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Fire Ratings for Construction Materials

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Introduction

If you live in the wildland urban interface (WUI) you have probably heard or read about terms which describe materials that are recommended for use on your home to improve its chances of surviving a wildfire. These materials are described using terms like noncombustible, non-flammable, ignition resistant, Class A rated and fire-resistant – terms that describe the relative combustibility of materials. Sometimes these terms refer to a material (e.g., when you replace your siding, select a *fire-resistant* material) and sometimes they refer to a type of construction (e.g., your home should incorporate *ignition- resistant* construction, or you should use *ignition- resistant* building techniques). Do you lump noncombustible, non-flammable, ignition resistant, and fire-resistant into the same "good" category or is one better than another? Should all combustible materials be lumped into a "bad" category, or is there a way to evaluate differences in anticipated performance between two combustible materials? The objective of this article is to describe how building codes and associated standards have defined and used these terms, and to provide ways to evaluate differences between combustible materials.

Definitions

Building codes and test standards have provided definitions for some terms commonly used to describe how a given material or assembly will perform in a fire. Terms that have been defined include:

- Combustible
- Noncombustible
- Fire-resistant or Fire-resistance

- Ignition-resistant

Combustible and noncombustible refer to the performance of a material (e.g., wood, stucco, steel). Fire-resistant can refer to a material or an assembly (e.g., all the component s in a wall – siding, insulation, and sheathing products). An example of a roof assembly is given in Figure 1. Ignition resistant can refer to a material or an assembly (e.g., when discussing ignition resistant construction). Definitions of these terms have been developed by a number of groups and are provided in Appendix A.

Figure 1. This aluminum roof covering has a Class A fire rating “by assembly”. In this case, the roof assembly consists of the aluminum roof covering, overlapping layers of a capsheet roofing material (for the improved fire rating), and structural sheathing, all attached to the lumber framing.

How the Terms are Used

Combustible

Combustible materials are those that readily ignite and burn. Many common construction materials are combustible, including wood and wood-plastic composite and plastic products (commonly used for decking and siding). A number of tests have been developed that evaluate the fire performance of combustible materials. With regard to wildfire, two properties are helpful in characterizing the relative combustibility of different materials – flame spread index and heat release rate.

The flame spread rating of a material is determined by subjecting material placed in a horizontal tunnel to a gas flame (Figure 2). A combustible material will be rated as Class A, Class B, or Class C based on its performance in this test. A material rated as Class A would have a lower flame spread, and therefore a better performance rating, than a Class C material. The results of the flame spread test results in a numeric rating. If the numeric value is less than 25, then a Class A flame spread index is assigned. Numeric values for Class B are between 25 and 75. Values above 75 fall into the Class C category. Most commercial wood species have a flame spread index between 90 and 160 (Forest Products Laboratory, 1999).

Another method used for comparing the combustibility of materials is to evaluate the heat release rate. This can be done by measuring the mass (weight) loss of a burning material or by measuring the total and/or rate of energy released while a material is burning. The heat release rates have been published for common construction materials, and are one of the criteria some materials must meet to comply with Chapter 7A of the California Building Code (CBC). Chapter 7A provides the requirements for new construction in California's designated wildfire prone areas. The heat release rate of a material is determined by collecting the gases of combustion (oxygen, carbon dioxide and carbon monoxide) in an oxygen depletion calorimeter. The heat of combustion per

unit mass of oxygen consumed is nearly constant for a wide range of materials (Quintiere 1998) and therefore the heat release rate of a material (HHR) is directly proportional to the rate at which oxygen is consumed during combustion. To measure the HRR of assemblies and larger-component sections, they are burned under a large hood that is tied into an air collection system (Figure 3). The heat release rate of small samples can be measured in a smaller calorimeter called a Cone Calorimeter. Smaller values of heat release rate reflect lower combustibility than larger values. Chapter 7A of the CBC specifies a maximum net peak heat release of (no more than) 25 kW/ft2 [269 kW/m2] for deck boards. For comparison, the HHR for a large juniper bush can be as high as one 1000 kW. Decking products that comply with the CBC can be found in an on-line document published by the California Office of the State Fire Marshal (OSFM 2010).

Figure 2. A horizontal, or “Steiner”, tunnel used to evaluate the flame spread rating of a material. The material is attached to the upper surface of the tunnel and is rated on the distance the flame travels down

the length of the tunnel, on the exposed surface of the material. The duration of this test is 10 minutes. *Photograph courtesy of Mr. Bill Hendricks, Safer Building Solutions and Southwest Research Institute, San Antonio, Texas.*

The flame spread rating and heat release rate of materials have been used to characterize combustible materials. This information is becoming available for materials commonly used on the outside of buildings, and is being used to compare performance of combustible construction materials. The range of numeric values for Class C flame spread is large. You won't know if the numeric value of the Class C product you may be considering is close to the Class B upper limit of 75, or much higher. Information about the net peak heat release rate for decking products complying with the CBC can be used if the product is sold in California and isn't otherwise classified as noncombustible. Unless you have access to the test report results, however, you will only know that the heat release rate was less than 25 kW/ft2 [269 kW/m2].

Figure 3. The hood and surrounding skirt over a wall assembly. The ducting (not visible) above the hood collects smoke and fire gases during combustion. This photograph also shows a radiant panel in front of the wood panel. *Photograph courtesy of Western Fire Center, Kelso, Washington.*

Noncombustible

A noncombustible material is one that is not capable of undergoing combustion under specified conditions (ASTM E 176). Non-combustibility can be assessed by a standard test method, ASTM E-136, Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750 degree C. The test described in ASTM E-136 uses a furnace similar to that shown in Figure 4. The test begins with four samples of a given material.

To be considered noncombustible, three of the four replicate test specimens must meet one of the following two sets of criteria:

1. When the weight loss of the specimen during the test is 50% or less, then

    a. The recorded temperature of the material is not greater than 30°C (54°F) above a temperature measured in the test apparatus.

    b. There is no flaming from the specimen after the first 30 seconds of the test.

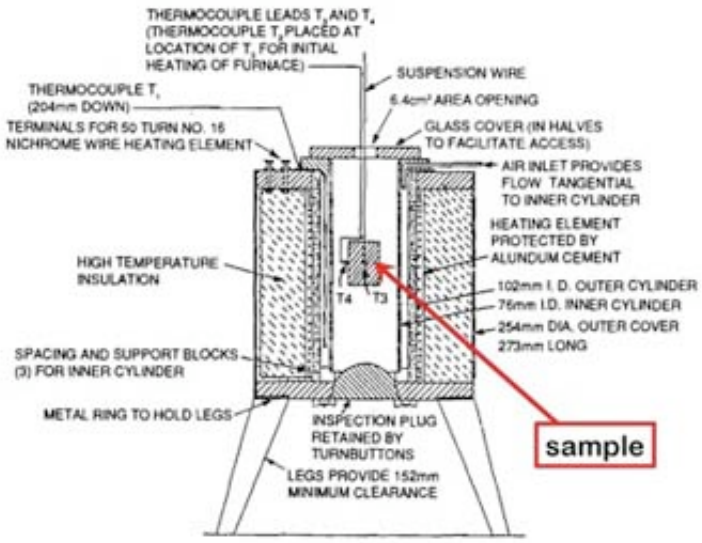

Figure 4. A diagram of a furnace used to evaluate whether or not a material can be considered "noncombustible". *Figure based on Figure 1, ASTM Standard E 136.*

1. When the weight loss of the specimen during the test exceeds 50%, then

    a. The recorded temperature of the material is not greater than the temperature measured at a specific location in the test apparatus.

    b. There is no flaming from the specimen at any time during the test.

Criteria No. 2 is provided for materials that contain large quantities of combined water or other gaseous components, a condition that would not apply to current exterior-use construction materials.

Criteria No. 1 is the most useful for characterizing construction materials. Note that a material complying by this criteria can be deemed noncombustible even though some limited flaming may occur. The conditions given in criteria No. 1 were based on research conducted by Setchkin (1952).

Ignition-resistant

In most parts of North America, “ignition-resistant” is not defined so it can mean different things to different people. The International Code Council’s International Wildland-Urban Interface Code and the California Building Code have defined ignition-resistant materials as those meeting a minimum flame spread rating after being subjected to a specified wetting-drying weathering cycle. The horizontal flame spread tunnel used for the fire test is shown in Figure 2. The duration of “ignition resistant” test is 30 minutes compared to the 10 minute duration used to evaluate flame spread. In California, a material labeled “ignition resistant” has passed the 30 minute test. An example of an ignition-resistant material is lumber that has been pressure impregnated with a fire retardant that has been rated for use on the exterior of a building.

Wood and wood-based products that qualify as an ignition resistant material have been

treated with a fire retardant, probably using a vacuum-pressure cycle. The accelerated weathering cycle is used to remove easily leached fire retardant chemicals from the product prior to the fire test.

Fire Resistant

Fire resistance ratings and tests provide guidance on fire safety issues. They are designed to evaluate the capability of a material or assembly to contain a fire within a compartment or building, or continue to provide a structural function in the event of an (internal) fire (Beitel 1995). For example, fire resistance ratings will help determine if a given building construction will allow enough time for people to exit a burning building before it collapses (Kruppa 1997).

A common fire test to evaluate fire resistance of walls uses a large vertical furnace (Figure 5) to expose a wall to radiant heat from gas burners. The duration of the test ranges from 20 minutes to several hours, depending on the desired rating and the product or assembly being tested. Temperatures inside the furnace reach about 1700°F (~925°C) during the first hour.

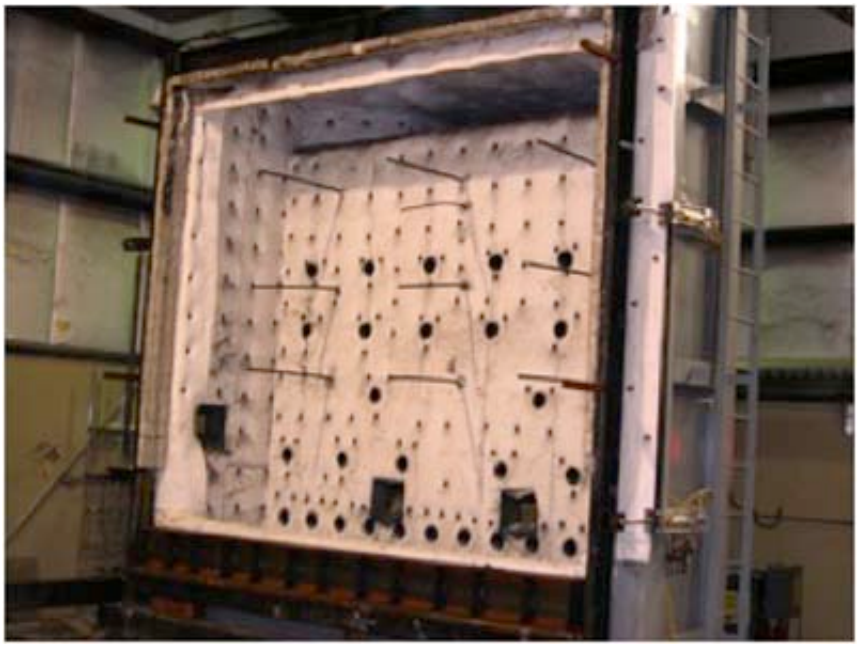

Figure 5. This vertical furnace is used to evaluate the fire resistance of wall assemblies, doors and windows. The assembly to be tested is fastened to the outside perimeter of the furnace. The larger dark circles on the back wall of the furnace are the gas burners. A similar horizontal furnace is used to evaluate the fire resistance of floor assemblies. *Photograph courtesy of Western Fire Center, Kelso, Washington.*

Gypsum wallboard is often used to improve the fire resistance of a wall. As seen in Figure 6, gypsum wallboard has been used on the common wall adjoining these two buildings. Incorporating gypsum wallboard in the wall system is another example of an assembly. Using gypsum wallboard in the construction of exterior wall assemblies is one way some combustible siding products can meet the provisions for use in wildfire prone

areas.

Figure 6. A townhouse project where the common wall between units achieve a “one-hour” fire resistance rating through the use of gypsum wallboard. *Photograph courtesy of Richard Avelar and Associates, Oakland, California.*

The tests used to determine the fire ratings for roofs also provide fire resistance information. In this case, the Class A (highest degree of fire resistance), B, or C rating provides relative information about the ability of the roof covering and assembly to

resist the penetration of fire as a result of a standard fire exposure (ASTM E 108). The diagram of the test apparatus used to evaluate flame penetration is shown in Figure 7. The relative sizes of the standard brands are shown in Figure 8. The Class A and B brands are larger than the common sizes of embers (firebrands) lofted during wildfires, but they provide a consistent, and perhaps conservative, fire source by which to evaluate the roof covering's resistance to the penetration of fire into the area underneath. The standard roof test also evaluates flame spread over the material and the propensity of the covering (e.g., shingle) to generate embers.

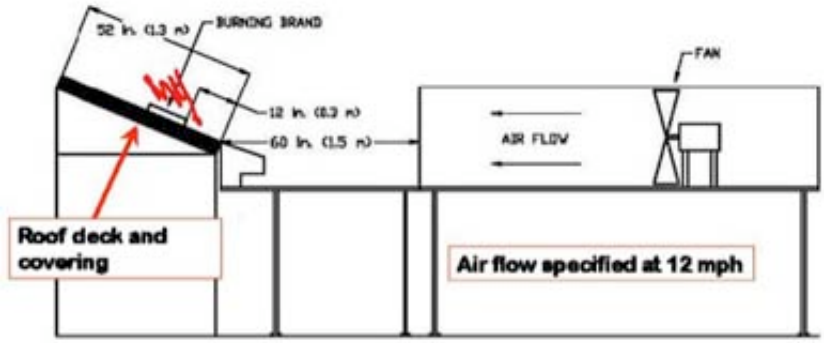

Figure 7. Test apparatus used to determine the fire rating for roof coverings.

Figure 8. From upper right, counter-clockwise: Class A (12 in. x 12 in.), Class B (6 in. x 6 in.) and Class C brands used in standard roof tests.

Summary

Differences in fire performance between different materials can be evaluated by comparing flame spread ratings (Class A is the greatest resistance, followed by B and C) and heat release rate.

Noncombustible materials are either defined as such in the building code, or have met the requirements of a standard test.

Ignition resistant materials have passed a 30-minute flame spread test after being subjected to an accelerated weathering cycle that consists of 12 weeks of alternate wetting and drying exposures. Ignition resistant materials are combustible.

Fire resistance is typically associated with an assembly construction, and therefore considers the performance of a number of materials that would be incorporated in a wall, floor or roof. The exterior material (i.e., the one exposed to the fire) can be combustible, ignition resistant, or noncombustible since the entire assembly contributes to the rating. Although the fire ratings are in terms of a time (e.g., 20-minute, one-hour, two-hour), they only represent a relative performance (i.e., a two-hour wall is better than a one-hour wall, but they may or may not resist a given fire exposure for those time periods). A nominal "one-hour" wall has been used as one way for a wall having combustible siding to be used in wildfire prone area. Whereas fire resistance information can be used to judge the ability to resist flame penetration into the building, it does not necessarily provide information regarding flame spread. This is especially true since this type of construction is only used when combustible siding is used as the outermost material.

Given the use of these terms, you can rank the expected performance of construction materials as follows:

Noncombustible – Best performance for both flame spread and penetration.

Fire resistance – Fire Resistant construction – Rely on assembly rating for resistance to fire penetration, and the exterior material (i.e., the one that would be exposed to the fire) for information regarding flame spread.

Ignition Resistant – Provides information regarding flame spread. Materials with this classification can be expected to perform better than combustible materials but not as well as noncombustible.

Combustible – Materials with this classification will not perform as well as the

others discussed in this article, given a comparable fire exposure.

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Appendix A

International Code Council

The Wildland Urban Interface Code, published by the International Code Council (2009) uses the following definitions:

Fire-Resistance-Rated Construction – The use of materials and systems in the design and construction of a building or structure to safeguard against the spread of fie within a building or structure and the spread of fire to or from buildings or structures to the wildland-urban interface area.

Flame Spread Index – A comparative measure, expressed as a dimensionless number, derived from visual measurements of the spread of flame versus time for a material tested in accordance with ASTM E-84.

Ignition-Resistant Building Material – A type of building material that resists ignition or sustained flaming combustion sufficiently so as to reduce losses from wildland urban interface conflagrations under worst-case weather and fuel conditions with wildfire exposure of burning embers and small flames, as prescribed in Section 503 [Author's Note: Section 503 describes the extended (30-minute) American Society of Testing and Materials (ASTM) Standard E-84 flame spread test that is conducted after subjecting the material to be tested to an accelerated weathering procedure defined in ASTM Standard D-2898. The weathering procedure includes wetting, drying and ultraviolet exposures.]

Ignition-Resistant Construction – The code provides a number of requirements for various components of a building based on the anticipated fire hazard – Class 1 (extreme), 2 (high), or 3 (moderate).

Noncombustible – As applied to building construction material, means a material that, in the form in which it is used, is either one of the following:

1. Materials of which no part will ignite and burn when subjected to fire. Any material conforming to ASTM Standard E 136 shall be considered noncombustible within the meaning of this section.

2. Materials having a structural base of noncombustible material as defined in Item 1 above, with a surfacing material not over ⅛ inch (3.2 mm) thick, which has a flame

spread index of 50 or less. Flame spread index as used herein refers to a flame spread index obtained according to tests conducted as specified in ASTM Standard E 84 or Underwriters Laboratory (UL) Standard 723.

Noncombustible Roof Covering. One of the following:

1. Cement shingles or sheets.
2. Exposed concrete slab roof.
3. Ferrous or copper shingles or sheets.
4. Slate shingles.
5. Clay or concrete roofing tile.
6. Approved roof covering of noncombustible material.

National Fire Protection Association

The National Fire Protection Association (NFPA) Standard 1144, Standard for Reducing Structure Ignition Hazards from Wildland Fire (2008), provides similar definitions for these terms, including:

Fire Resistive – Construction designed to provide reasonable protection against fire.

Ignition Resistant Material – Any product designed for exterior exposure that, when tested in accordance with applicable standards, has a flame spread of not more than 25, shows no evidence of progressive combustion, and whose flame front does not progress more than 10 ½ feet (3.2 m) beyond the centerline of the burner at any time during the test.

Noncombustible – Any material that, in the form in which it is used and under the

condition anticipated, will not ignite and burn nor will add appreciable heat to an ambient fire.

California Building Code

Chapter 7A of the California Building Code provide some definitions for these terms.

From 704A.2 Ignition-resistant Material. Ignition-resistant material shall be determined in accordance with the test procedures set forth in SFM 12-7A-5 “Ignition-resistant material” or in accordance with this section.

Author’s note: California Office of the State Fire Marshal Standard 12-7A-5 refers to ASTM Standard Test Methods E-84 and ASTM D-2898. This section in the building code is the same as the definition used by the International Code Council.

Noncombustible [Section 202 in the California Building Code]– a material which, in the form in which it is used, is either one of the following:

1. Material of which no part will ignite and burn when subjected to fire. Any material passing ASTM E 136 shall be considered noncombustible.
2. Material having a structural base of noncombustible material as defined in #1, with a surfacing material not over 1/8” (3.2 mm) thick which has a flame-spread rating of 50 or less.

704A.3 Alternative methods for determining Ignition-resistant material. Any one of the following shall be accepted as meeting the definition of ignition-resistant material:

1. Noncombustible material. Material that complies with the definition for noncombustible materials in section 202

2. Fire-retardant-treated wood. Fire-retardant-treated wood identified for exterior use that complies with the requirements of section 2303.2.

3. Fire-retardant-treated wood shingles and shakes. Fire-retardant-treated wood shingles and shakes, as defined in section 1505.6 and listed by State Fire Marshal for use as “Class B” roof covering, shall be accepted as an Ignition-resistant wall covering material when installed over solid sheathing.

Author’s note: This section states that rated noncombustible materials, exterior-rated fire retardant treated wood, and exterior- rated fire retardant treated wood shingles and shakes can be used anywhere “ignition resistant materials” are required.

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