Designation: C794 − 15a

Standard Test Method for Adhesion-in-Peel of Elastomeric Joint Sealants[1]

This standard is issued under the fixed designation C794; 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 This test method covers a laboratory procedure for determining the strength and characteristics of the peel properties of a cured-in-place elastomeric joint sealant, single- or multicomponent, for use in building construction.

1.2 The values stated in metric (SI) units are to be regarded as the standard. The values given in parentheses are provided for information only.

1.3 The committee with jurisdiction over this standard is not aware of any comparable standards published by other organizations.

1.4 *This standard does not purport to address all of the safety problems, if any, 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.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C717 Terminology of Building Seals and Sealants

C1375 Guide for Substrates Used in Testing Building Seals and Sealants

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. Terminology

3.1 For the definitions used in this test method, see Terminology C717, standard conditions.

4. Summary of Test Method

4.1 This test method consists of preparing test specimens by embedding a wire mesh screen between two thin layers of the sealant being tested, on test substrates, curing these specimens under specified time and conditions, then placing the specimen in a tension-testing machine in such a way that the embedded wire mesh screen is peeled back from the substrate at 180°, while measuring the force exerted as well as the mode of failure of the sealant from the substrate.

5. Significance and Use

5.1 There are differences in opinion among those concerned with sealant technology whether or not this adhesion-in-peel test simulates the type of strain and e-tensile stresses encountered by a sealant in normal use. Nevertheless, this test provides a valuable measurement of the ability of the cured sealant to maintain a bond to the substrate under severe peel conditions.

5.2 Many sealant manufacturers utilize the adhesion-in-peel test for determining the adhesive characteristics of sealant/primer combinations with unusual or proprietary substrates. This test is especially useful for quality measurements comparing batches of the same sealant relative to adhesion or for studying adhesion of a given sealant to a variety of substrates.

5.3 This test method alone is not appropriate for comparing the overall performance of different sealants in a given application. The adhesive force that determines if a given sealant is useful in a given application also depends on the modulus of elasticity and the degree to which the sealant will be strained. This test, as it exists, does not consider the modulus of elasticity, nor amount of stress that will be produced by a given strain in an actual sealant in a moving joint. No known correlations are given to relate and apply modulus values to the peel values.

5.4 This test requires that the results indicate whether the failure mode is primarily adhesive or cohesive. It is important to note that a cohesive failure is not necessarily better than an adhesive failure, if the adhesive value is sufficient for the application. Having adhesive failure allows one to study the change of adhesion with time and with the various stress conditions.

[1] This test method is under the jurisdiction of ASTM Committee C24 on Building Seals and Sealants and is the direct responsibility of Subcommittee C24.30 on Adhesion.

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[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.

6. Apparatus and Materials

6.1 *Tensile Testing Machine* with tension grips capable of pulling at the rate of separation of approximately 50 mm (2 in.)/min, and having a chart indicator calibrated in 0.45-N (0.1-lbf) units.

6.2 *Standard Substrates*—This test method may be performed on a wide variety of substrates. See Guide C1375 for a description of standard substrates and recommended surface preparation. Since adhesive properties of a joint sealant are related to the nature of the substrate, it is strongly recommended that whenever possible that adhesion-in-peel testing be performed on substrate samples that are representative of the building materials. Examples of such substrates include brick, marble, limestone, granite, aluminum, stainless steel, plastic, ceramic tile, and others.

6.3 *Masking Tape,* paper, roll, 25 mm (1 in.) wide.

6.4 *Wire Mesh Screen*[3]stainless steel or aluminum, 20-mesh, 0.4 mm (0.016 in.) wire thickness, cut to a width of 25 + 0, -2 mm (1.0 + 0, -0.08 in.) by a minimum length of 250 mm (10 in.). The wire mesh screen selected must be flexible yet strong enough to not tear during adhesion-in-peel testing. The wire mesh screen must be flat and free of kinks. To ensure adhesion of the joint sealant to the wire mesh, thoroughly clean the screen prior to use. Sealant primer on the wire mesh screen is generally recommended by the sealant manufacturer to enhance adhesion of the joint sealant to the screen. Sealant may also be pre-applied to the screen to enhance adhesion.

6.4.1 *Discussion*—Adhesion of the joint sealant to the mesh screen is essential to evaluate adhesion-in-peel properties of the sealant to the substrate. Due to the unique characteristics of each sealant, the sealant manufacturer must determine for each sealant the appropriate screen composition, mesh dimension, wire diameter and screen cleaning and priming procedure. Polyester mesh, fiberglass mesh, airplane cloth, fabric, plastic film or similar material can be used in lieu of a wire mesh provided that the material is pliable, of a thickness no greater than 0.5 mm (0.02 in.), does not adversely affect sealant cure and does not rupture during adhesion-in-peel testing.

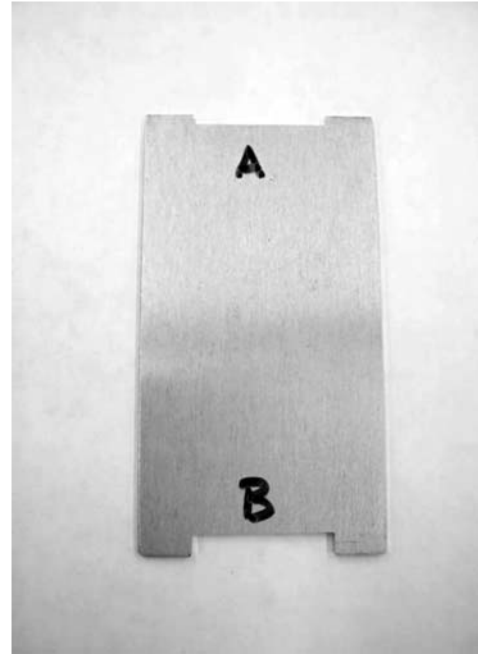
6.5 *Tooling Device*—aluminum or similar rigid material, created to produce a 2 mm (0.08 in.) by 25 mm (1 in.) sealant bead and 4 mm (0.16 in.) by 25 mm (1 in.) sealant bead after tooling (Fig. 1). The width of the tooling device may be up to 27 mm (1.06 in.) to allow easy tooling of the sealant without snagging the edges of the screen.

6.6 *Putty Knife,* rigid, approximately 40 mm (1.6 in.) wide.

6.7 *Knife,* with sharp razor-type blade.

7. Test Specimens and Cure Procedures

7.1 Four test specimens (adhesion-in-peel samples) shall be prepared on each of the substrates using the following procedures:



NOTE 1—A – 25 by 2 mm (1 by 0.08 in.) indentation
B – 25 by 4 mm (1 by 0.16 in.) indentation

FIG. 1 Special Tooling Device

7.1.1 Condition a minimum of 250 g of sealant for 24 h at standard conditions. Multi-component sealants will require mixing for 5 min or as recommended by the sealant manufacturer. Specific mixing equipment and mixing procedures may be recommended by the sealant manufacturer.

7.1.2 Clean and prepare the substrate samples as described in Guide C1375. Substrate materials not described in C1375 should be prepared in accordance with the sealant manufacturer's recommendations.

7.1.3 Apply primer(s) to the substrate(s) if recommended by the sealant manufacturer.

7.1.4 Masking tape can be applied to the substrate surfaces adjacent to the test area to allow easy removal of excess joint sealant.

7.1.5 Wire mesh screens must be thoroughly cleaned and primed, if required, as recommended by the sealant manufacturer.

7.1.6 For each substrate preparation/cleaning condition to be tested, apply a bead of sealant at least 100 mm (4 in.) in length to the substrate surface (Fig. 2).

7.1.7 Immediately place the wire mesh screen on the sealant bead and lightly tap it into the joint sealant (Fig. 3).

7.1.8 Holding the screen with a finger to prevent slippage, gently draw down the sealant imbedding the wire mesh into the wet sealant, using the special tooling device – side A (Fig. 1) at an 90° angle to the substrate (Fig. 4). The wire mesh screen should be imbedded to a uniform depth of 2 mm (0.08 in.) from the substrate surface (Fig. 5).

7.1.9 Immediately apply a second bead of joint sealant over the first bead of sealant and wire mesh screen (Fig. 6).

7.1.10 Again holding down the screen with a finger to prevent slippage, use the special tooling device – side B (Fig. 1) and draw down the sealant at a 90° angle to the substrate.

[3] Available from Tetko Inc., 333 South Highland Ave., Briarcliff Manor, NY 10510. Also available from McMaster Carr Supply Co., P.O. Box 4355, Chicago, IL 60680.

FIG. 2 First Sealant Bead Applied to Substrate (with masking tape)

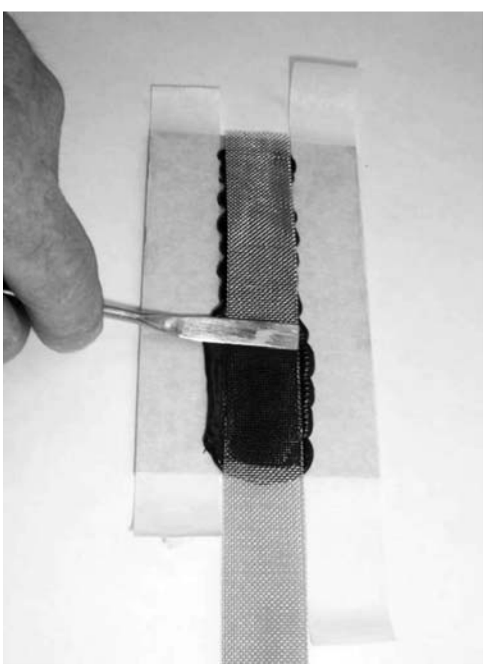


FIG. 3 Wire Mesh Screen being Imbedded in Wet Sealant Bead

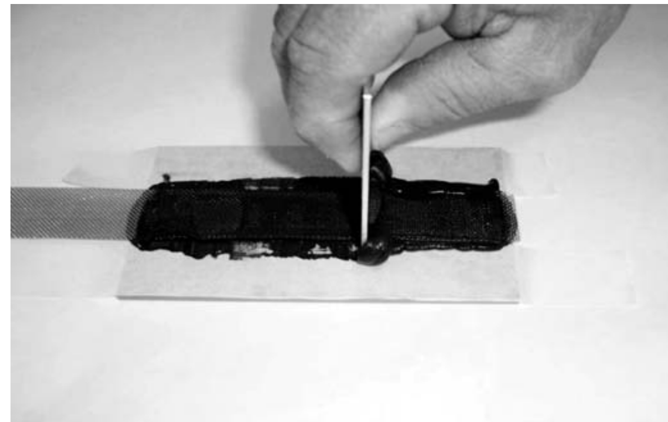


FIG. 4 Tooling Sealant after Imbedding Wire Screen Mesh with Special Tooling Device – Side A

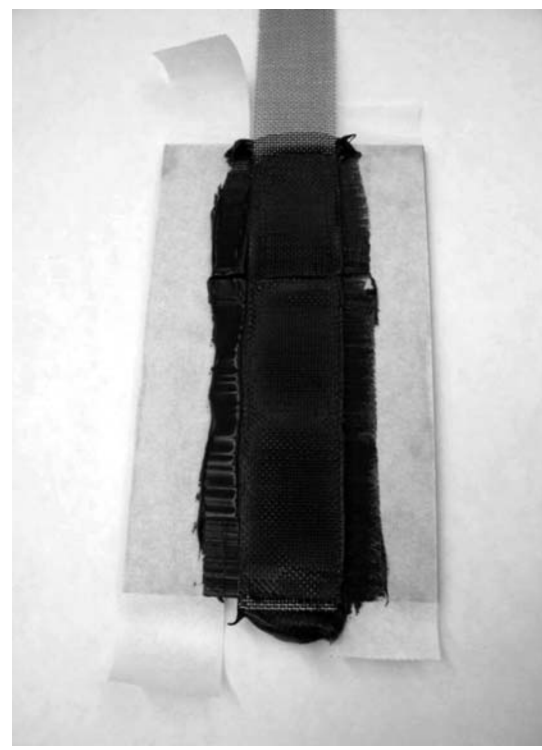


FIG. 5 Adhesion-in-Peel Test Specimen after Imbedding Wire Mesh Screen

The total depth of the sealant should be 4 mm (0.16 in.) (Fig. 7) and the wire mesh screen should be imbedded uniformly at the approximate midpoint of the total sealant depth.

7.1.11 Excess sealant beyond the edge of the wire mesh screen may be removed while the sealant is wet using a putty knife or spatula. Avoid moving the screen imbedded in the sealant. Masking tape, if used, should be removed at this time.

7.1.12 After the sealant is cured, excess sealant may be carefully removed along the length of the test sample using a razor knife. Fig. 8 shows a final prepared adhesion-in-peel test sample.

7.1.13 Allow the sealant to cure as recommended by the sealant manufacturer. Standard curing time is 21 days at standard conditions. Curing time and conditions may vary depending on the sealant type and application.

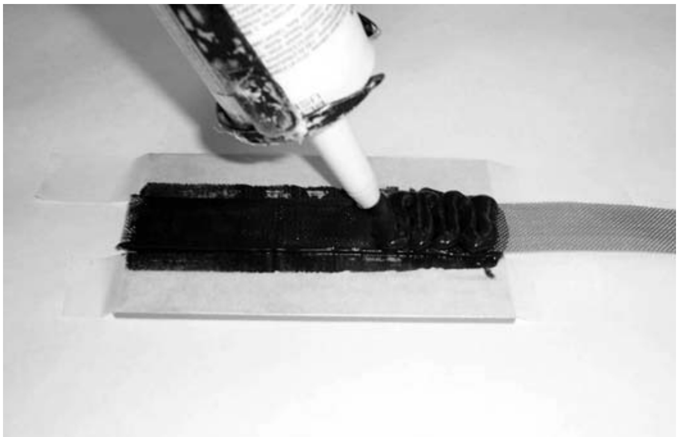


FIG. 6 Applying Second Bead of Sealant

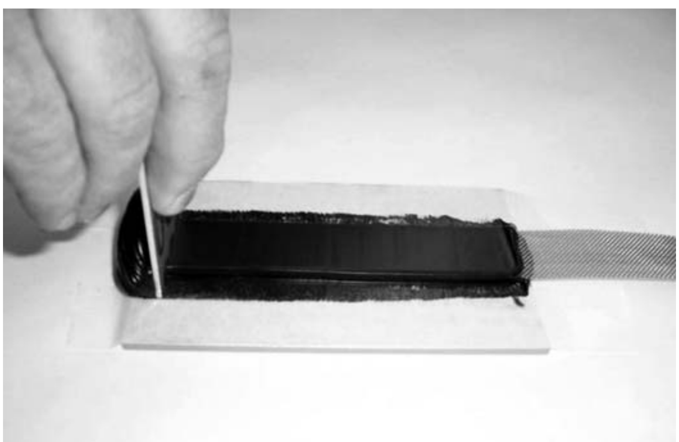


FIG. 7 Tooling Second Bead of Sealant with Special Tooling Device – Side B

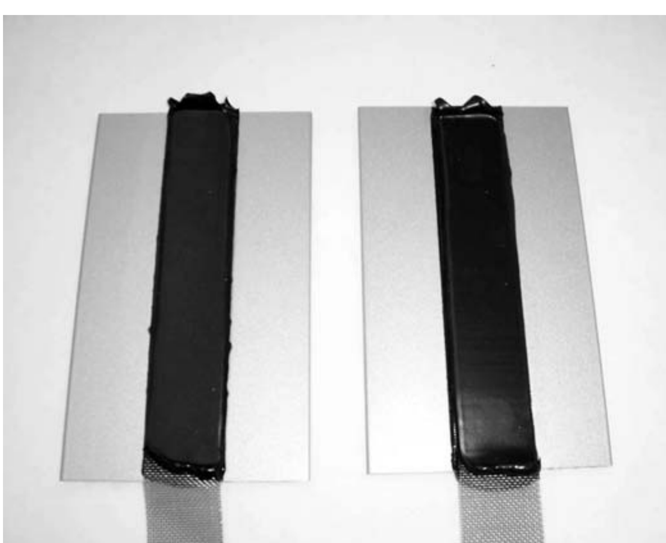


FIG. 8 Finished Adhesion-in-Peel Test Samples

8. Test Procedure

8.1 Once the sealant is fully cured, gently wrap the loose end of the wire mesh screen and bend back. Using a razor knife, provide a fresh cut along the sealant to the substrate interface (Fig. 9).

8.1.1 Place the test specimen in the tensile testing machine with the substrate secured to the fixed member and the loose end of the wire mesh screen secured to the movable member at an angle of 180° (Fig. 10).

8.1.2 Pull the screen at a rate of 50 mm (2 in.)/min for a total of 1 min (Fig. 11).

8.1.2.1 If the screen breaks during the testing, disregard the value. If possible, undercut the sealant with a razor knife and repeat the test. If the screen continues to break, prepare new test samples using a higher strength wire mesh screen.

8.1.2.2 If the sealant peels away cleanly from the screen, disregard the value. Undercut the sealant with the razor knife and repeat the test. If adhesive failure to the screen continues, prepare new test samples using a more thoroughly cleaned or primed, or both, wire mesh screen. If necessary, use a material other than a wire mesh screen.

8.1.2.3 If the adhesion-in-peel test sample shows adhesive failure to the screen in two repeated attempts but peel force values are above the specified requirements, further sample testing may not be required. In such cases, report failure mode as screen delamination, since adhesive or cohesive failure of the sealant to the substrate is not fully established. The screen should be pulled for a total of 1 min as described in 8.1.2.

NOTE 1—Discussion—Some sealants may have a non-homogeneous mode of failure during the initial adhesion-in-peel testing. During the first 30 to 60 s of testing, the sealant may achieve a steady state and longer test duration may be needed to accurately assess the failure mode of the sealant.

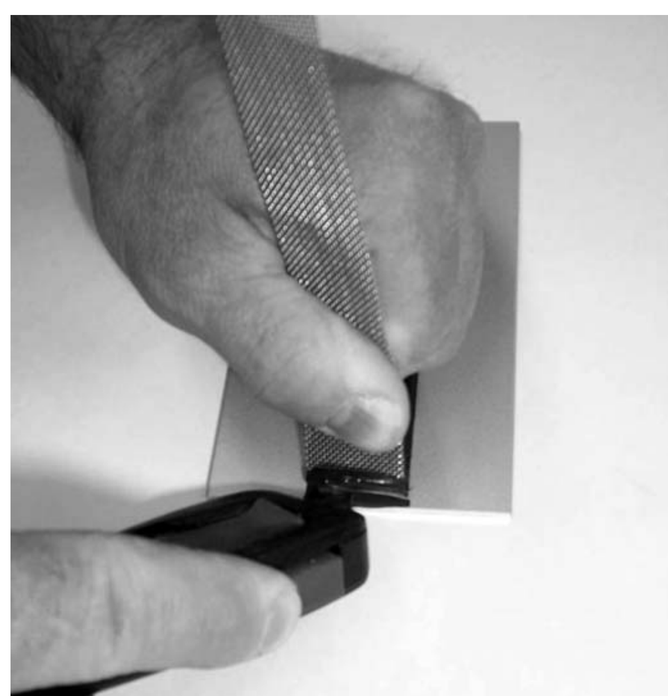


FIG. 9 Cut Along Sealant/Substrate Interface with Razor Knife

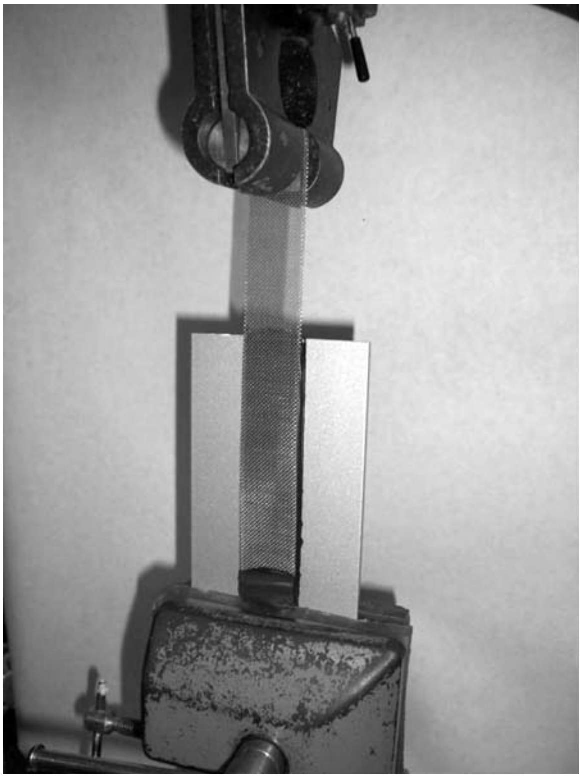


FIG. 10 Adhesion-in-Peel Test Specimen Secured in Tensile Testing Machine

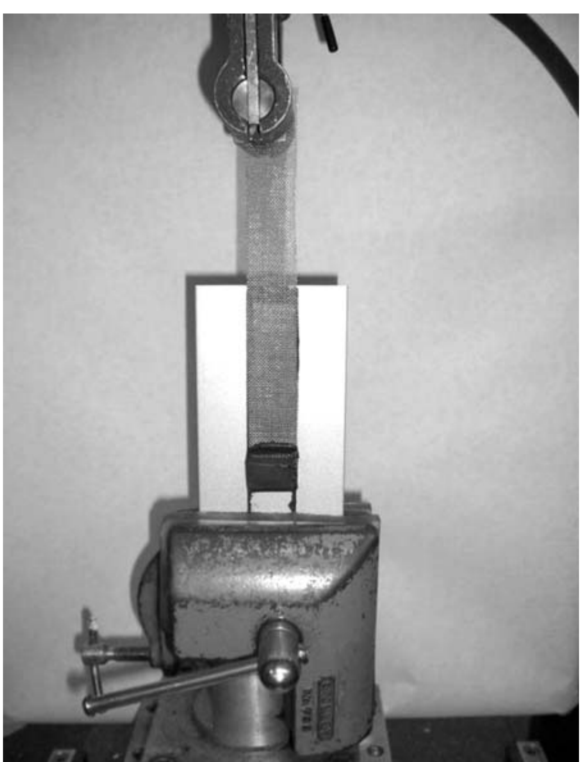


FIG. 11 Wire Mesh Screen Pulled at 180° on Tensile Testing Machine

8.1.3 Record the average peel force in Newton (pound-force) over the duration of the test.

8.1.4 Record the peak force in Newton (pound force).

8.1.5 Observe and record the approximate percentages of sealant failure modes over the total test area. Sealant failure is described as either adhesive or cohesive failure. See Fig. 12 for an example of each failure mode. Failure observed within the substrate (that is, paint removal, etc.) should be reported as substrate failure.

8.2 *Water Immersion Test*—Using either four separate test specimens or the same test specimen used for dry adhesion testing and following completion of standard cure as described in 7.1.12, immerse the test samples for 7 days in distilled water conditioned to 23 ± 2°C (73 ± 4°F). Mortar and concrete specimen should be placed in a separate container from glass and aluminum specimen because the high alkali condition generated could have an adverse effect on the glass and aluminum.

8.2.1 Following water immersion, remove the test samples, lightly dry with a cloth or paper towel and test within 10 min as described in 8.1 through 8.1.5.

8.3 Additional conditions may be used including different cure conditions, different water temperature or duration of immersion, exposure of sealant to chemicals or other materials or exposure to ultraviolet radiation, heat or weathering.

9. Report

9.1 Report the following information for each sample tested:

9.1.1 Description of substrate test sample, that is, bronze anodized aluminum, clear float glass, polished granite, etc.

9.1.2 Description of substrate surface preparation and cleaning,

9.1.3 Description of screen cleaning, and priming, if performed,

9.1.4 Identification of the type of sealant, such as single- or multi-component, color, product name, etc.,

9.1.5 Identification of primer type if used or record "no primer",

NOTE 1—Left: Cohesive Failure
Right: Adhesive Failure

FIG. 12 Examples of Cohesive Failure and Adhesive Failure

9.1.6 Average and peak peel strength in Newton (pound-force) for each adhesion-in-peel test,

9.1.7 Percent sealant failure type for each adhesion-in-peel test.

9.1.8 Variation, if any, from the specified test procedure. Examples of common variation in the test method include:

9.1.8.1 Use of a material other than a wire mesh screen, that is, polyester mesh, fiberglass mesh, airplane cloth, etc.,

9.1.8.2 Screen width different than 25 mm (1 in.),

9.1.8.3 Screen mesh count different than 20,

9.1.8.4 Sealant cure condition different than standard conditions,

9.1.8.5 Variation in water temperature or duration of immersion,

9.1.8.6 Exposure of test samples to chemicals or other materials,

9.1.8.7 Exposure of test samples to ultraviolet light, heat or weathering conditions.

10. Precision and Bias

10.1 The precision of this test method is based on an interlaboratory study of C794, Standard Test Method for Adhesion-in-Peel of Elastomeric Joint Sealants, conducted in 2008. Results in this study were obtained from a total of six laboratories, testing a single sealant. Every "test result" reported represents an individual determination. Each participating laboratory was asked to report four replicate test results for each time/analysis combination. Except for the use of only a single material, and the inability of all six laboratories to report every result, Practice E691 was followed for the design and analysis of the data.[4]

10.1.1 *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 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.

10.1.1.1 Repeatability limits are listed in Tables 1-6

10.1.2 *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.

10.1.2.1 Reproducibility limits are listed in Tables 1-6.

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

10.1.4 Any judgment in accordance with 10.1.1 and 10.1.2 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 materials tested guarantees that there will be times when differences greater than those 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.

10.2 *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.

10.3 The precision statement was determined through statistical examination of all reported results, from six laboratories, on a single material. This sealant was described as the following: Sealant A: Single-component Silicone Sealant.

11. Keywords

11.1 adhesion-in-peel; elastomeric joint sealant; water immersion

[4] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report RR:C24-1058.

TABLE 1 21 Day Dry Adhesion – Average Load (*units*)

Sealant	Average[A] $\bar{x}$	$S_{\bar{x}}$	Repeatability Standard Deviation S_r	Reproducibility Standard Deviation S_R	Repeatability Limit r	Reproducibility Limit R
Sealant A	19.18	6.03	3.71	6.84	10.40	19.15

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

TABLE 2 21 Day Dry Adhesion – Peak Load (*units*)

Sealant	Average[A] $\bar{x}$	$S_{\bar{x}}$	Repeatability Standard Deviation S_r	Reproducibility Standard Deviation S_R	Repeatability Limit r	Reproducibility Limit R
Sealant A	23.13	4.84	3.43	5.68	9.61	15.90

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

TABLE 3 21 Day Dry Adhesion – Percent CF (%)

Sealant	Average[A] $\bar{x}$	$S_{\bar{x}}$	Repeatability Standard Deviation S_r	Reproducibility Standard Deviation S_R	Repeatability Limit r	Reproducibility Limit R
Sealant A	90.00	22.36	6.32	23.02	17.71	64.46

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

TABLE 4 7 Day Water Immersion Adhesion – Average Load (*units*)

Sealant	Average[A] $\bar{x}$	$S_{\bar{x}}$	Repeatability Standard Deviation S_r	Reproducibility Standard Deviation S_R	Repeatability Limit r	Reproducibility Limit R
Sealant A	15.56	3.01	1.70	3.35	4.76	9.37

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

TABLE 5 7 Day Water Immersion Adhesion – Peak Load (*units*)

Sealant	Average[A] $\bar{x}$	$S_{\bar{x}}$	Repeatability Standard Deviation S_r	Reproducibility Standard Deviation S_R	Repeatability Limit r	Reproducibility Limit R
Sealant A	18.76	3.73	2.01	4.12	5.63	11.53

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

TABLE 6 7 Day Water Immersion Adhesion – Percent CF (%)

Sealant	Average[A] $\bar{x}$	$S_{\bar{x}}$	Repeatability Standard Deviation S_r	Reproducibility Standard Deviation S_R	Repeatability Limit r	Reproducibility Limit R
Sealant A	92.50	18.37	2.36	18.48	6.60	51.76

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