Designation: D1761 – 20

Standard Test Methods for Mechanical Fasteners in Wood and Wood-Based Materials[1]

This standard is issued under the fixed designation D1761; 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.

This standard has been approved for use by agencies of the U.S. Department of Defense.

INTRODUCTION

The use of wood and wood-based materials in many structural and other applications often involves the use of mechanical fasteners, such as nails, screws, bolts, lag screws, and timber connectors. Data on the resistance and performance of such fasteners are frequently needed for design and for comparative purposes. Presented are methods of conducting tests for nail, staple, and screw (except machine screws) withdrawal resistance and lateral load transmission by nail, staple, screw, bolt, and timber connector. The use of standard methods for these tests is recommended as a means of obtaining comparable data and of eliminating variables in test results because of variations in testing methods.

The tests appear in the following order:

	Sections
Nail, staple, or screw withdrawal test	4 to 13
Nail, staple, or screw lateral resistance test	14 to 21
Bolted or timber connector joint test	22 to 30
Keywords	31

1. Scope

1.1 These test methods provide a basic procedure for evaluating the withdrawal and lateral resistance of fasteners installed in wood and wood-based materials. Spikes are included as nails in this standard.

1.2 The tests also provide a basis for determining comparable performance of different types and sizes of fasteners installed in wood and wood-based materials.

1.3 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:*[2]

D9 Terminology Relating to Wood and Wood-Based Products
D143 Test Methods for Small Clear Specimens of Timber
D2395 Test Methods for Density and Specific Gravity (Relative Density) of Wood and Wood-Based Materials
D2915 Practice for Sampling and Data-Analysis for Structural Wood and Wood-Based Products
D4442 Test Methods for Direct Moisture Content Measurement of Wood and Wood-Based Materials
E4 Practices for Force Verification of Testing Machines
F547 Terminology of Nails for Use with Wood and Wood-Base Materials
F1667 Specification for Driven Fasteners: Nails, Spikes, and Staples

[1] These test methods are under the jurisdiction of ASTM Committee D07 on Wood and are the direct responsibility of Subcommittee D07.05 on Wood Assemblies.

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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.

2.2 *Other Standards:*
ASME B18.6.1 Wood Screws (Inch Series)[3]
Federal Specification FF-W-92 for Washers, Metal, Flat (Plain)[4]

3. Terminology

3.1 *Definitions:*

3.1.1 For general definitions of terms related to wood, refer to Terminologies D9 and F547.

NAIL, STAPLE, OR SCREW WITHDRAWAL TEST

4. Summary of Test Method

4.1 These test methods provide a basic procedure for evaluating the resistance of wood and wood-based materials to withdrawal of nails, staples, and screws. The tests also provide a basis for determining comparable performance of different types and sizes of nails, staples, and screws in withdrawal from wood and wood-based materials.

4.2 Specimens consist of wood members (prisms of wood or wood-based products), with nails, staples, or screws installed at right angles to one or more faces. The fasteners are withdrawn at a uniform rate of speed by means of a testing machine, and the maximum load is recorded. Supplementary physical properties of the wood or wood-based product are also determined.

5. Significance and Use

5.1 The resistance of a species of wood or a wood-based product to withdrawal of nails, staples, or screws is a measure of its ability to hold or be held to an adjoining object by means of such fasteners. Factors that affect this withdrawal resistance include the physical and mechanical properties of the wood; the size, shape, and surface condition of the fasteners; the speed of withdrawal; physical changes to wood or fasteners between time of driving and time of withdrawal; orientation of the fastener relative to the fiber axis; and the occurrence and nature of pre-bored lead holes.

5.2 By using consistent sizes and types of nails, staples, and screws, withdrawal resistance of a wood species or wood product can be determined, and such values for two or more wood species or wood products can be compared. Similarly, comparative performances of different sizes or types of nails, staples, or screws can be determined by using a standard procedure with a particular wood or wood-based product, which eliminates the wood or the wood-based product as a variable. Since differences in test methods can have considerable influence on results, it is important that a standard procedure be specified and adhered to if test values are to be related to other test results.

6. Apparatus

6.1 *Testing Machine*—Any suitable testing machine that is capable of operation at a constant rate of motion of the movable head and has an accuracy of ±1 % when calibrated in accordance with Practices E4.

6.2 *Grips*—A gripping device shaped to fit the base of the fastener head and of such a design as to allow accurate specimen positioning and true axial loading, is required. A clamping assembly that will hold the specimen to one platen of the machine is also required. A suitable test mechanism for screw withdrawal is illustrated in Fig. 1.

7. Test Materials

7.1 *Nails:*

7.1.1 Nails used for withdrawal tests shall typically be described by Specification F1667; however, other nails shall be permitted to be tested in accordance with this method provided the fastener is fully described. The actual size and details of the nails selected shall be recorded. Nails shall be cleaned before use to remove any coating or surface film that may be present as a result of manufacturing operations and exposure. If collated nails that rely upon coating to adhere the fasteners together need to be installed with a tool that requires them to be adhered, then they shall be cleaned without removing the cohering coating that occurs between fasteners and the report shall indicate that some coating was present. Each nail shall be used only once.

7.1.2 Where the effect of coatings or surface film on the nail, treatments or conditioning of the wood, or other conditions are to be investigated, representative test specimens that are appropriate to the objectives of the testing program shall be selected.

7.2 *Staples:*

7.2.1 Staples used for withdrawal tests shall typically be described by Specification F1667; however, other staples shall be permitted to be tested in accordance with this method provided the staple is fully described. The actual size and details of the staples selected shall be recorded. Hand-driven staples shall be cleaned before use to remove any coating or surface film that may be present as a result of manufacturing operations and exposure. If collated staples that rely upon coating to adhere the fasteners together need to be installed with a tool that requires them to be adhered, then they shall be cleaned without removing the cohering coating that occurs

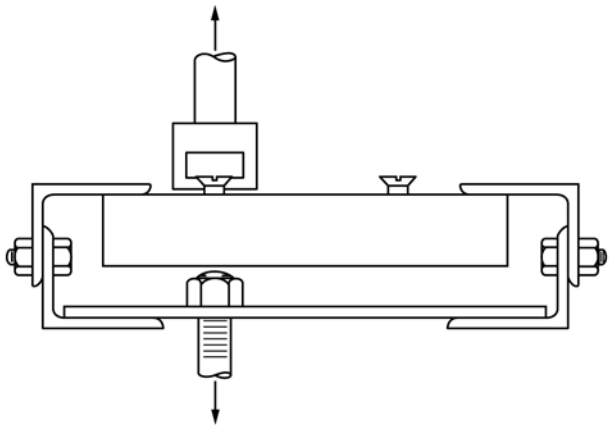

FIG. 1 Diagram of Assembly for Screw Withdrawal Test

[3] Available from American Society of Mechanical Engineers (ASME), ASME International Headquarters, Two Park Ave., New York, NY 10016-5990, http://www.asme.org.

[4] Available from DLA Document Services, Building 4/D, 700 Robbins Ave., Philadelphia, PA 19111-5094, http://quicksearch.dla.mil.

between fasteners and the report shall indicate that some coating was present. Each staple shall be used only once.

7.2.2 Where the effect of surface film on the staple legs, treatments or conditioning of the wood, or other conditions are to be investigated, representative test specimens that are appropriate to the objectives of the testing program shall be selected.

7.3 *Screws:*

7.3.1 Screws used for withdrawal tests shall typically be described by ASME B18.6.1; however, other screws shall be permitted to be tested in accordance with this method provided the fastener is fully described. Screws shall be cleaned before use to remove any coating or surface film that may be present as a result of manufacturing operations and exposure. Each screw shall be used only once.

7.3.2 Where the effect of coatings or surface film on the screw, treatments or conditioning of the wood, or other conditions are to be investigated, representative test specimens that are appropriate to the objectives of the testing program shall be selected.

7.4 *Wood Members (Wood and Wood-Based Products)*—Wood members shall be cut accurately and square to the required dimensions and have a smooth surface to ensure proper fastener penetration measurement. The wood fibers shall be aligned with the longitudinal axis of the wood member. The wood member shall have a specific gravity that is representative of the assigned specific gravity of the species of wood, free of defects and growth irregularities, and of specified moisture content.

8. Sampling

8.1 Sampling shall provide for selection of representative wood or wood-based material on an objective and unbiased basis, covering an appropriate range in density (specific gravity) and properties as circumstances suggest.

8.2 The specific objectives of the test program shall be used to determine the required precision and number of tests in accordance with Practice D2915.

NOTE 1—General experience indicates that the coefficient of variation for fastener tests ranges from 15 % to 30 %. A precision of 5 % to 10 % with 75 % or 95 % confidence are typical expectations for data.

9. Conditioning

9.1 Except for special tests evaluating the effect of moisture content of wood on withdrawal resistance, the tests shall be made on seasoned material. The wood or wood-based product, whether kiln-dried, air-dried, or as received from the manufacturer, shall be stored in a room having a controlled temperature of 20 ± 3°C (68 ± 6°F) and a controlled relative humidity of 65 ± 3 % for a period sufficiently long to bring it to approximate moisture equilibrium. The fasteners shall not be installed in the wood members until the moisture equilibrium is attained.

9.2 Where required, withdrawal tests may be made on drier, partially seasoned or unseasoned material. It is sometimes desired to apply the fasteners to unseasoned material and allow the completed specimen to season prior to withdrawal.

NOTE 2—As in 9.1 these specimens should attain the desired moisture equilibrium in a controlled atmosphere to ensure uniform moisture content at the time of test. Soaking in water will produce and maintain an unseasoned condition of the wood, but it may result in an extremely high moisture content, particularly at the surface, and undesirable and non-representative corrosion of the fasteners near the wood surface.

10. Test Specimen

10.1 *Nail and Staple Withdrawal:*

10.1.1 Nails and staples shall be driven into the wood member at a right angle to the face of the wood member. Where the specimen includes only the single wood member, the fastener shall be driven assuring enough of the nail shank or staple legs remains above the surface to allow the test apparatus to grip the fastener. Where the specimen includes a holding member and one or more members attached thereto, the fastener shall be driven as expected in use. For staples, the crown shall be oriented parallel to the grain of the holding member, but if there is no discernible grain direction, the staple crown shall be oriented at a 45° (±10°) angle to the long dimension of the wood member.

10.1.2 The wood member shall be of convenient size to accommodate the quantity of fasteners to be tested in each specimen, without exceeding the edge and end distances and spacings necessary to avoid splitting. Fasteners shall be driven to penetrate the holding member at least 9 times the nail diameter or staple leg thickness (penetration measurement includes the nail or staple tip length). In thin wood products where the minimum thickness is less than 9 times the nail diameter or staple leg thickness, the fastener shall be driven completely through the thickness and the penetration shall be reported as the thickness of the thin wood product.

10.1.3 The fasteners shall be driven by the method intended to be used in practice, that is, either manually with a hammer, or with an applicator or appropriate tool if this is the normal method. Power-driven fasteners shall be installed either manually or with an appropriate tool.

NOTE 3—Power-driven fasteners are permitted to be installed manually as a means to reliably control the depth of penetration and as an option to test without coatings or collating adhesion materials.

10.1.4 If the withdrawal resistance is influenced by the attached member through which the fastener is to be driven, such as a metal plate with no holes, the fastener shall be driven through the attached member and into the holding member to be evaluated as it would be used.

10.2 *Screw Withdrawal:*

10.2.1 Screws shall be installed into the wood member at a right angle to the face of the wood member. Where the specimen includes only the single wood member, the screw shall be installed assuring enough of the screw shank remains above the surface to allow the test apparatus to grip the fastener. The minimum penetration of the screw into the holding member shall be 9 times the screw diameter (penetration measurement includes the screw tip). Screws shall be installed into the wood member for the length of the threaded portion of the shank or at least two thirds of the shank length if it is threaded throughout. In thin wood products where the minimum thickness is less than 9 times the screw diameter, the screw shall be screwed completely through the thickness and

the penetration shall be reported as the thickness of the thin wood product. The screws shall be permitted to be coated with paraffin wax or other similar lubricant when necessary to facilitate installing and its use shall be reported.

10.2.2 The wood member shall be of convenient size to accommodate the quantity of screws to be tested in each specimen, without exceeding the edge and end distances and spacings necessary to avoid splitting. The size of lead hole, if one is to be drilled, shall be 70 % of the root diameter of the screw for a distance of one half of the screw length unless otherwise specified by the screw manufacturer or required for the purpose of the test program. The size of the lead hole shall be documented.

10.2.3 If the withdrawal resistance can be influenced by the attached material through which the screw is to be installed, the screw shall be screwed through the attached material and into the holding member. The length of penetration into the holding member shall be reported.

11. Procedure

11.1 *General*—Withdraw fasteners as soon as practical after installation, and within 1 h. If longer delays are required for the purposes of the test program, then the time elapsed between installation of the fastener and the test shall be reported.

11.2 *Basic Loading Method:*

11.2.1 Where the specimen includes only the holding member and the fasteners, withdraw the fasteners by means of a tensile force applied at a uniform rate of withdrawal. Attach the wood member to one platen of the testing machine. Attach the fastener head (for headed fasteners) or staple legs to a suitably designed grip which is fastened to the other platen through a universal joint. Apply the load by separation of the platens of the testing machine at a uniform rate of withdrawal (see 11.4). Read the maximum load required to withdraw the fastener to three significant figures. Disregard test values resulting from any failure of the fastener in the evaluation of the performance of wood and wood-based materials but report them; consider such failures in the evaluation of the performance of different types and sizes of fasteners. In such cases, additional replications are desirable.

11.2.2 Where the specimen consists of a holding member plus one or more attached members fastened thereto with a fastener, two test procedures are possible:

(1) The attached member can be grasped and pushed or pulled away from the holding member in the axial direction of the fastener, whereby the fastener head exerts a force on the attached member. Under this procedure, if the attached member exerts less resistance to the passage of the fastener head than the holding member exerts on fastener, head pull-through can occur. In such a case, the fastener head pull-through resistance of the attached member material will be indicated, but shall not be recorded as the fastener withdrawal from the holding member and an additional specimen shall be tested.

(2) The attached member can be split off and the fastener withdrawn as in 11.2.1.

11.3 *Special Loading Methods*—It may sometimes be necessary to determine the resistance to withdrawal as a result of an impact force or by repetitive loads. In the case of the former, this can be accomplished with standard apparatus such as the U.S. FPL toughness testing machine suitably modified to hold and grip the specimen. The latter test may require the use of a cycling or pulsating loading head. The resulting data are based on the displacement angle of the pendulum and the forces resulting from the setting of the repetitive loading mechanism, respectively, required to withdraw the fastener from the wood or wood-based product. Disregard test values resulting from any failure of the fastener in the evaluation of the performance of wood and wood-based materials but report if desired; consider such failures in the evaluation of the performance of different types and sizes of fasteners. In such cases, additional replication are desirable.

11.4 *Speed of Testing:*

11.4.1 For the basic loading method for fastener withdrawal, apply the load throughout the test at a uniform rate of platen separation of 0.10 in. (2.54 mm)/min ± 25 %.

11.4.2 For special loading methods, special rates of withdrawal may be required. Record the rate used and the reasons for choosing it in the report.

NOTE 4—The rate of platen separation shall mean the free-running, or no-load, crosshead speed for testing machines of the mechanical drive type, and the loaded crosshead speed for testing machines of the hydraulic loading type.

11.5 *Supplementary Tests*—If information on the actual withdrawal during load application is desired or may be of influence on the interpretation of the withdrawal resistance of a given fastener, measure and record such withdrawal, in inches (millimetres), at given withdrawal loads or at the ultimate withdrawal resistance to three significant numbers. Under given conditions, it may be expeditious to obtain an automatic plot of withdrawal load versus withdrawal distance in order to determine the stiffness of the joint and the work involved up to a given point of withdrawal of the fastener under construction.

11.6 *Minor Tests*—For all tested specimens, determine the oven-dry specific gravity and moisture content of each wood member at the time of testing using Test Methods D2395 and D4442, respectively. For wood-based members, determine the density and moisture content at the time of testing using Test Methods D2395 and D4442, respectively.

12. Report

12.1 The report shall include the following:

12.1.1 Failure loads for individual fasteners, average test values, and statistical evaluation of the test data, if justified;

12.1.2 A complete description of the test method and loading procedure used;

12.1.3 A description of the specimen, including the dimensions of the wood or wood-based product components, size of fastener, fastener penetration, end and edge distances, and spacings;

12.1.4 Number of tests;

12.1.5 Specific gravity and moisture content of wood components,;

12.1.6 Details of any deviations from the prescribed or recommended methods as outlined in the standard; and

12.1.7 Details of any factors not included above that might have a bearing on results.

13. Precision and Bias

13.1 *Precision*—It is not possible to specify the precision of the withdrawal test procedure in Test Method D1761 for measuring fastener withdrawal because the data is not available.

13.2 *Bias*—No information can be presented on the bias of the withdrawal test procedure in Test Method D1761 for measuring fastener withdrawal because no fastener withdrawal having an accepted reference value is available.

NAIL, STAPLE, OR SCREW LATERAL RESISTANCE TEST

14. Summary of Test Method

14.1 This test method covers the determination of the resistance to lateral movement offered by a single nail, staple, or screw in wood members. The test provides comparative data for various species of wood. This general test method can also be used for evaluating other types and sizes of fasteners either in wood or wood-based building materials such as plywood, hardboard, etc., or combinations of materials. Furthermore, where required for specific purposes, the general method can be used for evaluating the lateral resistance of nails, staples, and screws other than those specified in Section 15, and joints employing two or more fasteners. It is recommended that when such tests are made, the specified procedure be followed as closely as possible and all deviations be completely described.

15. Test Nails, Staples, or Screws

15.1 Nails used for lateral tests shall typically be described by Specification F1667; however, other nails shall be permitted to be tested in accordance with this method provided the fastener is fully described. Nails selected for test shall be representative of the product. Nails shall be cleaned before use to remove any coating or surface film that may be present as a result of manufacturing operations and exposure unless the effects of any coatings or surface film are to be evaluated. Each nail shall be used only once. The actual size and details of the nails selected shall be recorded, including data on the properties of the metal.

15.2 Staples used for lateral tests shall typically be described by Specification F1667; however, other staples shall be permitted to be tested in accordance with this method provided the fastener is fully described. Staples shall be representative of the product. Hand-driven staples shall be cleaned before use to remove any coatings or surface film that may be present unless the effects of coatings or surface film are to be evaluated. If collated staples that rely upon coating to adhere the fasteners together need to be driven with a tool that requires them to be adhered, then they shall be cleaned without removing the cohering coating that occurs between fasteners and the report shall indicate that some coating was present. Each staple shall be used only once. Actual size and details of the staple used shall be recorded.

15.3 Screws used for lateral tests shall typically be described by ASME B18.6.1; however, other screws shall be permitted to be tested in accordance with this method provided the fastener is fully described. Screws shall be cleaned before use to remove any coating or surface film that may be present as a result of manufacturing operations and exposure unless the effects of any coatings or surface film are to be evaluated. Each screw shall be used only once. The screws shall be selected to be representative of the type chosen for test.

16. Sampling

16.1 Tests shall be made using clear, straight-grained representative material. The specific objectives of the test program shall be used to determine the required precision and number of tests in accordance with Practice D2915.

NOTE 5—General experience indicates that the coefficient of variation for fastener tests ranges from 15 % to 30 %. A precision of 5 % to 10 % with 75 % or 95 % confidence are typical expectations for data.

17. Conditioning

17.1 The material shall be conditioned in accordance with Section 9.

18. Test Specimen

18.1 The dimension of the wood member that receives the point of the fastener (main member) shall be at least six times the fastener diameter or thickness. The dimension of the wood member through which the fastener is installed (side member) shall be appropriate to the objectives of the test. The width of the wood members shall be of sufficient width to accommodate the load fixture. The actual dimension of each piece shall be determined and reported.

18.2 The test specimen shall be assembled by overlapping the ends of the side and main members by a distance of at least 4 in. (100 mm). The test fastener shall be installed at the center of the width of the side and main members and 2 in. (50 mm) from the overlapping end of each. The main member shall be oriented to permit the installation of the test fastener into a tangential face.

NOTE 6—The description of the grain and growth-ring orientations of the main and side members are for a standard test. The test objectives may make it necessary to arrange the grain and growth-ring orientations of the main and side members in an alternate manner.

18.3 When testing with a nail, the top of the nail head shall be driven flush with the surface. The nail shall be driven as nearly perpendicular to the wood member surface as possible.

18.4 When testing with a staple, the staple shall be installed with an appropriate tool as nearly as possible perpendicular to the wood member surface with the staple crown oriented parallel to grain, but if there is no discernible grain direction in the wood product, the staple crown shall be oriented at a 45° (±10°) angle to the length of the main member. All staples shall be driven flush or slightly (1⁄16 in.) (1.6 mm) countersunk.

18.5 When testing with a screw, the screw shall be installed through prebored lead holes unless self-drilling screws are to be tested where a lead hole would not be used. Lead holes shall be perpendicular to the wood member surface. The lead hole in

the side member shall equal the shank diameter of the screw for hardwoods and 90 % of the shank diameter for softwoods. The lead hole in the main member shall have a diameter of 90 % of the root diameter for hardwoods and 70 % of the root diameter for softwoods. The top of the lead hole in the side member shall be countersunk and the top of the screw installed flush with the surface.

19. Procedure

19.1 As quickly as possible after assembly, but within 1 h, test each specimen by tensile loading in a testing machine of suitable capacity. If longer delays are required for the purposes of the test program, then the time elapsed between installation of the fastener and the test shall be reported. Fig. 2 and Fig. 3 show a lateral resistance nail test specimen ready for test. Use the same procedure for evaluating the lateral resistance of staples and screws. The end fixtures shall be such as to provide freedom of alignment. Since the load applied to the specimen is eccentric, use an alignment support such as the roller bearing shown. Fig. 2 and Fig. 3 illustrate one method of measuring the differential movement between the two members under load by means of a dial gauge. Other methods may be used, including automatic recording. Measure the movement to the nearest 0.001 in. (0.025 mm). Obtain simultaneous values of differential movement and load at movements of 0.01, 0.015, 0.05, 0.1, 0.2, and 0.3 in. (0.25, 0.38, 1.27, 2.54, 5.08, and 7.62 mm), and at maximum load. Record the first drop in load.

19.2 *Speed of Testing*—Apply the load in accordance with 11.4.

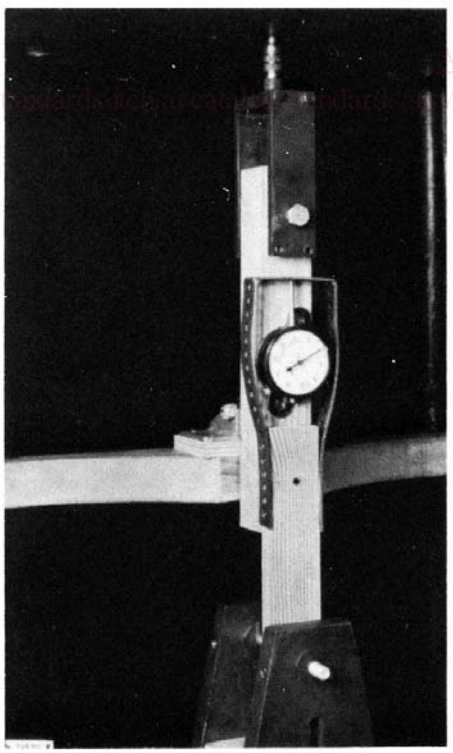

FIG. 2 Assembly for Lateral Resistance Test of Nails, Staples, or Screws

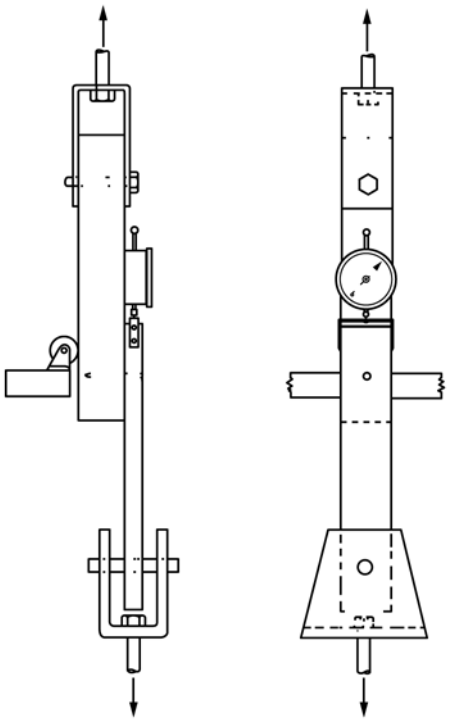

FIG. 3 Diagram of Assembly for Lateral Resistance Test of Nails, Staples, or Screws

19.3 *Minor Tests*—For all tested specimens, determine the oven-dry specific gravity and moisture content of each wood member at the time of testing using Test Methods D2395 and D4442, respectively. For wood-based members, determine the density and moisture content at the time of testing using Test Methods D2395 and D4442, respectively.

20. Report

20.1 The report shall include the following:

20.1.1 Simultaneous values of load and differential movement at deformations of 0.01, 0.015, 0.05, 0.1, 0.2 and 0.3 in. (0.25, 0.38, 1.27, 2.54, 5.08, and 7.62 mm), and at maximum load;

20.1.2 Type of fastener tested;

20.1.3 Size of the wood members;

20.1.4 Species of wood used;

20.1.5 Average moisture content and specific gravity; and

20.1.6 Any other special details that may have a bearing on the results.

21. Precision and Bias

21.1 *Precision*—It is not possible to specify the precision of the lateral test procedure in Test Method D1761 for measuring lateral resistance because the data is not available.

21.2 *Bias*—No information can be presented on the bias of the lateral test procedure in Test Method D1761 for measuring lateral resistance because no lateral resistance having an accepted reference value is available.

BOLTED OR TIMBER CONNECTOR JOINT TEST

22. Summary of Test Method

22.1 This test method provides a suitable procedure for evaluating the resistance and rigidity of timber joints fastened with bolts or with timber connectors (split rings or shear plates) which usually also require bolts to form the joint. The test serves as a basis for developing design criteria and for determining the effect of various factors on the resistance and efficiency of the joint.

22.2 Specimens consisting of three-member or two-member wood joints fastened with bolts or bolts and timber connectors are evaluated for their capacity to resist compressive or tensile forces applied at a uniform rate of deformation with a suitable testing machine. The deformation of the joint at various intervals of loading is measured. Supplementary physical properties of the wood members are also determined.

23. Significance and Use

23.1 The joint may be the weakest link in timber construction. While the resistance of a metal bolt or connector can be determined on the one hand, and the strength properties of a particular grade and species of wood on the other, only by testing a complete joint can their performance in combination be fully evaluated. Such variables as member thickness, member width, end and edge margins, type of fastener and number of units, spacing between fastener units, moisture content of wood, preservative or fire-retardant treatment of the wood, and species of wood, to mention a few, may affect joint behavior. In order to compile accurate design criteria for established bolt and connector types as well as for those under development, the effect of these variables on joint strength must be known. The tests described herein permit obtaining data on the strength and rigidity of timber joints under the influence of any or all of the above-mentioned factors.

24. Apparatus

24.1 *Testing Machine*—Any suitable testing machine that is capable of operation at a constant rate of motion of the movable head and has an accuracy of ±1 % when calibrated in accordance with Practices E4.

24.2 *Spherical Bearing Block,* for compressive loading of specimens.

24.3 *Grips*—Gripping devices capable of attaching the specimen between the moving heads of the testing machine in such a way as to ensure true axial loads, required for tensile loading of specimens.

24.4 *Displacement Measuring Device*—A device capable of measuring the differential movement between two members under load to the nearest 0.001 in. (0.025 mm). One method using a dial gauge is illustrated in Fig. 2 and Fig. 3. Other suitable methods shall be permitted, including automatic recording.

25. Sampling

25.1 Sampling of wood or wood-based materials and of bolts or connectors shall provide for selection of representative test material on an objective and unbiased basis. Materials tested for the purpose of getting reliable general averages and variation applying broadly to wood and wood-based materials shall be selected at random by a technique that permits correct proportionment to expected density (specific gravity) and other physical properties that may influence test results.

NOTE 7—Sampling required for more limited experiments, as for defining relationships or examining causes and effects, may be accordingly more limited, but should be appropriate to the objectives of the testing program and by unbiased procedures.

25.2 The specific objectives shall be used to determine the required precision and number of tests in accordance with Practice D2915.

NOTE 8—General experience indicates that the coefficient of variation for fastener tests ranges from 15 % to 30 %. A precision of 5 % to 10 % with 75 % or 95 % confidence are typical expectations for data.

26. Conditioning

26.1 Except for special tests evaluating the effect of moisture content of the wood on the strength of the joints, the tests shall be made with seasoned wood.

NOTE 9—Specimens, whether kiln dried, air dried, or as received from manufacturer, preferably should be stored before testing in a room having a controlled temperature of 20 ± 3°C (68 ± 6°F) and a controlled relative humidity of 65 ± 3 % for a period sufficiently long to bring them to approximate equilibrium. For most species of wood, exposure to these conditions will result in a moisture content of approximately 12 %.

26.2 For special tests involving drier, unseasoned, or partially seasoned wood components, care shall be taken to maintain the desired moisture content prior to and during testing.

27. Specimens and Tests

27.1 *General*—Wood members shall be selected, and the fasteners positioned in them, in such a way that the results are not affected by knots, cross grain, or other natural or manufacturing characteristics. Frequently, this will necessitate selecting members which are essentially clear and straight grained.

27.2 *Joints Containing Bolts Only:*

27.2.1 Tests shall be made on three-member joints as shown in Fig. 4 and Fig. 5 except where specific data on two-member joints are being sought. The width, length, and thickness of the wood members shall be selected with due regard to the edge and end distances required.

27.2.2 For joints involving metal or other side members, the thickness shall be that anticipated in service. For all-wood joints, the thickness of each side member shall be at least one half of the thickness of the center member and width and length of all members shall be selected with regard to the edge and end distances required for a specific application.

27.2.3 Bolt-hole diameters shall be between 1/32 and 1/16 in. (0.8 and 1.6 mm) larger than the bolt diameters (Note 10) and holes shall be carefully bored perpendicular to the surface, so that the surface of the hole is smooth and uniform to ensure good bearing of the bolt.

NOTE 10—It is suggested that the excess of hole diameter over bolt