



Designation: D8391 – 22<sup>ε</sup><sup>1</sup>

# Standard Specification for Demonstrating Equivalent Fire Performance for Wood- Based Floor Framing Members to Unprotected 2 by 10 Dimension Lumber or Equal-Sized Structural Composite Lumber<sup>1</sup>

This standard is issued under the fixed designation D8391; 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 ( $\epsilon$ ) indicates an editorial change since the last revision or reapproval.

<sup>ε</sup><sup>1</sup> NOTE—Information about copyrighted text was included in March 2023.

## 1. Scope

1.1 This specification provides the test methodology and procedures to demonstrate that the fire performance of wood-based floor framing members is equivalent to unprotected 2 by 10 dimension lumber or equal-sized structural composite lumber (SCL) floor joists used in interior floor assemblies. This specification is applicable to floor framing members with or without applied treatments or materials used to increase fire resistance, including fire-resistive paints, coatings, or chemical treatments, and including mechanically attached or adhered fire protection materials. It is applicable to any wood-based residential floor framing member product including, but not limited to, prefabricated wood I-joists, open-web wood joists, and trusses with wood flanges and wood or metal web members. In addition, specific requirements for the evaluation of fire-resistive paints, coatings, or chemical treatments used with these floor framing members are included.

**NOTE 1**—This specification provides a method of comparing the fire performance of floor framing members to benchmarked performance of unprotected 2 by 10 dimension lumber or equal-sized SCL floor joists. It has been successfully used to evaluate the performance of prefabricated wood I-joists and wood trusses with various forms of fire protection. While the principles of this specification are generally applicable to all floor framing members, the development of the specification did not consider additional requirements or modifications which may be necessary for the evaluation of floor framing members of other materials, such as steel joists or trusses.

1.2 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.

1.3 *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.*

1.4 *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:<sup>2</sup>

- D9 Terminology Relating to Wood and Wood-Based Products
- D198 Test Methods of Static Tests of Lumber in Structural Sizes
- D610 Practice for Evaluating Degree of Rusting on Painted Steel Surfaces
- D1037 Test Methods for Evaluating Properties of Wood-Base Fiber and Particle Panel Materials
- D1761 Test Methods for Mechanical Fasteners in Wood and Wood-Based Materials
- D2898 Practice for Accelerated Weathering of Fire-Retardant-Treated Wood for Fire Testing
- D2915 Practice for Sampling and Data-Analysis for Structural Wood and Wood-Based Products
- D4761 Test Methods for Mechanical Properties of Lumber and Wood-Based Structural Materials
- D5055 Specification for Establishing and Monitoring Structural Capacities of Prefabricated Wood I-Joists
- D5664 Test Method for Evaluating the Effects of Fire-Retardant Treatments and Elevated Temperatures on Strength Properties of Fire-Retardant Treated Lumber
- D7032 Specification for Establishing Performance Ratings

<sup>1</sup> This specification is under the jurisdiction of ASTM Committee D07 on Wood and is the direct responsibility of Subcommittee D07.05 on Wood Assemblies.

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<sup>2</sup> For referenced ASTM standards, visit the ASTM website, [www.astm.org](http://www.astm.org), or contact ASTM Customer Service at [service@astm.org](mailto:service@astm.org). For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

for Wood-Plastic Composite and Plastic Lumber Deck Boards, Stair Treads, Guards, and Handrails

**E119** Test Methods for Fire Tests of Building Construction and Materials

**E176** Terminology of Fire Standards

**E2309** Practices for Verification of Displacement Measuring Systems and Devices Used in Material Testing Machines

**E3048** Test Method for Determination of Time to Burn-Through Using the Intermediate Scale Calorimeter (ICAL) Radiant Panel

2.2 *TPI Standard*:<sup>3</sup>

**ANSI/TPI 1** National Design Standard for Metal Plate Connected Wood Truss Construction

2.3 *AWC Standard*:<sup>4</sup>

**ANSI/AWC NDS** National Design Specification for Wood Construction

2.4 *AWPA Standard*:<sup>5</sup>

**AWPA E12** Standard Method of Determining Corrosion of Metal in Contact with Treated Wood

2.5 *ISO Standards*:<sup>6</sup>

**ISO/IEC 17011** Conformity Assessment – Requirements for Accreditation Bodies Accrediting Conformity Assessment Bodies

**ISO/IEC 17020** Conformity Assessment – Requirements for the Operation of Various Types of Bodies Performing Inspection

**ISO/IEC 17065** Conformity Assessment – Requirements for Bodies Certifying Products Processes and Services

2.6 *U.S. Department of Commerce Standards*:<sup>7</sup>

**PS 1** Structural Plywood, U.S. Department of Commerce Voluntary Product Standard

**PS 2** Performance Standard for Wood Structural Panels, U.S. Department of Commerce Voluntary Product Standard<sup>7</sup>

<https://standards.iteh.ai/catalog/standards/sist/5cd18184-b4>

### 3. Terminology

3.1 *Definitions*—Definitions used in this specification are in accordance with Terminology **D9** and Terminology **E176**, unless otherwise indicated.

3.2 *Definitions of Terms Specific to This Standard*:

3.2.1 *chemical treatment, n*—chemical substance applied to the structural member with the purpose of improving performance in fire.

3.2.2 *factory-applied, adj*—applied in a factory setting by or under the direction of the manufacturer of the floor framing members.

3.2.3 *field-applied, adj*—installed after the time of manufacture of the floor framing member by an entity not under the direction of the manufacturer of the floor framing member.

3.2.4 *floor joist, n*—structural floor framing member.

3.2.5 *prefabricated wood I-joist, n*—structural framing member manufactured using sawn or structural composite lumber flanges and structural panel webs, bonded together with exterior exposure adhesives, forming an “I” cross-sectional shape and primarily used as a joist in floor and roof construction.

### 4. Applicability

4.1 All floor framing members to be evaluated in accordance with this specification, regardless of protection method, shall be subject to the requirements in Sections 5 through 9.

4.2 Floor framing members relying on protection from fire-resistive paints, coatings, and chemical treatments shall meet additional requirements described in **Annex A1**. Provisions are included in this specification for both factory-applied products and field-applied products.

### 5. Test Performance Requirements

5.1 The floor framing members being evaluated shall support not less than 50 % of the load associated with the allowable stress design (ASD) reference design value in bending for an elapsed time of not less than 15 min, 30 s from the beginning of the furnace test to the end of the test, while meeting the specified deflection criteria.<sup>8</sup>

NOTE 2—The required minimum duration for the test was derived using the methodology specified in Chapter 16 of the NDS assuming unprotected 2 by 10 dimension lumber or equal-sized structural composite lumber floor joists, a three-sided fire exposure, a nominal char rate of 1.5 in./h (38.1 mm/h), a bending strength to ASD ratio of 2.85, and a load corresponding to 50 % of the full ASD bending design load. It is recognized that achieving the required test duration of 15 min, 30 s with a load greater than 50 % of the full ASD bending design load would be conservative relative to the reference case, therefore no upper limit on loading is imposed.<sup>8</sup>

5.2 The end of the test shall be defined by the first occurrence of one of the following:<sup>8</sup>

5.2.1 The furnace is extinguished for any reason, or

5.2.2 Any individual framing member within the test assembly ruptures, or

5.2.3 The test assembly center span deflection, as determined in accordance with **8.2**, exceeds 1/40 of the clear span, or

5.2.4 The deflection rate,  $dx/dt$ , decreases without recovering,

where:

$dt$  = a 1-s time interval, and

$dx$  = deflection increment in a 1-s time interval,  $dt$ , after smoothing of deflection data using a centered moving average with a time window of 10 s.

<sup>3</sup> Available from Truss Plate Institute, 218 N. Lee Street, Ste 312, Alexandria, VA 22134.

<sup>4</sup> Available from American Wood Council (AWC), 222 Catocin Circle SE, Suite 201, Leesburg, VA 20175, <https://www.awc.org>.

<sup>5</sup> Available from American Wood Protection Association (AWPA), P.O. Box 361784, Birmingham, AL 35236-1784, <http://www.awpa.com>.

<sup>6</sup> Available from International Organization for Standardization (ISO), ISO Central Secretariat, Chemin de Blandonnet 8, CP 401, 1214 Vernier, Geneva, Switzerland, <https://www.iso.org>.

<sup>7</sup> Available from U.S. Government Publishing Office (GPO), 732 N. Capitol St., NW, Washington, DC 20401, <http://www.gpo.gov>.

<sup>8</sup> Acceptance Criteria for Prefabricated Wood I-Joists (AC14), Copyright © 2019 ICC-ES. All rights reserved.

5.2.4.1 *Exception*—Item 5.2.4 shall not apply when evidence is submitted to show that the decrease in deflection rate was not due to a change in the load-carrying mechanism of the test assembly.

NOTE 3—Experience has demonstrated that the difference in deflection between two data points separated by one second can fluctuate significantly, potentially due to noise induced by the furnace test environment. The requirement for data smoothing using a 10-s moving average eliminates most of the noise and facilitates evaluation of  $dx/dt$  relative to the requirement in 5.2.4. However, data smoothing should not be used for comparison of overall deflection with the deflection limit in 5.2.3.

5.3 Graphs illustrating the assembly center-span deflection and the deflection rate, as functions of elapsed time, shall be included in the test report to demonstrate compliance with 5.2.3 and 5.2.4.

NOTE 4—Additional guidance on the evaluation of deflections in accordance with 5.2 and 5.3 is provided in Appendix X2.

## 6. Drawings, Details, and Calculations<sup>8</sup>

6.1 Drawings shall be prepared showing the configuration of the test assembly including but not limited to: framing plans detailing all materials used to construct the assembly and their method of attachment, loading apparatus and framing member support conditions, location of deflection measurements, and any other details used as part of the test.

6.2 Structural load calculations demonstrating that the load on the floor framing members was equal to 50 % of their ASD bending load shall be prepared.<sup>8</sup>

## 7. Specimen Configuration

7.1 The test specimen shall consist of a single floor framing member or multiple floor framing members plus other elements as necessary to provide lateral bracing of the compression edge and to enclose the top of the furnace.<sup>8</sup>

7.1.1 The test specimen shall have a minimum clear span of 12 ft (3.7 m).

7.1.2 The floor framing member(s) tested shall represent the range of member sizes and configurations for which equivalent fire performance to unprotected 2 by 10 is to be demonstrated in accordance with 7.1.2.1 or 7.1.2.2.<sup>8</sup>

7.1.2.1 Prefabricated wood I-joists evaluated in accordance with Specification D5055 shall be tested with the minimum flange dimensions, minimum web thickness, and minimum joist depth to be recognized for equivalent fire performance to unprotected 2 by 10.

NOTE 5—Test results are considered applicable to larger members than those tested. However, the intent of this specification is not to prescribe a minimum size of floor framing member to be evaluated for qualification.

7.1.2.2 Floor framing members, other than prefabricated wood I-joists, shall be tested with minimum component dimensions, minimum member depth, and representative connection details to be recognized for equivalent fire performance to unprotected 2 by 10 floor joists. Connections between components shall be optimized for the design load.

NOTE 6—Test results are considered applicable to larger members than those tested. However, the intent of this specification is not to prescribe a minimum size of floor framing member to be evaluated for the qualification.

NOTE 7—Connections used to construct the test members, such as truss

plates or pins connecting chords and webs, should be installed in accordance with the manufacturer's requirements and should be designed and detailed to provide the lowest capacity that would be permitted in application to resist the full design load for the framing member with the span used in the furnace test.

7.1.3 If holes in floor framing members are allowed in application, a minimum of one representative hole shall be included in each test member, placed in a zone of high shear force.<sup>8</sup>

NOTE 8—Appendix X3 provides guidance for holes in prefabricated wood I-joists.

7.1.4 All components of the floor framing members used in application (for example, fasteners, plates, hardware, etc.), including flange or chord splices, shall be included in the test members and noted in the test report.<sup>8</sup>

7.1.5 The use of blocking or strongback(s) to transfer load from floor framing members to the boundaries of the assembly, or to the furnace walls shall not be permitted.

7.2 The compression edge of floor framing members shall be braced to prevent lateral movement of the floor framing members. Where floor sheathing is used for lateral bracing of the floor framing members, it shall be detailed in accordance with 7.2.1 through 7.2.7.<sup>8</sup>

7.2.1 The sheathing shall comply with the requirements of PS 1 or PS 2 for 23/32 or lower performance category.<sup>8</sup>

7.2.2 All sheathing edges shall be square (that is, without tongue-and-groove).<sup>8</sup>

7.2.3 The sheathing shall be cut so that no piece is continuous across framing members.

7.2.4 Panel joints perpendicular to the framing members shall be located at maximum 4 ft (1.2 m) intervals along the length of the framing member(s).

7.2.5 The sheathing shall be installed with a minimum gap of 1/8 in. (3.2 mm) between adjacent panels in all directions.<sup>8</sup>

7.2.6 The sheathing shall be attached to framing members using 0.131 in. (3.32 mm) maximum diameter by 2.5 in. (63.5 mm) maximum length fasteners spaced approximately 24 in. (610 mm) o.c.<sup>8</sup>

7.2.7 Adhesive shall not be permitted for the attachment of the sheathing to the framing members.<sup>8</sup>

7.3 Moisture content of tested materials shall be representative of that in similar construction of buildings in accordance with Test Method E119.

7.4 Noncombustible protection up to 5/8 in. (16 mm) thick is permitted to be added to combustible assembly components other than the floor framing members under evaluation, such as to the underside of sheathing and to the inside face of rim boards.<sup>8</sup>

## 8. Test Procedure

8.1 *Furnace Exposure*—The test specimen shall be tested in a horizontal position and unrestrained for thermal expansion. Use of an intermediate-scale or full-scale furnace shall be permitted. The test specimen shall be subjected to the time/temperature environment described in Test Method E119 Section 7.1 for the duration of the test, as noted in 5.2. Furnace temperatures shall be measured by thermocouples described in

Section 7.2 of Test Method E119. The accuracy of the furnace control shall be such that the area under the time-temperature curve, obtained by averaging the results from the thermocouple readings, is within 10 % of the corresponding area under the standard time-temperature curve described in Test Method E119.<sup>8</sup>

8.2 *Deflection*—Mid-span deflection shall be measured at one location at the geometric center of the floor assembly using a displacement transducer calibrated in accordance with the requirements for Class B of Practices E2309 and reported. The device shall reference the top surface of the floor sheathing and does not need to be positioned over an individual floor framing member. Where necessary to accommodate the loading apparatus, the device is permitted to be located up to 18 in. (457 mm) away from center-span, provided that the displacement reading is adjusted to reflect the deflection at center-span by principles of mechanics. The minimum sampling rate shall be 1.0 Hz.<sup>8</sup>

8.3 *Report*—The test report shall include the following:

8.3.1 Detailed specimen description and drawings showing the construction, including floor framing members, truss plates and splices, hole placement, fire-protection materials and placement, lateral bracing and attachment, and any other details relevant to the fire-performance of the floor framing members.

8.3.2 Detailed descriptions and drawings showing the loading mechanism and placement of superimposed loads applied to the specimen.

8.3.3 Calculations demonstrating that the superimposed load resulted in not less than 50% of the load associated with the ASD reference design value in bending for the floor framing member(s) and calculations showing the percentage of floor framing member demand to capacity at the location of holes or other critical sections.

8.3.4 A graph showing time-temperature data throughout the duration of the test relative to the E119 time-temperature curve.

8.3.5 Graphs illustrating the assembly center-span deflection and the deflection rate, as functions of elapsed time.

## 9. Use of Fire-Resistant Floor Framing Members in Construction

9.1 All components that provide some or all of the required fire resistance to the floor framing members shall be installed as intended for use and as described and detailed in the test report.<sup>8</sup>

9.2 Factory-applied protection shall be installed in a manner consistent with the test report with oversight by an inspection agency accredited under ISO/IEC 17020 by a recognized accreditation body conforming to the requirements of ISO/IEC 17011 and acceptable to a certification body accredited under ISO/IEC 17065 by a recognized accreditation body conforming to the requirements of ISO/IEC 17011.

9.2.1 Factory-applied protection shall retain its effectiveness after the accelerated weathering exposures required in A1.4.4.

9.3 Field-applied protection shall be installed in a manner consistent with the test report.

9.3.1 Field-applied protection shall be installed after the exterior shell of the structure is complete to protect from weather exposure unless demonstrated to be durable and weather resistant by testing in accordance with the requirements of factory-applied protection.

9.3.2 Field-applied protection shall be installed according to the manufacturer's instructions, including, but not limited to, requirements for substrate preparation, substrate moisture content, and ambient temperature and relative humidity during installation and drying.

9.3.3 Inspection of field-applied protection shall be required to verify that the installation of the field-applied protection is consistent with specimens used for qualification testing and product evaluation.

NOTE 9—The inspection requirement for field-applied fire-protection is intended to ensure that the application of fire protection meets manufacturer specifications and complies with requirements and limitations based on qualification testing. For fire protection using common construction methods and materials using typical mechanical fasteners, the intent is not to require special inspections. However, where the effectiveness of the fire protection, as described in the test report, relies upon special material configurations, unusual methods of attachment, special surface preparations, heat-resistant adhesives, or other details that cannot be readily assessed after installation is completed, special inspection should be considered.

## 10. Precision and Bias

10.1 The precision and bias of the test method included in this specification have not been established.

## 11. Keywords

11.1 factory-applied; field-applied; fire; floor framing members; floor joist; inspection

**ANNEX**
**(Mandatory Information)**
**A1. REQUIREMENTS FOR FIRE PROTECTION PROVIDED BY FIRE-RESISTIVE PAINTS, COATINGS, OR CHEMICAL TREATMENTS**

A1.1 Fire protection provided by fire-resistive paints, coatings, or chemical treatments, whether intended to be applied directly to the floor framing member or to other components that are attached to the floor framing member shall be evaluated in accordance with and meet the requirements and conditions of **A1.2** through **A1.5**.

A1.1.1 Factory-applied fire-resistive paints, coatings or chemical treatments shall be applied with oversight by an inspection agency accredited under ISO/IEC 17020 by a recognized accreditation body conforming to the requirements of ISO/IEC 17011 and acceptable to a certification body accredited under ISO/IEC 17065 by a recognized accreditation body conforming to the requirements of ISO/IEC 17011.<sup>8</sup>

A1.1.2 Field-applied fire-resistive paints, coatings, or chemical treatments shall require inspection to verify application consistent with specimens used for qualification testing and product evaluation. For field-applied fire-resistive paints, coatings, chemical treatments, or field-attached components with factory-applied treatments, the durability evaluation in accordance with Section **A1.4** is permitted to be waived if field application occurs after the exterior shell of the structure is complete to protect the fire protection material from moisture, and the temperature during installation and drying is maintained within the range specified by the manufacturer of the fire protection material.

NOTE A1.1—Proper application of fire-resistive paints, coatings, or chemical treatments is critical to ensure the effectiveness of the fire protection. Factory application requires oversight by an accredited inspection agency. Similarly, field application requires inspection to ensure a comparable level of quality assurance. Where installation consistent with the product evaluation and in accordance with the manufacturer's requirements cannot be verified after installation is completed, special inspection should be considered.

**A1.2 Corrosion Effects of Fire-Resistive Paints, Coatings or Chemical Treatments:**<sup>8</sup>

A1.2.1 The corrosion effects of fire-resistive paints, coatings, or chemical treatments, where used, shall be evaluated in accordance with AWP A E12 with the following modifications:

(1) Instead of evaluating the corrosion effects of a preservative, the corrosion effects of the fire protection material shall be evaluated. Thus, the provisions relating to AWP A Use Categories do not apply. Those provisions relating to minimum retention levels do not apply unless the fire protection is in the form of a wood-penetrating chemical treatment.

(2) Fire-resistive paints and coatings shall be applied to structural composite lumber, sawn lumber of any species or species combination identified in NDS Supplement 2.1, or wood structural panels complying with PS 1 or PS 2. Wood-penetrating chemical treatments shall be applied to the substrate intended for use.

(3) Benchmark materials shall consist of unprotected structural composite lumber, unprotected sawn lumber of any species or species combination identified in NDS Supplement 2.1, or unprotected wood structural panels complying with PS 1 or PS 2.

(4) The unprotected benchmark and the protected materials shall be tested with SAE 1010 uncoated carbon steel coupons as specified in AWP A E12.

(5) The unprotected benchmark and protected materials shall be tested under conditions of 90 % relative humidity and 90 °F (32 °C) for a minimum of 720 h.

A1.2.2 For acceptance, the protected material shall be assessed to be equal to or less corrosive than the unprotected benchmark material using a one-tail *t*-test with a significance level of 0.05. Assessment shall be based on comparison of visible corrosion in accordance with Practice **D610** or based on comparison of average weight-loss measurements.

NOTE A1.2—The intent of the corrosion evaluation is to verify that the use of a fire-resistive paint, coating, or chemical treatment does not result in floor framing members that are more corrosive to steel when exposed to interior use conditions than the wide variety of wood products that have been successfully used in similar applications for decades. As such, the corrosion effects of protected specimens are permitted to be compared to the corrosion effects of any of the referenced unprotected benchmark materials. It is not required that the protected specimens demonstrate equal or less corrosion effects than matched unprotected material from the same substrate. For example, a protected wood material that results in more corrosion than matched unprotected material from the same species, but less than another species, is permitted.

**A1.3 Effect of Fire-Resistive Paints, Coatings, or Chemical Treatments on Framing Member Mechanical Properties**—Where fire-resistive paints, coatings or chemical treatments are used as fire protection materials, tests shall be performed to ensure that the joist mechanical properties are not adversely affected by the fire protection materials.<sup>8</sup>

A1.3.1 When evaluating I-joists, either of the test programs from **A1.3.1.1** or **A1.3.1.2** shall be followed.

A1.3.1.1 Flange stiffness, flange tension, flange compression, and I-joist shear shall be evaluated in accordance with Specification **D5055**.

A1.3.1.2 I-joist stiffness, moment and shear shall be evaluated in accordance with Specification **D5055**.

A1.3.2 When evaluating floor-framing members other than prefabricated wood I-joists, either of the test programs from **A1.3.2.1** or **A1.3.2.2** shall be followed.

A1.3.2.1 Flange or chord stiffness, flange or chord tension strength, and flange or chord compression strength shall be evaluated after testing in accordance with Test Methods **D198** or Test Methods **D4761**. In addition, representative connections shall be evaluated after testing in accordance with an appropriate test standard, such as Test Methods **D1761** or ANSI/TPI 1.