NCDOI OSFM Evaluation Services

Scope of DOI White Paper: The Purpose of this document is to provide clarification on North Carolina State Code requirements to Code Officials (CEO) who are agents for the Authority Having Jurisdiction (AHJ).

DOI File #: WP61-11
Edition Date: 09/08/11, Revision 1: 12/05/11

Subject of White Paper: Classification of Building Materials According to Combustibility

Contents

1.0 Introduction

Chapter 6 of the North Carolina Building Code (NCBC) classifies buildings on the basis of the combustibility of the materials from which they are constructed. Classifications by materials are referred to as the "Type of Construction" of the building. Types I and II construction by definition require all structural (load-bearing) frame members to be **non-**

combustible materials, i.e., materials that do not readily burn. Exterior walls in Types III and IV construction are also required to be non-combustible. Other structural members in Types III and IV construction and all structural members in Type V construction may be **combustible materials**; that is, materials that readily burn.

The amount of fuel available to feed a fire is known as the "fire loading." Increasing fire loading increases the heat release and the smoke release of a fire. Higher heat and smoke release pose a greater hazard to building occupants and increase the difficulty of fighting a fire. In an effort to limit fire loading, Table 503 of the NCBC limits the height and area of a building based on construction type and occupancy classification, both of which are an indication of the amount of combustible materials present in the building. Limiting the fire loading in a building increases the amount of time occupants have to exit the building, provides firefighters with more time for rescue, and limits the resources, including manpower, equipment and water, required to extinguish the fire.

As an aid to the CEO, the remainder of this document deals with the classification of materials based on combustibility. Emphasis is on testing required to establish non-combustibility, common materials considered to be non-combustible, and materials which may be substituted for non-combustible materials under certain circumstances.

2.0 Summary of Code References (2012 edition)

- **NCBC Section 602** – Defines building construction types on the basis of materials and fire resistance ratings.
- **NCBC Section 603** – Lists exceptions to non-combustible materials in Type I and Type II Construction.
- **NCBC Section 703.4** – Establishes ASTM E 136 as the test required for non-combustibility and references ASTM E 136 for passing criteria. This section also establishes criteria for classification of composite materials as non-combustible.
- **NCBC Section 803.2** – Allows NFPA 286 test as an alternative to ASTM E 84 to establish combustibility of finish materials, and provides acceptance criteria for the NFPA 286 test.
- **NCBC Section 2303.2** – Defines fire retardant treated wood in terms of an extended ASTM E 84 test and establishes labeling requirements.
- **NCBC Section 2603.9** – Allows passing NFPA 286, UL 1715, or FM 4880 as alternatives to providing a prescriptive thermal barrier for foam plastics.
- **NCFC (Fire Prevention Code) Section 803.4** – Allows use of intumescent coatings to achieve flame spread requirements in existing buildings, and requires maintenance of the coating.

3.0 Classes of Materials Commonly Encountered in Building Construction

A. **Non-combustible material** – A non-combustible material is a substance that will not ignite, burn, support combustion, or release flammable vapors when subject to fire or heat, in the form in which it is used and under conditions anticipated. Any solid substance complying with either of two sets of passing criteria listed in Section 8 of ASTM E 136 when the substance is tested in accordance with the procedure specified in ASTM E 136 is considered to be non-combustible.

1. Passing Criteria #1:
    a. Weight loss of the specimen cannot exceed 50%.
    b. Temperatures on the surface of the specimen and at the geometric center of the specimen during the test may not rise more than 54^{o}F (30^{o}C) above the equilibrium temperature of the furnace measured prior to introducing the specimen.
    c. During the first 30 seconds of the test, there can be no flaming from the specimen.
2. Passing Criteria #2:
    a. If more than 50% of the weight of the specimen is lost, the material may still be classified as non-combustible provided both of the following conditions are met.
    b. Temperatures on the surface of the specimen and at the geometric center of the specimen during the test may not rise above the equilibrium temperature of the furnace measured prior to introducing the specimen.
    c. No flaming from the specimen can occur at any time during the test.
3. Examples of non-combustible materials include:
    a. Portland cement concrete, gypsum concrete (normally used in drywall or poured gypsum floor toppings), or magnesite (magnesium oxide) concrete having aggregates of sand, gravel, expanded vermiculite, expanded or vesicular slags, diatomaceous silica, perlite, or pumice. This class of products includes Portland cement stucco, Portland cement plaster, and gypsum plaster, as well as concrete.
    b. Brick masonry, concrete block masonry, and ceramic tiles.
    c. Metals except aluminum (aluminum is classified as limited-combustible), magnesium and magnesium alloys.
    d. Sheet glass, block glass, and uncoated glass fibers.
    e. Mineral wool and rock wool.
4. Composite materials may be considered non-combustible if the material has a structural base of non-combustible material, the combustible surfacing is not

more than 0.125" thick, and the surfacing has a flame spread less than 50 when tested in accordance with ASTM E 84.

B. **Combustible material** – Any solid substance that does not comply with either Passing Criteria #1 or Passing Criteria #2 when tested in accordance with ASTM E 136 is considered to be combustible. Combustible materials will ignite, burn, support combustion, or release flammable vapors. Wood is by far the most common combustible material used for structural purposes in building construction.

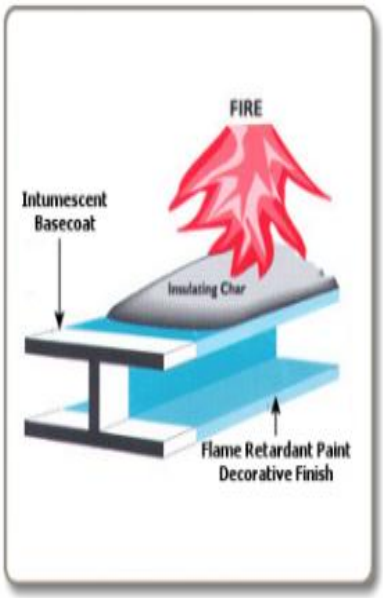
C. **Fire Retardant Treated Wood** – "Fire retardant treated wood is any wood product which, when impregnated with chemicals by a pressure process or other means during manufacture, shall have, when tested in accordance with ASTM E 84, a listed flame spread index of 25 or less and show no evidence of significant progressive combustion when the test is continued for an additional 20-minute period. In addition, the flame front shall not progress more than 10.5 feet beyond the centerline of the burners at any time during the test." (NCBC Section 2303.2)

1. **Fire retardant treated wood is a combustible material**; even though, when first introduced, the product was marketed as "Non-comb" wood. There are, however, certain circumstances under which fire retardant treated wood may be substituted for non-combustible materials. For instance, fire retardant treated wood is allowed in exterior walls of Type III buildings when the exterior wall is 2 hour rated (Section 602.3). Section 603 of the NCBC lists the following locations where fire retardant treated wood may be substituted for non-combustible materials in Type I and II Construction.

   a. Non-load-bearing partitions with a fire resistance rating of 2 hours or less.
   b. Non-load-bearing exterior walls requiring no fire rating.
   c. Roof construction in Type I Construction two stories or less and Type II Construction of any height, including girders, trusses, framing, and decking.
   d. Roof construction in Type I Construction exceeding two stories in height when the vertical distance from the upper floor to the roof is 20 feet or more.

2. Usually, fire retardant treated wood appears darker than untreated wood. Sometimes the color difference is subtle, and identification by color alone in not always possible. As a result, labeling of fire retardant treated wood is required. Labels shall identify the approving agency and the treating manufacturer. Species of the wood, trade name of the treatment, flame spread, and smoke developed must also appear on the label.
3. Exposure to weather or moisture can cause leaching of the salts deposited by the treating chemicals. Leaching salts can increase the flame spread of the material and facilitate corrosion of metals in contact with the fire retardant treated wood. Consequently, fire retardant treated wood for exterior use must be subjected to a Standard Rain Test (ASTM D 2898). Upon passing the test, the material may be labeled for exterior exposure, and only materials labeled for exterior exposure should be used in exterior or moist environments, including locations where condensation is likely to form.

D. **Intumescent Coatings** – Liquid applied in either the shop or the field, intumescent coatings encapsulate the material to which they are applied. When exposed to heat, intumescent coatings char and swell, increasing in volume and decreasing in density, thereby creating an insulating effect.
   1. There are two types of intumescents.
      a. Soft char intumescents produce a light char when heated that acts as an insulator due to poor heat conduction characteristics. In addition, hydrates in these products liberate water vapor in the presence of heat, producing a cooling effect. Expansion pressures associated with these products are low, and soft char intumescents are, consequently, best suited for coatings.
      b. Hard char intumescents typically contain sodium silicates or graphite, which create a heavy char with substantial expansion pressure associated with volume increase. Often, these materials are used for firestopping materials and sometimes for coatings.



   2. The wide variety of intumescent coatings on the market may be used in several different applications. Whatever the application, the product must be subjected to the appropriate

testing for the intended use. Uses of intumescent coatings and appropriate testing include the following:

a. When applied to specific structural elements and the coated element is tested in accordance with ASTM E 119, some intumescent coatings are capable of maintaining a fire resistance rating on certain materials, primary of which is structural steel. These coatings are typically referred to in marketing literature as "fire resistive" coatings.
b. Coatings used to achieve a flame spread are generally referred to as "fire retardant" coatings. Products in this class may be tested to ASTM E 84. More commonly, alternative tests allowed by the NCBC, including UL 1715, NFPA 286, and FM 4880 are preferred by the manufacturers. Passing one of these three tests allows the coating to be used as an alternative to a prescriptive thermal barrier or ignition barrier when applied to foam plastic insulations, as well as for increasing the flame spread of an interior finish material.

c. When used as an alternative to fire retardant treated wood, fire retardant coatings, applied to the same material intended for field use, must pass the same extended ASTM E 84 test as fire retardant treated wood. (See item 3C above.) Protection of metal fasteners must also be addressed.

3. Intumescent coatings are vulnerable to environmentally induced deterioration, and must be maintained. Abraded areas must be touch coated as soon as possible after damage is incurred, and coatings must be re-applied periodically in accordance with the manufacturer's recommendations. Therefore, use of these coatings in areas that are not accessible after completion of the project is not recommended.

4.0 Descriptions of Tests

A. ASTM E 136 – Standard Test for Behavior of Materials in a Vertical Tube Furnace at 750°C

1. ASTM E 136 is the test specified by the code as required to establish a material as a non-combustible material. This test does not apply to laminated or coated materials. Aluminum will not pass an E 136 test; therefore, aluminum cannot be classified as non-combustible.
2. A tube furnace is pre-heated to a temperature of 750°C. A pre-weighed material specimen is, then, lowered into the furnace with a thermocouple attached to the surface and a thermocouple located at the geometric center of the specimen. Testing continues until both thermocouples have stabilized at a maximum reading or until one of the acceptance criteria is violated. (See item 3.0A for acceptance criteria.)

B. **ASTM E 84 – Standard Method for Surface Burning Characteristics of Building Materials**
   1. ASTM E 84 is specified by the code as the test to assess the contribution of surface finishes on walls and ceilings to fire loading. ASTM E84 does not measure heat transmission to determine fire resistance ratings or if the material should be classified as non-combustible.
   2. The test is a comparative test intended to measure the propagation of flame from an ignition source along a specified length of the material and compare the distance of propagation to a reference material, red oak. ASTM E84 is an industry standard for defining how a product performs when tested for surface flame spread. The result of the test is based on a scale that compares the surface burning to select grade red oak, which is rated 100. A product that has a flame spread of 25 has a surface burning spread 25% of red oak. A test report for a product may also include the smoke developed index, which is required to be less than 450.
   3. A full length, full width specimen is attached to the ceiling of a nominally 24 foot long by 18 inch wide duct with a gas burner at one end. Airflow, calibrated to spread the flame the full length of a red oak specimen in 5 ½ minutes, is introduced, and the burner ignited. Distance the flame spreads in 10 minutes is measured, and flame spread is calculated from formulas included in the test standard.

   4. For fire retardant treated wood the test is extended an additional 20 minutes, subject to the acceptance criteria specified in Section 2303.2 of the NCBC.

C. **ASTM E 119 – Standard Test Methods for Fire Tests of Building Construction and Materials**

1. Fire resistance ratings required by the NCBC for wall assemblies, floor/ceiling assemblies, roof/ceiling assemblies and individual structural members are established by or based on testing in accordance with ASTM E 119. The term "assembly" refers to a collection of components, structural and non-structural, arranged in a specific way. Fastening of components in an assembly is limited to the tested fastening method and arrangement. Ratings on assemblies may be required by the code to prevent structural collapse, to compartmentalize a building, to protect an element of an egress system, or some combination of the three. Individual structural members, beams and columns, are typically required to be rated in certain types of construction to prevent structural collapse.
2. An assembly or structural member is placed in a flat furnace in either the horizontal or vertical position, depending on in service use. If the specimen is a load-bearing element, a specific load is imposed on the specimen. The specimen is, then, subjected to a controlled flame introduced from one side of the assembly, simulating exposure conditions during in-service use and producing temperatures increasing to a maximum along a specific time-temperature relationship. Columns are exposed to the heat source on all sides to simulate actual in-service use. Testing continues until one of the following three failure modes is observed:

   a. Structural collapse occurs.
   b. The temperature measured on the unexposed surface of the assembly exceeds 250^{o}F. This criterion is a measure of heat transmission through the assembly.
   c. Cotton waste placed on the unexposed side of the assembly ignites. This criterion is a measure of the passage of flame and hot gases through the assembly.

3. Classification of the assembly is reported in hours based on the duration of the test.

D. **NFPA 286 – Fire Tests for Evaluating Contribution of Wall and Ceiling Interior Finish to Room Fire Growth (a.k.a. the Room Corner Test)**

1. As stated in the title of the standard, NFPA 286 is intended to evaluate the contribution of interior surface finishes to a fire. To this purpose, the NCBC allows NFPA 286 as an alternative to ASTM E 84. Chapter 26 of the NCBC also allows passage of the room corner test as an alternative to providing a thermal barrier between foam plastics and occupied interior spaces. A modified version of NFPA 286 has been developed by the foam plastic insulation industry as an alternative to ignition barriers in non-storage attics and crawl spaces. ICC has adopted this modified test as part of their evaluation criteria AC 377 for foam plastic insulation. UL 1715 is a test protocol similar to NFPA 286 used for the same purposes.
2. A room is constructed in an indoor laboratory from wood framing, light gage metal framing, or concrete block. The room door opening remains an opening without a door. Interior walls and ceiling of the room are covered with the test material. A gas burner of specific height is placed in one corner of the room, and thermocouples are located at specific locations within the room. Duration of the test is 15 minutes. For the first five minutes the burner is operated at an output of 40 kW. After five minutes the burner output is increased to 160 kW and remains at 160kW for the final ten minutes of the test.

3. NFPA 286 has a specific definition of flashover, but specifies no acceptance criteria. Acceptance criteria are specified in Section 803.2.1 of the NCBC, one of which is the room must not flashover during the 160 kW exposures.

5.0 Technical References

A. Wikipedia - http://en.wikipedia.org/wiki/Intumescent

B. Answers.com - http://www.answers.com/topic/noncombustible-material-1

6.0 Photographic Credits

A. www.alpinepainting.com

B. www.alertinsulation.com

C. www.pathnet.org

D. www.independent.com

E. www.buildinggreen.com

F. www.westernfire.com

G. www.harvel.com

H. www.contegointernational.com