New Developments in Structural Engineering and Construction
Yazdani, S. and Singh, A. (Eds.)
ISEC-7, Honolulu, June 18 –23, 2013

NFPA CODE PROVISIONS AND FIRE-RETARDANT-TREATED WOOD

DAVID G. BUECHE[1]

[1]*Hoover Treated Wood Products, Thomson, Georgia, USA*

It is generally recognized that there is really no such thing as a fireproof building. Fires can occur in any type of structures. The severity of a fire, however, is contingent on the ability of a construction to confine the fire, limit its effect on the supporting structure, and control the spread of smoke and gasses. Building construction and life safety codes are concerned with the types of materials used in buildings. Their concern is rooted in risk posed by fire to the structure and persons using it. Both aim to reduce property loss and protect life safety. This paper examines these National Fire Protection Association (NFPA) codes and their referenced standards. It specifically addresses how fire-retardant-treated wood (FRTW) can be used in building construction and examines a few case histories demonstrating the use of FRTW in lieu of noncombustible building elements.

Keywords: Fire-retardant-treated wood, Fire resistance, Component additive method, NFPA Codes, Types of construction

1 General Appearance

Building construction and life safety codes are concerned with the types of materials used in buildings. Their concern is rooted in risk posed by fire to the structure and persons using it. Both aim to reduce property loss and protect life safety. Conceptually however, the codes are very different in scope. The *Life Safety Code* (NFPA 101) primarily addresses construction, protection, and occupancy exiting features necessary to minimize the danger to life from the effects of fire as well as conditions associated with non-fire emergencies. The *Building Construction and Safety Code* (NFPA 5000) addresses a wide range of considerations, including structural strength, stability, sanitation, means of egress, adequate light and ventilation, and energy efficiency.

Both NFPA 5000 and NFPA 101 incorporate a holistic implementation of fire protection and life safety requirements within the scope of each code. As a result, applications for combustible materials, such as wood, are limited, especially in unsprinklered and larger multistory structures. These codes and their referenced standards recognize the benefits of pressure impregnating fire retardants into wood. Fire-retardant-treated wood (FRTW) does not require water or electricity to protect the wood and therefore provides passive protection. When properly installed according to code requirements, FRTW never needs additional inspection or service and is free of these ongoing maintenance costs.

2 Fire-Retardant-Treated Wood

Pressure impregnated fire retardant treatments do not prevent wood from being destroyed by fire, but when added to wood, provide passive protection and slow down the decomposition to such an extent that the wood structurally out performs most other building materials during actual fire conditions.

When temperatures reach a point slightly below the kindling point, the chemicals react with each other. Nonflammable gases and water vapor are formed and released at a slow persistent rate which envelope the wood fibers insulating them from temperatures that cause the wood to decompose. The inflammable gases and tars are reduced and an insulating char forms on the surface of the wood, further slowing down the process of decomposition.

Because of the greatly reduced rate of decomposition or burning, the structural integrity of the wood is preserved for a long period of time. Smoke and toxic fumes are also greatly reduced, and when the heat source is removed, the wood ceases to decompose and the spread of fire by the wood is eliminated.

Section 45.2.8.1 of NFPA 5000, Section 3.3.99 of NFPA 101, and Section 3.3.2 of NFPA 703, *Standard for Fire Retardant – Treated Wood and Fire-Retardant Coatings for Building Materials*, define FRTW as "A wood product impregnated with chemicals by a pressure process or other means during manufacture, which is tested in accordance with ASTM E 84, *Standard Test Method of Surface Burning Characteristics of Building Materials*, NFPA 255, *Standard Method of Test of Surface Burning Characteristics of Building Materials* or UL 723, *Standard for Test for Surface Burning Characteristics of Building Materials*; has a listed flame

spread index of 25 or less; and shows no evidence of significant progressive combustion when the test is continued for an additional 20-minute period; nor does the flame front progress more than 10.5 feet (3200 mm) beyond the centerline of the burners at any time during the test."

This definition is a performance specification. Unlike the specifications for wood preservatives, FRTW is specified on the basis of performance and not retention. The "Flame Spread" index is a measure of the surface burning characteristics of a building material when compared to the relative surface burning characteristics of cement board (rated at 0) and untreated select red oak flooring (rated at 100). The index is determined by relative performance in a 25-foot long fire test tunnel furnace under controlled conditions of draft and temperature.

In the tunnel test, a gas jet is located near one end of the tunnel. Without a test specimen present in the tunnel, the ignition flame from the gas jet extends down the tunnel for a distance of 4½ feet from the burners. After a test specimen is placed in the tunnel and exposed to the ignition flame for a period of 10 minutes, the spread of the flame is measured from the fire end of the tunnel.

Keep in mind that the standard flame spread test is only for 10 minutes. This method demonstrates delayed ignition and gives little indication of non-combustibility. The test period for FRTW is extended another 20 minutes to demonstrate that there is no signification progressive combustion during the test allowing its use in lieu of non-combustible materials in structural applications.

3 Types of Construction

Chapter 7 of NFPA 5000 and its extract NFPA 220, *Standard on Types of Construction*, describe five types of construction as summarized in Table 1. NFPA 101 refers to NFPA 220 for definitions. These types of construction distinguish between combustible or noncombustible construction and the degree of fire resistance of the primary structural framing material. The NFPA classification system designates the five types of construction using Roman numerals (I, II, III, etc.) followed by three Arabic numbers (332, 211, etc.) that indicate the hourly fire-resistance rating requirement for specific structural elements. Each number of the Arabic trio designates the following:

- First Arabic number – exterior bearing walls
- Second Arabic number – columns, beams, girders, trusses and arches, supporting bearing walls, columns or loads from more than one floor
- Third Arabic number – floor construction before.

The principal structural elements of the building in Types I and II construction are required to be noncombustible, with some exceptions. The NFPA 5000 classification system assigns the highest structural fire resistance to Types I. Accordingly, the more critical building occupancies and uses with more liberal heights and area limitations are prescribed to have Type I and protected Type II-222 construction designations. Types III, IV and V are progressively more restrictive in terms of allowable heights and areas. The building size, footprint, and its fire protection are typically determined in conjunction with the occupancy and type of construction allowed by the code.

Table 1. NFPA Types of construction

Type	NFPA description
Noncombustible	Type I (442)
	Type I (332)
	Type II (222)
	Type II (111)
	Type II (000)
Mixed noncombustible and combustible including frame and heavy timber (HT)	Type III (211)
	Type III (200)
	Type IV(2HH)
Combustible–traditional wood frame	Type V (111)
	Type V (000)

4 Uses of Fire-Retardant-Treated Wood

Combustible building elements in noncombustible buildings are listed in Section 7.2.3.2 of NFPA 5000. This list includes structural elements that are constructed of fire-retardant treated-wood. FRTW can often be used in place of noncombustible materials, for instance, exterior walls of Type I, II, III and IV buildings, and in roof structures of Type II and low-rise buildings of Types I construction. NFPA 101 also recognizes that FRTW can be used for scenery and stage properties in both new and existing construction. Table 2 summarizes where FRTW is permitted to be used with or in lieu of noncombustible materials.

In Section 7.2.4, NFPA 5000 defines Type III Construction as being that type in which the exterior walls and structural elements that are portions of the exterior walls are of approved noncombustible materials and the interior building elements are of any material permitted by the code. The section also states that FRTW is permitted in exterior wall assemblies in lieu of noncombustible materials when the rating of the wall is required to be 2-hours or less. Therefore, for many of the most common occupancies, buildings constructed entirely of wood can be just as large and as high as noncombustible buildings. Table 3 shows that non-sprinklered buildings of NFPA 5000 Type III-200 construction, in many occupancies, may be just as large as non-sprinklered buildings of Type II-000 (noncombustible unprotected) construction. Buildings of Type III-200, for the occupancies shown,

may be entirely of wood if FRTW is used in the exterior walls.

Table 2. Allowable uses of FRTW in NFPA 5000 and NFPA 101

Uses of fire-retardant-treated wood	NFPA 5000	NFPA 101
Architectural trim, exterior.	37.2.1	
Awnings & canopies.	32.4.2.1#3	NFPA 101 is an exits code. Consult building code requirements.
Balconies and similar appendages	37.2.2.1	
Bay and oriel windows	37.2.2.1	
Combustible projections.	37.2	
Corridors	7.2.3.2.11.2	7.1.3.1
Exterior bearing & nonbearing walls: Type III const.	7.2.4.2.1	4.4.2.1[1]
Exterior bearing and nonbearing walls: Type IV const.	7.2.5.6.7	4.5.6.7[1]
Exterior nonbearing walls in Type I & Type II const.	7.2.3.2.12.1	4.3.2.12.1[1]
Enclosed combustible spaces in sprinklered buildings of all types of construction: Sprinklers not required	NFPA 13, 8-13.1.1#9 1999 edition NFPA 13, 8.14.1.2.11 2002 edition NFPA 13, 8.15.1.2.11 2007, 2010 editions	
Fire barriers: see interior partitions Type I & Type II const.	7.2.3.2.11.2	4.3.2.11.2[1]
Fuel dispensing station (marine and motor vehicle).	32.4.5.2	See building code
Grandstands: allowable heights increased	32.7.5.4	12.4.8.3.3
Interior finish with flame spread index ≤25 (Class A).	10.3.2.1	10.2.3.4
Kiosks in Covered Mall Buildings	27.4.4.12.1	36.4.4.8
Parapet not required when FRTW is used for sheathing:		
Exterior walls	37.1.3.1	See building code
Townhouses, 4 ft. each side of wall.	22.5.4	
Fire and party walls in Type III, IV, and V.	8.3.3.6.5.2	6.6.4[2]
Partitions in Type I and Type II construction	7.2.3.2.11.2	4.3.2.11.2[1]
Platforms in Type I and Type II construction	7.2.3.2.7	4.3.2.7[1]
Plenums in all types of construction	7.2.3.2.15.8	4.3.2.15.8[1]
Ramps		7.2.5.3.1
Roof construction in Type I and Type II construction.	7.2.3.2.9.2	4.3.2.9.2[1]
Roof construction in Type I, II, III, VA, no rating when >20ft above floor	7.2.3.2.9.1 (Type I,II)	4.3.2.8[1] (Type I, II)
Roof construction, pedestrian walkways	7.2.3.2.9.2	See building code
Shakes and shingles Class A, B, and C roofs.	38.3.2	
Scenery and stage properties in new and existing construction		13.4.5.11.3

[1]NFPA 220, [2]NFPA 221

Table 3. Comparison of NFPA 5000 type II-000 and III-200 construction

NFPA 5000 Occupancy	NFPA 5000 Table 7.4.1 allowable area (sq ft)		NFPA 5000 Table 7.4.1 allowable height (stories/feet)	
	Type II-000	Type III-200	Type II-000	Type III-200
Assembly ≤300	8,500	8,500	1/55	1/55
Business	23,000	19,000	4/55	4/55
Educational	14,500	14,500	2/55	2/55
Mercantile	12,500	12,500	4/55	4/55
Residential	16,000	16,000	4/55	4/55
Residential, 1- & 2-family	UL	UL	4/55	4/55
Storage, low hazard	26,000	26,000	4/55	4/55

5 Fire Resistive Construction

The NFPA Codes provide for both prescriptive and performance based fire-resistant designs. For example, Section 8.2.1.1 of NFPA 5000 allows the designer to choose methods for design as long as they meet the fire exposure and criteria specified in NFPA 251, *Standard Method of Tests of Fire Resistance of Building Construction and Materials*, or other approved test methods or analytical methods. Section 8.2.3.2.1 allows ASCE/SFPE 29, *Standard Calculation Methods for Structural Fire Protection*, for calculating the fire resistance rating of structural elements.

The component additive method (CAM) is a calculation procedure, described in Section 3.4 of ASCE/SFPE 29. It is used to determine fire resistance ratings of light-frame wood floor, roof, and wall assemblies. This procedure assumes that a time can be assigned to the type and thickness of the protective membrane and that an assembly with two or more protective membranes has a fire resistance rating at least that of the sum of the times assigned for the individual layers plus the time assigned to the framing.

The times assigned to the protective membranes (Table 4), the framing (Table 5), and other factors are added together to obtain the fire resistance rating for the assembly. The times are based on empirical correlation with actual ASTM E119, *Standard Test Methods for Fire Tests of Building Construction and Materials*, tests of assemblies.

Table 4. Time assigned to protective membranes

Description of Finish	Time (min)
3/8 in. (9.5 mm) Douglas fir plywood phenolic bonded	5
1/2 in. (12.7 mm) Douglas fir plywood phenolic bonded	10
5/8 in. (15.9 mm) Douglas fir plywood phenolic bonded	15
3/8 in. (9.5 mm) gypsum board	10
1/2 in. (12.7 mm) gypsum board	15
5/8 in. (15.9 mm) gypsum board	20
1/2 in. (12.7 mm) Type X gypsum board	25
5/8 in. (15.9 mm) Type X gypsum board	40
Double 3/8 in. (9.5 mm) gypsum board	25
1/2 + 3/8 in. (12.7 mm) gypsum board	35
Double 1/2 in. (9.5 mm) gypsum board	40
Double 5/8 in. (9.5 mm) gypsum board	55

Example 1: Determine the fire endurance rating of the interior wood stud wall assembly shown in Figure 1 having one layer of 5/8 in. (15.9 mm) Type X gypsum board attached to both sides of the wood studs.

Solution: Table 4 shows that 5/8 in. (15.9 mm) Type X gypsum board has an assigned time of 40 minutes. Table 5 shows that wood studs spaced 16 in. (406 mm) on center have a time of 20 minutes. Summing the two components, results in a fire endurance rating of 60 minutes.

Table 5. Time assigned to wood-frame components

Description of Frames	Time (min)
Wood studs minimum 2 in. nominal (38mm), 16 in. (406 mm) on center	20
Wood joists minimum 2 in. nominal (38mm), 16 in. (406 mm) on center	10
Wood roof and floor truss assemblies, 24 in. (610 mm) on center	5

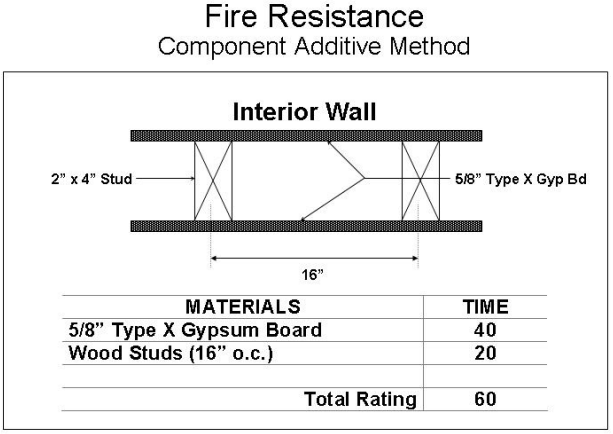

Figure 1. Interior wood stud wall of Example 1

Section 47.2.1.3.2 of NFPA 5000, acknowledges that fire-rated gypsum board systems are to be constructed in accordance with GA-600, *Fire Resistance Design Manual*, or other recognized sources. Numerous associations are recognized sources and publish design configurations meeting various fire criteria. Examples of these publications are Fire Rated Wood Floor and Wall Assemblies (DCA-3) published by the American Wood Council, and Fire Rated Systems Design/Construction Guide (W305) published by APA-The Engineered Wood Association.

Underwriters Laboratories Inc. (UL) is also a recognized source of documented construction designs rated for fire resistance. UL conducts tests of various building components and fire protection materials. The assemblies are tested under recognized testing procedures, including ASTM E119, NFPA 251, and ANSI/UL 263, *Standard for Fire Tests of Building Construction and Materials*, all of which are essentially the same. When the assembly complies with the acceptance criteria of the fire test standard, a detailed report is provided including its

description and performance in the test, pertinent details, and specifications of materials used. A summary of the important features is produced and given a UL designation, which is then added to the *UL Fire Resistance Directory*.

FRTW has a surface burning classification and, by itself, does not have a resistance rating in hours any greater than untreated wood. References such as UL's Fire Resistance Directory specifically point out that FRTW may be substituted for untreated wood in any rated assembly without altering the fire endurance of the assembly. FRTW can therefore be used as a component of such assemblies (Figure 2) in structures where the code does not permit the use of untreated wood.

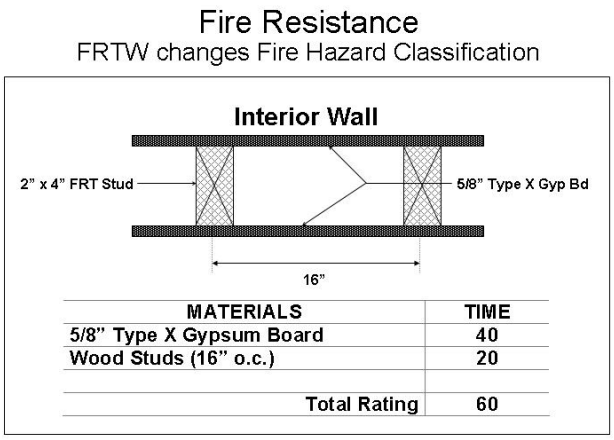

Figure 2. Interior stud wall of Example 1 with FRTW studs

If the studs are FRTW, the assembly of Example 1 can be used for one hour rated interior, non-bearing partitions, in Type I and Type II construction. In a similar manner, by substituting FRTW for untreated wood, other one and two hour wall and ceiling assemblies can be used in noncombustible type buildings.

6 Case Studies

Figure 3 shows a 1.2 million square foot warehouse that was developed for multiple tenants and features a hybrid panelized roof system utilizing fire-retardant-treated wood and tilt-up concrete wall panels. This low hazard Industrial/Storage occupancy building is classified as Type II-000 construction. Because it is surrounded and adjoined by public ways not less than 60 ft (18 m) in width, under Section 7.6.3 of NFPA 5000, it is permitted to be of unlimited areas and not subject to the sprinkler requirements that allow unlimited area buildings.

The hybrid roof system consists of 4 ft x 8 ft fire-retardant-treated plywood on 2x and 3x fire-retardant-treated sawn lumber sub-purlins. The primary framing consists of steel bar joist spaced 8 ft on center with steel girder trusses as the main structural members. This system uses panelized units assembled on the ground and then lifted into position at the roof level, where the steel bar joists are welded or bolted to the primary steel girder trusses. The free edge of the wood decking for each panelized unit is nailed to the framing edge of the previously placed unit. Pre-framed panel ends attached to the main steel trusses complete the assembly.

The ability to pre-frame large roof panelized units reduce cost, cuts construction time, and enhances job site safety since fewer man-hours are spent on the roof. Panelized roof systems are one of the safest systems to erect because most of the work is accomplished on the ground during the fabrication of the large pre-framed roof panels.

Figure 3. FRTW panelized roof system

The apartment complex in Figure 4 contains 500,000 square feet of residential space, 40,000 square feet of retail space, and a 350,000 square foot parking garage. The wood frame portion of the building is Type III-211-S construction. The exterior bearing walls are constructed with fire-retardant-treated wood studs. The interior framing is untreated wood.

Figure 4. Apartment complex utilizing FRTW studs

The two story parking garage consists of a one-story enclosed parking garage and a one-story open garage. The parking garages are not considered in determining the maximum number of stories allowed in the building under NFPA 5000 when constructed of Type I construction and a three hour occupancy separation is maintained between the parking garage and the residential occupancy.

NFPA 5000 allows the base area to be doubled and a one-story height increase when a NFPA 13 sprinkler system is installed.

7 Summary

Fire-safe construction is a major focus of the building and life safety codes, which mandate certain levels of fire protection. The building size, footprint, and its fire protection are typically determined in conjunction with the occupancy and type of construction allowed by the code. Types of construction distinguish between combustible or noncombustible construction and the degree of fire resistance of the primary structural framing material. This article has demonstrated that the codes recognize the use of fire-retardant-treated wood in lieu of noncombustible materials in many applications with specific advantage in Types I and II construction were materials are required to be noncombustible.

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