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# Standard Practice for Assigning Allowable Properties for Mechanically Graded Lumber[1]

This standard is issued under the fixed designation D6570; 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 practice covers the methodology of grade qualification, assignment of design properties, and requirements for the quality control of mechanically graded solid sawn lumber.

1.2 This practice acknowledges alternative methods for the assignment of specific properties. These methods are assignment by test, relationship to other properties, and by procedures in other appropriate standards.

1.3 *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]

D9 Terminology Relating to Wood and Wood-Based Products

D143 Test Methods for Small Clear Specimens of Timber

D198 Test Methods of Static Tests of Lumber in Structural Sizes

D245 Practice for Establishing Structural Grades and Related Allowable Properties for Visually Graded Lumber

D1165 Nomenclature of Commercial Hardwoods and Softwoods

D1990 Practice for Establishing Allowable Properties for Visually-Graded Dimension Lumber from In-Grade Tests of Full-Size Specimens

D2395 Test Methods for Density and Specific Gravity (Relative Density) of Wood and Wood-Based Materials

D2555 Practice for Establishing Clear Wood Strength Values

D2915 Practice for Sampling and Data-Analysis for Structural Wood and Wood-Based Products

D3737 Practice for Establishing Allowable Properties for Structural Glued Laminated Timber (Glulam)

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

D4761 Test Methods for Mechanical Properties of Lumber and Wood-Base Structural Material

D7438 Practice for Field Calibration and Application of Hand-Held Moisture Meters

2.2 *ANSI Standards:*[3]

ANSI/AITC A190.1 American National Standard for Wood Products—Structural Glued Laminated Timber

ANSI/AWC NDS National Design Specification for Wood Construction

2.3 *Canadian Standards Association Standard:*[4]

CSA O141 Softwood Lumber

2.4 *National Institute of Standards and Technology Standard:*[5]

PS 20 Voluntary Product Standard, American Softwood Lumber Standard

## 3. Terminology

3.1 *Definitions*—For definitions of terms related to wood, refer to Terminology D9.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *mechanical evaluation, n*—identification and appraisal of one or more physical or mechanical lumber characteristics as part of the lumber segregation process.

3.2.2 *mechanically graded lumber, n*—solid sawn lumber graded by mechanical evaluation. Visual evaluation also may be required. The material has assigned design properties and is manufactured for use as structural members.

[1] This practice is under the jurisdiction of ASTM Committee D07 on Wood and is the direct responsibility of Subcommittee D07.02 on Lumber and Engineered Wood Products.

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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.

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

[4] Available from Canadian Standards Association (CSA), 5060 Spectrum Way, Mississauga, ON L4W 5N6, Canada, http://www.csa.ca.

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

3.2.3 *qualified agency, n*—an organization, hereafter referred to as the agency, that has trained personnel and procedures to ensure the system evaluations and grades comply with all applicable requirements of this practice.

3.2.3.1 *Discussion*—The agency shall have no financial interest in, nor shall be financially dependent upon, any single company manufacturing the product being inspected or tested; and shall not be owned, operated, or controlled by any such company.

3.2.3.2 *Discussion*—The agency shall conform with the provisions for agency accreditation under the appropriate consensus standard.

3.2.4 *visual evaluation, n*—identification and appraisal of lumber growth and manufacturing characteristics by visual means as part of the lumber segregation process.

NOTE 1—In the United States and Canada, criteria for agency accreditation are contained in PS 20, ANSI/AITC A190.1, and CSA O141.

## 4. Significance and Use

4.1 The procedures described in this practice are intended to be used to establish appropriate allowable unit stresses, moduli of elasticity, and specific gravity for mechanically graded solid sawn lumber. An on-going quality control program to monitor compliance with the assigned grade properties is required.

## 5. System Requirements

5.1 *Mechanical Device Requirements* —A mechanical device used as part of the grading process shall demonstrate the ability to measure the mechanical or physical wood property used to segregate the lumber.

5.2 *Visual Requirements:*

5.2.1 Characteristics to be limited by visual evaluation, shall be documented as part of the qualification and quality control procedures. Such limitations shall be part of the grade requirements.

5.2.2 Personnel conducting visual evaluations shall be qualified by the agency.

## 6. Criteria for Grade Qualification

6.1 *General Requirements:*

6.1.1 A minimum of one assigned property of a grade shall be qualified by test. The grade assignment for properties qualified by test is given in 7.2.

6.1.1.1 If the modulus of elasticity (*MOE*) is the only property assigned to a grade, it shall be evaluated by test.

6.1.1.2 If both strength and *MOE* properties are assigned to a grade, a minimum of one strength property and one *MOE* property shall be evaluated by test. If only one strength property is tested, that property shall be either the modulus of rupture (*MOR*) or ultimate tensile stress (*UTS*).

6.1.2 Each grade shall be qualified at each size and for each species/species group.

6.1.3 Sampling, evaluation, and presentation of data shall be in accordance with Practice D2915.

6.2 *Qualification Samples:*

6.2.1 The criteria for selecting qualification samples shall be documented and shall be in accordance with 6.1.3.

6.2.2 All qualification samples shall meet the visual requirements established for the grade.

6.2.3 The minimum sample size for estimation of strength properties, and *MOE* shall be 53 specimens.

6.2.4 The minimum sample size for estimation of mean or median property values, other than *MOE*, shall be 30 specimens.

6.2.5 When the allowable shear stress parallel to grain ($Fv$) or the allowable compressive stress perpendicular to grain ($Fc\perp$) are determined in accordance with 7.3.4 and 7.3.5, respectively, the specific gravity of a minimum of 30 qualification test specimens shall be measured and recorded.

6.3 *Qualification Test Methods:*

6.3.1 When mechanical and physical properties in Section 7 are determined by tests, the appropriate ASTM standards shall be used:

6.3.1.1 The determination of the *MOE* by edgewise bending shall employ third-point in accordance with Test Methods D4761.

6.3.1.2 The determination of the *MOR* by edgewise bending shall employ third-point in accordance with Test Methods D4761.

6.3.1.3 The determination of the *MOE* by flat-wise bending shall be in accordance with Test Methods D4761.

6.3.1.4 The *UTS* of a sample shall be determined according to Test Methods D4761.

6.3.1.5 Whenever possible, a minimum gage length of not less than 96 in. (2.44 m) shall be used. When determination of the tension parallel to the grain *MOE* is desired, testing shall be conducted according to the provisions of Test Methods D198.

6.3.1.6 The determination of the ultimate shear strength parallel to grain values shall be in accordance with Test Methods D143.

6.3.1.7 The determination of the compression perpendicular to grain values shall be in accordance with Test Methods D143.

6.3.2 Determination of the moisture content of the lumber sample shall be in accordance with Test Methods D4442 or D7438.

6.3.3 Specific gravity shall be based on weight and dimensions when oven dry as specified in Test Methods D2395. Measurements shall either be taken on oven-dried specimens, or at some other moisture content and the values adjusted to the oven-dry condition.

## 7. Procedures for Assignment of Allowable Mechanical Properties and Specific Gravity

7.1 Allowable mechanical properties and specific gravity shall be assigned using the qualification test procedures of 7.2, the property correlation procedures of 7.3, or the procedures of 7.4. These alternative procedures of 7.2 – 7.4 define the maximum property values, which are permitted to be assigned to a grade of mechanically graded lumber.

7.1.1 Selection of the procedures specified in 7.1 to establish a value for any particular property assigned to a grade is the prerogative of the grade specification author.

7.1.2 The factors used in 7.2 and 7.3 apply to softwood lumber.

7.1.3 If the *Fb* is to be an assigned property, it shall be determined by the test procedures of 7.2.

7.1.4 Hardwood lumber species shall be reduced by the applicable factors in Practice D245, Table 8.

7.1.4.1 Species containing interlocked grain shall have *Fb*, *Ft*, and *Fc* evaluated by test procedures of 7.2. Sample size selection shall consider the evidence of interlocked grain and its representation in the sample.

7.2 *Assignment of Allowable Properties by Qualification Tests:*

7.2.1 Assignment of allowable properties by test shall follow the procedures of this section. Test results shall be evaluated according to Practice D2915.

7.2.1.1 Qualification tests are used to either establish allowable mechanical property values for new grades or to qualify for published grade categories.

7.2.2 *Extreme Fiber Stress in Bending (Fb)*—The fifth percentile tolerance limit (75 % confidence) for the *MOR* of the qualification sample shall equal or exceed 2.1 times the assigned *Fb* value.

7.2.3 *Fiber Stress in Tension Parallel to Grain (Ft)*—The fifth percentile tolerance limit (75 % confidence) for the *UTS* of the qualification sample shall equal or exceed 2.1 times the assigned *Ft* value.

7.2.4 *Fiber Stress in Compression Parallel to Grain (Fc)*—The fifth percentile tolerance limit (75 % confidence) for ultimate compressive strength parallel to grain (*UCS*) of the qualification sample shall equal or exceed 1.9 times the assigned *Fc* value.

7.2.5 *Shear Stress Parallel to Grain (Fv)*—The fifth percentile tolerance limit (75 % confidence) *Fv* for the qualification sample shall equal or exceed 2.1 times the assigned *Fv* value.

7.2.6 *Modulus of Elasticity:*

7.2.6.1 The upper bound of the 95 % confidence interval of the qualification sample mean *MOE* shall meet or exceed the assigned grade *MOE*.

7.2.6.2 For grades that include a near-minimum *MOE* specification, the sample parametric or non-parametric point estimate as determined in accordance with Practice D2915 shall equal or exceed the near-minimum *MOE* for the grade.

7.2.7 *Specific Gravity (SG)*—The upper bound of the 95 % confidence interval of the qualification sample mean specific gravity shall meet or exceed the assigned specific gravity value.

7.2.8 *Fiber Stress in Compression Perpendicular to Grain (Fc⊥)*—The *Fc⊥* shall be determined by test in accordance with Test Methods D143, and adjusted by the procedures of Practice D245.

7.3 *Assignment of Allowable Properties Based on Relationships:*

7.3.1 The methods of 7.3 permit assignment of certain allowable properties based on recognized relationships between the assigned properties. This assignment shall be in accordance with the following procedures.

7.3.2 *Fiber Stress in Tension Parallel to Grain:*

7.3.2.1 The maximum allowable *Ft* shall be assigned in accordance with an established grade assignment model based on the assigned *Fb*, which has been published by the agency.

7.3.2.2 In the absence of corroborative data, a maximum *Ft/Fb* ratio of 0.45 shall be used.

7.3.3 *Fiber Stress in Compression Parallel to Grain:*

7.3.3.1 The maximum allowable *Fc* shall be calculated from the following equation:

$$Fc = (0.7098\ Fb + 2060.7)/1.9 \quad (1)$$

where:

*Fb* = the assigned *Fb* for the grade.

7.3.4 *Shear Parallel to Grain*—The *Fv* determined by a specific gravity-based model (see Appendix X1) is permitted when the specific gravity is assigned in accordance with 7.2.7 or 7.3.6.

7.3.5 *Fiber Stress in Compression Perpendicular to Grain (Fc⊥)*—The *Fc⊥* determined by a specific gravity-based model (see Appendix X1) is permitted when specific gravity is assigned in accordance with 7.2.7 or 7.3.6.

7.3.6 *Specific Gravity*—It is permitted to assign specific gravity in accordance with a model that relates grading machine measurement to specific gravity. When such a model is used, the agency shall develop corroborative data to support the appropriateness of the assigned specific gravity.

7.4 *Assignment of Allowable Properties by Other Standards:*

7.4.1 The methods of 7.4 permit assignment of certain allowable properties based on procedures in the appropriate ASTM and ANSI standards.

7.4.2 *Shear Parallel to Grain Stress*—The *Fv* shall be assigned in accordance with the procedures of Practice D245 for visually graded solid sawn lumber of the same species or species group.

7.4.3 *Fiber Stress in Compression Perpendicular to Grain*—The *Fc⊥* shall be assigned in accordance with the procedures of Practice D245 for visually graded solid sawn lumber of the same species or species group.

7.4.4 *Specific Gravity*—The specific gravity shall be assigned as reported in ANSI/AWC NDS for visually graded solid sawn lumber of the same species or species group.

## 8. Minimum Allowable Property Increment

8.1 Allowable properties shall be rounded in accordance with Table 1.

## 9. Quality Control

9.1 A quality control program shall be developed for each mechanical grading system. The quality control program shall delineate the respective responsibilities of the producer and the agency.

**TABLE 1 Rounding Rules for Allowable Property Values**

| | |
|---|---|
| *MOE* | 100 000 psi |
| *Fb* | 50 psi at 1000 psi and above<br>25 psi below 1000 psi |
| *Ft* | 25 psi |
| *Fc* | 25 psi |
| *Fc⊥* | 5 psi |
| *Fv* | 5 psi |
| *SG* | 0.01 |

9.2 The quality control program shall include monitoring and control of both the mechanical and visual portions of the system.

9.2.1 The visual evaluation of the grade shall be conducted in accordance with the applicable agency requirements.

9.2.2 The quality control program shall address the procedures for quality control of the mechanical system.

9.3 The quality control program shall require periodic evaluation of at least one of the assigned properties qualified in 6.1.1.

9.4 A quality manual shall be prepared for each production facility.

9.4.1 The quality manual shall address precision and bias of calibration and measurement.

9.4.2 The manual shall describe the inspection, sampling, testing, and analysis to be conducted in accordance with this practice and other applicable requirements.

9.4.3 The manual shall describe corrective action to be taken with nonconforming material.

9.4.4 Documentation requirements of the quality control program shall be described in the manual, including retention and other applicable requirements.

9.4.5 The manual shall describe the individual and joint responsibilities of the production facility and the agency.

## 10. Keywords

10.1 lumber; mechanically graded lumber; solid sawn lumber; wood

## APPENDIXES

**(Nonmandatory Information)**

## X1. FORMULAS FOR DETERMINING THE SHEAR STRESS PARALLEL TO GRAIN AND FIBER STRESS IN COMPRESSION PERPENDICULAR TO GRAIN

### X1.1 Shear Stress Parallel to Grain

X1.1.1 When qualified by measurement of the specific gravity (*SG*), the allowable stress in shear stress parallel to the grain (*Fv*) shall be calculated by a relationship between *SG* (based on oven dry weight/oven dry volume basis) and *Fv*:

X1.1.2 For Douglas Fir, Douglas Fir-Larch, Douglas Fir-South, Hem-Fir, Southern Pine, Spruce-Pine-Fir (South), Western Woods, and Western Cedars:

$$Fv = (266 \times SG) + 40 \quad \text{(X1.1)}$$

X1.1.3 For Douglas Fir-Larch (N), Hem-Fir (N), and Spruce-Pine-Fir:

$$Fv = (284.8 \times SG) + 26.6 \quad \text{(X1.2)}$$

where:

*SG* = specific gravity (oven-dry weight/oven-dry volume basis)

### X1.2 Compression Perpendicular to the Grain ($Fc\perp$) (0.04-in. deformation limit)

X1.2.1 When qualified by measurement of the *SG*, the allowable stress shall be calculated by a relationship between *SG* (based on oven dry weight/oven dry volume) and $Fc\perp$:

X1.2.1.1 For Douglas Fir, Douglas Fir-Larch, Douglas Fir-South, Hem-Fir, Southern Pine, Spruce-Pine-Fir (South), Western Woods, and Western Cedars:

$$Fc\perp = (2252.4 \times SG) - 480 \quad \text{(X1.3)}$$

X1.2.1.2 For Douglas Fir-Larch (N), Hem-Fir (N), and Spruce-Pine-Fir:

$$Fc\perp = (2243.8 \times SG) - 473.8 \quad \text{(X1.4)}$$

### X1.3 Compression Perpendicular to the Grain ($Fc\perp$) (0.02-in. deformation limit)

X1.3.1 Refer to the appropriate agency grading rules for equations to adjust the $Fc\perp$ from a 0.04-in. deformation limit to a 0.02-in. deformation limit.