Designation: D 5516 – 01a

# Standard Test Method for Evaluating the Flexural Properties of Fire-Retardant Treated Softwood Plywood Exposed to Elevated Temperatures[1]

This standard is issued under the fixed designation D 5516; 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 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 the standard. The values in parentheses are for information only.

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.*

## 2. Referenced Documents

2.1 *ASTM Standards:*

D 9 Terminology Relating to Wood[2]

D 1165 Nomenclature of Domestic Hardwoods and Softwoods[2]

D 2915 Practice for Evaluating Allowable Properties for Grades of Structural Lumber[2]

D 3043 Methods of Testing Structural Panels in Flexure[2]

D 5516 Test Methods for Evaluating the Mechanical Properties of Fire-Retardant Treated Softwood Plywood Exposed to Elevated Temperatures[2]

D 6305 Practice for Calculating Bending Strength Design Adjustment Factors for Fire-Retardant Plywood Wood Sheathing[2]

E 84 Test Method for Surface Burning Characteristics of Building Materials[3]

E 176 Terminology of Fire Standards[3]

2.2 *Other Standards:*

AWPA C–27 Plywood-Fire Retardant Treatment by Pressure Processes[4]

U.S. Product Standard PS1 for Construction and Industrial Plywood[5]

NFPA 703 Standard for Fire Retardant Impregnated Wood and Fire Retardant Coatings for Building Materials[6]

## 3. Terminology

3.1 *Definitions*—Definitions used in this test method are in accordance with Terminologies D 9 and E 176, and Nomenclature D 1165.

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 X1.2.)

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

[1] 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.

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[2] *Annual Book of ASTM Standards*, Vol 04.10.

[3] *Annual Book of ASTM Standards*, Vol 04.07.

[4] Available from American Wood-Preservers' Assoc., P.O. Box 5690, Granbury, TX 76049–0690.

[5] Available from U.S. Department of Commerce, Washington, DC.

[6] Available from National Fire Protection Association, P.O. Box 9191, Quincy, MA 02269-9101.

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.

## 6. Test Specimens

6.1 *Material Selection*:

6.1.1 Test 3, 4, or 5-ply commercially available panels.

NOTE 2—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 Thickness shall not be less than 0.012 ± 0.001 m (15⁄32 ± 1⁄32-in.) nor greater than 0.016 ± 0.0005 m (5⁄8 ± 1⁄64-in. ).

6.1.3 Select as source materials 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 free of voids, core gaps, and core laps. 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 1.22-m (4-ft) wide sections to be treated and adjacent untreated 1.22–m (4-ft) sections shall have visually similar wood quality. Sample sections may be specially fabricated or selected from production.

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

NOTE 3—A special 5-ply, 0.0158-m ( 5⁄8-in.), unsanded N-grade Southern pine plywood has been used for this test. This type of plywood minimizes voids in the laminates and the veneers are specially selected to minimize knots and other natural defects.

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

6.1.4 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 0.61 by 1.22-m (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.

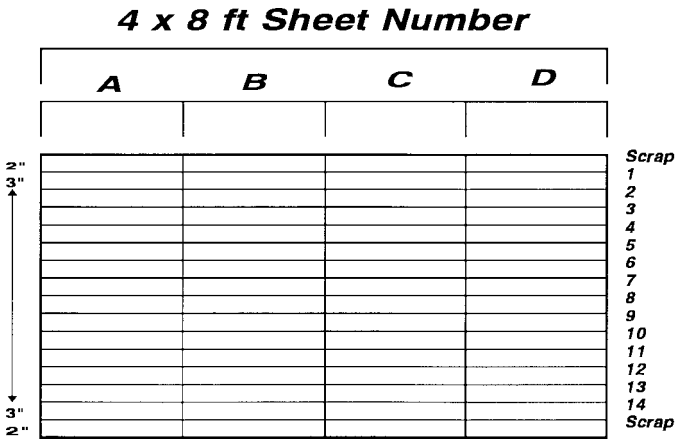


FIG. 1 Plywood Cutting Pattern

6.2 *Treatment*:

6.2.1 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 of the treated plywood. The retention range specified by the certifying agency shall provide a flame-spread index of 25 or less when tested in accordance with Test Method E 84 for 10 min, show no evidence of significant progression combustion when the test is continued for an additional 20-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 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 Standard C-27, NFPA Standard 703, or similar building code requirements for “fire-retardant-treated wood” that require the Test Method E 84 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 ducument 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 American Wood-Preservers' Association (AWPA) and National Fire Protection Association (NFPA) standards for fire retardant treated wood products limit kiln dry bulb temperatures. AWPA Standard 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 Standard 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. The sections shall not be damaged or warped during the drying process. Keep a well-documented kiln charge report and kiln recorder chart showing temperatures and humidities on the dried material.

6.4 *Specimen Preparation*:

6.4.1 After drying, cut the treated and untreated 0.61 by 1.22-m (2 by 4-ft) sections into nominal 0.076 by 0.61-m (3 by 24-in.) test specimens as shown on Fig. 1. Alternatively, specimen sizes in accordance with Methods D 3043 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 7).

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 D 2915).

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.[7]

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 ± 2 %. 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 ±0.2 %.

## 7. Procedure

7.1 *Specimen Exposure*:

7.1.1 After preconditioning, test the unexposed controls (see 6.4.1) as described in 7.1.2 and 7.1.3 for initial, unexposed bending strength properties.

7.1.2 Expose all the remaining treated and untreated specimen sets in a chamber controlled to 77 ± 1°C (170 ± 2°F) and a minimum of 50 % relative humidity. The control of the relative humidity in the chamber shall be ±4 % and average ±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°C (170°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 days are normally sufficient (Fig. 2 illustrates modulus of rupture (MOR) response with time).

7.2 *Postconditioning*—After exposure to elevated temperatures, postcondition all sets of treated and untreated specimens at an ambient temperature and relative humidity that allow the untreated specimens to equilibrate to a moisture content of 10 ± 2 %, using the same general procedure as for preconditioning described earlier. Then equilibrate the treated specimens to whatever equilibrium moisture content these conditions produce.

7.3 *Strength Testing—Flexural Properties*:

7.3.1 Test untreated and treated specimens for flexural stiffness and strength using the general procedures specified in Methods D 3043, Method A.

7.3.2 Deviations from Methods D 3043, Method A (see Ref **((2))**) are required as follows:

7.3.2.1 Nominal specimen size of 0.076 by 0.61 m (3 by 24 in.).

7.3.2.2 Test span of 0.56 m (22 in.).

[7] Cochran, W. G., and Cos, G. M., *Experimental Designs*, J. Wiley and Sons, Inc., New York, NY, 1957.