

Fire Retardants and Truss Design

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Structural Building Components Association (SBCA)

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Introduction:

Fire retardant treatment (FRT) was developed to be applied to building materials, such as dimension lumber (i.e., fire retardant-treated wood or FRTW) and plywood, to reduce the ability of the wood to fuel a fire. This treatment can allow FRT materials to be used as an acceptable alternative for building code requirements that specify noncombustible material in specific applications. This treatment does not make wood a noncombustible material as defined by the building codes, but it does reduce the ability of the treated wood to contribute significantly to the growth of a fire.

While reducing the flammability of the wood, FRT may also degrade the structural properties of the wood. The treatments must be carefully applied according to applicable standards. Depending on the treatment used, constructing buildings with FRT materials may require a reduction in the design values of the wood and a reduction in the capacity of connectors used in conjunction with FRTW.

There are FRT applications for both interior and exterior use. The focus of this report is on interior use of FRTW. The wood or product is impregnated with a mineral salt or water insoluble organic retardant, generally a resin polymer or graft polymer that reduces the temperature of thermal degradation, results in more charring, and decreases flammable volatiles. This report is limited to a consideration of when and how FRTW is permitted to be used in truss design.

The Structural Building Components Association (SBCA) has developed this Research Report to provide a clear perspective on the use of fire retardant materials used in construction. The analysis is based on code requirements developed by the International Code Council (ICC) within the 2012 and 2015 *International Building Code (IBC)*, ANSI/TPI 1-2014 *National Design Standard for Metal Plate Connected Wood Truss Construction*, ANSI/AWC NDS-2015 *National Design Specification (NDS) for Wood Construction* and other industry resources.

Key Definitions:

Building – Any structure used or intended for supporting or sheltering any use or occupancy.

Building Code – As it applies to a building, any set of standards set forth and enforced by a jurisdiction for the protection of public safety.

Combustible Material – A material that does not qualify as noncombustible.

Noncombustible Material – A material that, under the conditions anticipated, will not ignite or burn when subjected to fire or heat. Materials that pass ASTM E 136 are considered noncombustible materials.

Fire Retardant-Treated Wood (FRTW) – Wood products that, when impregnated with chemicals by a pressure process or other means during manufacture, exhibit reduced surface-burning characteristics and resist propagation of fire.

Truss – An individual metal plate connected wood component manufactured for the construction of a building.

Truss Designer – A person responsible for the preparation of truss design drawings.

Truss Manufacturer – A person or organization engaged in the fabrication of trusses.

Truss Design Drawings – The written, graphic and pictorial depiction of each individual truss provided to the building official for approval prior to installation and provided with the shipment of trusses delivered to the job site.

Background:

Code requirements related to FRTW are located in two places in the IBC.

- Chapter 6 details the circumstances under which FRTW is permitted and the acceptable exceptions to these rules.
- Chapter 23 governs the materials, design, construction and quality of wood members, including FRTW, and their fasteners.

Requirements related to fire retardant materials specific to trusses are located in ANSI/TPI 1-2014.

- Chapter 3 stipulates that lumber treated with fire retardant chemicals must be identified and clearly marked by the manufacturer.
- Chapter 6 details the appropriate design value reductions for both lumber, including FRTW, and metal connector plate values.

ANSI/AWC NDS-2015 includes FRT reductions for material in Chapter 2 and for connections in Chapter 11:

2.3.4 Fire Retardant Treatment The effects of fire retardant chemical treatment on strength shall be accounted for in the design. Adjusted design values, including adjusted connection design values, for lumber and structural glued laminated timber pressure-treated with fire retardant chemicals **shall be obtained from the company providing the treatment and redrying service.** Load

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duration factors greater than 1.6 shall not apply to structural members pressure-treated with fire retardant chemicals (see Table 2.3.2).

11.3.5 Fire Retardant Treatment Adjusted design values for connections in lumber and structural glued laminated timber pressure-treated with fire retardant chemicals **shall be obtained from the company providing the treatment and redrying service** (see 2.3.4). The impact load duration factor shall not apply to connections in wood pressure-treated with fire retardant chemicals (see Table 2.3.2).

Chapter 6 of the IBC addresses types of construction and includes information on when and where FRTW may be used. FRT materials are permitted in non-bearing walls with low fire-resistance ratings and in roof construction and decking.

602.2 Types I and II. Types I and II construction are those types of construction in which the building elements listed in Table 601 are of noncombustible materials, except as permitted in Section 603 and elsewhere in this code.

602.3 Type III. Type III construction is that type of construction in which the exterior walls are of noncombustible materials and the interior building elements are of any material permitted by this code. Fire-retardant-treated wood framing complying with Section 2303.2 shall be permitted within exterior wall assemblies of a 2-hour rating or less.

602.4 Type IV. Type IV construction (Heavy Timber, HT) is that type of construction in which the exterior walls are of noncombustible materials and the interior building elements are of solid or laminated wood without concealed spaces. The details of Type IV construction shall comply with the provisions of this section and Section 2304.11. Exterior walls complying with Section 602.4.1 or 602.4.2 shall be permitted. Minimum solid sawn nominal dimensions are required for structures built using Type IV construction (HT). For glued laminated members and structural composite lumber (SCL) members, the equivalent net finished width and depths corresponding to the minimum nominal width and depths of solid sawn lumber are required as specified in Table 602.4. Cross laminated timber (CLT) dimensions used in this section are actual dimensions.

602.4.1 Fire-retardant-treated wood in exterior walls. Fire-retardant-treated wood framing complying with Section 2303.2 shall be permitted within exterior wall assemblies with a 2-hour rating or less.

602.4.2 Cross-laminated timber in exterior walls. Cross-laminated timber complying with Section 2303.1.4 shall be permitted within exterior wall assemblies with a 2-hour rating or less, provided the exterior surface of the cross-laminated timber is protected by one the following:

1. Fire-retardant-treated wood sheathing complying with Section 2303.2 and not less than 15/32 inch (12 mm) thick;
2. Gypsum board not less than 1/2 inch (12.7 mm) thick; or
3. A noncombustible material.

602.5 Type V. Type V construction is that type of construction in which the structural elements, exterior walls and interior walls are of any materials permitted by this code.

603.1 Allowable materials. Combustible materials shall be permitted in buildings of Type I or II construction in the following applications and in accordance with Sections 603.1.1 through 603.1.3:

1. *Fire-retardant-treated wood* shall be permitted in:
 - 1.1. Nonbearing partitions where the required *fire-resistance rating* is 2 hours or less.
 - 1.2. Nonbearing *exterior walls* where fire-resistance rated construction is not required.
 - 1.3. Roof construction, including girders, trusses, framing and decking.

Exception: In buildings of Type IA construction exceeding two *stories above grade plane*, *fire-retardant-treated wood* is not permitted in roof construction when the vertical distance from the upper floor to the roof is less than 20 feet (6096 mm).

Chapter 23 of the IBC includes the following information regarding FRTW:

2303.2 Fire-retardant-treated wood. *Fire-retardant-treated wood* is any wood product which, when impregnated with chemicals by a pressure process or other means during manufacture, shall have, when tested in accordance with ASTM E 84 or UL 723, a *listed* flame spread index of 25 or less and show no evidence of significant progressive combustion when the test is continued for an additional 20-minute period. Additionally, the flame front shall not progress more than 10-1/2 feet (3200 mm) beyond the centerline of the burners at any time during the test.

2303.2.1 Pressure process. For wood products impregnated with chemicals by a pressure process, the process shall be performed in closed vessels under pressures not less than 50 pounds per square inch gauge (psig) (345 kPa).

2303.2.2 Other means during manufacture. For wood products produced by other means during manufacture, the treatment shall be an integral part of the manufacturing process of the wood product. The treatment shall provide permanent protection to all surfaces of the wood product.

2303.2.3 Testing. For wood products produced by other means during manufacture, other than a pressure process, all sides of the wood product shall be tested in accordance with and produce the results required in Section 2303.2. Wood structural panels shall be permitted to test only the front and back faces.

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2303.2.4 Labeling. Fire-retardant-treated lumber and wood structural panels shall be labeled. The *label* shall contain the following items:

1. The identification *mark* of an *approved agency* in accordance with Section 1703.5.
2. Identification of the treating manufacturer.
3. The name of the fire-retardant treatment.
4. The species of wood treated.
5. Flame spread and smoke-developed index.
6. Method of drying after treatment.
7. Conformance with appropriate standards in accordance with Sections 2303.2.5 through 2303.2.8.
8. For *fire-retardant-treated wood* exposed to weather, damp or wet locations, include the words "No increase in the *listed* classification when subjected to the Standard Rain Test" (ASTM D 2898).

2303.2.5 Strength adjustments. Design values for untreated lumber and wood structural panels, as specified in Section 2303.1, shall be adjusted for *fire-retardant treated wood*. Adjustments to design values shall be based on an *approved* method of investigation that takes into consideration the effects of the anticipated temperature and humidity to which the *fire-retardant-treated wood* will be subjected, the type of treatment and redrying procedures.

2303.2.5.1 Wood structural panels. The effect of treatment and the method of redrying after treatment, and exposure to high temperatures and high humidities on the flexure properties of fire-retardant-treated softwood plywood shall be determined in accordance with ASTM D 5516. The test data developed by ASTM D 5516 shall be used to develop adjustment factors, maximum loads and spans, or both, for untreated plywood design values in accordance with ASTM D 6305. Each manufacturer shall publish the allowable maximum loads and spans for service as floor and roof sheathing for its treatment.

2303.2.5.2 Lumber. For each species of wood that is treated, the effects of the treatment, the method of redrying after treatment and exposure to high temperatures and high humidities on the allowable design properties of fire-retardant-treated lumber shall be determined in accordance with ASTM D 5664. The test data developed by ASTM D 5664 shall be used to develop modification factors for use at or near room temperature and at elevated temperatures and humidity in accordance with ASTM D 6841. Each manufacturer shall publish the modification factors for service at temperatures of not less than 80°F (27°C) and for roof framing. The roof framing modification factors shall take into consideration the climatological location.

2303.2.6 Exposure to weather, damp or wet locations. Where *fire-retardant-treated wood* is exposed to weather, or damp or wet locations, it shall be identified as "Exterior" to indicate there is no increase in the *listed* flame spread index as defined in Section 2303.2 when subjected to ASTM D 2898.

2303.2.7 Interior applications. Interior *fire-retardant treated wood* shall have moisture content of not over 28 percent when tested in accordance with ASTM D 3201 procedures at 92-percent relative humidity. Interior *fire retardant-treated wood* shall be tested in accordance with Section 2303.2.5.1 or 2303.2.5.2. Interior *fire-retardant treated wood* designated as Type A shall be tested in accordance with the provisions of this section.

2303.2.8 Moisture content. *Fire-retardant-treated wood* shall be dried to a moisture content of 19 percent or less for lumber and 15 percent or less for wood structural panels before use. For wood kiln-dried after treatment (KDAT), the kiln temperatures shall not exceed those used in kiln drying the lumber and plywood submitted for the tests described in Section 2303.2.5.1 for plywood and 2303.2.5.2 for lumber.

2303.2.9 Type I and II construction applications. See Section 603.1 for limitations on the use of *fire-retardant treated wood* in buildings of Type I or II construction.

Chapter 3 of ANSI/TPI 1-2014 includes the requirement that FRTW must be clearly identified and marked and provides further explanation in the non-mandatory commentary (§).

3.4.4 Preservative Treatment Identification. Preservative treated lumber shall be identified by the quality mark of, or a certificate of inspection from, an approved inspection agency and shall be identified by a label affixed to the package (see also Section 6.4.9).

3.4.5 Fire Retardant Identification Lumber Impregnated with fire retardant chemicals shall be identified by the quality mark of, or a certificate of inspection from, an approved inspection agency and shall be identified by a label affixed to the package.

§3.4.4 Preservative Treatment & §3.4.5 Fire Retardant Identification. The marking by an approved inspection agency is specified to assure that lumber processing during the treatment process, and subsequent processes such as kiln-drying, are conducted in accordance with the processes employed during the evaluation of the treatment's effects. Approval of an inspection agency for treated lumber is typically the authority of the local Building Official. Inspection agencies may be accredited for inspection of pressure treated wood products by the American Lumber Standard Committee, Inc. (ALSC, see www.alsc.org), the International Accreditation Service, Inc. (IAS, see www.iasonline.org), or other accrediting services.

Chapter 6 of ANSI/TPI 1-2014 addresses acceptable conditions for FRTW before installation as well as the possible reduction of design values for the treated lumber product. The degree of reduction may depend on the ambient conditions

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where the building is being constructed, and therefore the design values must be approved by local authorities. Truss engineering software has the ability to apply the required lumber and plate reduction values applicable to FRTW.

6.4.9.1 Fire Retardant Treated (FRT) Lumber. All FRT lumber used in Trusses shall be re-dried after treatment to 19 percent maximum moisture content at temperatures not to exceed 160°F (71°C). FRT lumber design values shall be developed from approved test methods and procedures that consider potential strength-reduction characteristics, including effects of elevated temperature and moisture. Design values shall be approved by the authorities having Jurisdiction.

6.4.9.2 Metal Connector Plates Installed in FRT Metal Connector Plates installed in lumber pressure-impregnated with fire retardant chemicals shall have the reductions for lateral resistance values specified by the FRT chemical manufacturer. The quality mark shall indicate that the design value adjustments are in accordance with either the FRT manufacturer's specifications or based upon an approved method of investigation which takes into consideration the effects of the anticipated temperature and humidity to which the FRT will be subjected.

§6.4.9 Chemically Treated Lumber. Further information on Preservative Treated Lumber can be found at: www.tpinst.org/, and through information from the proprietary preservative treatment and fire retardant treatment manufacturers. Allowable lumber design stresses shall be adjusted, when needed, as recommended by these manufacturers.

§6.4.9.2 Metal Connector Plates Installed in FRTW. Metal Connector Plate design values shall be adjusted per recommendations by the chemical manufacturer.

Discussion:

Where FRTW Can Be Used

**TABLE 601
FIRE-RESISTANCE RATING REQUIREMENTS FOR BUILDING ELEMENTS (HOURS)**

BUILDING ELEMENT	TYPE I		TYPE II		TYPE III		TYPE IV	TYPE V	
	A	B	A	B	A	B	HT	A	B
Primary structural frame ^f (see Section 202)	3 ^a	2 ^a	1	0	1	0	HT	1	0
Bearing walls									
Exterior ^{e, f}	3	2	1	0	2	2	2	1	0
Interior	3 ^a	2 ^a	1	0	1	0	1/HT	1	0
Nonbearing walls and partitions	See Table 602								
Exterior									
Nonbearing walls and partitions							See Section 602.4.6		
Interior ^d	0	0	0	0	0	0		0	0
Floor construction and associated secondary members (see Section 202)	2	2	1	0	1	0	HT	1	0
Roof construction and associated secondary members (see Section 202)	1 ^{1/2} ^b	1 ^{b, c}	1 ^{b, c}	0 ^c	1 ^{b, c}	0	HT	1 ^{b, c}	0

For SI: 1 foot = 304.8 mm.

- a. Roof supports: Fire-resistance ratings of primary structural frame and bearing walls are permitted to be reduced by 1 hour where supporting a roof only.
- b. Except in Group F-1, H, M and S-1 occupancies, fire protection of structural members shall not be required, including protection of roof framing and decking where every part of the roof construction is 20 feet or more above any floor immediately below. Fire-retardant-treated wood members shall be allowed to be used for such unprotected members.
- c. In all occupancies, heavy timber shall be allowed where a 1-hour or less fire-resistance rating is required.
- d. Not less than the fire-resistance rating required by other sections of this code.
- e. Not less than the fire-resistance rating based on fire separation distance (see Table 602).
- f. Not less than the fire-resistance rating as referenced in Section 704.10.

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The IBC limits the use of FRTW in Types I and II construction because these typically require all materials to be noncombustible.

603.1 Allowable materials. Combustible materials shall be permitted in buildings of Type I or II construction in the following applications and in accordance with Sections 603.1.1 through 603.1.3:

1. *Fire-retardant-treated wood* shall be permitted in:
 - 1.1. Nonbearing partitions where the required *fire-resistance rating* is 2 hours or less.
 - 1.2. Nonbearing *exterior walls* where fire-resistance rated construction is not required.
 - 1.3. Roof construction, including girders, trusses, framing and decking.

Exception: In buildings of Type IA construction exceeding two *stories above grade plane*, *fire-retardant-treated wood* is not permitted in roof construction when the vertical distance from the upper floor to the roof is less than 20 feet (6096 mm).

Use of FRTW is less limited in Type III construction. Although exterior walls are required to be of noncombustible material, all other structural members are not required to be of noncombustible material so as long as the construction meets the specific fire-resistance rating given in Table 601 (reprinted above), it is allowed.

602.3 Type III. Type III construction is that type of construction in which the exterior walls are of noncombustible materials and the interior building elements are of any material permitted by this code. **Fire-retardant-treated wood framing complying with Section 2303.2 shall be permitted within exterior wall assemblies of a 2-hour rating or less.**

FRTW use in Type IV (Heavy Timber) Construction is typically not an issue, but is allowed as follows:

602.4.1 Fire-retardant-treated wood in exterior walls. Fire-retardant-treated wood framing complying with Section 2303.2 shall be permitted within exterior wall assemblies with a 2-hour rating or less.

FRTW use in Type V Construction is not required but would be permitted. Combustible materials are allowed, although in Type V-A major building elements must be protected by material with a 1-hour fire-resistance rating. Use of FRTW is also permitted in accordance with the footnotes to IBC Table 601 (reprinted above) as applicable to Roof Construction in Type IA, 1B, IIA, IIIA and VA as follows:

- b. Except in Group F-1, H, M and S-1 occupancies, fire protection of structural members shall not be required, including protection of roof framing and decking where every part of the roof construction is 20 feet or more above any floor immediately below. Fire-retardant-treated wood members shall be allowed to be used for such unprotected members.

In addition, there are special circumstances in reference to sprinklering where FRTW may provide an advantage per Section 8.15.1.2.11 of NFPA 13 *Standard for the Installation of Sprinkler Systems*:

Concealed spaces in which the exposed materials are constructed entirely of fire-retardant treated wood as defined by NFPA 703 ... shall not require sprinkler protection.

FRTW Requirements

Because FRTW is allowed in some applications where noncombustible materials are otherwise required, it is important that these products meet rigorous requirements. IBC Section 2303.2 requires that the effectiveness of the pressure-impregnated FRT be determined by subjecting the material to tests conducted in accordance with ASTM E84, with the modification that the test is extended an additional 20 minutes. Using this procedure, a flame spread index is established during the standard test period. The test is continued for an additional 20 minutes. During this added time period, there must not be any significant flame spread and at no time can the flame spread more than 10¹/₂ feet (3200 mm) past the centerline of the burners.

The impregnation discussed in IBC Section 2303.2 requires further discussion. Impregnation does not mean the chemical penetrates all the way through the lumber. The penetration depth may vary with lumber species and treatment method. There is no definition of how much penetration is needed for the material to be considered "impregnated." IBC Section 2303.2.2 requires FRT to be a permanent protection of all surfaces. Treatments that stay on the lumber surface and can therefore be chipped off or lose their bond to the lumber are not sufficient to create FRTW. Those products would need to be qualified as an alternative material under IBC Section 104.11 or IRC Section R104.11.

Treatment by a method other than a pressure process is addressed in IBC Section 2303.2.3. Equivalent performance is required from all sides of the FRTW product, so that orientation of the product is not an issue. The intent is that all sides of the material are protected. The requirement in this code section is that the product is tested on all sides. This is problematic from a testing perspective. How does one determine what is the front or back of a piece of lumber? If I test one side of a sample, I cannot use that same sample for the next test. A new sample must be used. How do I then determine which side to test? What is the front? What is the back? Meeting this requirement is not typically possible, so some judgement on the part of the testing facility is necessary.

Specifics related to design value adjustments are discussed below, but IBC Section 2303.2.6 also requires consideration of situations when FRTW may be exposed to the weather or may be used in damp or wet locations. This requires

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evaluation of the flame spread index when tested in accordance with ASTM D2898. This test is applicable only to pressure treated material and simulates the effects of leaching, drying, temperature and, in one method, ultraviolet light. If the FRTW product might be subject to these environmental concerns, the FRTW manufacturer must state that testing to ASTM D2898 has been done on the product.

IBC Section 2303.2.8 requires FRTW drying temperatures not to exceed those typically used for non-FRTW.

FRTW Design Requirements

IBC Sections 2303.2.5 and 2303.2.5.2 require FRTW to be tested to determine applicable adjustment factors in accordance with ASTM D5664 and D6841, taking into account both the impact of the chemical treatment and the environment in which the FRTW product is to be used.

ANSI/AWC NDS-2015 and ANSI/TPI 1-2014 are clear that applicable adjustments to design values are to be provided by the FRTW supplier. All of the FRTW suppliers do provide reductions for design values based on their chemical and process, applicable to specific wood species. The adjustment values should be based on current product information and typically include reductions to the following material properties:

- Compression Parallel to Grain
- Horizontal Shear
- Tension Parallel to Grain
- Bending – Modulus of Elasticity
- Bending – Extreme Fiber Stress
- Fasteners/Connectors

There may be additional design value adjustment factors for FRTW used in high temperature applications. However, because most FRTW suppliers do not stock the high grades of lumber typically used in trusses, truss manufacturers may have to send material out to be treated.

Manufacturer Warranties on FRTW Chemicals

Because FRTW is subject to design value reductions that are to be supplied by the FRTW supplier, it is important to acquire a warranty from the FRTW supplier. Such a warranty protects the builder from liability for structural failures associated with these reduced design values. A warranty for FRT also protects those who use or supply products that include the FRT material in the case that the treated lumber deteriorates or otherwise breaks down as a result of the chemical treatment. Manufacturer warranties make FRTW suppliers liable for the design values they publish and the effects of their products on wood structural elements. An FRTW warranty should include the following:

- Extent of coverage, including which materials are covered and under what circumstances.
- Duration of coverage.
- Limitations of coverage, including all circumstances under which the warranty will not be honored. Examples of limited coverage scenarios commonly include:
 - Improper installation, storage, and handling of FRTW products.
 - Non-code-compliant building design.
 - Damage from insects or mold.
 - Use of other FRT chemicals in addition to the treatment provided by the company offering the warranty.
- Claim procedure to be followed in the event of a failure incident.

Almost all manufacturer FRTW warranties are dependent on proper installation and code compliance. If a failure occurs and improper installation can be demonstrated, then the warranty will almost certainly not be honored, even if the improper installation is shown to not be the cause of the failure. Likewise, warranties will not be honored for structures which are not built in accordance with applicable building codes.

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Conclusion:

- FRT materials can be incorporated into buildings to reduce the ability of lumber products to contribute to a fire. The IBC requirements dictate where, and under what circumstances, FRT materials are allowed.
- When designing trusses with FRTW, ANSI/TPI 1-2014 should be followed as a guide for the appropriate drying conditions for the lumber after treatment. In addition, appropriate design value reductions for the lumber and metal connector plates should be applied according to the FRT material manufacturer's specifications.

References:

ANSI/AWC NDS-2015 *National Design Specification (NDS) for Wood Construction*

ANSI/TPI 1-2014 *National Design Standard for Metal Plate Connected Wood Truss Construction*

ASTM D2898 - Standard Practice for Accelerated Weathering of Fire-Retardant-Treated Wood for Fire Testing

ASTM D3201 - Standard Test Method for Hygroscopic Properties of Fire-Retardant Wood and Wood-Based Products

ASTM D5516 - Standard Test Method for Evaluating the Flexural Properties of Fire-Retardant Treated Softwood Plywood Exposed to Elevated Temperatures

ASTM D5664 - Standard Test Method for Evaluating Dowel-Bearing Strength of Wood and Wood-Based Products

ASTM D6841 - Standard Practice for Calculating Design Value Treatment Adjustment Factors for Fire-Retardant-Treated Lumber

ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials

ASTM E136 - Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750°C

International Code Council, *International Building Code (IBC)*

International Code Council, *International Residential Code (IRC)*

NFPA 13 *Standard for the Installation of Sprinkler Systems*

United States Department of Agriculture Forest Service, Forest Products Laboratory *Wood Handbook: Wood as an Engineering Material*, Chapter 18: "Fire Safety of Wood Construction," 2010