Designation: D7446 – 09 (Reapproved 2017)

Standard Specification for Structural Insulated Panel (SIP) Adhesives for Laminating Oriented Strand Board (OSB) to Rigid Cellular Polystryene Thermal Insulation Core Materials[1]

This standard is issued under the fixed designation D7446; 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 specification is designed to evaluate adhesives suitable for the bonding of oriented strand board (OSB) to rigid cellular polystyrene insulation core materials for general structure use.

1.2 The requirements of the structural insulated panel (SIP) adhesive are based on the performance of the adhesive as measured by:

1.2.1 Resistance to shear by compression loading in ambient conditions and after accelerated aging.

1.2.2 Resistance to tensile loading in ambient conditions and after accelerated aging.

1.2.3 Resistance to creep (deformation) under static load in ambient conditions and after accelerated aging.

1.2.4 Tensile and shear strength to polystyrene core materials.

1.3 The classification of the adhesive formulation is based on, but not limited to the adhesive's industry accepted generic names, for example: phenol-resorcinol, emulsion polymer isocyanate, one and two-part urethane. The type of adhesive application and curing terminology are also usually included for classification purposes such as cold-setting phenol resorcinol, heat-cured phenol resorcinol, and hot melt one component urethane.

1.4 Evaluation of adhesive performance at high temperature conditions, such as during a fire exposure, is beyond the scope of this specification.

1.5 The values stated in SI units are to be regarded as the standard. The values given in parentheses are for information only.

1.6 *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.*

1.7 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

C273/C273M Test Method for Shear Properties of Sandwich Core Materials

C297/C297M Test Method for Flatwise Tensile Strength of Sandwich Constructions

C578 Specification for Rigid, Cellular Polystyrene Thermal Insulation

D572 Test Method for Rubber—Deterioration by Heat and Oxygen

D905 Test Method for Strength Properties of Adhesive Bonds in Shear by Compression Loading

D907 Terminology of Adhesives

D1183 Practices for Resistance of Adhesives to Cyclic Laboratory Aging Conditions

D1583 Test Method for Hydrogen Ion Concentration of Dry Adhesive Films

D2294 Test Method for Creep Properties of Adhesives in Shear by Tension Loading (Metal-to-Metal)

D4300 Test Methods for Ability of Adhesive Films to Support or Resist the Growth of Fungi

D4442 Test Methods for Direct Moisture Content Measurement of Wood and Wood-Based Materials

D4444 Test Method for Laboratory Standardization and Calibration of Hand-Held Moisture Meters

E4 Practices for Force Verification of Testing Machines

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

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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.

2.2 *Other Standards:*

PS2 Performance Standard for Wood-Based Structural-Use Panels[3]

ISO 17025 General Requirements for the Competence of Testing and Calibration Laboratories[4]

3. Terminology

3.1 *Definitions*—Many terms in this specification are defined in Terminology D907.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *core material, n*—located between structural insulated panel facings; for this specification, consists of rigid cellular polystyrene thermal insulation, either expanded polystyrene (EPS) or extruded polystyrene (XPS) that conforms to Specification C578.

3.2.2 *facings, n*—the outer layers of a structural insulated panel typically consisting of oriented strand board.

3.2.3 *oriented strand board (OSB), n*—a mat formed panel product with oriented layers resulting in directional properties.

3.2.3.1 *Discussion*—Oriented strand board is comprised primarily of wood strands bonded with exterior adhesive formulations under heat and pressure. Design capacities are referenced to the primary and secondary structural axis, which typically correspond to the manufacturing machine and cross-machine directions, respectively. The primary direction is often referred to as the strength direction.

3.2.4 *practical equilibrium, n*—physical state in which the material weight does not change more than 0.5 % in 24 h.

3.2.5 *standard conditions, n*—consist of a controlled environment set at 23 ± 2°C (73 ± 3°F) and 65 ± 3 % relative humidity (RH).

3.2.6 *structural insulated panel (SIP), n*—factory manufactured assembly consisting of a rigid polystyrene bonded with a structural adhesive between two rigid facings such as OSB.

4. Significance and Use

4.1 This specification addresses minimum performance criteria for adhesives used to laminate oriented strand board (OSB) structural panel facing material to expanded or extruded polystyrene core materials. Adhesive performance is based on tests that simulate exposure to moisture, temperature, seasonal weathering, and creep. Additionally, the adhesive is to demonstrate resistance to oxidation, mold, chemical reagents, and compatibility to the specific laminating materials.

4.2 The adhesive manufacturers can use this specification for new product development and quality control purposes.

4.3 Structural insulated panel manufacturers rely on an adhesive performance specification that determines its suitability before use.

4.4 Performance of the SIP adhesive when evaluated in accordance with this specification aids in determining the suitability of the adhesive for laminating OSB facings to rigid cellular polystyrene core materials in the manufacture of structural insulated panels.

5. Fillers and Extenders

5.1 If amylaceous or protein fillers and extenders are used, the adhesive shall not only pass requirements of this specification but, in addition, possess antifungal properties to inhibit the growth of selected fungal species when tested in accordance with Test Method D4300. The adhesive manufacturer's literature shall indicate whether such materials are present.

6. Apparatus

6.1 *Testing Machine*—shall conform to the requirements of and have the capabilities of the machines prescribed in Test Methods C297/C297M, C273/C273M, and D905 and have an accuracy of ±1 % when calibrated in accordance with Practices E4 requirements. The grips shall be capable of securely grabbing the specimen throughout the test without allowing the specimen to slip. The grips shall be self-aligning.

6.2 *Temperature and RH-Controlling Equipment*—The equipment shall be capable of maintaining the test temperature to ±3°C (±5°F) and the relative humidity to ±3 %.

7. Chemical Requirements

7.1 The cured adhesive film shall develop a pH value of not less than 2.5 when tested in accordance with Test Method D1583.

8. Physical Requirements

8.1 Adhesive manufacturer recommendations for preparation, application, and handling of the SIP adhesive shall ensure proper usage and maintain product integrity. The adhesive manufacturer shall furnish written instructions stating the general chemical type of adhesive, its storage and mixing procedure, the method of surface preparation with materials to be laminated, and any other data that is pertinent to the use of the adhesive in the manufacture of structural insulated panels.

8.2 The adhesive shall pass the tests required by this specification. See Table 1, Table 2, and Section 10. The adhesive manufacturer's application specification sheet shall provide application instructions which include the limiting conditions.

8.2.1 The adhesive manufacturer is to provide specific application instructions for the test adhesive related to the preparation of test assemblies required by this specification including both Douglas-fir to Douglas-fir and OSB to Core to OSB.

8.3 Limiting conditions are conditions that must be controlled within maximums, minimums, or ranges so that the adhesive can function as designed. These conditions include, but are not limited to the following:

8.3.1 Maximum storage life of adhesive;

8.3.2 Assembly conditions including temperature and humidity;

8.3.3 Allowable moisture content and temperature for facings and core materials;

[3] Available from National Institute of Standards and Technology (NIST), 100 Bureau Dr., Stop 1070, Gaithersburg, MD 20899-1070, http://www.nist.gov.

[4] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

TABLE 1 Douglas-fir to Douglas-fir Qualification Series

Test Type	Shear (Test Method D905)		Tension (Test Method C297/C297M)		Creep (Test Method D2294)
Specimen Type	Solid Douglas-fir	Bonded Douglas-fir	Solid Douglas-fir	Bonded Douglas-fir	Bonded Douglas-fir
Treatment	NA	Dry Shear	NA	Dry Tensile	Uncontrolled
Reference Section	NA	14.5	NA	14.6	14.9.7 and Table 3
Minimum Requirements	NA	7033 kPa (1020 psi)	NA	2110 kPa (306 psi)	344.7 kPa (50 psi) for 30 days
Reference Section	NA	10.1.1.1	NA	10.1.2.1	10.1.3
Treatment	Practices D1183 "C"	Practices D1183 "C"	Practices D1183 "C"	Practices D1183 "C"	Practices D1183 "C"
Reference Section	14.5.4	14.5.3	14.6.3	14.6.3	14.9.9 and Table 3
Minimum Requirements	NA	80 % of Solid Douglas-fir Practices D1183 "C"	NA	80 % of Solid Douglas-fir Practices D1183 "C"	344.7 kPA (50 psi) for 7 days
Reference Section	NA	10.1.1.2	NA	10.1.2.2	10.1.3
Treatment	Soak/Re-dry	Soak/Re-dry	Soak/Re-dry	Soak/Re-dry	Soak/Re-dry
Reference Section	14.5.5 and Table 3	14.5.3 and Table 3	14.6.4 and Table 3	14.6.4 and Table 3	14.9.10 and Table 3
Minimum Requirements	NA	80 % of Solid Douglas-fir Soak/Re-dry	NA	80 % of Solid Douglas-fir Soak/Re-dry	344.7 kPa (50 psi) for 7 days
Reference Section	NA	10.1.1.3	NA	10.1.2.3	10.1.3
Treatment	NA	Oxidation	NA	Mold (as required)	Elevated Temperature
Reference Section	NA	14.5.6 and 14.7	NA	14.6.5 and 14.8	14.9.8 and Table 3
Minimum Requirements	NA	80 % of Bonded Douglas-fir-Conditioned	NA	90 % of Bonded Douglas-fir-Conditioned	344.7 kPa (50 psi) for 7 days
Reference Section	NA	10.1.1.4	NA	10.1.2.4	10.1.3
Treatment	NA	Mold (as required)	NA		
Reference Section	NA	14.5.7 and 14.8	NA		
Minimum Requirements	NA	90 % of Bonded Douglas-fir-Conditioned	NA		
Reference Section	NA	10.1.1.5	NA		

TABLE 2 OSB to Core to OSB Qualification Series

Test Type	Shear (Test Method C273/C273M)	Tension (Test Method C297/C297M)
Specimen Type	SIP	SIP
Treatment	Conditioned	Conditioned
Reference Section	15.1	15.2
Minimum Requirement	62 kPa (9 psi)	103.4 kPa (15 psi)
Reference Section	10.2.1	10.2.2

8.3.4 Mixing ratios, if applicable;

8.3.5 Pot life, if applicable;

8.3.6 Application method: applied to one surface or both contracting surfaces:

8.3.7 Spread rate expressed as weight per unit area and tolerance;

8.3.8 Open and closed assembly times;

8.3.9 Laminating pressure and press time;

8.3.10 Curing conditions such as time, temperature, and humidity.

9. Qualification Tests

9.1 Douglas-fir to Douglas-fir Qualification Series (Table 1) and OSB to Core to OSB Qualification Series (Table 2).

10. Test Requirements

10.1 *Douglas-fir to Douglas-fir:*

10.1.1 *Test Method D905 Block Shear Strength:*

10.1.1.1 *Dry Shear Test*—The average shear strength of bonded Douglas-fir specimens shall be a minimum of 7033 kPa (1020 psi) at 12 % moisture content.

NOTE 1—The 7033 kPa (1020 psi) requirement is based on 90 % of the shear strength parallel to grain at 12 % moisture content from Table 4-3 of the 1999 Wood Handbook for Douglas-fir.[5]

10.1.1.2 *Practices D1183 Test Condition "C"*—After cycling bonded Douglas-fir specimens in accordance with Practices D1183 "C" procedure (see Table 3), the average shear strength shall be equal to or greater than 80 % of the average shear strength of solid Douglas-fir specimens exposed to the same accelerated aging procedure. Preparation details for solid Douglas-fir specimens are located in 14.1, 14.5, and Fig. 1.

10.1.1.3 *Soak/Re-dry*—After cycling bonded Douglas-fir specimens in accordance with the soak/re-dry procedure (see Table 3), the average shear strength shall be equal to or greater than 80 % of the average shear strength of solid Douglas-fir specimens exposed to the same accelerated aging procedure. Specimen preparation details for solid Douglas-fir specimens are located in 14.1, 14.5, and Fig. 1.

10.1.1.4 *Oxidation Resistance Test*—After cycling bonded Douglas-fir specimens in accordance with procedures indicated in 14.7 the average shear strength shall be equal to or greater than 80 % of the average dry shear strength of bonded Douglas-fir specimens tested in 10.1.1.1.

10.1.1.5 *Mold Resistance Test (when required)*—After conditioning and aging bonded Douglas-fir specimens in accordance with 14.8 procedure, the average shear strength shall be equal to or greater than 90 % of the dry shear strength of the bonded Douglas-fir specimens tested in 10.1.1.1.

[5] Available from U. S. Department of Agriculture, Forest Products Laboratory, One Gifford Pinchot Drive Madison, WI 53726, http://www.fpl.fs.fed.us.

TABLE 3 Douglas-fir Procedures

Practices D1183 Procedure C	Soak/Re-dry	Creep Resistance
48 h at 71 ± 2°C (170 ± 3°F) <10 % RH	48 h submerged in 18 to 23°C (65 to 75°F) tap water	Set 1: Control Test for 30 days in uncontrolled temperature and relative humidity
48 h submerged in at 23± 2°C (73 ± 3°F) tap water	8 h oven dry at 63 ± 3°C (175 ± 5°F)	Set 2: Elevated Temperature Test at 70°C (158°F) for 7 days in uncontrolled (ambient) humidity
8 h at -40 ± 2°C (-40 ± 3°F) ~ 100 % RH	followed by three cycles comprised of the following:	Set 3: Test after Practices D1183 Procedure C
64 h at 39 ± 2°C (100 ± 3°F) ~ 100 % RH	17 h submerged soak in 18 to 23°C (65 to 75°F) tap water	Set 4: Test after soak/re-dry in uncontrolled temperature and relative humidity
all steps repeated twice more for a total of three cycles	8 h oven dry at 63 ± -3°C (175 ± 5°F)	
after cycling, then 7 days at standard conditions	after cycling, then 7 days at standard conditions	

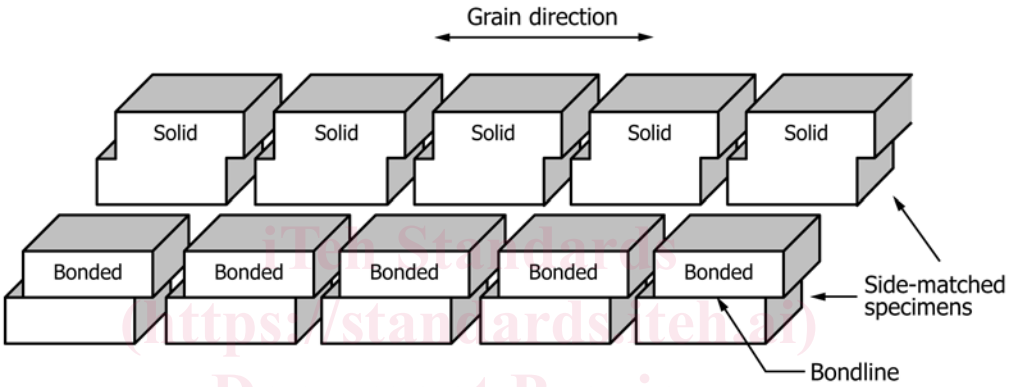

FIG. 1 ASTM Test Method D905 Shear Block — Matched Pair Diagram

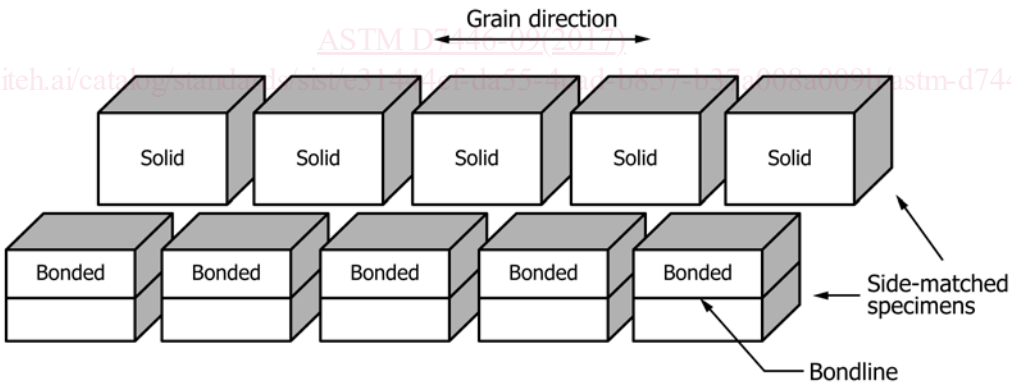

FIG. 2 ASTM Test Method C297/C297M Tensile Specimen — Matched Pair Diagram

10.1.2 *Douglas-fir to Douglas-fir Tensile Strength:*

10.1.2.1 *Dry Tensile Bond Strength*—The minimum average dry tensile strength of bonded Douglas-fir specimens shall be 2110 kPa (306 psi) at 12 % moisture content.

NOTE 2—The 306 psi value is based on 90 % of the Wood Handbook Table 4-2,[5] Tension, perpendicular to grain-maximum tensile strength for Douglas-fir, Coast, Dry (12 % M.C.).

10.1.2.2 *Practices D1183 Test Condition "C"*—After cycling the bonded Douglas-fir specimens in accordance with Practices D1183 Test Condition "C," or the soak/re-dry accelerated aging procedures (see Table 3), the minimum average tensile strength shall be equal to or greater than 80 % of the average tensile strength of solid Douglas-fir specimens exposed to the same accelerated aging procedure. Specimen preparation of solid Douglas-fir specimens is detailed in 14.1, 14.6, and Fig. 2.

10.1.2.3 *Soak/Re-dry Test*—After cycling the bonded Douglas-fir specimens in accordance with the soak/re-dry accelerated aging procedures (see Table 3), the minimum average tensile strength shall be equal to or greater than 80 %