 0.05 in. (1.3 mm)/min. After the first and second



1—Flat Metal Plate.
2—Specimen.
3—Metal Plate 4½ by 4½ by ½ in. (102 by 102 by 13 mm).
4—U-Shape Bridge.
5—Measuring Device.
6—Hollow Cylinder.
7—Spherical Bearing Block.

FIG. 1 Typical Mounting of the Specimen for Recovery and Compression Tests

applications, release the load immediately, and permit the specimen to recover 30 min before the load is again applied. After the third application, release the load immediately and permit the specimen to recover 1 h; then measure the thickness again. Remove the load-transferring apparatus and spherical bearing block from the test specimen during recovery periods between compressions and following the third application of load. Acceptance shall be based on the results of these check tests. Calculate the percentage of recovery as follows:

$$\text{Recovery, } \% = \frac{t_1}{t} \times 100 \quad (3)$$

where:

t = thickness of the specimen before test, and
t_1 = thickness 1 h after completion of the third application of load.

7.2.5 *Compression*—Calculate the unit pressure by dividing the maximum load in lbf (N) as determined in 7.2.4 by the area, 16 in.^{2} (0.0104 m^2), and record as the unit pressure in psi (kPa).

7.3 *Extrusion:*

7.3.1 *Test Specimens*—For this test, use one of the test specimens prepared as described in 6.1 (or one of the self-expanding cork specimens prepared in 6.2). In the case of cork, sponge rubber, bituminous cork, and fiber expansion joint fillers, make these tests on specimens of the materials as received. If the cork filler fails to meet the requirements of the specifications, make check tests on specimens that have been immersed in water for 24 h and subsequently air-dried for 24 h. Base acceptance on the results of these check tests.

7.3.2 *Mounting*—Place the test specimen in a suitable steel mold so constructed as to confine the lateral movement of the specimen under compression to one side only, as described in 4.6. Cover the specimen with a ½ by 4 by 4-in. (13 by 102 by 102-mm) metal plate ground to have plane parallel faces, as described in 4.7. Use a simple U-shaped bridge to support above the center of the specimen a dial or other suitable measuring device reading to 0.001 in. (0.03 mm). Place upon the plate metal cylinder or other device for transferring the load from the moving head of the testing machine around the measuring apparatus to the plate covering the specimen.

7.3.3 *Measurement of Thickness*—When the specimen has been mounted as described in 7.3.2 and is subjected only to the pressure of the dead weight of the ½ by 4 by 4-in. (13 by 102 by 102-mm) metal plate, determine its thickness by means of the measuring device. When the load-transferring apparatus and spherical bearing block are placed on the test specimen, some compression may result. Consider this reduction in thickness as part of the 50 % reduction in thickness to be applied.

7.3.4 *Extrusion*—For the determination of the amount of extrusion, give the specimen one application of a load sufficient to compress it to 50 % of its thickness before test. Apply the load without shock at such a rate that the specimen will be compressed approximately 0.05 in. (1.3 mm)/min. Determine the amount of extrusion in inches by measuring the maximum movement of the free edge of the test specimen during the 50 % compression of the specimen. Measure the extrusion by means of a dial micrometer or other suitable device reading to 0.001 in. (0.03 mm).

7.4 *Boiling in Hydrochloric Acid:*

7.4.1 In the case of cork and self-expanding cork expansion joint fillers only, use one of the test specimens prepared as described in 6.1 (or one of the expanded specimens prepared as described in 6.2). Immerse the specimen in hydrochloric acid

(HCl, sp gr 1.19) and boil for 1 h. Examine the test specimen for evidences of disintegration.

7.5 *Asphalt Content:*

7.5.1 From the test specimens prepared as described in 6.1, cut narrow strips of sufficient length to pack the thimble of the Soxhlet Extractor; approximately 45 g is sufficient. Oven dry the strips at 220 ± 5°F (104 ± 3°C) to constant weight in an open tared weighing dish, then cool in a desiccator. Weigh to the nearest 0.01 g, and subtract tare to obtain initial oven dry weight of specimen.

7.5.2 Transfer the test strips to the extraction thimble of known oven dry weight. Extract the asphalt in the Soxhlet Extractor using a suitable solvent (see Note 2) until the extract is essentially clear (color of weak tea).

NOTE 2—A "suitable solvent" is any solvent that effectively separates the asphalt. Dichloromethane (methylene chloride) or N-Propyl-Bromide are commonly recommended. The solvent used shall be included in the report.

7.5.3 After extraction, allow excess solvent to drain from the thimble before transferring to an open tared weighing dish and oven dry at 220 ± 5°F (104 ± 3°C) for 1 h. Cool in a desiccator, then weigh and subtract weighing dish and thimble to obtain the oven dry weight of the extracted fiber.

7.5.4 Calculate the percentage asphalt content by weight on an oven dry basis as follows:

$$\text{Asphalt, \%} = \frac{W^{1} - W}{W^{1}} \times 100 \quad (4)$$

where:

W^{1} = initial oven dry weight of test strips, and
W = oven dry weight of extracted fiber.

7.6 *Water Absorption:*

7.6.1 Using a test specimen prepared as described in 6.1, dry the specimen in air, weigh to the nearest 0.1 g, and immerse in water at a temperature of 65 to 75°F (18 to 25°C) in a horizontal position supported from the bottom of the container with 1 in. (25 mm) of water over the specimen for 24 h. Remove the specimen from the water and remove the excess surface water from all sides of the specimen with blotting paper or a paper towel. Quickly weigh the specimen to the nearest 0.1 g. Calculate percent water absorption by volume as follows:

$$\text{Absorption by Volume, \%} = \frac{W_1 - W}{262t} \times 100 \quad (5)$$

where:

W_1 = weight after immersion, g,
W = weight before immersion, g, and
t = thickness, in.

7.6.2 In the event that the metal template or the test specimen or both does not measure to within the tolerances established in 4.7, the length and width of the test specimen must be measured to within 0.01 in. and percent water absorption by volume calculated as follows:

$$\text{Absorption by Volume, \%} = \frac{W_1 - W}{16.41 \times l \times w \times t} \times 100 \quad (6)$$

where:

W_1 = weight after immersion, g,
W = weight before immersion, g,
l = length of specimen, in.,
w = width of specimen, in., and
t = thickness of specimen, in.

7.7 *Density:*

7.7.1 Using a specimen prepared as described in Section 6 and, after air drying, weigh to the nearest 0.1 g. For air dry material the specimen shall come to constant weight and moisture in a conditioning atmosphere described in Test Methods D1037 for "wood based fiber and particle panel materials," 65 ± 1 % RH at 68 ± 6°F. Constant weight is defined as no change greater than 1 % sample weight after 24 h.

7.7.2 For fiber joint only, oven dry the specimen at 220 ± 5°F (104 ± 3°C) for 2 h. After oven drying, cool the specimen to room temperature in a covered desiccator and weigh to nearest 0.1 g.

7.7.3 Calculate the density in lb/ft^3, as follows:

$$\text{Density} = \frac{0.238\ W}{t} \quad (7)$$

where:

W = weight, g, and
t = thickness, in.

7.7.4 In the event that the metal template or the test specimen or both does not measure to within the tolerances established in 4.7, the length and width of the specimen must be measured to within 0.01 in. and density calculated in lb/ft^3 as follows:

$$\text{Density} = \frac{3.81\ W}{l \times w \times t} \quad (8)$$

where:

W = weight, g,
l = length, in.,
w = width, in., and
t = thickness, in.

8. Precision and Bias

8.1 The precision of these test methods are based on an interlaboratory study (ILS) of this standard conducted in 2007. Results in this study were obtained from a total of six laboratories, testing five different joint-filler materials. Every "test result" reported represents an individual determination. Each participating laboratory reported up to ten replicate test results for each material. Except for the inability of every participating laboratory to provide test results for all study parameters, Practice E691 was followed for the design and analysis of the data; the details are given in ASTM Research Report No. D04-1027.[3]

8.1.1 *Repeatability Limit (r)*—Two test results obtained within one laboratory shall be judged not equivalent if they differ by more than the "*r*" value for that material; "*r*" is the

[3] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:D04-1027.

interval representing the critical difference between two test results for the same material, obtained by the same operator using the same equipment on the same day in the same laboratory.

8.1.1.1 Repeatability limits are listed in Tables 1-7.

8.1.2 *Reproducibility Limit (R)*—Two test results shall be judged not equivalent if they differ by more than the "*R*" value for that material; "*R*" is the interval representing the critical difference between two test results for the same material, obtained by different operators using different equipment in different laboratories.

8.1.2.1 Reproducibility limits are listed in Tables 1-7.

8.1.3 The above terms (repeatability limit and reproducibility limit) are used as specified in Practice E177.

8.1.4 Any judgment in accordance with statements 8.1.1 and 8.1.2 would normally have an approximate 95 % probability of being correct, however the precision statistics obtained in this ILS must not be treated as exact mathematical quantities which are applicable to all circumstances and uses. The limited number of laboratories reporting results guarantees that there will be times when differences greater than predicted by the ILS results will arise, sometimes with considerably greater or smaller frequency than the 95 % probability limit would imply. The repeatability limit and the reproducibility limit should be considered as general guides, and the associated probability of 95 % as only a rough indicator of what can be expected.

8.2 *Bias*—At the time of the study, there was no accepted reference material suitable for determining the bias for these test methods, therefore no statement on bias is being made.

8.3 The precision statement was determined through statistical examination of 328 results, from six laboratories, on five materials. These five joint fillers were described as the following:

Filler A	Cork
Filler B	Self-Expanding Cork
Filler C	Sponge Rubber
Filler D	Closed-Cell Polyolefin Foam
Filler E	Preformed Expansion Joint, Bituminous Type

To judge the equivalency of two test results, it is recommended to choose the joint filler closest in characteristics to the test filler.

9. Keywords

9.1 joint fillers; nonextruding; resilient types

TABLE 1 Expansion (%)

Joint Filler	Average $(\bar{X})^A$	Repeatability Standard Deviation (S_r)	Reproducibility Standard Deviation (S_R)	Repeatability Limit (r)	Reproducibility Limit (R)
B	161.4	12.9	43.5	36.0	121.9

[A] The average of the laboratories' calculated averages.

TABLE 2 Density (*lbs/cu ft*)

Joint Filler	Average $(\bar{X})^A$	Repeatability Standard Deviation (S_r)	Reproducibility Standard Deviation (S_R)	Repeatability Limit (r)	Reproducibility Limit (R)
C	30.06	0.77	7.02	2.16	19.66
D	2.15	0.02	0.14	0.05	0.39
E	19.32	0.47	1.29	1.32	3.62

[A] The average of the laboratories' calculated averages.

TABLE 3 Compression (*psi*)

Joint Filler	Average $(\bar{X})^A$	Repeatability Standard Deviation (S_r)	Reproducibility Standard Deviation (S_R)	Repeatability Limit (r)	Reproducibility Limit (R)
A	212.4	14.3	46.7	40.0	130.8
B	225.1	24.9	192.6	69.8	539.3
C	96.6	18.1	66.9	50.5	187.2
D	17.0	1.1	5.5	3.0	15.3
E	327.8	23.6	63.8	65.9	178.6

[A] The average of the laboratories' calculated averages.

TABLE 4 Water Absorption (*%*)

Joint Filler	Average $(\bar{X})^A$	Repeatability Standard Deviation (S_r)	Reproducibility Standard Deviation (S_R)	Repeatability Limit (r)	Reproducibility Limit (R)
E	10.9	0.4	4.3	1.3	12.0

[A] The average of the laboratories' calculated averages.

TABLE 5 Asphalt Content (*%*)

Joint Filler	Average $(\bar{X})^A$	Repeatability Standard Deviation (S_r)	Reproducibility Standard Deviation (S_R)	Repeatability Limit (r)	Reproducibility Limit (R)
E	39.1	0.5	3.3	1.3	9.2

[A] The average of the laboratories' calculated averages.

TABLE 6 Recovery (*%*)

Joint Filler	Average $(\bar{X})^A$	Repeatability Standard Deviation (S_r)	Reproducibility Standard Deviation (S_R)	Repeatability Limit (r)	Reproducibility Limit (R)
A	89.4	9.0	9.5	25.3	26.7
B	91.7	3.8	4.9	10.5	13.7
C	98.3	0.3	1.2	0.7	3.4
D	96.6	0.9	2.0	2.5	5.5
E	84.4	6.0	8.4	16.8	23.6

[A] The average of the laboratories' calculated averages.

TABLE 7 Extrusion (*in.*)

Joint Filler	Average $(\bar{X})^A$	Repeatability Standard Deviation (S_r)	Reproducibility Standard Deviation (S_R)	Repeatability Limit (r)	Reproducibility Limit (R)
A	0.032	0.009	0.022	0.024	0.062
B	0.060	0.083	0.083	0.232	0.232
C	0.068	0.025	0.048	0.071	0.133
D	0.021	0.009	0.019	0.027	0.055
E	0.018	0.011	0.015	0.031	0.041

[A] The average of the laboratories' calculated averages.