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Standard Test Method for Bond Strength of Thermoplastic Traffic Marking Materials[1]

This standard is issued under the fixed designation D4796; 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.~~ loading fixtures.

1.2 The values stated in SI 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:*[2]

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

D16 Terminology for Paint, Related Coatings, Materials, and Applications

~~C881/C881M Specification for Epoxy-Resin-Base Bonding Systems for Concrete~~ D4541 Test Method for Pull-Off Strength of Coatings Using Portable Adhesion Testers

~~D883 Terminology Relating to Plastics~~ 5179 Test Method for Measuring Adhesion of Organic Coatings to Plastic Substrates by Direct Tensile Testing

~~E284 Terminology of Appearance~~ D7234 Test Method for Pull-Off Adhesion Strength of Coatings on Concrete Using Portable Pull-Off Adhesion Testers

~~F412 Terminology Relating to Plastic Piping Systems~~ D7307 Practice for Sampling of Thermoplastic Traffic Marking Materials

D7308 Practice for Sample Preparation of Thermoplastic Traffic Marking 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. Terminology

~~3.1 *Definitions*—Definitions are in accordance with Terminology D883, E284, and F412 unless otherwise indicated.~~

3.1 The terms and definitions in Terminology D16 apply to this method.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *cement brick*, *n*—~~a brick formed by mixing cement and fine sand together and allowing to harden.~~ a brick formed by mixing cement and fine sand together and allowing to harden with 210.9 to 351.5 kg/cm^2(3000 to 5000 psi) compression strength.

3.2.2 *loading fixture*, *n*—(also referred to as dollies, studs, or jigs) metal fixture round and flat on one end for bonding to test sample and shaped on the other end for attaching to tensile testing device (Fig. 1).

3.2.3 *thermoplastic*, *n*—traffic marking (same as ~~3.2.3~~3.2.4).

~~3.2.3~~3.2.4 *thermoplastic traffic marking*, *n*—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 or road marking thermoplastic usually melted to 218°C (425°F).

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.~~

[1] This test method is under the jurisdiction of ASTM Committee D01 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] 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.

~~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.~~

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 using a hot drawdown bar (Fig. 2), heated to 104 ± 2°C (220 ± 5°F), at 3.175 mm (125 mils) thickness. While the thermoplastic is still soft, three cuts are made with a 40.6 mm (1.6 in.) diameter die, heated to 104 ± 2°C (220 ± 5°F), in order to separate the test area from the rest of the drawdown. The die may be heated while submerged in glycerin to prevent thermoplastic from sticking to the die. The test areas are allowed to cool slightly and then three 40.6 mm (1.6 in.) diameter heated loading fixtures are laid on the test areas. The samples are then allowed to cure overnight before determining the bond strength on a tensile testing 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,~~and/or adhesive 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.

~~5.3Strict 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.~~

5.3 The method has been revised to be more consistent to methodology in other ASTM bond methods for coatings in Test Methods D4541, D5179, and D7234.

5.4 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 the method.

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.~~ Thermoplastic to Loading Fixture Separation—This type of separation occurs where there is an insufficient bond between the thermoplastic and loading fixture probably due to insufficient coverage of the thermoplastic to the fixture at the time of placement or too low temperature or both. This separation is acceptable when it exceeds the specified bond strength.

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.~~ —This type of separation is caused by the failure of the bond between the

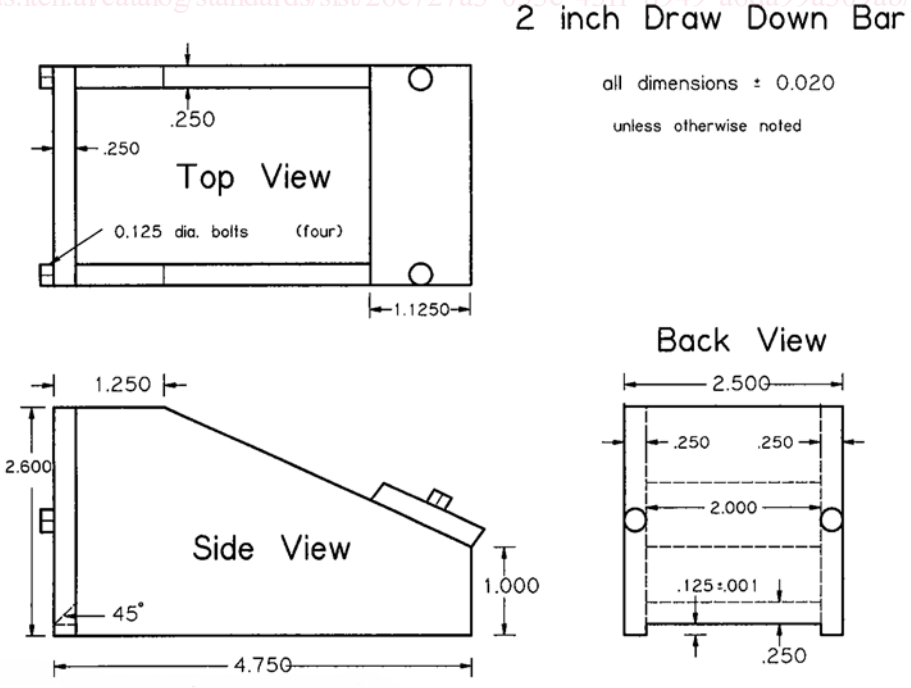

FIG. 2 Drawdown Bar (in inches)

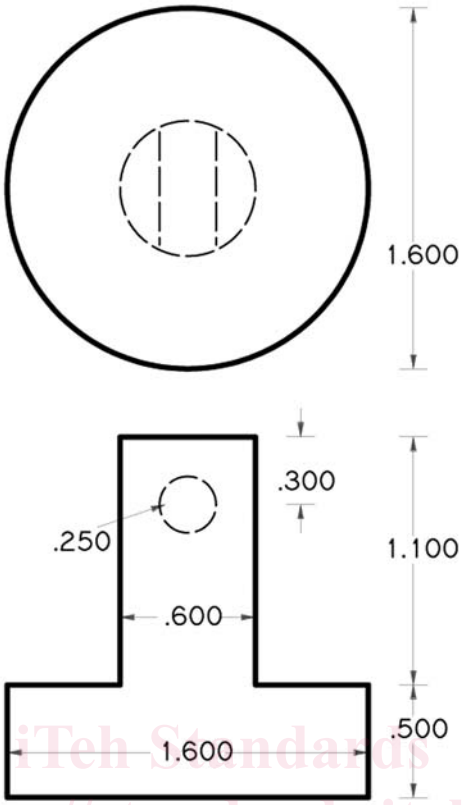

FIG. 1 Loading Fixture

thermoplastic specimen and the cement brick. This separation is acceptable when it exceeds the specified bond strength.

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

7. Apparatus

7.1 ~~*Agitator Blade*, 150 mm (6 in.) long with a 10 mm (½-in.) steel shaft and a 45 by 25 by 3 mm (1¾ by 1 in. by ⅛-in.) straight horizontal steel blade.~~ Loading Fixture (three), 40.6 mm (1.6 in.) diameter 50.8 sq mm (2 sq in.) area on one end and post for attaching to the tensile testing device and load cell (Fig. 1).

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

~~7.3~~*Cement Bricks*~~, 9 by 5 by 19 cm (3½ by 2 by 7½-in.) in size with a compressive strength of 3000 to 5000 psi (Note 1).~~ , 9 by 5.5 by 19 cm (3.75 by 2.5 by 7.75 in.) in size with a compressive strength of 210.9 to 351.5 kg/m^2(3000 to 5000 psi).

NOTE~~1—Concrete bricks conforming to Test Method C109/C109M 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.~~ 1—Cement bricks can be obtained at a local block plant or Block USA. Home improvement paving bricks usually do not have enough cohesive strength. Concrete bricks conforming to Test Method C109/C109M 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.

7.3 *Tensile Testing Equipment* with a minimum capacity of 910 ± 1 kg (200 ± 2 lbs) having a pull-rate capability of 7 mm/min (0.275 in./min).

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

~~7.4~~*Dynamometer*~~, with a capacity of 6000 lbs in 2700 kg in 10 kg (25-lb) divisions having a pull-rate capability of ¼ in./min. (6 mm/min) (Note 2) (See Fig. 1, Fig. 2,~~ 2—The unit should be fitted with a steel frame to hold the cement brick for testing (see Fig. 3~~, and Fig. 4~~).

7.4 *Draw Down Bar*, 5 by 2.5 by 10 cm (2 by 1 by 4 in.) in size capable of laying down a 3.175 mm (125 mil or 0.125 in.) molten thermoplastic film 50.8 mm (2 in.) wide (Fig. 2).

7.5 ~~*Draw Down Blade*, 5 by 2.5 by 10 cm (2 by 1 by 4 in.) in size capable of laying down a 125 mil (0.125 in.) wet thermoplastic film 2-in. wide.~~ Hot Plate, capable of maintaining 104 ± 2°C (220 ± 5°F).

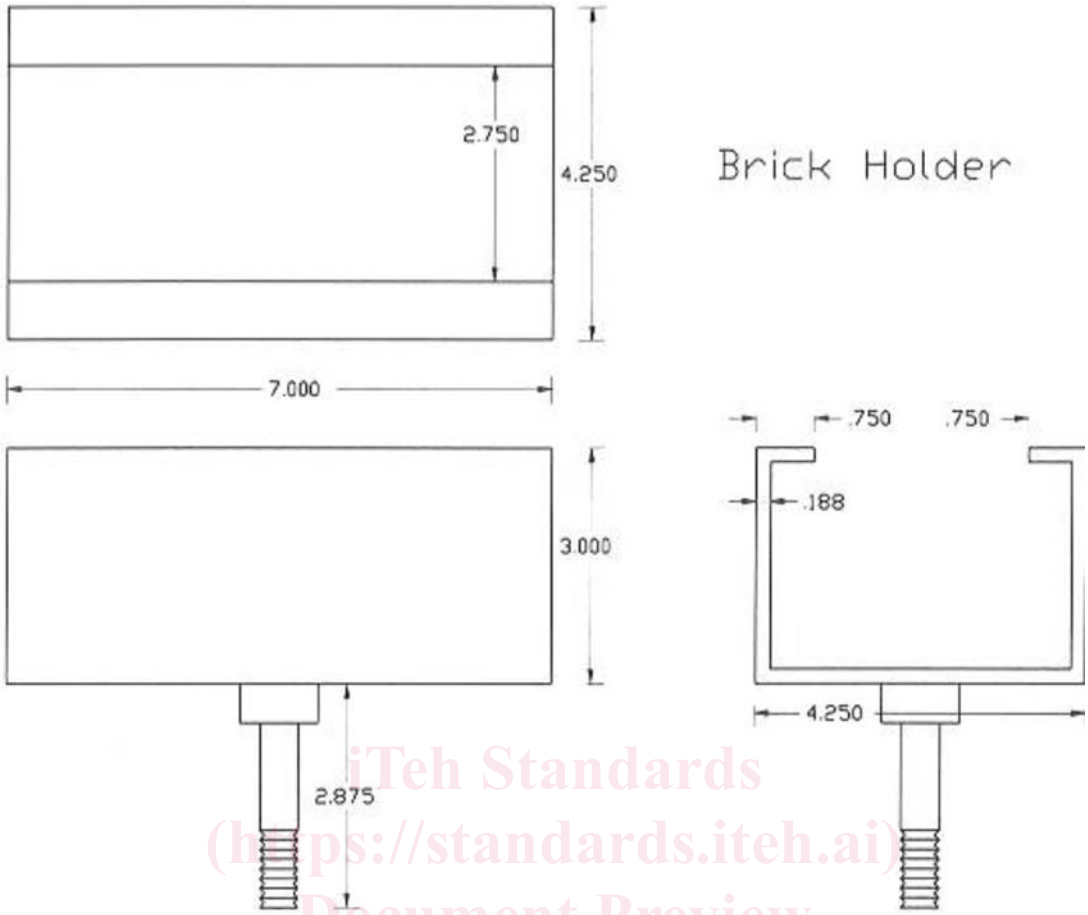

FIG. 3 Brick Holder

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.~~ Oven, capable of maintaining 218 ± 2°C (425 ± 5°F).

7.7 ~~*Epoxy Resin and Hardener*, Type I or II, Grade 2, Class C in accordance with Specification C881/C881M.~~ Die Cutter, 40.6 mm (1.6 in.) diameter (Fig. 4).

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.~~

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

~~7.12*Steel Cubes, two*, 50 by 50 by 50 mm (2 by 2 by 2 in.) in size threaded in the center of one side for a 16-mm (⅝-in.) capped bolt.~~ Metal Frame for holding concrete brick (Fig. 3).

8. Sampling

~~8.1Samples may be obtained by an appropriate quartering or riffle sampling method where deemed necessary considering the physical form of the material.~~

8.1 Samples may be obtained by following Practice D7307.

9. Procedure

~~9.1Under 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.~~

9.1 After sampling a batch of road marking thermoplastic by Practice D7307, prepare a representative molten sample for testing by following Practice D7308.

~~NOTE3—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.~~

~~9.2Heat the draw down blade to 218°C.~~