Designation: D 5516 – 01

An American National Standard

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 3201 Test Method for Hygroscopic Properties of Fire-Retardant Wood and Wood-Base Products[2]

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

E 176 Terminology of Fire Standards[3]

2.2 *American Wood Preservers' Association Standard:*

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

2.3 *Federal Standard:*

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

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 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.

[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.

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.

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 extended to 30 min, when the flame spread progresses no more than 10.5 ft (3.2 m) beyond the center line of the burners during the extended test and shows no more evidence of significant progressive combustion.

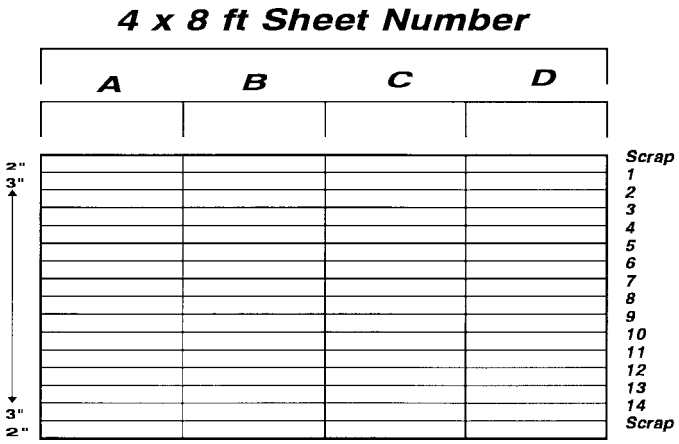


FIG. 1 Plywood Cutting Pattern

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. For 21 of the first 24 h of drying, the dry bulb temperature shall not be more than 2°C (3.6°F) below the maximum redry temperatures specified during that step of the manufacturer's procedures. For the remainder of the required kiln drying period, the dry bulb temperature shall not be more than 3°C (5.4°F) below the manufacturer's maximum for that step. 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.

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 5).

NOTE 5—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.[6]

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

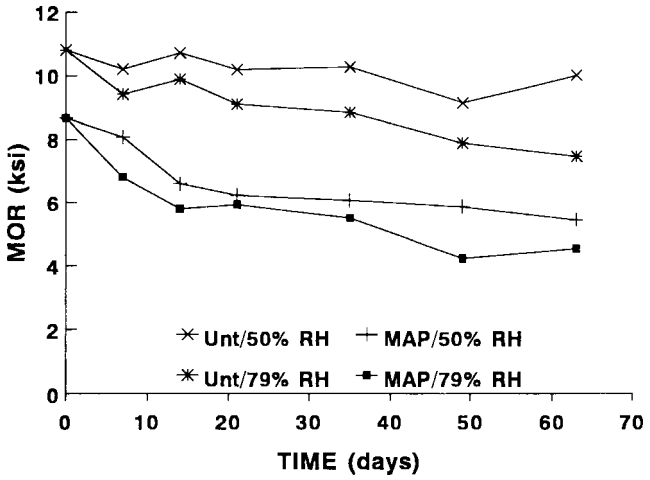
7.1 *Specimen Exposure*:

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.



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

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

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.).

7.3.2.3 Rotational end plates and lateral rotation of end supports are optional. However, the end supports shall be rounded if rotational end plates are not provided.

7.3.2.4 Loading rate of 0.305 m/s (0.20 in./min).

7.3.3 Load and deflection data shall be collected up to the maximum bending load and continued until the specimen can no longer withstand 50 % of the maximum load.

7.3.4 After testing, if a specimen has one or more of the following characteristics at the location of failure measure and report these characteristics:

7.3.4.1 Average short grain steeper than 1:16 in the tension ply or steeper than 1:8 in the compression ply;

7.3.4.2 Core lap of any width;

7.3.4.3 Core gap wider than 3.2 mm (⅛) in.

7.3.4.4 These characteristics may be listed as reasons for elimination of specimens from subsequent calculations. However, the minimum sample size is 18 specimens. Report strength data both with and without results from specimens containing these characteristics.

8. Report

8.1 Report the following information:

8.1.1 The average relative humidity and temperature for each conditioning environment.

8.1.2 Thickness, specific gravity (oven-dry mass/volume at test), test moisture content, modulus of elasticity, and modulus of rupture for each specimen; as well as maximum moment,

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