



Designation: D 6305 – 98^{ε1}

Standard Practice for Calculating Bending Strength Design Adjustment Factors for Fire-Retardant-Treated Plywood Roof Sheathing¹

This standard is issued under the fixed designation D 6305; 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.

^{ε1} NOTE—Eq 18 was corrected in April 2000.

1. Scope

1.1 This practice covers procedures for calculating bending strength design adjustment factors for fire-retardant-treated plywood roof sheathing. The methods utilize the results of strength testing after exposure at elevated temperatures and computer generated thermal load profiles reflective of exposures encountered in normal service conditions in a wide variety of climates.

1.2 Necessarily, common laboratory practices were used to develop the methods herein. It is assumed that the procedures will be used for fire-retardant-treated plywood installed using appropriate construction practices recommended by the fire retardant chemical manufacturers which include avoiding exposure to precipitation, direct wetting, or regular condensation.

1.3 The heat gains, solar loads, roof slopes, ventilation rates and other parameters used in this practice were chosen to reflect common sloped roof designs. This practice is applicable to roofs of 3 in 12 or steeper slopes, to roofs designed with vent areas and vent locations conforming to national standards of practice and to designs in which the bottom side of the sheathing is exposed to ventilation air. These conditions may not apply to significantly different designs and therefore this practice may not apply to such designs.

1.4 Information and a brief discussion supporting the provisions of this practice are in the Commentary in the appendix. A large, more detailed, separate Commentary is also available from ASTM.²

1.5 The methodology in this practice is not meant to account for all reported instances of fire retardant plywood undergoing premature heat degradation.

1.6 This practice is written in inch-pound units with SI units provided in parentheses for information only.

1.7 *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 This practice is under the jurisdiction of ASTM Committee D-7 on Wood and is the direct responsibility of Subcommittee D07.07 on Fire Performance of Wood. Current edition approved July 10, 1998. Published March 1999.

² Commentary on this practice is available from ASTM Headquarters. Request File No. D07-1004.

2. Referenced Documents

2.1 *ASTM Standards:*

D 9 Terminology Relating to Wood³

D 5516 Test Method for Evaluating the Mechanical Properties of Fire-Retardant Treated Softwood Plywood Exposed to Elevated Temperatures³

3. Terminology

3.1 *Definitions:*

3.1.1 Definitions used in this practice are in accordance with Terminology D 9.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *bin mean temperature*—10°F (5.5°C) temperature ranges having mean temperatures of 105 (41), 115 (46), 125 (52), 135 (57), 145 (63), 155 (68), 165 (74), and 175°F (79°C).

4. Summary of Practice

4.1 The test data determined by Test Method D 5516 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 and the practice thus extends laboratory strength data measured after accelerated aging to design value recommendations.

5. Significance and Use

5.1 This practice develops treatment factors that shall be used by fire retardant chemical manufacturers to adjust bending strength design values for untreated plywood to account for the fire-retardant treatment effects. This practice uses data from reference thermal load cycles designed to simulate temperatures in sloped roofs of common design to evaluate products for 50 iterations.

5.2 This practice applies to material installed using construction practices recommended by the fire retardant chemical manufacturers that include avoiding exposure to precipitation, direct wetting, or regular condensation. This practice is not meant to apply to buildings with significantly different designs than those described in 1.3.

5.3 Test Method D 5516 caused thermally induced strength losses in laboratory simulations within a reasonably short

³ *Annual Book of ASTM Standards*, Vol 04.10.

period. The environmental conditions used in the laboratory activated chemical reactions that are considered to be similar to those occurring in the field. This assumption is the fundamental basis of this practice.

6. Procedure to Calculate Strength Loss Rate

6.1 Use the load-carrying capacity in bending, referred to as maximum moment (M), as the controlling property for purposes of determining allowable spans.

6.1.1 *Test Results Based on Randomized Block Sampling*—Analyze average maximum moment (M) data for treated and untreated plywood developed in accordance with Test Method D 5516 using randomized block sampling as in the following sections:

6.1.1.1 Linear regressions of the form:

$$M = a(D) + b \quad (1)$$

where:

M = average maximum moment,

D = number of days of elevated temperature exposure, and

a, b = constants.

shall be fitted to the maximum moment and exposure time data for each elevated temperature exposure for both treated and untreated specimens. Average moments for specimens conditioned at room temperature but not exposed to elevated temperature prior to testing shall be included as zero day data in the regression analysis.

6.1.1.2 The intercept, or estimated maximum moment at zero days, of the regression for the treated specimens shall be taken as the unexposed average for treated specimens. For the untreated specimens, if a significant negative slope term (a) at the 95 % confidence level is obtained, the intercept of the untreated regression shall be designated the unexposed average. If a negative slope of the untreated specimen regression is not significant at the 95 % level or if the slope is positive, the average of the mean maximum moments at each exposure period, including zero, shall be considered the unexposed average moment for untreated specimens.

6.1.1.3 The ratio of the unexposed average maximum moment (M) for treated specimens to the unexposed average moment for untreated specimens shall be designated the immediate treatment effect, R_o , associated with the room temperature conditioning exposure of T_o . The ratio of the maximum moments estimated from the regression for treated specimens at 60 days⁴ to the unexposed average for untreated specimens shall be designated the 60 day treatment ratio R_{ti} at exposure temperature T_i :

$$R_o = M_{TRT,UNEX}/M_{UNTRT,UNEX} \text{ at Temperature, } T_o \quad (2)$$

$$R_{ti} = M_{TRT,60}/M_{UNTRT,UNEX} \text{ at Temperature, } T_i \quad (3)$$

6.2 *Test Results Using End-Matched Treated and Untreated Samples*—When end-matching of treated and untreated specimens is employed to reduce variability in accordance with Test Method D 5516 and each conditioning temperature used is represented by at least one paired specimen set from each

plywood panel providing test material, the analysis shall be as in the following sections.

6.2.1 The average maximum moment (M) of the treated and untreated specimens from each panel conditioned at the same temperature for the same period of time shall be computed and the ratio of these moments determined. The average of these panel ratios shall be designated the test treatment ratio, R_t :

$$R_t = M_{TRT,EX}/M_{UNTRT,EX} \quad (4)$$

6.2.2 The slope and intercept of the linear relationship between the mean average maximum moment for untreated specimens and days of exposure for all elevated temperatures evaluated using the specimens from the same panels shall be determined in accordance with 6.1.1.2. Averages for untreated specimens conditioned at room temperature but not exposed to elevated temperature prior to testing shall be included as zero day data in the regression analysis. If the slope of this relationship is negative and is significant at the 95 % confidence level, the test treatment ratio determined in 6.2.1 shall be adjusted by the ratio of the average untreated test maximum moment for all specimens at the same temperature and exposure period and the intercept or zero day average maximum moment for untreated specimens.

6.2.3 For each temperature exposure, linear regressions of the form:

$$R_t = a(D) + b \quad (5)$$

where:

D, a, b = as previously defined.

shall be fitted to the test treatment ratio, or adjusted test treatment ratio, and number of days of elevated temperature exposure. The intercept or zero day ratio estimated from this regression shall be designated the immediate treatment effect, R_o , associated with the room temperature conditioning exposure of T_o . The treatment ratio estimated from the regression for 60 day exposure shall be designated the 60 day treatment ratio, R_{ti} , at exposure temperature T_i :

$$R_o = b_{TRT,UNEX} \text{ at Temperature, } T_o \quad (6)$$

$$R_{ti} = R_{TRT,60} \text{ at Temperature, } T_i \quad (7)$$

6.3 The ratio R_{ti} from 6.1.1.3 or 6.2.3 shall be adjusted to a 50 % relative humidity (RH) basis by the following equation:

$$R_i = R_o - [R_o - R_{ti}][50/RH_i] \quad (8)$$

where:

R_i = 60 day treatment ratio at 50 % RH,

RH_i = elevated temperature test RH, and

R_o, R_{ti} = as previously defined.

6.4 If Test Method D 5516 protocol testing was only done at one elevated temperature, rates at other temperatures shall be estimated by the use of an Arrhenius equation that states that the rate of a chemical reaction is approximately halved for each 18°F (10°C) the temperature is reduced. (Conversely, the rate approximately doubles for each 18°F (10°C) that the temperature is increased.)

6.4.1 To accomplish this, the rate constant, k_1 , for the loss of maximum moment (M) at the temperature, T_1 , shall be first determined as:

⁴ The 60 day period was selected as a reference level for calculation purposes. See Test Method D 5516.