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CONTENTS UNDER PRESSURE: DISTINGUISHING IMPREGNATED FIRE-RETARDANT-TREATED WOOD FROM SURFACE-APPLIED TREATMENTS

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Increasing populations combined with decreasing developable plots are leading to higher real estate prices. Communities are attempting to address these higher prices by increasing the number of residential units per acre. One way to increase the supply is to use fire-retardant-treated wood (FRTW) to build larger and taller structures. However, as FRTW is increasingly being used, substitute products that do not meet the definition of FRTW in the building codes are also being increasingly used. How does one distinguish the two? By relying on knowing how FRTW is manufactured, where it can be used, and on building code requirements, responsible parties will better understand why FRTW is different from these products and how to verify that only code-compliant, chemically impregnated FRTW is used in larger, taller structures.

Keywords: Pressure-impregnated, Intumescent, Paints, Cementitious Coatings, Steiner Tunnel Test, Extended UL 723, 2018 International Building Code.

1 INTRODUCTION

As populations increase, the supply of housing in proximity to workplaces and desired amenities declines, in turn leading to rising real estate prices. Urban areas have responded to this price pressure by spreading, but with decreasing amounts of outlying undeveloped areas, these urban areas are now responding by consolidating; in other words, urban areas are becoming increasingly densified by building up instead of building out. This trend is expected to continue. By the year 2040, two-thirds of the United States' population will be concentrated in just 10 large-scale, regional "megapolitan" clusters (Nelson and Lang 2013). The question becomes how do we build sustainably in densifying, urban areas while maintaining standards for life safety?

One answer is to use more fire-retardant-treated wood (FRTW). FRTW products are defined in the 2018 International Building Code (IBC 2018) as "wood products that, when impregnated with chemicals by a pressure process or other means during manufacture, exhibit reduced surface-burning characteristics and resist the propagation of fire" (International Code Council [ICC] IBC 2018). FRTW can contribute to a sustainable housing solution while helping to mitigate environmental impacts. FRTW can be manufactured to meet standards required by independent, third-party, green building certification systems (e.g., FSC, SFI, etc.) It can also be used as a substitute for untreated wood in any rated assembly without altering its fire resistance, as stated in references such as UL's Fire Resistance Directory (Bueche 2013). Through this substitution, FRTW could be used in applications where untreated wood is not allowed, like the exterior walls in a Type III building or the interior, nonbearing partitions of a Type I or II building i.e., FRTW could be used in certain applications in larger, taller buildings where the use of untreated wood is

prohibited. Finally, because extracting, manufacturing, and constructing with wood releases substantially less greenhouse gas and consumes much less energy than other building materials with (e.g., steel, concrete), using sustainably harvested FRTW provides a more environmentally friendly solution to the housing crisis (Malmsheimer *et al.* 2008).

One unintended consequence stemming from this increased use of FRTW currently is the installation of products that do not meet the FRTW definition in the IBC (2018) but are touted as fully code-compliant substitutes for FRTW. Often these products are less expensive than FRTW and appear to be properly credentialed; if building inspectors or other officials are not familiar with the FRTW provisions in the building codes, they could easily overlook the discrepancies. The way to identify legitimate FRTW starts with knowing how the product is manufactured.

2 HOW FRTW IS PRODUCED

Most FRTW will be chemically impregnated using a pressure process, although other, non-pressurized methods are possible; pressure impregnation, however, is the only effective means for fire-retardant treating wood (Bueche 2010). This pressure impregnation, first patented in 1893, occurs through a simple six-step process, as shown in Figure 1.

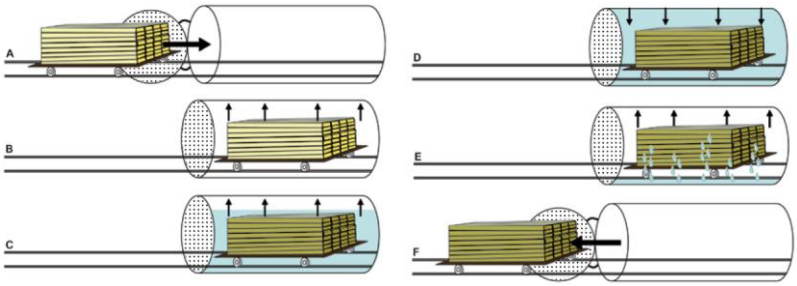

Figure 1. The pressure-impregnation process used by FRTW. Adapted from USDA Forest Service, Forest Products Laboratory (2010), 15-19.

First, untreated wood is loaded into a horizontal cylinder (A); then, the cylinder door is sealed and a vacuum is applied to remove air from the cylinder and the wood (B); next, the treatment is then pumped into the cylinder (C); the pressure in the cylinder is then increased, forcing the treating solution deep into the wood (D); after pressurizing, the treating solution is then pumped out, and a second vacuum removes any excess treatment (E); finally, the treated wood is moved to a kiln to be dried using carefully controlled moisture conditions (F). Once kiln-dried after the treatment to moisture content levels prescribed by the IBC, the FRTW is ready to be labeled and is then subsequently ready for use.

3 HOW FRTW WORKS

Once through the chemical impregnation process, fire-retardant treatment of wood improves fire performance by greatly reducing the amount of flammable gases released, thus reducing the rate at which flames spread over the surface. Treatments reduce the amount of heat available or released by the volatiles during the initial stages of fire and result in the wood self-extinguishing once the primary source of external fuel is exhausted.

To ensure that the treatment is effective, FRTW is required to pass the UL 723 (2018) "Test for Surface Burning Characteristics of Building Materials." This test is designed to gauge the fire-spread over the surface of a material and the smoke developed due to the burning. The test

apparatus, originally developed by Steiner (1936), consists of a 25-foot-long rectangular tunnel with two gas burners at one end that direct a 4.5-foot flame under controlled conditions of draft and temperature onto the surface of a 24-foot-long by 20-inch-wide specimen. Flame spreads along the surface of the material as the test progresses. The distance of flame travel and rate at which the flame front advances during a 10-minute exposure determine the calculated flame spread index (FSI).

However, UL 723 (2018) realized that this 10-minute period only demonstrated delayed ignition and gave little indication of non-combustibility. At the request of several insurance rating bureaus, UL wrote a performance standard for pressure impregnated FRTW that requires the test period to be extended an additional 20 minutes to a total of 30 minutes. Malcomson and Bono (1967) wrote that during the 20-minute extension, "the test samples are observed to determine that the flame spread does not exceed the equivalent of 25 (5 ft. beyond the standard igniting flame) and that there is no evidence of significant progressive combustion."

Over the years, changes to the standard affected the calculation procedures used to determine FSI values from raw data. In order to allow listed FRTW from older tests to remain compliant, an additional criterion was added to the codes to address what was already required by the UL Listings. This additional code criterion requires that "the flame front shall not progress more than 10-½ feet beyond the centerline of the burners at any time during the test."

4 FRTW APPLICATIONS

Because of its working properties stemming from the chemical impregnation, FRTW has myriad applications. Table 1 lists these applications next to their code citation in the 2018 IBC. These applications identify applications where an architect may decide to use FRTW or where a building or fire inspector may encounter FRTW in the field. These applications can be significant to address the housing crisis. For instance, UL Design Number V314 is a two-hour rated exterior wall assembly permitted by the code. It consists of two sheets of 5/8" Type X Gypsum Board on an interior-facing side, with 2x4 FRTW studs and either mineral wood or fiberglass insulation behind them, with FRTW plywood on the exterior-face side, and finished with any exterior cladding as permitted by the authority having jurisdiction.

5 DISTINGUISHING FRTW FROM SURFACE-APPLIED TREATMENTS

With so many applications, how specifically can a person distinguish FRTW from surface-applied treatments. Three main approaches exist: how these wood products are manufactured, how they are listed, and how they are labeled.

5.1 Means of Manufacture

For the 2018 IBC (2018), clarifying language was added to the FRTW provisions in Chapter 23 (Section 2303.2.2.): "*The use of paints, coating, stains or other surface treatments is not an approved method of protection as required in this section*" (emphasis added). In other words, materials such as intumescent paints, cementitious coated wood panel products (e.g., oriented strandboard), stains, and other surface-applied or topical treatments do not meet the definition of FRTW in the 2018 IBC.

To reiterate, this added code language, while new, was more clarifying in nature; these surface-applied treatments never met the definition of FRTW since the initial IBC's promulgation in 2000. The primary reason that these surface treatments do not meet the definition of FRTW is that FRTW is "impregnated with chemicals" (ICC 2018, 41). These other treatments are applied

topically to the surface of a wood product typically on only one side, or in the case of the cementitious coated products, possibly two (front and back)—but never all six sides. FRTW, because of its pressurized chemical impregnation, provides passive protection for all sides of a wood product, including lumber and plywood, instead of relying on a vulnerable surface barrier.

Table 1. Selected FRTW applications contained in the 2018 IBC.

Code Application	**Citation**
Architectural trim, exterior wall coverings	1405.1.1#3
Attics, elimination of sprinklers in residential occupancy	903.3.1.2.3
Awnings & canopies	3105.2
Balconies and similar projections	603.1#1.4
Bay and oriel windows	705.2.4
Children playground structures in malls	424.2#1
Combustible projections	705.2.3
Exterior bearing & nonbearing walls: Type III const.	602.3
Exterior bearing & nonbearing walls: Type IV const.	602.4.1
Exterior nonbearing walls in Types I & II construction	603.1#1.2
Enclosed combustible spaces in sprinklered buildings of all types of construction: Sprinklers not required	**NFPA 13:** 1999 ed. 8-13.1.1#9; 2002 ed. 8.14.1.2.11; 2007, 2010, 2013, 2016 ed. 8.15.1.2.11
Fire barrier: See partitions Types I & II construction	603.1#1.1
Fuel dispensing station (marine and motor vehicle)	406.7.2
Interior finish with flame spread index < 25 (Class A)	803.1.2
Kiosks in covered and open mall buildings	402.6.2
Liquid storage rooms (shelving, racks, and wainscotting)	415.11.5.2#3
Mechanical equipment screens	1510.6.2#2
Parapet not required when using FRTW sheathing:	
Exterior walls	705.11#5.1
Fire and party walls in Types III, IV, and V	706.6#4.3
Townhouses: Exterior and common wall use within 4ft of such walls	**International Residential Code:** R302.2.4
Partitions (2 hr or less) in Types I & II construction	603.1#1.1
Partitions (fixed) establishing corridors in buildings with one tenant serving no more than 30 people	603.1#11
Pedestrian walkways	3104.3#2
Platforms in Types I, II, and IV construction	410.3
Plenums in all types of construction	**International Mechanical Code:** 602.2.1
Roof construction in Types I & II construction	603.1#1.3
Roof construction in Types I, II, III, & VA construction when > 20 ft. above the floor	Table 601, Footnote b
Rooftop structures (penthouses)	1510.2.4
Shakes and shingles: Wood	1505.6
Wood veneer	1404.5.1
Walls and ceiling furred & dropped more than 1-3/4"	803.15.2.1

The ramifications for an entity approving a product with a surface-applied treatment as a substitute for FRTW could be severe. Imagine a cementitious coated wood panel product with both the front and back sides protected by the coating. These panels are typically installed, per the manufacturer's recommendations, with a minimum one-eighth inch gap. Should a fire find its way into the gap, then that fire has unfettered access to the panel product's exposed, combustible, engineered wood core. Similarly, if an intumescent painted wood panel product is damaged during installation or if it is not maintained or reapplied per the manufacturer's recommendations,

then its fire resistance is jeopardized, to say nothing about its likely exposed edges and unprotected, opposite-facing side.

5.2 Listing

Defined in the IBC (2018), a listed product is a product "listed by an organization acceptable to the building official and concerned with evaluation of products or services that maintains a periodic inspection" of those products to ensure that they meet "identified standards or [have] been tested and found suitable for a specified purpose." To earn a UL listing, FRTW must meet the requirements of the UL 723 (2018) test as discussed previously.

Often, proponents for materials that do not meet the building code's definition of FRTW will state that their products do conform as they pass the UL 723 test. Remember, however, that UL 723 is only a 10-minute test. For a product to meet the standard for the purposes of a UL listing, it must pass the extended UL 723 (2018) test i.e., it must also endure the 20-minute extension for a total of 30 minutes.

Once an FRTW product is listed, the listing indicates that the FRTW has been tested for conformance to an applicable standard and is subject to a third-party inspection quality assurance (QA) program. The QA verifies that the minimum level of quality required by the appropriate standard is maintained. The listing agency performing the third-party inspection must be approved by the code official and the basis for this approval may include, but is not limited to, the capacity and capability of the agency to perform the specific testing and inspection.

5.3 Labeling

Closely linked to the FRTW listing is the FRTW label. FRTW, for interior and exterior applications, is required by the IBC to be labeled with all the information shown in Figure 2. Label provisions in the IBC for both interior and exterior FRTW applications are essentially identical except for two key requirements. First, the exterior label must have the text "No increase in the listed classification when subjected to the standard rain test," signifying that the FRTW product has successfully passed the ASTM D2898 (2017) "Standard Practice for Accelerated Weathering of Fire-Retardant-Treated Wood for Fire Testing" test, which is a 12-week test that simulates FRTW exposed to 80 inches of rain per year for a decade. Second, the label must feature the word "Exterior" to signify the FRTW is to be used in a weather-exposed as opposed to a weather-protected application.

Two additional features of the label link it to the listing. First is the mark of an approved agency, in this case the UL Classified Mark. Through its Classification and Follow-Up Services program, UL verifies a material's quality and provenance of production through countercheck and on-site surveillance. As part of the FRTW label, this Classified Mark provides assurances that FRTW products are "listed," and have been tested and produced under the UL Classification and Follow-Up Services program. Second, the phrase "30 Minute Test" reiterates that this material has successfully undergone the code-required extended UL 723 (2018) test.

6 CONCLUSIONS

With the ever-increasing pressures to increase the supply of housing nationwide, the use of FRTW is rapidly increasing as are products that do not meet the definition of FRTW in the building code but are being touted as such. The way to distinguish code-compliant FRTW from these other surface-applied treatments is for architects and building and fire officials to know and understand how these products are manufactured, how they are listed and labeled, and be familiar

with the FRTW provisions in the building codes. Only by taking these steps can all involved stakeholders ensure that the pressure to build is used to create larger, taller structures that are code-compliant and safer for the public to occupy.

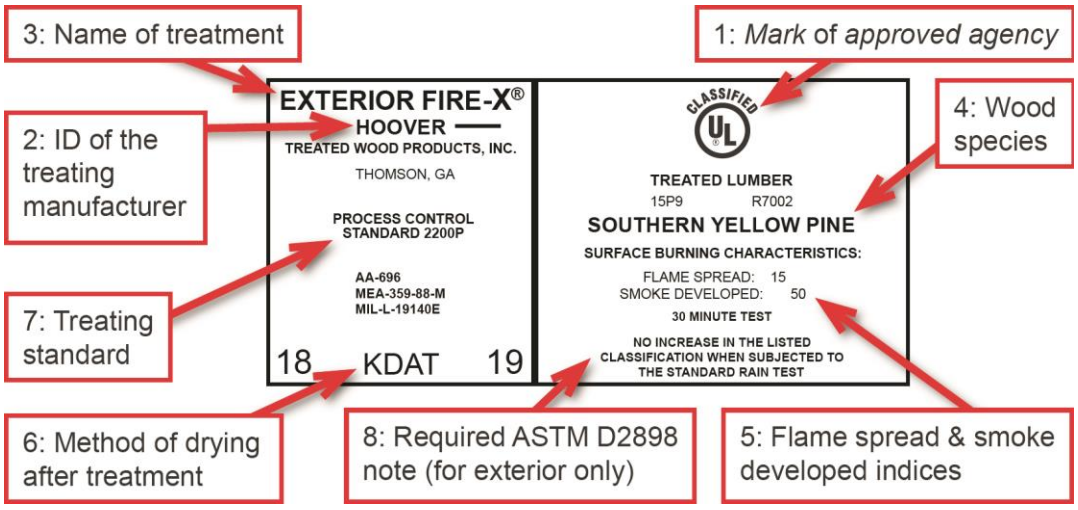

Figure 2. An example of a code-complaint FRTW label for an exterior application.

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