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AMERICAN SOCIETY FOR TESTING AND MATERIALS
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Standard Specification for Adhesives for Fastening Gypsum Wallboard to Wood Framing[1]

This standard is issued under the fixed designation C 557; 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 Department of Defense.

1. Scope

1.1 This specification covers minimum standards for adhesives intended for bonding the back surface of gypsum wallboard to wood framing members.

1.2 This specification also covers test requirements and test methods for the adhesive used for the application of all thicknesses of gypsum wallboard.

2. Referenced Documents

2.1 *ASTM Standards:*

C 36 Specification for Gypsum Wallboard[2]

D 828 Test Method for Tensile Properties of Paper and Paperboard Using Constant-Rate-of-Elongation Apparatus[3]

D 907 Terminology of Adhesives[4]

D 1779 Specification for Adhesive for Acoustical Materials[4]

D 4338 Test Method for Flexibility Determination of Supported Adhesive Films by Mandrel Bend Test Method[4]

3. Terminology

3.1 *Definitions*—Many terms in this specification are defined in Terminology D 907.

3.1.1 *gap-filling adhesive, n*—an adhesive capable of forming and maintaining a bond between surfaces that are not close-fitting.

3.1.1.1 *Discussion*—Close-fitting is relative to a given material and industry; for example, standards in construction differ from standards in electronics. Some adhesives will bond by bridging without completely filling the gap; others by filling the gap completely.

3.1.2 *shear strength, n—in adhesive joint*, the maximum average stress when a force is applied parallel to the joint.

3.1.2.1 *Discussion*—In most adhesive test methods, the shear strength is actually the maximum average stress at failure of the specimen, not necessarily the true maximum stress in the material.

3.1.3 *tensile strength, n—in an adhesive joint*, the maximum average stress when a force is applied perpendicular to the joint.

3.1.3.1 *Discussion*—In most adhesive test methods, the tensile strength is actually the maximum average stress at failure of the specimen, not necessarily the true maximum stress in the material.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *lot, n*—material from the same batch or blending operation that was processed in accordance with standard manufacturing conditions.

4. Significance and Use

4.1 The specification applies to organic adhesives for bonding the back surface of gypsum wallboard of any thickness to wood-framing members.

4.2 This specification provides a basis for ensuring the quality of the adhesives.

4.3 Although the bonds rendered by these adhesives shall have enough strength by themselves to maintain the bond between adherends, they are not intended as a substitute for the common practice of using mechanical fasteners to maximize integrity of drywall-wood-framing structures.

5. Adhesive Physical Property Requirements

5.1 *Adhesives*—The adhesives shall be uniform, homogeneous mixtures of elastomeric polymers or viscoelastic resins, or both, free of lumps or foreign matter.

5.1.1 *Workability*—When applied to the framing member with a caulking gun or notched trowel, or both, in accordance with the manufacturer's instructions, the adhesive shall exhibit a consistency capable of ensuring non-sagging properties.

5.1.2 *Open Time*—The adhesive shall have an open assembly time of between 10 to 20 min to give the user sufficient time to apply and, if necessary, reposition the wallboard at ambient temperatures, ranging from 40 to 100°F (4 to 38°C).

5.1.3 *Storage Life*—The adhesive shall remain serviceable and meet all the requirements of this specification for not less than six months after delivery, when stored in original unopened containers at temperatures ranging from 40 to 85°F (4 to 30°C).

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[1] This specification is under the jurisdiction of ASTM Committee D-14 on Adhesives and is the direct responsibility of Subcommittee D14.70 on Construction Adhesives.

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[2] *Annual Book of ASTM Standards*, Vol 04.01.

[3] *Annual Book of ASTM Standards*, Vol 15.09.

[4] *Annual Book of ASTM Standards*, Vol 15.06.

6. Adhesive Performance Property Requirements

6.1 The adhesives shall conform to the requirements summarized in Table 1.

7. Sampling

7.1 Sample each selected lot of adhesives in accordance with Specification D 1779.

8. Materials for Conducting Tests

8.1 *Gypsum Wallboard*—½-in. (12.7 mm) thick, complying with Specification C 36; the dimensions are specified in each test.

8.2 *Douglas Fir Plywood*—¾-in. (19.0 mm) thick plywood-grade PSI Exterior A-A or A-B; the dimensions are specified in each test.

8.3 *Douglas Fir Plywood*—¼-in. (6.3 mm) thick plywood grade PSI Exterior A-A or A-B; the dimensions are specified in each test.

8.4 *Douglas Fir Lumber*—1½ by 1½ by 3½in. (38.0 by 38.0 by 89.0 mm) in cross section; No. 1 straight-grained, and knot-free; the dimensions are specified in each test.

8.5 *Polyvinyl Acetate Adhesive*—Any commercially available product.

8.6 *Steel Plates*—¼-in. thick steel with two ¼-in. diameter threaded holes; the dimensions are specified in the shear-strength test method.

8.7 *Turn Key* ¼-in. Diameter Threaded Bolts—With hex nuts; dimensions are specified in each test.

8.8 *Garnet Paper*—No. 120 grit, 3/0.

8.9 *Spacers*—No. 20 gage (American Standard or B&S) bronze or brass wire 1⁄32-in. (0.8-mm) diameter.

8.10 *Trowels*—Plastic or metal with 3⁄16-in. (4.76 mm) deep V-notches.

8.11 *Overlapping Steel Collar*—Two 2 by 1 in. (51.0 by 25.4 mm) U-channels welded to a 1⁄16-in. (1.6-mm) thick galvanized-steel frame and assembled with a flathead screw, two washers, and a nut.

8.12 *Wood Shim*—¾-in. (19.0 mm) thick plywood with dimensions of 4 by 1¼-in. (102.0 by 89.0 mm) with two ¼-in (6.3 mm) diameter drilled holes.

8.13 *T-bar Steel Pin*—4½ by ⅜ in. (114.0 by 9.5 mm) for insertion into perforated tensile wood block.

8.14 *Aluminum Tensile Test Jig*—4 by 1⅝ in. (102.0 by 41.0 mm) T-bar perforated aluminum fixture with 1-in. (25.4 mm) long and ¼-in. (6.3 mm) diameter screw and hex nut for insertion of looped steel cable with a collar (Fig. 1).

9. Conditioning of Materials and Specimens

9.1 Condition the Douglas fir, lumber, plywood, and wallboard to a constant weight at 73 ± 2°F (23 ± 1°C) and 50 ± 5 % relative humidity, unless specified otherwise.

9.2 Subject all test assemblies and adhesives to be evaluated to standard conditioning (24 h at 73 ± 2°F (23 ± 1°C) and 50 ± 5 % relative humidity) unless specified otherwise.

10. Test Methods

10.1 *Shear Strength (Rate-of-Shear Strength Development)*:

10.1.1 *Preparation of Wallboard-Plywood Laminates*—Prepare each test assembly individually from plywood and a wallboard-plywood laminate. Each laminate is made by bonding a piece of 4 by 3½ by ½ in. (102.0 by 89.0 by 12.7 mm) wallboard to a ¾-in. thick (19.0 mm) plywood piece of the same dimensions with a commercially available PVA adhesive. The grain of the wallboard facing paper shall run lengthwise in the 3½-in. (89.0) direction. After conditioning the precut ¾-in. (19.0 mm) plywood pieces and wallboard-plywood laminates as indicated in 9.2, drill at the extremities of each two ¼in. (6.3-mm) diameter holes as shown in Fig. 2. The distance of these holes from the pertinent edges is approximately 1.0 in. (25.4 mm).

10.1.2 *Preparation of Test Assembly*—Prepare the test assembly by bonding a 4 by 3½ by ¾in. (102.0 by 89.0 by 19.0 mm) piece of the described plywood to the previously prepared laminate as follows:

10.1.2.1 Sand the face of the ¾-in. (19.0-mm) thick plywood smooth with garnet paper and wipe the sanded surface free of dust.

10.1.2.2 Spread the adhesive on the sanded surface with a trowel having 3⁄16-in. (4.8-mm) deep V-notches so that the adhesive ridges are parallel to the grain of wood. The trowel

TABLE 1 Adhesive Properties and Performance Requirements

Test Method	Reference Number	Property	Condition	Requirements
Rate of shear strength	10.1.4	shear strength	24 h at RT	10 psi (69 kPa) min
	10.1.5	shear strength	14 days at RT	40 psi (276 kPa) min
	10.1.6	shear strength	14 days at RT, + cyclic lab exposure, + 2 days at RT	32 psi (220 kPa) min
	10.1.7	shear strength	(a) 40 lb (178 N) for 24 h at RT	no bond separation
			(b) 20 lb (89 N) for 24 h at 100°F	no bond separation
Rate of strength development	10.2.3	tensile strength	24 h at RT	15 psi (103 kPa) min
	10.2.4	tensile strength	14 days at RT	25 psi (172 kPa) min
Adhesive open-time determination	10.3	open-time	24 h at RT	75 % paper transfer, min
Substrate wet-out by adhesive				
1. Plywood	10.4.1	wet-out	spatula applied	good wetting property
2. Wallboard	10.4.2	wet-out	spatula applied	good wetting property
Bridging	10.5	gap filling	48 h at RT	continuous (adhesive) bond line
Adhesive aging	10.6	accelerated aging	500 h at 158°F	no cracking or chipping
			3 cycles of:	
Freeze-thaw stability	10.7	low-temperature storage	24 h at 0°F + 24 h at RT	no change in workability; 10 psi (69 kPa) shear strength, min
Suitability as a laminating adhesive for vinyl-covered wallboard	10.8.1	compatibility	24 h at 100°F	no blistering, vinyl-film discoloration, or bond failure
	10.8.2	staining	1 h at RT	no swelling or discoloration

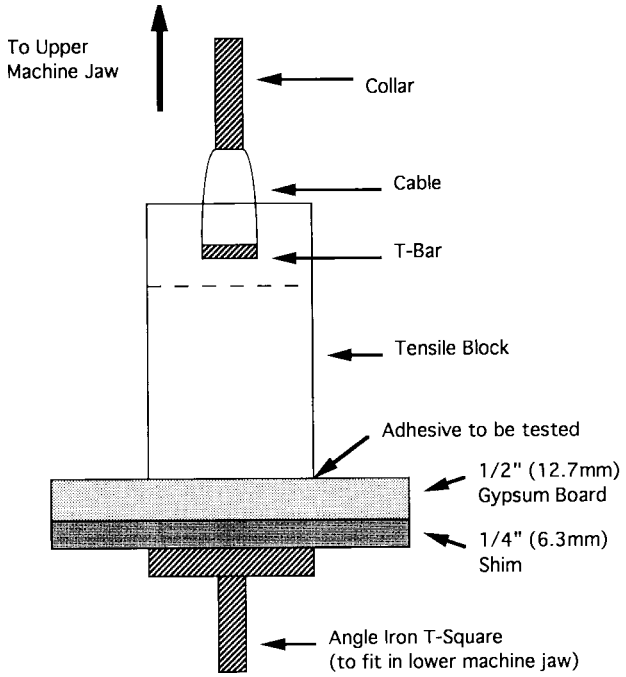

FIG. 1 Tensile Strength Test Specimen Assembly

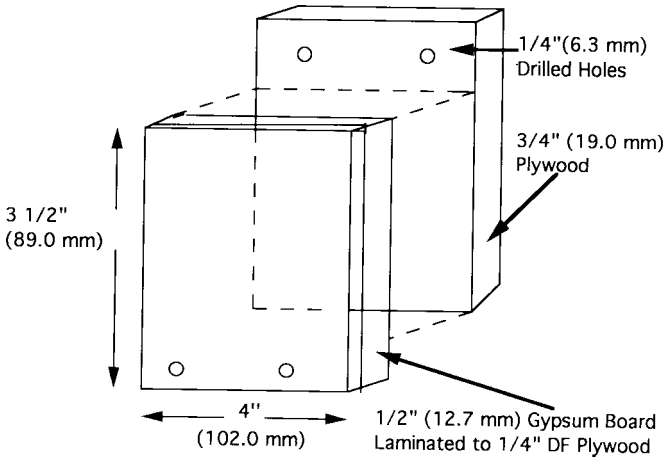

FIG. 2 Predrilled Test Specimens Prior to Assembly

shall be held during application as close as possible to a 90° angle to the sanded wood surface to ensure the deposition of a ridge of adhesive.

10.1.2.3 Allow an open time of 30 s upon completion of spreading.

10.1.2.4 Squarely position the wallboard-plywood laminate on the coated plywood overlapping exactly 2½ in. (63.5 mm), thus forming the 10 in.^{2}(64.5 cm^2) bonded area.

10.1.2.5 Insert six wire spacers No. 20 gage at least 2-in. (51.0-mm) long in the joint exactly 1-in. (25.4 mm). Position the spacers so that one is on the center line of the bonded area (perpendicular to the ridges), and the others are 1 in. (25.4 mm) away from the center spacers and parallel to it.

10.1.2.6 Immediately following assembly, compress each specimen (test assembly) under a uniformly distributed load of 15 lb (67 N) for a period of 3 min.

10.1.2.7 After the 3-min period, remove the load, wipe the excess adhesive from the bonded edges with a square-edged spatula, and withdraw the spacers, taking care not to disturb the alignment of the bonded pieces.

10.1.3 *Shear Strength Determination*—After selecting the appropriate conditioning or aging cycle, or both, join each test assembly with two ¼-in. (6.3 mm) steel plates of identical size and perforations. These supporting steel plates are snugly fitted to the test assembly by means of protruding turn-key bolts and hex nuts, and are subsequently attached to the upper and lower machine jaws as illustrated in Fig. 3. Determine the shear strength at a loading rate of 0.5-in. (12.7 mm)/min. When inserting the test assemblies in the testing machine, adjust if necessary with shims to ensure that the stress applied is parallel to the joint.

10.1.4 *Shear Strength After 24 h*:

10.1.4.1 Prepare five test assemblies using the procedure outlined in 10.1.1 to 10.1.2.

10.1.4.2 After aging the assemblies 24 h at standard conditions, determine the shear strength in accordance with 10.1.3.

10.1.5 *Shear Strength After 14 Days*:

10.1.5.1 Prepare five test assemblies using the procedure outlined in 10.1.1 to 10.1.2.

10.1.5.2 After aging the assemblies 14 days at standard conditions, determine the shear strength in accordance with 10.1.3.

10.1.6 *Shear Strength After Cyclic Exposure*:

10.1.6.1 Prepare five test assemblies using the procedure outlined in 10.1.1 to 10.1.2.

10.1.6.2 After aging the assemblies 14 days at standard conditions, process the assemblies through four complete cycles (Table 2). Store the assemblies at standard conditions for 24 h after each cycle.

10.1.6.3 At the end of the cycling, determine the shear strength in accordance with 10.1.3.

10.1.7 *Shear Strength for Static Load*:

10.1.7.1 Prepare ten assemblies using the procedure outlined in 10.1.1 to 10.1.2.

10.1.7.2 Condition the assemblies 14 days at standard conditions.

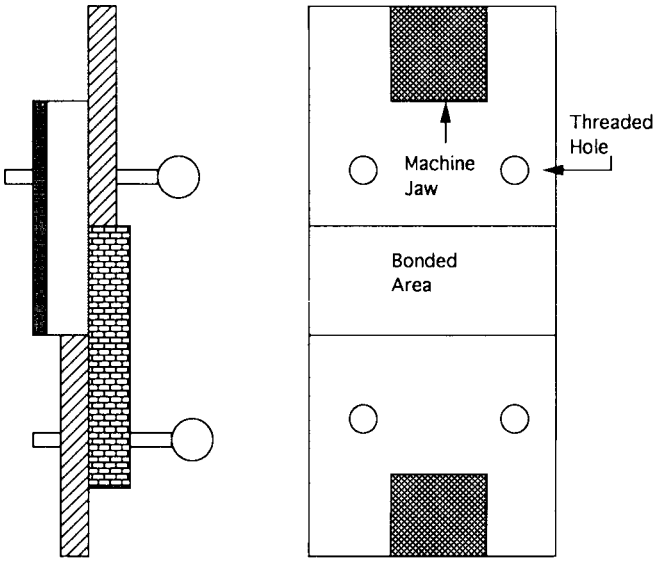

FIG. 3 Shear Strength Test Specimen Assembly

TABLE 2 Cyclic-Exposure Conditioning for Shear-Test Assemblies (See 10.1.6)

NOTE 1—Four complete aging cycles to be used.
NOTE 2—Room temperature storage required over weekends.

Time, h	Temperature °F (°C)	Relative Humidity, %
4	100.0 (38.0)	85 ± 2
4	40.0 (4.5)	uncontrolled
16	122.0 (50.0)	uncontrolled

10.1.7.3 Subject five test assemblies to a static load of 40 lb (178 N) at 73 ± 2°F (23 ± 1°C) and five assemblies to 20 lbs (89 N) at 38 ± 1°C (100.2 ± 2.0°F) for a period of 24 h. When testing, clamp the top (wallboard/plywood) of the assembly to a rigid frame and attach the load to the bottom (plywood), making sure that perfect alignment of the suspended assembly and the loads is achieved.

10.1.7.4 At the end of the 24-h period, examine the assembly for bond separation. Such separation shall be regarded as a failure.

10.2 *Tensile Strength (Rate of Strength Development)*:

10.2.1 *Preparation of Test Assemblies*—Prepare each tensile-test assembly as follows:

10.2.1.1 Condition the ½-in. (12.7-mm) thick wallboard, the wooden shims, and 1½ by 1½ by 3½ in. (38.0 by 38.0 by 89.0 mm) Douglas fir lumber to standard conditions. Bond the wooden shim to the wallboard using a commercially available PVA adhesive. Cut in the center top of each block a ¼-in. (6.3-mm) wide and ¾-in. (19.0-mm) deep groove. Drill a ¼-in. (6.3-mm) thick diameter hole a distance of ½-in. (12.7 mm) from the top, perpendicular to the ¾-in. (19.0-mm) groove.

10.2.1.2 Bond the back surface of a piece of ½ by 4 by 4 in. (12.7 by 102.0 by 102.0 mm) wallboard to one of the wood blocks by applying to the bottom by a trowel sufficient adhesive to cause uniform squeeze-out of excess adhesive on all sides when the bond area is compressed to a line thickness of approximately 1/32 in. (0.8 mm).

10.2.1.3 Insert and position two wire spacers of No. 20 gage at least 2-in. (51.0-mm) long into the bonded area with the spacers positioned ¼-in. (6.3 mm) from each edge of the wood block.

10.2.1.4 Compress each assembly immediately under a load of 5 lb (22 N) for 3 min.

10.2.1.5 Scrape all excess adhesive away from edges using a square-tipped spatula. Remove the weight and next the spacers, taking care to avoid disturbing the alignment.

10.2.1.6 Prior to testing, lower the free-cable loop of the aluminum test jig into the block's precut groove and insert a ⅜-in. (9.5-mm) diameter T-bar pin laterally through the predrilled holes just above the cable's loop, as shown in Fig. 1.

10.2.2 *Tensile-Strength Determination*—Determine the tensile strength of the adhesive on a testing machine capable of providing loading at a rate of 60 lb (267 N)/min.

10.2.3 *Tensile Strength After 24 h*:

10.2.3.1 Prepare five test assemblies using the procedure outlined in 10.2.1.

10.2.3.2 After aging the assemblies 24 h at standard conditions, determine the tensile strength in accordance with 10.2.2.

10.2.4 *Tensile Strength After 14 Days*:

10.2.4.1 Prepare five test assemblies using the procedure outlined in 10.2.1. In this test, use plywood for wallboard. The plywood shall be prepared as outlined in 10.1.2.1.

10.2.4.2 After aging the assemblies 14 days at standard conditions, determine the tensile strength in accordance with 10.2.2.

10.3 *Adhesive Open-Time Determination*:

10.3.1 *Wallboard*—Prepare five assemblies as follows:

10.3.1.1 Using a suitable template (Fig. 4), spread a uniform bead of adhesive ⅜in. (9.5 mm) by ⅜ in. (9.5 mm) at least 2 in. (51.0 mm) long on the back surface of a 2 by 2 in. (51.0 by 51.0 mm) piece of wallboard that has been conditioned for 24 h at standard conditions.

10.3.1.2 After conditioning the assembly for 30 min at standard conditions, position a 2 by 2 in. (51.0 by 51.0 mm) piece of wallboard centrally over the bead. Immediately place a 5-lb (2.3-kg) weight on the assembly. Remove the weight after 30 min.

10.3.1.3 After a period of 24 h under standard conditions, pull the assembly apart.

10.3.1.4 Examine the assembly after testing for percent of transfer and paper failure. Report the average for the five assemblies.

10.4 *Substrate Wet-Out by Adhesive*:

10.4.1 *Plywood*—Prepare five assemblies as follows:

10.4.1.1 Using a spatula, place a small amount of adhesive on the surface of the Douglas fir plywood, grade PSI Exterior A-A or A-B, which has been conditioned 48 h at 73 ± 2°F (23 ±1°C) and 50 ± 2 % relative humidity. By reversing the pressure of the spatula, lift the adhesive from the surface.

10.4.1.2 Examine the surface of the plywood and the spatula to determine whether the failure is adhesive or cohesive. The adhesive is considered to have wetted the plywood if the failure is cohesive.

10.4.2 *Wallboard*—Prepare five assemblies as follows:

10.4.2.1 Using a spatula, place a small amount of adhesive on the surface of the wallboard which has been conditioned 48 h at 73 ± 2°F (23 ± 1°C) and 50 ± 2 % relative humidity. By reversing the pressure of the spatula, lift the adhesive from the surface.

10.4.2.2 Examine the surface of the wallboard and the spatula to determine whether the failure is adhesive or cohesive. The adhesive is considered to have wetted the wallboard if the failure is cohesive.

10.5 *Gap-Filling (Bridging Characteristics)*:

10.5.1 Construct a test frame 34 by 48 in. (864.0 by 1219.0 mm) as shown in Fig. 4 using 2 by 4 in. (51.0 by 102.0 mm) Douglas fir lumber. Nail a stud 16 in. (406.0 mm) on center between the two outer studs, but recessed ¼-in. (6.3 mm). By

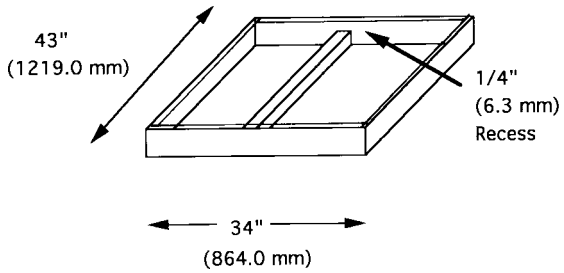

FIG. 4 Test Stud Frame

using a level, make sure the frame is perfectly flat. Condition the frame for 48 h at standard conditions (73 ± 2°F (23 ± 1°C) and 50 ± 2 % relative humidity).

10.5.2 Using a caulking gun and a suitable template (Fig. 5) spread a uniform ⅜by ⅜ in. (9.5 by 9.5 mm) bead of adhesive along the length of the center recessed stud. After 15 min, nail a ½-in. (12.7 mm) thick piece of wallboard 34 by 48 in. (864.0 by 1219.0 mm) to the outside longitudinal studs using 10-in. (254.0-mm) nail spacing. Firmly press the wallboard over the center recessed stud to ensure maximum deflecting and next allow the wallboard to spring back to its original position. Condition the test frame 48 h under standard conditions.

10.5.3 Remove the nails from the outside studs. Grasp one edge of the wallboard at points adjacent to each side of the recessed stud and pull outwardly at 90° to the stud. Examine the back of the wallboard and the stud and note the adhesive's gap-filling or bridging characteristics. A passing result shall give a continuous adhesive bond line if a cross-section was taken of the assembly.

10.6 *Accelerated Adhesive Aging (Oven Test)*:

10.6.1 Using Test Method D 4338 as a guide, cast a 12 ± 2 mil dry adhesive layer on a 2 by 6 in. (51.0 by 152.0 mm) strip of 1/32-in. (0.8-mm) aluminum panel with a blade. Place the specimen into a 150°F-(70°C) oven (humidity uncontrolled) for 500 h.

10.6.2 Allow the specimen to cool for 1 h at room temperature. Then slowly bend the specimen around a 1-in. (25.4-mm) steel mandrel with the adhesive side out. The specimen shall be free of cracks and show no sign of chipping away of the adhesive from the substrate.

10.7 *Freeze-Thaw Stability*:

10.7.1 Place 4 oz (118.0 mL) of adhesive in an 8-oz (236.0-mL) container, close the container tightly and store it at 0 ± 5°F (−17.8 ± 2.8°C) for 24 h and then store it at standard conditions for another 24 h.

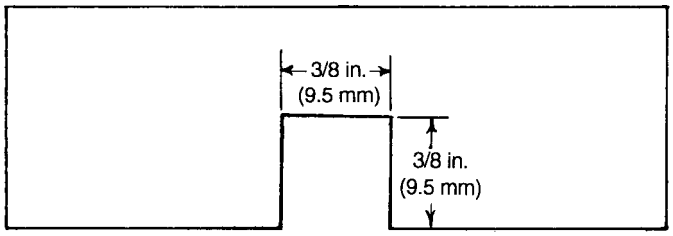

FIG. 5 Description of a Suitable Template for Uniform Bead Application

10.7.2 After three cycles, test the samples in accordance with 10.1.4.

10.8 *Suitability as a Laminating Adhesive for Vinyl-Covered Wallboard*:

10.8.1 *Vinyl-Covered Gypsum Wallboard Compatibility*:

10.8.1.1 Place 6 oz (177.0 mL) of adhesive into a clean, dry, open, 1 pt (0.5 L) tin-lined can. Place the can into a 1 gal (3.8 L) container. Seal a piece of vinyl-covered wallboard face-up on top of the gallon container using water-impervious duct tape. Place the assembly into an oven at 110°F (43°C) for 24 h.

10.8.1.2 Remove the assembly and the vinyl-covered wallboard and evaluate for blistering, vinyl film discoloration, and bond failure.

10.8.2 *Staining*:

10.8.2.1 In two areas, apply with a caulking gun two dabs of adhesive approximately 2 in. (51.0 mm) in diameter to the face surface of the vinyl-covered wallboard. Following manufacturer's recommendations, clean both areas 1 h after application of the adhesive to the vinyl surface.

10.8.2.2 Evaluate the sample for swelling or discoloration.

11. Packaging and Marking

11.1 *Packaging*—The adhesive shall be packaged in standard commercial containers. The containers shall be so constructed as to ensure acceptance by common or other carriers for safe transportation at the lowest rate to the point of delivery, unless otherwise specified in the contract or order.

11.2 *Marking*—Shipping containers shall be marked with the name of the adhesive, the quantity contained therein, the name of the manufacturer, and the batch number.

12. Report

12.1 Report the following information:

12.1.1 Complete identification of the material tested, including form, type, source, manufacturer's code number, etc.

12.1.2 Complete listing of the results in accordance with Table 1.

13. Keywords

13.1 adhesive; gap-filling; gypsum wallboard; shear strength; tensile strength; vinyl; workability.