



# Standard Test Method for Adhesion and Cohesion of Elastomeric Joint Sealants Under Cyclic Movement (Hockman Cycle)<sup>1,2</sup>

This standard is issued under the fixed designation C719; 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 ( $\epsilon$ ) 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 is an accelerated laboratory procedure for evaluating the performance of a building sealant in a test configuration that is subjected to water immersion, cyclic movement, and temperature change.<sup>3</sup>

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

## 2. Referenced Documents

2.1 *ASTM Standards:*<sup>4</sup>

C33 Specification for Concrete Aggregates

C109/C109M Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or [50-mm] Cube Specimens)

C150 Specification for Portland Cement

C717 Terminology of Building Seals and Sealants

## 3. Terminology

3.1 *Definitions*—For definitions of terms used in this test method, refer to Terminology C717.

<sup>1</sup> 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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<sup>2</sup> This test method is also known as the Hockman Cycle in recognition of Arthur Hockman who originated the method at the National Bureau of Standards.

<sup>3</sup> Supporting data are available from ASTM International Headquarters. Request RR:C24-1013.

<sup>4</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

## 4. Summary of Test Method

4.1 This test method consists of subjecting standard joint specimens to a series of treatments as follows: (a) immersion in water for seven days; (b) exposure in an oven for seven days while under compression; (c) automatic compression and extension cycling at room temperature at a specified rate and amount of joint movement; and (d) alternate compression and extension of the joint at high and low temperatures, respectively, under specified conditions described herein.

4.2 The effects of the test shall be evaluated by visual inspection for cohesive and adhesive failures, sealant deformation, and bubble formation within the sealant.

4.3 This test method is applicable to any joint movement. The most common test movements are  $\pm 12.5$  and  $\pm 25$  % as used in the examples.

## 5. Significance and Use

5.1 The failure of a building sealant in an active joint is usually manifested by cohesive failure in the sealant or adhesive failure between the sealant and the substrate, or both. The method described in this test method relates only to the performance of the sealant when properly installed with recommended primers, and does not evaluate sealant failures caused by improper joint design, excessive joint movement, improper application practices, and other factors known to cause sealant failure in buildings and building areas.

## 6. Apparatus

6.1 *Compression-Extension Machine*,<sup>5</sup> designed to automatically compress the joint width of the test specimen from 0.500 in. (12.7 mm) to the minimum dimension desired (Table 1,

<sup>5</sup> Series 520 Sealing Compound Tester, manufactured by Applied Test Systems Inc., 348 New Castle Rd., Butler, PA 16001, and a durability tester manufactured by Ambard, Inc., 269-11 81st Ave., New Hyde Park, NY 11040, have been found suitable for this purpose (Fig. 1(a)). For extension of the joint at cold temperature, the machine may be designed for extension only (Fig. 3).

The sole source of supply of the apparatus known to the committee at this time is Applied Test Systems Inc. and Ambard Inc. 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<sup>1</sup>, which you may attend.

**TABLE 1 Examples of Dimensions in Compression and Extension**

| Class  | Dimension                                 |   |
|--------|---|---|
|        | C—Width of Joint in Compression, in. (mm) | E—Width of Joint in Extension, in. (mm) |
| 12.5   | 0.438 (11.1)                              | 0.563 (14.3)                            |
| 25     | 0.375 (9.5)                               | 0.625 (15.9)                            |
| 35     | 0.325 (8.3)                               | 0.675 (17.1)                            |
| 50     | 0.250 (6.4)                               | 0.750 (19.1)                            |
| 50/100 | 0.250 (6.4)                               | 1.000 (25.4)                            |

Column C) and extend the specimen from 0.500 in. to the maximum extension desired (Table 1, Column E) at a constant rate of  $\frac{1}{8}$  in./h (3.2 mm/h). The machine shall be equipped with grips of sufficient strength to withstand, without bending, the resistance of high tensile strength sealants (see Figs. 1-3).

6.2 *Cold Box or Chamber*, maintained at  $-15 \pm 3^{\circ}\text{F}$  ( $-26.1 \pm 1.7^{\circ}\text{C}$ ).

6.3 *Forced-Draft Oven*, controlled at  $158 \pm 3.6^{\circ}\text{F}$  ( $70 \pm 2^{\circ}\text{C}$ ).

6.4 *C-clamps*, or other device for maintaining the specimen under compression.

6.5 *Spacer Blocks*.

6.6 *Room or Chamber*, maintained at standard conditions as noted in Terminology C717.

## 7. Test Specimens

7.1 The standard substrate used in the test shall be portland cement mortar, float glass, and aluminum alloy.

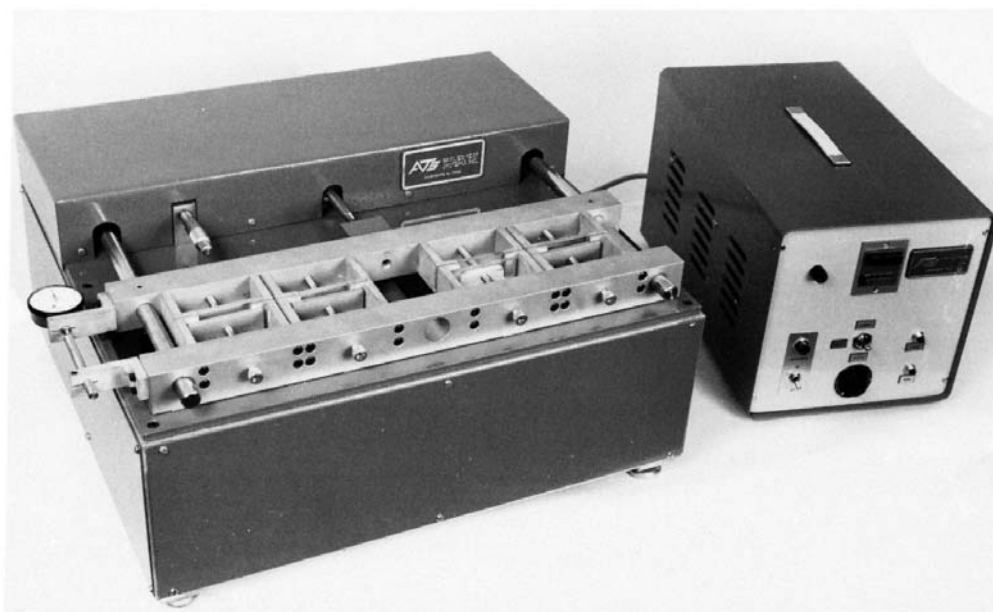
NOTE 1—When requested, only one or two of the standard materials may be tested with the sample. Likewise other substrates such as brick, marble, wood, etc., may be specified by the purchaser in place of or in addition to the standard substrate for test with the sealant sample.

7.1.1 *Mortar Block*— Prepare cement mortar blocks, each 3 by 1 by 1 in. (75 by 25 by 25 mm) in size, using one part of high early strength portland cement conforming to Type III of Specification C150 to two parts by weight of clean uniformly graded, concrete fine aggregate (sand) conforming to Specification C33. Use sufficient water to produce a flow of  $100 \pm 5\%$  when tested in accordance with the procedure for the determination of consistency of cement mortar described in Test Method C109/C109M. After curing one day in moist air and six days in saturated lime water at  $73 \pm 3^{\circ}\text{F}$  ( $23 \pm 2^{\circ}\text{C}$ ), prepare the surface of one face, 1 by 3 in. (25 by 75 mm), of each block by wet grinding either with a belt sander using No. 60 aluminum carbide sanding belt or using an iron lap with No. 60 silicon carbide (or aluminum oxide) grain until the aggregate is uniformly exposed. Return blocks to saturated lime water storage until needed.

7.1.1.1 Blocks may be prepared and shipped to other locations for use. The blocks may be shipped dry and shall be returned to lime water storage on arrival until needed.

7.1.1.2 Prior to use, wet grind the previously ground face to remove any laitance, rinse thoroughly under running tap water and dry the blocks overnight at  $220$  to  $230^{\circ}\text{F}$  ( $105$  to  $110^{\circ}\text{C}$ ). Clean the blocks of film or powder by vigorous brushing with a stiff-bristled fiber brush. Condition the blocks at standard conditions for not less than one day and not more than seven days.

7.1.2 *Float Glass*— Glass plates shall be 3 by 1 by  $\frac{1}{4}$  in. (76.2 by 25.4 by 6.4 mm) clear float glass. Prior to use, the glass shall be cleaned by wiping the surface with methyl ethyl ketone or similar solvent. Then dip the surface in a detergent solution. This should be a 0.04 % solution of an alcohol ethoxy



**FIG. 1 Compression-Extension Machine**

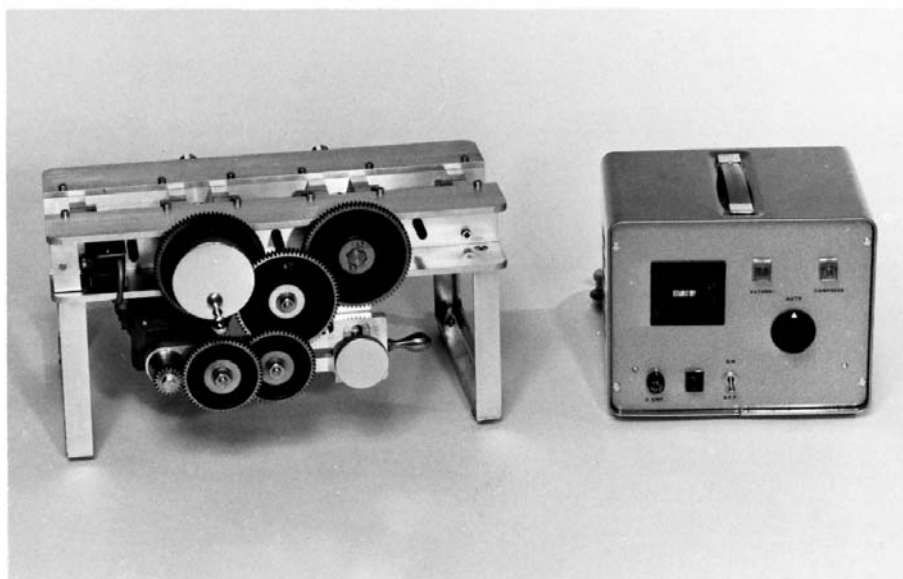


FIG. 2 Compression-Extension Machine with Control Unit

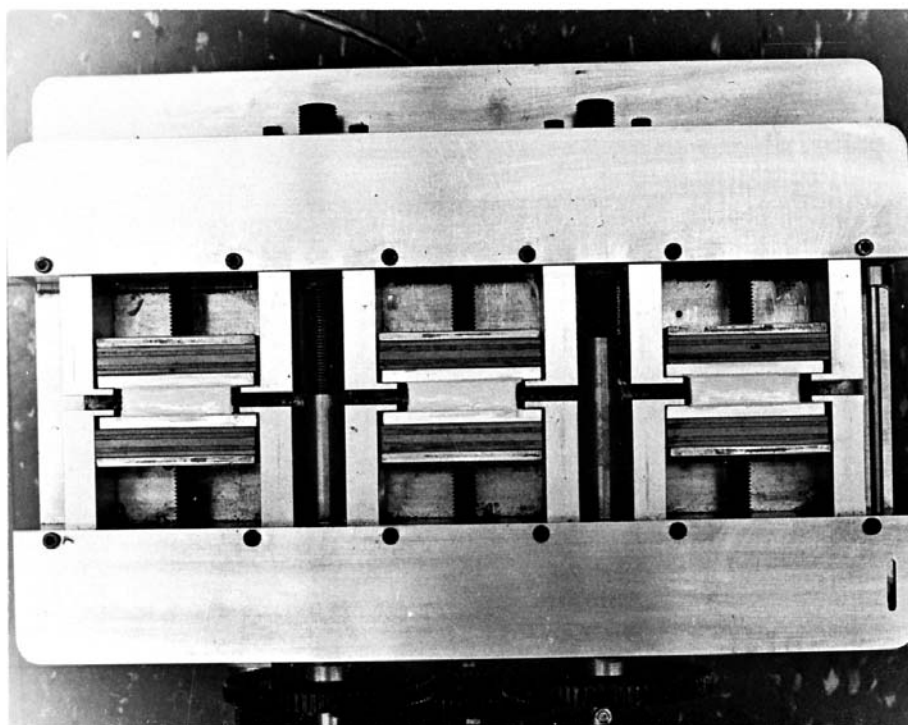


FIG. 3 Top View of Machine in Fig. 2 Showing Three Specimens Ready for Automatic Cycling

sulfate.<sup>6</sup> An alternative would be a 0.1 % solution of a clear hand dishwashing detergent.<sup>7</sup> These solutions should be made up in distilled or deionized water. Rinse the surface (without

<sup>6</sup> Neodol 25-35, a registered trademark of Shell Oil Co., One Shell Plaza, Houston, TX 77002, has been found suitable for this purpose.

<sup>7</sup> Dawn, a registered trademark of Proctor & Gamble Co., P.O. Box 599, Cincinnati, OH 54201, or Palmolive Green, a registered trademark of Colgate Palmolive Co., 300-T Park Ave., New York, NY 10022 have been found suitable for this purpose.

touching it) in distilled or deionized water and allow it to air dry. The float glass requires reinforcement to survive the rigors of the subsequent testing procedures. This must be done prior to the compression-extension cycling performed in 9.4. Reinforcement is provided by adhering 3 by 1 by ¼ in. (76.2 by 25.4 by 6.4 mm) aluminum plates to the two outside surfaces of the formed test specimen. Any adhesive may be used. Commercially available two part epoxies have been found suitable. Although the time of reinforcement is not critical,

application of the aluminum plates to the glass before preparing the test specimens has been found convenient.

a bead of sealant  $\frac{1}{2}$  by  $\frac{1}{2}$  by 2 in. (12.7 by 12.7 by 50.8 mm) between parallel 1 by 3-in. (25.4 by 76.2 mm) faces of similar

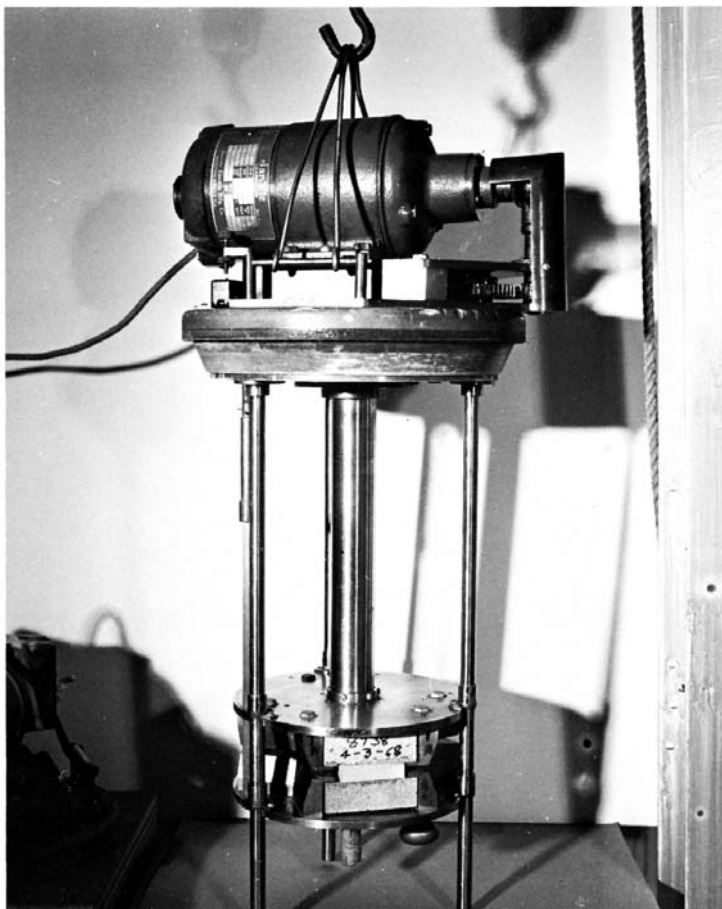


FIG. 4 A Motor-Driven Machine That Can be Used for Extension of Specimens at  $-15^{\circ}\text{F}$  ( $-26.11^{\circ}\text{C}$ )

**7.1.3 Aluminum**—The aluminum plates shall be 3 by 1 by  $\frac{1}{4}$  in. (76.2 by 25.4 by 6.4 mm) aluminum alloy, 6063-T5, or 6061-T6 with anodizing process AA-M10C22A31. Prior to use, the aluminum (and other metallic substrates, when specified) shall be cleaned as specified for float glass (7.1.2) (Notes 2 and 3).

NOTE 2—Methyl ethyl ketone and similar solvents are both toxic and flammable and should be handled with caution in a well ventilated hood.

NOTE 3—At the request of the sealant producer, the detergent cleaning step shall be omitted.

**7.2 Primers**—Where use of primer is recommended by the sealant manufacturer, substrate materials shall be primed with the recommended primer or primers.

### 7.3 Preparation of Test Specimens:

**7.3.1 Standard conditions** of temperature and relative humidity used throughout this test method are defined in Terminology C717.

**7.3.2 Multicomponent Sealants**—Prepare three test specimens for each substrate that is to be used in the test. After maintaining the unopened sample for at least 24 h at standard conditions, mix thoroughly for 5 min at least 250 g of base compound with the appropriate amount of curing agent. Apply

blocks or plates (Fig. 5(a), Fig. 5(b), and Fig. 5(c)). Use appropriate spacer blocks to form the proper size of the bead. Apply polyethylene adhesive tape or any other suitable inert release agent to the inside surfaces of the spacers to prevent adhesion of the spacers to the sealant after cure. Use adhesive tape, rubber bands, or clamps to hold the test assembly together before and after filling it with the compound. In the case of a pourable-type compound, use masking or any other suitable tape to retain the compound.

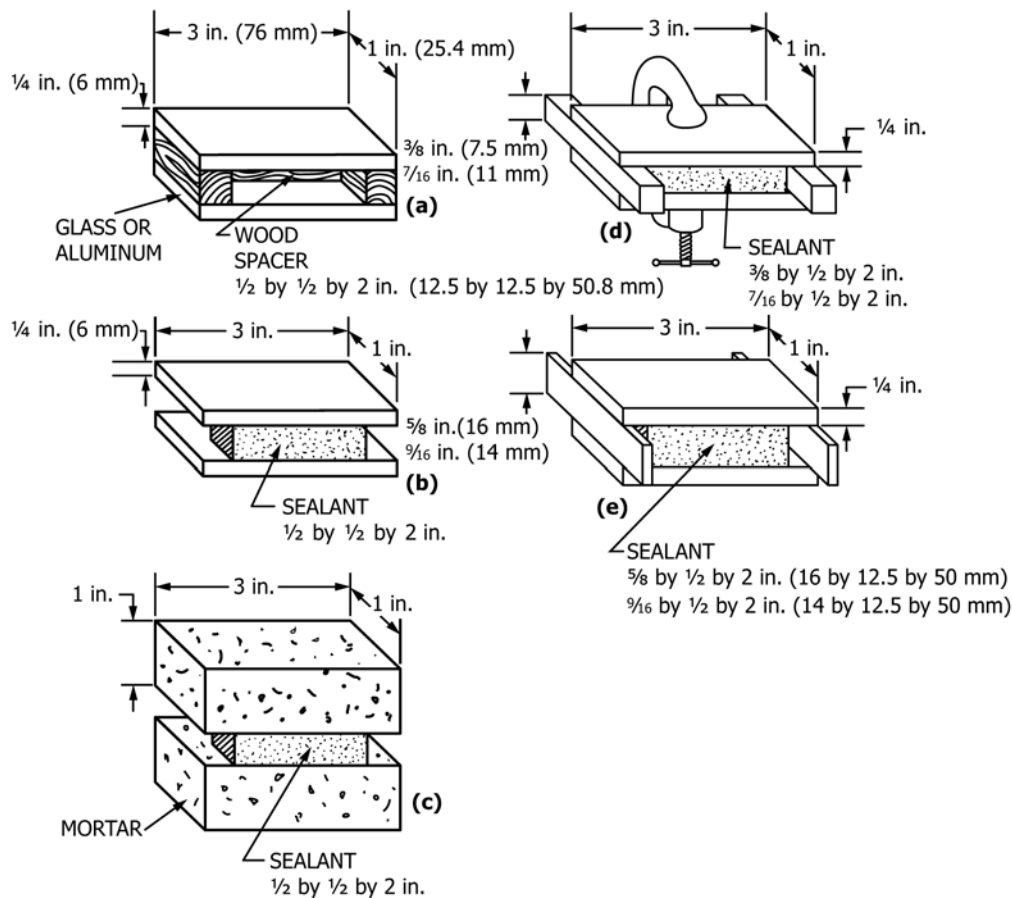
**7.3.3 Single-Component Sealants**—Prepare three test specimens as described in 7.3.2 except that no mixing of components is required. Condition the sealed cartridge or bulk container at standard conditions at least 24 h before use.

## 8. Conditioning

**8.1** Cure specimens made with multicomponent sealants for 14 days at standard conditions. During the second week of the curing period, make attempts to free the compound from the spacer blocks at the ends and bottom without damaging the sealant bead.

**8.2** Cure specimens made with single-component sealants for a total of 21 days as follows: (a) seven days at standard





Test specimens:

(a) Prepared specimen before placement of sealant, (b) Sealant with spacers removed, (c) Sealant between mortar blocks, (d) Sealant in the compressed state during heat treatment, (e) Sealant in the extended state.

FIG. 5 Test Specimen for Class 25 and Class 12.5 Sealants

conditions; (b) seven days at  $100 \pm 3.6^\circ\text{F}$  ( $37.8 \pm 2^\circ\text{C}$ ) and 95 % relative humidity; and (c) seven days at standard conditions (Note 4). Separate the spacer blocks from the sealant as soon as practical during the curing period without damaging the sealant.

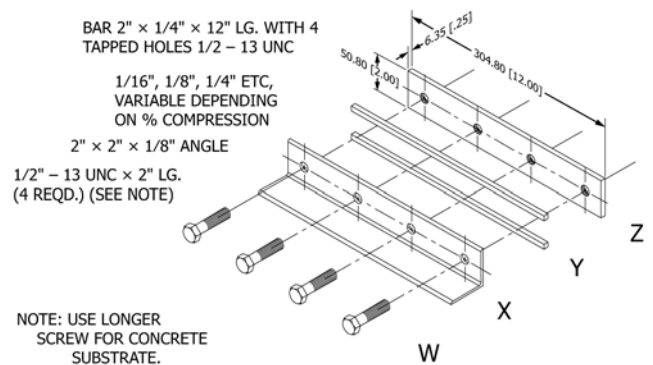
NOTE 4—The producer may request conditions other than those specified in 8.2 for the curing period of single-component sealants provided they meet the following requirements: (1) The curing period shall extend for 21 days; and (2) The temperature during the curing period shall not exceed  $122^\circ\text{F}$  ( $50^\circ\text{C}$ ).

## 9. Procedure

9.1 Immediately following the curing period allow the specimens to cool to standard temperature if higher temperature cure conditions were used. Remove spacers and proceed as follows:

9.2 Immerse the specimens in distilled or deionized water for seven days.

9.3 Following immersion, hand flex each specimen twice, about  $60^\circ$  to check the bond. If the bond is still firm, compress the specimens to the minimum desired dimension such as given under Column C, Table 1 (Dimension C) for the class under test. A c-clamp and spacer bars (Fig. 5(d)) or other adequate device may be used for compression. Fig. 6 shows an apparatus



NOTE: USE LONGER SCREW FOR CONCRETE SUBSTRATE.

NOTE 1—Use longer screw for concrete substrate.

FIG. 6 Oven Compression Apparatus

that has been suitable for the oven compression of the specimens. It is comprised of two steel members (X and Z) and bolts (W) that hold and compress the test specimens. The members may be 3 in. high for convenience and sufficiently long to accommodate multiple specimens. They should be lined with felt, cork, or other material to provide a cushioned surface. Two long rods (Y) of square cross section (Dimension C) are used to control the compression of the specimens. Where substrates of uneven dimensions are used, individual

spacers may be required. Place the compressed specimens in the 158°F (70°C) oven for seven days.

9.4 After the oven treatment, remove the clamps and allow the specimens to cool to standard temperature. Within 24 h of removal from the oven, place the specimens in the compression-extension machine. Subject the specimens to ten cycles of joint movement at standard conditions, as follows: (a) compression from the original ½-in. (12.7 mm) width to Dimension C, followed by (b) extension to Dimension E, and (c) compression again to ½ in. The rate of compression and extension shall be ⅛ in. (3.2 mm)/h.

9.5 At the completion of ten cycles, extend the width of the joint in the specimens by hand crank to Dimension E, insert spacer blocks, remove the specimens from the machine, and examine them for bond or cohesive failure Fig. 5(e)). Remove any specimens showing complete adhesive or cohesive separation at this stage.

9.6 Compress the width of the joint in the remaining specimens to Dimension C with a c-clamp and spacers or other suitable device and, while compressed, place them in the oven for 16 to 20 h at 158 ± 3.6°F (70 ± 2°C).

9.7 Remove the specimens from the oven. Allow them to cool for 2 to 3 h with the clamps and spacers removed to achieve standard temperature. Place them in the extension machine within the cold box or chamber maintained at -15 ± 3°F (-26.1 ± 1.7°C). With the specimen grips set at Dimension C wide and regardless of the amount of recovery of the sealant after compression, extend the joint width of the specimens to Dimension E at the rate of ⅛ in. (3.18 mm)/h, while they are being cooled down to -15 ± 3°F (26.1 ± 1.7°C). On completion of the extension, insert blocks, remove the specimens, and allow them to warm for 2 h with blocks in

place to achieve standard temperature. Examine the specimens for adhesive or cohesive failure and deformation.

9.8 Repeat the compression-extension cycles described in 9.6 and 9.7 for a total of ten cycles. If complete adhesive or cohesive failure occurs before the tenth cycle, the test is considered complete.

## 10. Report

10.1 Report the following information:

10.1.1 Name of the sealant producer, type of sealant and identifying number,

10.1.2 Percentage of cyclic movement,

10.1.3 Substrates used, and method of cleaning used on each substrate,

10.1.4 Name and description of primers used, if any,

10.1.5 Nature of test effects observed, such as amount of adhesive or cohesive failure, deformation, bubbles, or other characteristics,

10.1.6 Description of and reasons for any variations from the test procedure, and

10.1.7 Statement of time, temperature, and humidity used to achieve cure (describe the cure cycle).

## 11. Precision and Bias

11.1 Inadequate precision and bias data are presently available. The precision and bias of this test method is currently undergoing round-robin testing by members of Committee C24. Earlier round-robin testing of a similar procedure performed by members of the Adhesives and Sealants Council indicates the test method is capable of discriminating between a Class 12.5 and a Class 25 sealant.

## 12. Keywords

12.1 adhesion; cohesion; cyclic movement; elastomeric joint sealant; Hockman cycle

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