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AMERICAN SOCIETY FOR TESTING AND MATERIALS
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Standard Test Method for Bond Strength of Thermoplastic Traffic Marking Materials[1]

This standard is issued under the fixed designation D 4796; 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 This test method provides an instrumental means for the determination of thermoplastic traffic marking material bond strengths using cement bricks and steel cubes.

1.2 The values stated in inch-pound units are to be regarded as the standard. The values given in parentheses are for information only.

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:*

C 109 Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. or 50-mm Cube Specimens)[2]

C 881 Specification for Epoxy-Resin-Base Bonding Systems for Concrete[3]

D 883 Terminology Relating to Plastics[4]

E 284 Terminology of Appearance[5]

F 412 Terminology Relating to Plastic Piping Systems[6]

3. Terminology

3.1 *Definitions*—Definitions are in accordance with Terminology D 883, E 284, and F 412, unless otherwise indicated.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *cement brick*—a brick formed by mixing cement and fine sand together and allowing to harden.

3.2.2 *thermoplastic*—traffic marking (same as 3.2.3).

3.2.3 *thermoplastic traffic marking*—a highly filled 100 % total solids highway marking system that when heated to a molten state can be extruded or sprayed onto a road surface and when cooled forms a solid durable delineator.

4. Summary of Test Method

4.1 The thermoplastic specimen is prepared for this test by first melting a sample to its application temperature under continuous agitation. The specimen is then applied to the specified cement brick by a hot drawdown blade. Two steel cubes are then immediately placed onto the hot thermoplastic line and the excess thermoplastic trimmed away from around the two steel cubes. After the trimming is complete, the steel cubes are removed. A heated steel cube is bonded with epoxy to the square of thermoplastic and allowed to cure overnight before determining the bond strength on a Dillon dynamometer or similar device.

5. Significance and Use

5.1 The function of this test method is to provide numerical instrumental results indicating the cohesive or adhesive, or both, bond strength of thermoplastic traffic marking to a specified cement brick substrate.

5.2 The use of this test method allows the user and manufacturer to control the quality of the product and make inferences about the performance of the thermoplastic traffic marking product. Results from these tests also provide information helpful in researching and developing thermoplastic traffic marking materials.

5.3 Strict adherence to the procedures outlined is necessary for precision of the test method. Under no conditions should the bond strength be accepted unless there is conformance to 9.14. Precise results are obtained only when one steel block is epoxied to the thermoplastic traffic marking on the cement brick.

6. Types of Separation in Bond Strength Tests

6.1 *Thermoplastic to Steel Cube Separation*—This type of separation occurs where there is an insufficient bond between the thermoplastic and steel cube probably due to insufficient coverage of the epoxy adhesive.

6.2 *Thermoplastic to Thermoplastic Separation*—This type of separation is caused by internal cohesive failure of the thermoplastic. This separation is acceptable when it exceeds the specified bond strength.

6.3 *Thermoplastic to Cement Brick Separation*—This type of separation is caused by the failure of the bond between the thermoplastic specimen and the cement brick.

6.4 *Cement Brick to Cement Brick*—This type of separation is caused by the internal cohesive failure of the brick. This is due, in most cases, to a bond between the thermoplastic and cement brick that exceeds the cohesive strength of the cement

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[1] This test method is under the jurisdiction of ASTM Committee D-1 on Paint and Related Coatings, Materials, and Applications and is the direct responsibility of Subcommittee D01.44 on Traffic Coatings.

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

[3] *Annual Book of ASTM Standards*, Vol 04.02.

[4] *Annual Book of ASTM Standards*, Vol 08.01.

[5] *Annual Book of ASTM Standards*, Vol 06.01.

[6] *Annual Book of ASTM Standards*, Vol 08.04.

brick. This separation is not acceptable when the bond strength values are lower than specified.

7. Apparatus

7.1 *Agitator Blade*, 6 in. (150 mm) long with a ½-in. (10 mm) steel shaft and a 1¾ by 1 in. by ⅛-in. (45 by 25 by 3 mm) straight horizontal steel blade.

7.2 *Capped Bolts*, two, ⅝ in. (16 mm) in size.

7.3 *Cement Bricks*, 3½ by 2 by 7½-in. (9 by 5 by 19 cm) in size with a compressive strength of 3000 to 5000 psi (Note 1).

NOTE 1—Concrete bricks conforming to Test Method C 109 have been used but proved more variable due to migration of a thin veneer of cement to the top of the brick making determinations erratic. The cement bricks may be obtained from local block plants. The term "cement" brick is common for the industry and is used in this test method extensively.

NOTE 2—The unit should be fitted with a steel frame to hold the cement brick for testing.

7.4 *Dynamometer*, [7] with a capacity of 6000 lbs in 25-lb (2700 kg in 10 kg) divisions having a pull-rate capability of ¼in./min. (6 mm/min) (Note 2) (See Fig. 1, Fig. 2, Fig. 3, and Fig. 4).

7.5 *Draw Down Blade*, 2 by 1 by 4 in. (5 by 2.5 by 10 cm) in size capable of laying down a 125 mil (0.125 in.) wet thermoplastic film 2-in. wide.

7.6 *Drill Press*, or other apparatus capable of agitating the thermoplastic during meltdown to the application temperature at 600 to 800 r/min in the jacketed electric pots.

7.7 *Epoxy Resin and Hardener*, Type I or II, Grade 2, Class C in accordance with Specification C 881.

7.8 *Hot Plate*, capable of maintaining 537°C.

7.9 *Gravity Convection Oven*, capable of maintaining 260°C.

7.10 *Electric Pots, Jacketed*, for heating and melting the thermoplastic to 218°C.

[7] The sole source of supply of a Dillon Dynamometer known to the committee at this time is Weigh–Tranex, 1000 Armstrong Drive, P.O. Box 1000, Fairmount, MN 56031. If you are aware of alternative suppliers, please provide this information to ASTM Headquarters. Your comments will receive careful consideration at a meeting of the responsible technical cmmittee,[1] which you may attend.

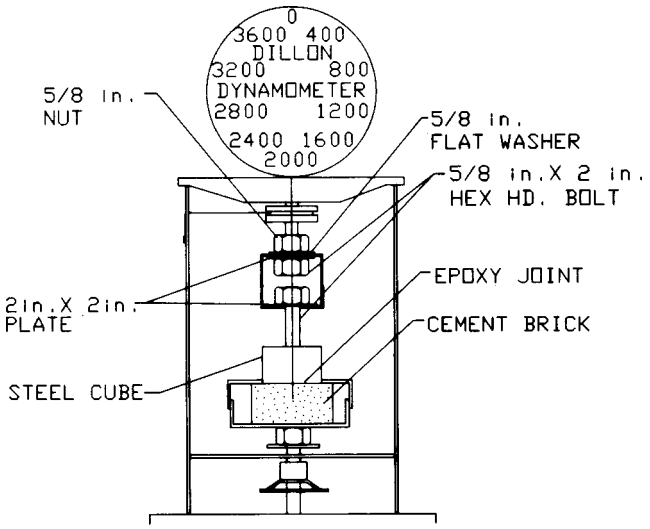


FIG. 1 Bond Strength Testing Apparatus

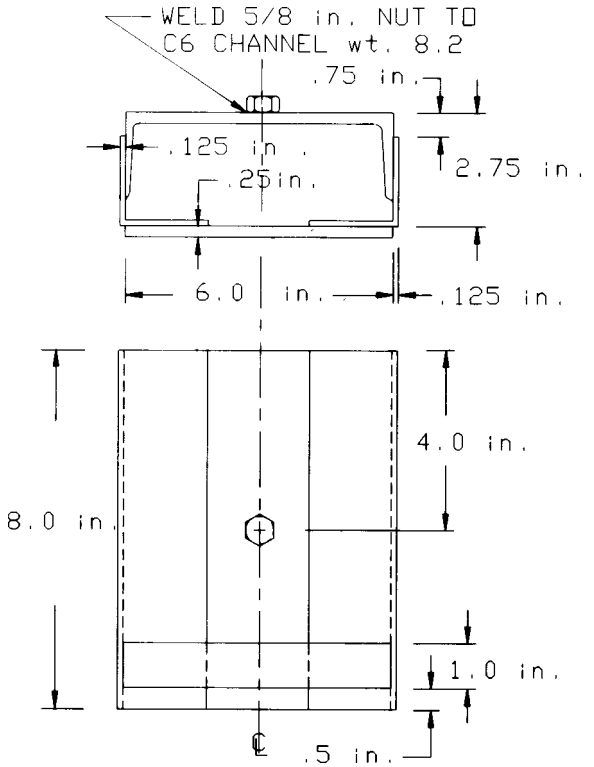
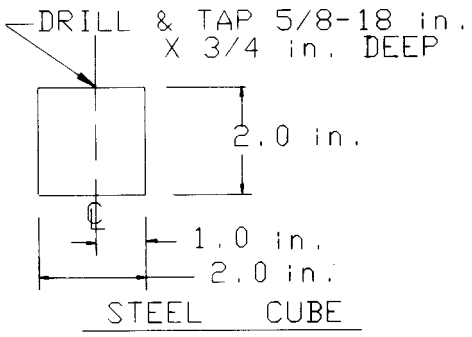


FIG. 2 Tension Bed



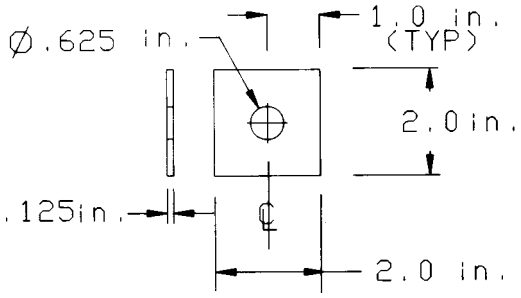


FIG. 3 Load Plate (2 Required)

7.11 *Spatulas*, for cutting, stirring, and shaping the thermoplastic.

7.12 *Steel Cubes, two*, 2 by 2 by 2 in. (50 by 50 by 50 mm) in size threaded in the center of one side for a ⅝-in. (16-mm) capped bolt.

8. Sampling

8.1 Samples may be obtained by an appropriate quartering

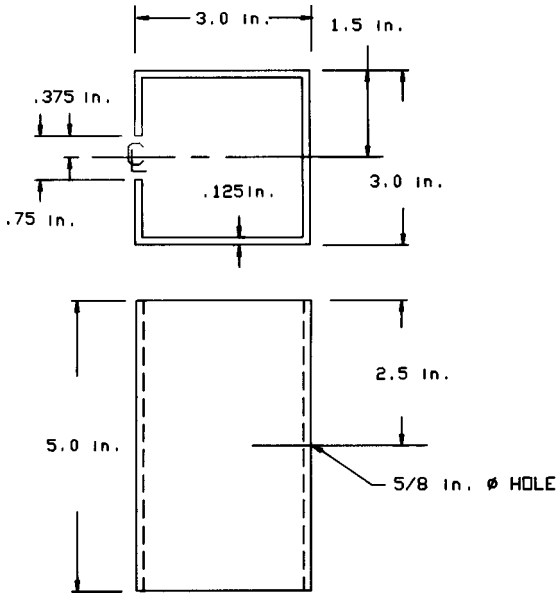


FIG. 4 Coupling Hitch

or riffle sampling method where deemed necessary considering the physical form of the material.

9. Procedure

9.1 Under continuous agitation melt a specimen of the thermoplastic to be tested to a temperature of 218°C. If the specimen is a dry powder mix, allow the specimen to cool to 193°C under continuous agitation and reheat under agitation to 218°C.

NOTE 3—Dry powder mixed thermoplastic must be conditioned to ensure a homogeneous melt necessary for consistent results. Premelted block thermoplastic does not require this conditioning. The specimen may be melted on a hot plate set at 537°C or in a jacketed electric pot. Continuous agitation is necessary to prevent scorching and settling. If the specimen is melted in an oven set at 260°C, the specimen must be agitated every 15 min until 218°C is reached.

9.2 Heat the draw down blade to 218°C.

9.3 Obtain a dry room temperature cement brick that has been brushed or textured on the side to be coated with thermoplastic.

9.4 Heat one 2 by 2 by 2 in. (50 by 50 by 50 mm) steel cube in an oven or on a hot plate to 49°C for 2 h prior to making the thermoplastic draw down on the cement brick.

9.5 When the thermoplastic specimen is melted to 218°C under continuous agitation, remove the agitator blade from the thermoplastic.

9.6 Remove the draw down blade from the hot plate and immediately place it on the cement brick and make the draw down the full length of the brick with the melted thermoplastic on the brushed or rough textured side of the brick.

9.7 Immediately place two room temperature steel cubes on the thermoplastic approximately 1 in. (25 mm) from each end of the brick and trim the plastic from around the two steel cubes before the plastic cools and hardens.

9.8 Remove the steel cubes by hand and allow the thermoplastic to cool for 1 h.

9.9 Prepare the epoxy solution using the proper resin and hardener ratio and mix thoroughly.

9.10 Remove the steel cube heated to 49°C from the oven and place a small amount of epoxy on the heated cube. Place the steel cube on the thermoplastic square and rub to ensure an even coating and good adhesion. To ensure an even coating, remove the steel cube from the thermoplastic square and visually inspect the square and cube and then replace the steel cube on the square and rub. Do not allow any excess expoxy solution to flow from the steel cube and thermoplastic square onto the cement brick.

NOTE 4—Only one steel cube can be epoxied at a time to the thermoplastic on the brick because the shock of the first pull will cause a premature release of the second thermoplastic square.

9.11 Place a weight such as a cement brick on the steel cube epoxied to the thermoplastic square and allow to cure for a minimum time of 8 h.

9.12 Screw the ⅝-in. (15.9-mm) capped bolt into the steel cube epoxied to the thermoplastic and place the brick into the steel frame mounted onto the dynamometer.

9.13 Set the dynamometer to zero and pull the steel cube at ¼ in./min (6 mm/min).

9.14 Two tests are run on each brick. Separations involving at least 80 % of the thermoplastic area to the cement brick, thermoplastic to thermoplastic, and cement brick to cement brick are acceptable for reporting bond strengths.

10. Calculations

10.1 Calculate the bond strength as follows:

10.1.1 Average the readings obtained in 9.13 if the conditions in 9.14 are met.

10.1.2 Divide the average reading obtained by 4. The result is the bond strength in pounds per square inch.

10.1.3 If one of the two tests fails then that test is repeated until the conditions of 9.14 are met.

11. Report

11.1 Report the following information:

11.1.1 The type of separation and bond strength, the batch number, color, and type of thermoplastic.

11.1.2 The determination of the area of separation is subjective. The area not involved in the separation is usually attached to the steel cube or cement brick.

12. Precision and Bias

12.1 *Precision*—No general statement of precision can be made because of lack of sufficient data at this time.

12.2 *Bias*—No statement of bias can be prepared for this test method since there is no absolute method for use as a comparative basis.

12.3 Experience dictates that test results with ±50 psi are acceptable.

13. Keywords

13.1 bond strength; cement brick; thermoplastic—traffic marking