



Designation: **D5516 – 09 D5516 – 17**

## Standard Test Method for Evaluating the Flexural Properties of Fire-Retardant Treated Softwood Plywood Exposed to Elevated Temperatures<sup>1</sup>

This standard is issued under the fixed designation D5516; 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.

### 1. Scope

1.1 This test method is designed to determine the effect of exposure to high temperatures and humidities on the flexure properties of fire-retardant treated softwood plywood. In this test method, plywood is exposed to a temperature of 77°C (170°F).

1.2 The purpose of the test method is to compare the flexural properties of fire-retardant treated plywood relative to untreated plywood. The results of tests conducted in accordance with this test method provide a reference point for estimating strength temperature relationships. This test method is intended to provide an accelerated test at elevated temperatures and controlled humidities of plywood sheathing treated with the same chemical formulation(s) and processing conditions as plywood used commercially.

1.3 The values stated in SI units are to be regarded as standard. The values given in parentheses are mathematical conversions to inch-pound units that are provided for information only and are not considered standard.

1.4 *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.*

1.5 *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:<sup>2</sup>

[D9 Terminology Relating to Wood and Wood-Based Products](#)

[D1165 Nomenclature of Commercial Hardwoods and Softwoods](#)

[D2915 Practice for Sampling and Data-Analysis for Structural Wood and Wood-Based Products](#)

[D3043 Test Methods for Structural Panels in Flexure](#)

[D4933 Guide for Moisture Conditioning of Wood and Wood-Based Materials](#)

[D6305 Practice for Calculating Bending Strength Design Adjustment Factors for Fire-Retardant-Treated Plywood Roof Sheathing](#)

[E84 Test Method for Surface Burning Characteristics of Building Materials](#)

[E176 Terminology of Fire Standards](#)

[E2768 Test Method for Extended Duration Surface Burning Characteristics of Building Materials \(30 min Tunnel Test\)](#)

#### 2.2 Other Standards:

[AWPA C-27 Plywood-Fire Retardant Treatment by Pressure Processes](#)<sup>3</sup>

[AWPA U1 Use Category System: User Specification for Treated Wood](#)<sup>3</sup>

[NFPA 703 Standard for Fire Retardant Impregnated Wood and Fire Retardant Coatings for Building Materials](#)<sup>4</sup>

[PS 1 U.S. Product Standard for Structural Plywood](#)<sup>5</sup>

<sup>1</sup> This test method is under the jurisdiction of ASTM Committee D07 on Wood and is the direct responsibility of Subcommittee D07.07 on Fire Performance of Wood. Current edition approved May 15, 2009/April 15, 2017. Published June 2009/June 2017. Originally approved in 1991 as ES 20 – 91. Last previous edition approved in 2003/2009 as D5516 – 03-D5516 – 09. DOI: 10.1520/D5516-09.10.1520/D5516-17.

<sup>2</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.

<sup>3</sup> Available from American Wood Protection Association (AWPA), P.O. Box 361784, Birmingham, AL 35236-1784, <http://www.awpa.com>.

<sup>4</sup> Available from National Fire Protection Association (NFPA), 1 Batterymarch Park, Quincy, MA 02169-7471, <http://www.nfpa.org>.

<sup>5</sup> Available from the U.S. Department of Commerce, 1401 Constitution Ave., NW Washington, DC 20230, <http://ts.nist.gov/Standards/Conformity/vps.cfm>.

**PS 2 U.S. Product Standard for Wood-Based Structural Use Panels<sup>5</sup>**

### 3. Terminology

3.1 *Definitions*—Definitions used in this test method are in accordance with Terminologies **D9** and **E176** and Nomenclature **D1165**.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *depth of beam*—that dimension of the beam which is perpendicular to the span and parallel to the direction in which the load is applied.

3.2.2 *span*—the total distance between the centerline of supports providing the reactions on which a beam is supported to accommodate a transverse load.

3.2.3 *span-depth ratio*—the numerical ratio of span divided by beam depth.

### 4. Summary of Test Method

4.1 After preconditioning (see **6.5**), matched specimens of treated and untreated plywood will be exposed to 77°C (170°F) temperature and relative humidity equal to or greater than 50 %.

4.2 Flexural strength tests are conducted on exposed specimens removed after various time periods. Flexural strength results shall include maximum moment, bending stiffness, and work to maximum load. Adjust the test results to ~~67 % relative humidity.~~ (See ~~50 % relative humidity~~ using Practice **D6305** procedures (see ~~X1-2X1.1~~).

4.3 The purpose of this test method is to determine the ratio of the treated mean to the untreated mean for the plywood and plot the accelerated exposure strength data against exposure time.

### 5. Significance and Use

5.1 The flexural properties evaluated by this test method are intended to provide any one or all of the following:

5.1.1 Data on the comparative effects of fire-retardant chemical formulations and environmental conditions on the flexural properties of plywood.

5.1.2 Data for use in developing modification factors for the allowable design properties of treated plywood when exposed to elevated temperatures and humidities.

5.1.3 Data comparing variables, such as other plywood species and dimensions.

5.2 Results obtained from tests conducted and analyzed in accordance with the procedures of this test method may be used with other information to establish recommended roof sheathing spans for fire-retardant treated plywood.

NOTE 1—Temperatures lower than the test temperature specified in this test method and the cumulative effects of the elevated temperatures and humidity exposures expected to be encountered in service should be taken into account when recommended roof sheathing spans are established.

NOTE 2—Practice **D6305** can be used to extend the laboratory strength data obtained by this test method to design value recommendations. The test data determined by this test method are used to develop adjustment factors for fire-retardant treatments to apply to untreated plywood design values. The test data are used in conjunction with climate models and other factors.

### 6. Test Specimens

6.1 *Material Selection:*

6.1.1 Source panels for this test shall be selected from grade marked PS 1 or PS 2 commercially available 3, 4, or 5 ply panels of a single thickness, grade, construction, and bond durability. The nominal panel thickness shall be between 12 mm (<sup>15</sup>/<sub>32</sub> in.) and 16 mm (<sup>5</sup>/<sub>8</sub> in.).

NOTE 3—Southern Pine is suggested as the test material because it requires higher fire-retardant chemical retentions to obtain the same flame spread rating compared to other softwood plywood species. Because the bending strength of treated plywood correlates to the chemical retention levels, Southern Pine plywood is believed to represent a worst case scenario for the same chemical formulation and treating/redrying procedures. Thus, evaluation of other species of plywood by testing of that species, rather than by application of southern pine test results, are considered to be indicative of that species only.

6.1.2 Select source panels that provide bending strength specimens after cutting with clear essentially straight-grained faces free of scoring or other manufacturing defects. The inner plies shall be essentially free of voids, core gaps, and core laps (see **7.3.4.2**). Panels shall have generally uniform grain orientation and percent latewood along and across the panel faces. A minimum of six sheets of plywood meeting this description is required. Alternate 610 mm (2 ft) long sections to be treated and adjacent untreated 610 mm (2 ft) sections (see **Fig. 1**) shall have visually similar wood quality.

6.1.2.1 Specimens shall be inspected and the culling of specimens done as necessary in accordance with the criteria in **7.3.4**.

NOTE 4—A minimum of six sheets of plywood is required but culling of specimens may require more sheets.

6.1.3 The specimen cutting pattern and numbering sequence is shown in **Fig. 1**. Each panel of plywood is to be labeled with a number from 1 to 6. Cut each sheet crosswise to provide 610 mm by 1220-mm (2 by 4-ft) sections. Each section is labeled with the sheet number and letter A, B, C, or D. The A and C sections of each of the six panels is to be treated, while the B and D sections of the six panels are to remain untreated.

**4 x 8 ft Sheet Number**

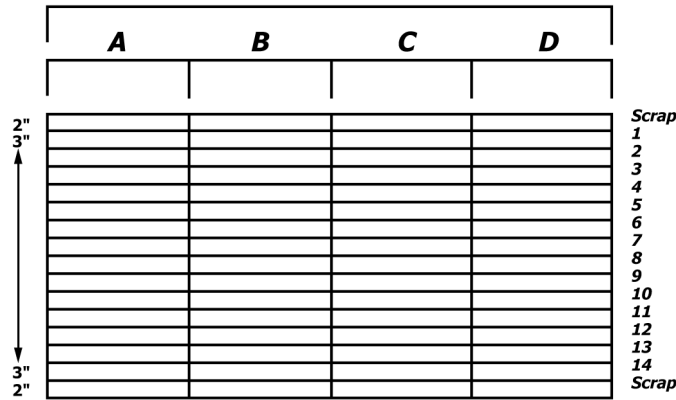


FIG. 1 Plywood Cutting Pattern

6.2 Treatment:

6.2.1 ~~Pressure~~ For applications requiring conformance to building code requirements for “fire-retardant-treated-wood” based on Test Method E84 test extended to 30 min or Test Method E2768, ~~pressure~~ treat the A and C section of each of the six plywood panels with the fire-retardant formulation being tested. The gage retention level of each charge shall not be less than the value midway between the middle of the retention range and the maximum retention as specified by the agency certifying the flame spread index surface burning characteristics of the treated plywood. The retention range specified by the certifying agency shall result in specimens that provide a flame-spread index of 25 or less when tested in accordance with Test Method and be reported as showing E84 for 10 min, show no evidence of significant progression progressive combustion when the test is continued for an additional 20 min throughout the 30-min period, and not allow progression of the flame front beyond a distance of 3.2 m (10.5 ft) beyond the centerline of the burners anytime during the 30-min extended test.

6.2.1.1 Alternate methods or processes of imparting fire-retardant properties can be substituted for pressure treatment for purposes of this test method since this method evaluates the impact of the fire retardant method on the properties of the underlying plywood.

6.2.1.2 The provisions of 6.2.1 are not intended to prevent use of this test method when the fire-retardant treatments being certified are for applications other than those requiring conformance to AWPA C-27, AWPA U1, NFPA 703, or similar building code requirements for “fire-retardant-treated wood” that require the Test Method E2768 or Test Method E84 test extended to 30 min. When alternative performance criteria for the treatment are being certified, the test report on specimens of that treatment shall state clearly the alternative performance criteria and that the treatment retention was limited to that required for the alternative performance criteria.

6.2.2 Weigh all plywood sections before and immediately after treatment to determine the chemical retention based on the solution retained and the concentration of chemicals in the solution. Complete a treating report for each charge of material to document the treating cycle, times, pressures, and plywood retentions.

6.3 Post-Treatment Drying:

6.3.1 After pressure treatment, kiln dry the twelve treated plywood sections to a maximum moisture content of 15 % following the standard redrying procedures established for the treatment by the manufacturer. Redry the sections at the manufacturer’s maximum specified dry bulb temperature with a minus 2°C (4°F) tolerance for 21 h of the first 24-h period. For the remainder of the drying period, the tolerance shall be minus 3°C (5°F). There is no upper limit on the redrying temperature. Sticker all plywood sections to obtain proper air flow across the panels and to provide even drying. If the manufacturer’s procedures permit double stacking of panels intended for structural application, treated plywood test sections also shall be double stacked rather than stickered individually.

NOTE 5—Research has shown that high kiln drying temperatures can adversely affect the structural properties of wood products. The AWPA and NFPA standards for fire retardant treated wood products limit kiln dry bulb temperatures. AWPA C-27 requires that the dry bulb temperature of the kiln not exceed 70°C (160°F) during any kiln drying of plywood treated with fire retardants. In the case of exterior fire retardants that require curing at higher temperatures, curing after the moisture content is 15 % or less is permitted. However, such elevated curing temperatures must not exceed 99°C (210°F) and the total curing time must not exceed 48 h. In NFPA 703, the dry bulb temperature must not exceed 70°C (160°F) until the average moisture content of the wood has dropped to 25 % or less.

NOTE 6—To establish the worst-case flexural properties of treated softwood plywood, the laboratory must redry the test material within a small negative tolerance of the maximum temperature used by the manufacturer. Therefore, there is no upper limit for the temperature used in the tests. If a manufacturer desires to establish conservative property values or provide a basis for evaluating production material that exceeds the limit, the test material can be redried at that temperature. A manufacturer then is allowed to determine the necessary production schedule for their treatment and equipment or conditions. Thus, a stepped schedule (for example, 10 h at 54°C (130°F), 10 h at 60°C (140°F), 10 h at 71°C (160°F), etc.) is allowed by the standard, provided the maximum temperature tolerance requirement is met. These provisions provide for air-drying production material provided the redry conditions for the test materials are within the tolerance of the maximum temperature specified by the manufacturer.

6.3.2 Monitor the moisture content of the plywood sections during the drying cycle by individually weighing the sections. Reduce as much as possible damage or warp during the drying process by adequately supporting the sections. Keep a well-documented kiln charge report and kiln recorder chart detailing the drying cycle and parameters.

6.4 Specimen Preparation:

6.4.1 After drying, cut the treated and untreated 610 by 1220-mm (2 by 4-ft) sections into nominal 75 by 610-mm (3 by 24-in.) test specimens as shown on Fig. 1. Alternatively, specimen sizes in accordance with Test Methods D3043, Test Method A shall be used instead of this size. Number these specimens consecutively from 1 to 14, creating 168 treated and 168 untreated specimens. Randomly select 20 of the 168 untreated and treated specimens as unexposed controls. The remaining 148 treated and 148 untreated specimens shall be randomly assigned to 7 sets of 20 specimens for both the treated and untreated material. These are subjected to exposure followed by strength testing. This results in 8 treated and 8 untreated specimens not assigned to any set for testing (see Note 67).

NOTE 7—The 168 treated and 168 untreated specimens (6.4.1) are 48 more specimens than are needed to be tested. The resulting two extra sets of 20 can be saved as replacement sets if the number of specimens in a set drops below the minimum of 18 (7.3.4). Alternatively, the extra 48 specimens can be used to increase the number of specimens in each set. A sample size of 28 allows one to estimate a 75 % confidence interval for the 5 % nonparametric tolerance limit (see Practice D2915).

6.4.1.1 Alternatively, the variation in the mean response can be reduced by a blocked specimen selection where each treated specimen is end-matched to an untreated specimen from the same original panel. If blocking is used and a specimen is eliminated either before or after testing, then its mate shall also be eliminated (1).<sup>6</sup>

6.5 Preconditioning—Equilibrate all sets of treated and untreated specimens at an ambient temperature and relative humidity to achieve an equilibrium moisture content in the untreated specimens of  $10 \pm 2\%$  (see Guide D4933). Specimens are considered to be at equilibrium moisture content when a constant weight has been achieved. A constant weight is assumed when two consecutive weighings at a 24-h interval differ by no more than  $\pm 0.2\%$ .

7. Procedure

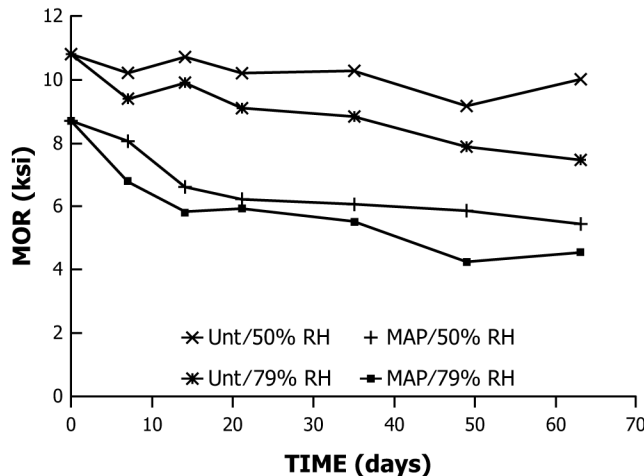
7.1 Specimen Exposure:

7.1.1 After preconditioning, test the unexposed controls (see 6.4.1) as described in 7.3 for initial, unexposed bending strength flexural properties.

7.1.2 Expose all the remaining treated and untreated specimen sets in a chamber controlled to  $77 \pm 1^\circ\text{C}$  ( $170 \pm 2^\circ\text{F}$ ) and a minimum of 50 % relative humidity. The control of the relative humidity in the chamber shall be  $\pm 4\%$  and average  $\pm 1\%$  around the set point.

7.1.3 The first set of 20 untreated and 20 treated specimens shall be subjected to flexural test after 14 days exposure in the  $77^\circ\text{C}$  ( $170^\circ\text{F}$ ) chamber. Remove 4 additional sets of 20 treated and 20 untreated specimens at well-spaced, appropriate intervals to establish the slope of the line when the strength properties are plotted versus time. Experience has shown that removals at 2 to 3-week intervals for an exposure period of  $>75$  at least 75 days are normally sufficient (Fig. 2 illustrates modulus of rupture (MOR) response with time).

<sup>6</sup> The boldface numbers in parentheses refer to a list of references at the end of this standard.



NOTE 1—UNT = Untreated and MAP = Monoammonium phosphate treated.

FIG. 2 SYP Southern Pine Plywood Exposed at 170°F (77°C) 77°C (170°F)