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# Standard Practice for Sampling Forest Trees for Determination of Clear Wood Properties[1]

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## INTRODUCTION

The everyday use of wood for many different purposes creates a continual need for data on its mechanical properties. Small clear specimen testing to characterize a species has historically been employed for such property determination, and related methods of test are outlined in Test Methods D143.

Because wood is a biological material, its mechanical properties are subject to considerable natural variation. Thus, the results of tests to evaluate the mechanical properties of a species depend to a great extent upon how the forest trees are sampled for test material. Ideally, if the results of mechanical property evaluations are to be representative of the forest sampled, probability sampling of materials such as outlined in Practice E105 must be used. However, true probability sampling of the forest trees for determination of mechanical properties can be extremely complex and expensive because of the broad geographic range and topographic conditions under which a tree species grows. In some instances, direct probability sampling may be impractical, necessitating the need for alternative sampling procedures.[2,3]

## 1. Scope

1.1 This practice offers two alternative physical sampling procedures: cruciform sampling and random sampling. The choice of procedure will depend upon the intended use for the test results, the resources available for sampling and testing, and the availability of existing data on the mechanical properties and specific gravity of the species of interest.

1.2 A third procedure, double sampling, is included primarily by reference. This procedure applies the results of cruciform or random samples through correlation to improve or update property values.

1.3 *Units*—The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI 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, health and environmental 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:*[4]

D9 Terminology Relating to Wood and Wood-Based Products
D143 Test Methods for Small Clear Specimens of Timber
D1038 Terminology Relating to Veneer and Plywood
D2555 Practice for Establishing Clear Wood Strength Values
E105 Practice for Probability Sampling of Materials

## 3. Terminology

3.1 *Definitions:*

[1] This practice is under the jurisdiction of ASTM Committee D07 on Wood and is the direct responsibility of Subcommittee D07.08 on Forests.

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[2] Bendtsen, B. A., Freese, F., and Ethington, R. L., "A Forest Sampling Method for Wood Strength," *Forest Products Journal*, Vol 20, No. 11, 1970, pp. 38–47.

[3] Pearson, R. G., and Williams, E. J., "A Review of Methods for Sampling of Timber," *Forest Products Journal*, Vol 8, No. 9, 1958, pp. 263–268.

[4] 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.

3.1.1 For definitions of terms used in this standard, refer to Terminologies D9 and D1038.

## 4. Significance and Use

4.1 This practice covers procedures of sampling for obtaining small, clear wood specimens which, when tested in accordance with Test Methods D143 and, in conjunction with full-size product tests, will provide mechanical properties for use in deriving design properties for lumber, panels, poles, house logs, and other products.

4.2 Data obtained by testing specimens sampled in accordance with these methods also provide information on the influence on mechanical properties of such factors as density, locality of growth, position in cross section, height in the tree, and moisture content.

4.3 Cruciform sampling is of principal value when information is desired on the influence on mechanical properties of height in the tree; of age or radial position in the tree; of rate of growth; the change from sapwood to heartwood; the relationships between mechanical properties and factors such as specific gravity; and making general comparisons between species for purposes of rating or selecting species for specific end-use products. Cruciform sampling does not provide unbiased estimates of mean values, percentile or other descriptive statistics, or a means of associating statistical confidence with estimates of descriptive statistics.

4.4 Double sampling is used when it is desired to improve or update existing estimates of mechanical property values that are the basis for establishing allowable design stresses for stress-graded lumber, plywood, poles and piling, and other wood products. The method involves predicting one property by carefully observing a well-correlated auxiliary property that is presumably easier or cheaper to measure. A sample estimate of the auxiliary property is obtained with a high degree of precision by representatively sampling the population. A smaller independent sample or a subsample of the large sample is used to establish a relationship between the auxiliary property and the property for which an estimate is desired. As applied to sampling a forest, double sampling has employed specific gravity to predict mechanical properties. The double-sampling method provides unbiased estimates of mean mechanical property values and an approximation method for estimating percentile values. Statistical confidence may be associated with the estimates of the means but not the percentile values.

4.5 Random sampling is used when probability estimates of descriptive statistics and property distributional characteristics are desired as the basis for establishing allowable design stresses for lumber and other stress-rated products. It is applicable when data for a species do not exist or when existing estimates are believed no longer applicable because of a changing forest character. Random sampling provides better probability estimates than double sampling and is less expensive and quicker if sampling and testing must be completed to establish mechanical property-specific gravity regressions for the double-sampling method.

## 5. Authentic Identification

5.1 The material shall be from trees selected in the forest by one qualified to identify the species and to select the trees. Where necessary, herbarium samples such as leaves, fruit, twigs, and bark shall be obtained to ensure positive identification.

## 6. Cruciform Sampling – Primary Method

6.1 The standard methods for preparing small, clear specimens of timber, primary method, provide for cutting the log sections (divided into and identified as bolts) systematically into sticks of nominal 2½ by 2½ in. (64 by 64 mm) in cross section, that are later surfaced to provide the test specimens 2 by 2 in. (51 by 51 mm) in cross section, on which the system is based. These methods have served as a basis for the evaluation of the various mechanical and related physical properties of the clear wood of different species of wood. These methods have been extensively used, and a large amount of data based on them have been obtained and published.

6.1.1 The 2 by 2 in. (51 by 51 mm) test specimen has the advantage that it embraces a number of growth rings, is less influenced by earlywood and latewood differences than smaller specimens, and is large enough to represent a considerable proportion of the material.

6.1.2 The choice of specimen size may be influenced by the objectives of sampling and by the rate of growth of the material. Radial property gradients are primarily influenced by age, and large specimens that encompass several rings may mask the age influence. Height gradients must be evaluated by specimens from the same annual ring because of age influence. Thus, small specimens are preferred for measuring both radial and height gradients. When the purpose of sampling is to estimate clear wood properties, large specimens that include a number of annual rings are preferred. Even with 2 by 2 in. (51 by 51 mm) specimens, fast rates of growth will result in few rings per specimen. Regardless of the purpose of sampling, the analysis and reporting of data may require careful consideration of the character of the specimen.

6.2 *Selection of Number of Trees*—For each species to be tested, select the number and the character of the trees to accomplish the purpose of the sampling. For traditional mechanical property data base development, a minimum of five trees have usually been selected that have been judged "representative" of the trees harvested of the species. Note that if unbiased estimates and statistical confidence statements are required, other methods are needed (Section 4).

6.3 *Selection and Number of Bolts*—The material of each species selected for test shall be representative of the clear, straight-grained wood in the merchantable bole of the tree. A traditional method of selection is shown in Appendix X2. Note that the sampling permits varying the intensity of sampling by tree (in accordance with Appendix X2) if the resulting data will support the anticipated analysis. X2.1 illustrates merchantable section and bolt labeling.

6.4 *Substitution of Flitches for Bolts:*

6.4.1 In cases where the logs or bolts are over 60 in. (1.52 m) in diameter, a single flitch 6 in. (15 cm) in thickness, taken through the pith representing the full diameter of the log, may be substituted, in the same length, for the full log or bolt specified in 6.3.

6.4.2 Where orientation of test specimen to geographic features is considered critical, flitch shall maintain the coordinates regarded as important in the specimen of 6.9.

6.5 *Selection for Site Representation*—Inferences in analysis that relate to geographic distribution or site-specific features must be anticipated in selecting both the sample numbers and sources. The number of trees shall conform to 6.2 and 6.3. If the analysis requires statistical inferences, random sampling (Section 8) is one method.

6.6 *Field Marking:*

6.6.1 Field marking procedures shall ensure identification of trees, bolts, and shipment. Appendix X2 provides a traditional method.

6.6.2 If the orientation of test specimens to geographical or bolt features is critical, maintenance of cardinal point orientation is recommended.

6.7 *Field Descriptions:*

6.7.1 Complete field notes describing the material shall be fully and carefully made by the collector. These notes shall be sufficient to supply documentation similar to that in Table X1.1, with actual content chosen as appropriate for the objectives of the study.

6.7.2 Photographs of the standing trees selected should be taken when practicable.

6.8 *Preparation for Shipment*—Maintenance of moisture content of the material and of all labeling documentation is a requirement. Paragraph X2.3 provides traditional guidelines.

6.9 *Sawing and Marking of Bolts and Test Sticks*—Sections of logs (consisting of two bolts) shall be marked and sawn into 2½ by 2½ in. (64 by 64 mm) sticks. Marking of bolts and sticks shall maintain continuity to the tree, and shipment. Consistency with 6.6 shall be maintained. X2.1 – X2.4 document the traditional procedures.

6.10 *Matching for Tests of Dry Material:*

6.10.1 If one purpose of sampling is to provide comparison of green and dry properties, provisions may be made for matching of specimens within the tree. The traditional approach is as follows:

6.10.2 The collection of the material (Section 6) has been arranged to provide for tests of both green and dry specimens that are closely matched by selection from adjacent parts of the same tree. The 8 ft (2.44 m) long sections, after being marked in accordance with 6.9, shall be sawn and marked in 2½ by 2½ in. by 8 ft (64 by 64 mm by 2.44 m) sticks. Each 2½ by 2½ in. by 8 ft (64 by 64 mm by 2.44 m) stick shall then be cut into two 4 ft (1.22 m) pieces, making sure that each part carries the proper designation and bolt letter.

6.10.3 Some of the 2½ by 2½ in. by 4 ft (64 by 64 mm by 1.22 m) sticks from each 8 ft (2.44 m) section are to provide specimens to be tested green (unseasoned) and the remaining ones are to be dried and tested. To afford matching, the 4 ft (1.22 m) sticks of one bolt shall be interchanged with the 4 ft (1.22 m) sticks of the next adjacent bolt from the same tree to form two composite bolts, each being complete and being made of equal portions of the adjacent 4 ft (1.22 m) bolts. The sticks from one of these composite bolts shall be tested green and those from the other shall be tested after drying. Thus, the sticks of each composite bolt shall be regarded as if they were from the same bolt. X2.5 illustrates a method of forming composite bolts.

6.10.4 The traditional procedure provides for end-to-end matching (end matching) of sticks to be tested dry with those to be tested green, which is to be preferred when practicable. If, because of the nature of the material, end matching is not practicable, side matching may be used.

## 7. Cruciform Sampling – Secondary Method

7.1 The cruciform secondary method is intended for use in evaluating the properties of wood only when relatively small trees, generally less than 12 in. (30 cm) in diameter when measured approximately 4½ ft (1.37 m), diameter breast height, are available to provide the test specimens and only when such trees because of crook, cross grain, knots, or other defects are of such quality that the longer clear, straight-grained specimens required by the primary method cannot reasonably be obtained. Whenever possible, the procedure for the primary method shall be used regardless of the size of trees. Since the procedure for the secondary method for many features, such as in selection and care of material, is identical with the primary method, the secondary method presented herewith are referenced to the primary method, and procedure is given only where it differs therefrom. For convenience the section numbers in the secondary method corresponds in the last two digits with the numbering of the primary method. Thus, Section 7 for the secondary method corresponds in subject matter to Section 6.

7.1.1 Because of the cross-sectional size and the length of specimen required for some of the tests (30 in. (76 cm) for static and impact bending) it is, however, sometimes difficult to obtain test specimens in adequate number and entirely free of defects from bolts representing smaller trees, particularly trees under 12 to 15 in. (30 to 38 cm) in diameter. With increasing need for evaluating the properties of species involving smaller trees, and the increasing importance of second-growth timber that is expected to be harvested much before it reaches the sizes attained in virgin stands, there has developed a need for secondary methods of test in which at least the longer test specimens are smaller than 2 by 2 in. (51 by 51 mm) in cross section.

7.1.2 The exceedingly rapid rate of growth and corresponding wide annual rings in much second-growth material, together with the desirability of incorporating more than a single year's growth increment in a test specimen, has necessitated limiting the minimum cross section of test piece in these secondary methods to 1 by 1 in. (25 by 25 mm). Data analysis based on these small specimens of rapid growth rate wood is particularly vulnerable if the purpose of the sampling is to estimate total clearwood properties. See additional comments in 6.1.2.