



Basis of IRC Membrane Protection Provisions

The provisions of Section R302.13 of the 2015 International Residential Code (IRC), moved but unchanged from the same wording in Section R501.3 of the 2012 IRC (shown below), were developed with the intent to ensure a minimum level of fire performance for floors in one- and two-family dwellings that were not otherwise required to be fire-resistance rated. Working together over the last several years, representatives of the fire service, building industry, and the wood products industry have developed testing, evaluation and design methods for establishing equivalence and compliance with these IRC provisions. A number of communications from sources that were not directly involved in development of these design methods are now circulating that mischaracterize the history and background of the IRC provisions, misstate the intent of the IRC requirements, and appear to be misinformed about the methods used to establish equivalence and compliance with the provisions. The purpose of this white paper is to provide the factual background and understanding of the IRC provisions and the method used for establishing equivalence and compliance.

From the 2012 International Residential Code (IRC)

R501.3 Fire protection of floors. Floor assemblies that are not required elsewhere in this code to be fire-resistance rated, shall be provided with a 1/2-inch (12.7 mm) gypsum wallboard membrane, 5/8-inch (16 mm) wood structural panel membrane, or equivalent on the underside of the floor framing member. Penetrations or openings for ducts, vents, electrical outlets, lighting, devices, luminaires, wires, speakers, drainage, piping and similar openings or penetrations shall be permitted.

Exceptions:

1. Floor assemblies located directly over a space protected by an automatic sprinkler system in accordance with Section P2904, NFPA 13D, or other approved equivalent sprinkler system.
2. Floor assemblies located directly over a crawl space not intended for storage or fuel-fired appliances.
3. Portions of floor assemblies shall be permitted to be unprotected where complying with the following:
 - 3.1. The aggregate area of the unprotected portions does not exceed 80 square feet (7.4 m²) per story
 - 3.2. Fireblocking in accordance with Section R302.11.1 is installed along the perimeter of the unprotected portion to separate the unprotected portion from the remainder of the floor assembly.
4. Wood floor assemblies using dimension lumber or structural composite lumber equal to or greater than 2-inch by 10-inch (50.8 mm by 254 mm) nominal dimension, or other approved floor assemblies demonstrating equivalent fire performance.

Membrane Protection

Building codes recognize the fire resistance of ½-inch regular gypsum wallboard to be 15 minutes when used as a protective membrane over wood, steel, and concrete products exposed to a standard E119 fire test. While the actual fire resistance of ½-inch regular gypsum wallboard is not specified in the product standard (ASTM C1396), the fire resistance of light-frame assemblies protected by ½-inch regular gypsum wallboard in residential construction has been deemed acceptable for decades. Similarly, the building codes recognize the fire resistance of 19/32-inch wood structural panel sheathing to be 15 minutes when used as a protective membrane. For this reason, protection of framing members with ½-inch regular gypsum wallboard or 5/8-inch wood structural panel sheathing was adopted in the Fire Protection of Floor provision (2015 IRC R302.13 or 2012 IRC R501.3) as an acceptable installation.

Development of the 2x10 Floor Joist Exception

Many within the fire service recognize that unprotected solid-sawn floor joist assemblies have been used in homes with unfinished basements for decades with few problems. Acknowledging this precedent and the fire services' consideration of unprotected 2x10 floor joists as the minimum acceptable construction for fire safety in residential applications, an exception to the Fire Protection of Floor provision was created. This appears as Exception 4 to 2015 IRC R302.13 or 2012 IRC R501.3.

Development of the 2x10 Floor Joist Equivalency

As new products and assembly configurations were developed, such as enhanced wood I-joist products and assemblies, the ICC Evaluation Service (ICC-ES) needed to develop criteria for estimating equivalent performance to unprotected 2x10 floor joist assemblies. ICC-ES utilizes an open hearing process to permit interested parties to present their recommendations. In order to provide a common reference point, the standard fire exposure from ASTM E119 was selected to be used with all assemblies to demonstrate equivalence. While this exposure was not intended to model all post-flashover residential fires, it did provide for the use of a standard test method that has historically been shown to provide repeatable results for comparison of various products and assemblies. Likewise, the loading ratio chosen for the equivalency criteria was set at the expected design load rather than the full (maximum) design load of the assembly. While full design load could have been selected, it was significantly higher than the expected load ratio and would have provided an extreme comparison that was unsuitable for the purpose of establishing equivalency to the expected fire performance of unprotected 2x10 floor joist assemblies.

Standard Test Times vs. Actual Fire Resistance

The fire performance of building materials is measured through use of standard fire tests, which are referenced in the codes. Standardized testing allows for the fire performance of any material or assembly to be compared on a relative basis and to demonstrate compliance with requirements in the governing code. However, the actual performance of materials in real fires is a function of many variables including the ignition source, fuel load, and ventilation rate. Some fires smolder for hours while others reach flashover quickly. Standard fire tests, such as ASTM E119 and UL 263, are intended to provide a very intense time-temperature exposure representing a post-flashover fire. These time-temperature relationships do not represent the time-temperature exposure of actual fire scenarios, but rather only provide a standardized exposure that allows comparison of the relative fire resistances of various products and assemblies under controlled and uniform fire exposure conditions.

Use of standard fire resistance tests as an indicator of the "time to failure" in an actual fire is both misleading and ill-advised. Although actual fire resistance times are likely to be much longer in a real fire

due to the lead time to reach flashover (which is already presumed to have occurred in a standard fire test), the actual ignition time, fuel load, ventilation, and time to reach flashover are unknown when emergency personnel reach the scene. Accordingly, any relation between actual burning time and results from a standardized test are tenuous at best, and reliance upon them for the purpose of estimating safe entry times into buildings for fire service personnel is inappropriate.

Full Design Loads vs. Actual Loads

It has long been recognized that the fire resistance of most structural products and assemblies is directly affected by the load ratio (i.e., the load applied to the assembly during the fire, expressed as a ratio or percentage of the assembly's allowable design load). Standard fire resistance tests are typically run at full design load so the results can be interpolated to other load ratios. The actual load ratio can range from very low to full design levels. Both ASTM E119 and UL 263 require products or assemblies to be run at full design load unless the reduced load is reported. When fire resistance ratings (FRR) are developed, these rules are very important to allow accurate comparison. However, surveys of actual day-to-day load ratios have indicated that, on average, commercial floor assemblies are typically loaded to less than 50% of full design load and residential floor assemblies are loaded to even lower levels. In fact, floor loading during a fire would be expected to be even lower given that the large occupant live load, assumed for structural design of residential floors, would not be present. As a precedent, ASCE Standard 7-10, *Minimum Design Loads for Buildings and Other Structures* contains a similar provision to reduce maximum loads to expected loads when designing for extraordinary events.

The current procedures described in ICC ES AC 14 utilize a load ratio of 50% of the allowable bending moment. This was selected for several reasons. As explained earlier, it was determined to be a relatively conservative assumption of the actual load ratio for residential floor loads during a fire. Methods incorporated into AWC's Technical Report 10 (TR10) and adopted into Chapter 16 of the *National Design Specification (NDS) for Wood Construction* allow for relatively quick estimation of standard E119 fire resistance times for unprotected wood joists at any load ratio (see Figure 1). NDS calculations, permitted by Section 722.1 of the 2015 International Building Code (IBC) for determining fire resistance times for wood assemblies, estimates the time to failure of a 2x10 member loaded to 50% of design capacity to be approximately 15.5 minutes, irrespective of wood species and lumber grades. Coincidentally, this resistance time is consistent with the code-recognized fire resistance of 1/2-inch regular gypsum wallboard when exposed to a standard E119 fire test (15 minutes), as mentioned above. It was also recognized that testing at this load ratio would extend the time that framing members are exposed to the harsh temperatures required in the ASTM E119 time/temperature curve (see Figure 2) and increase the exposure temperatures experienced by the framing members. This was deemed a reasonable and more effective approach when comparing alternative solutions. As can be seen in Figure 1, reducing the load ratio to 50% increases the exposure time. As can be seen in Figure 2, increasing the exposure time also increases the exposure temperature of the assembly.

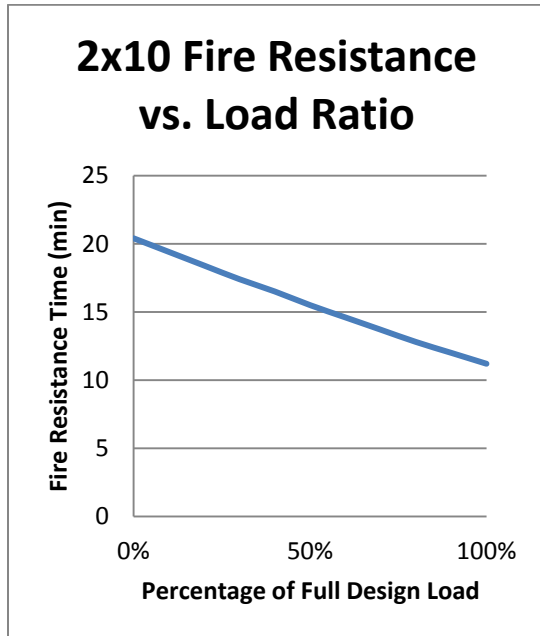


Figure 1. 2x10 Fire Resistance vs. Load Ratio

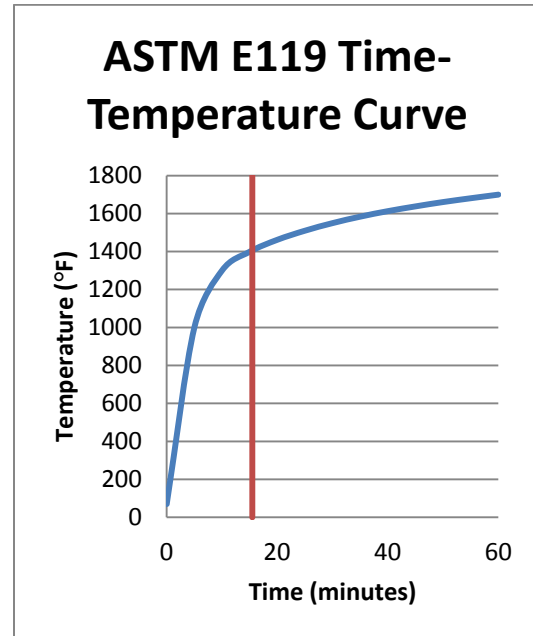


Figure 2. ASTM E119 Time-Temperature Curve

Code Acceptance

At the time of this publication, eight states have enacted the membrane protection requirement found in the 2012 or 2015 IRC for residential floors. Further, some states have chosen to provide modifications to the code provisions, while retaining the intent of the change. The wood I-joint industry has begun to develop innovative solutions that provide the required equivalency using the AC14 test protocol developed by ICC-ES.

Conclusion

Section R302.13 of the 2015 IRC and Section R501.3 of the 2012 IRC include the requirement that floor assemblies be protected with 1/2-inch gypsum wallboard membrane or 5/8-inch wood structural panel membrane. These sections provide an exception for wood floor assemblies using dimension lumber or structural composite lumber with a solid cross-section equal to or greater than 2-inch by 10-inch nominal dimension, or other approved floor assemblies. Through their public hearing process, ICC-ES developed criteria for estimating equivalent performance to unprotected 2x10 floor joist assemblies that utilizes standard E119 fire tests and expected load ratios. This ICC-ES protocol was chosen as a means of evaluating the “equivalent” fire performance of products and assemblies on a comparative basis. Although actual fire resistance is likely to be much longer in a real fire due to the lead time to reach flashover, the actual ignition time, fuel load, ventilation, and time to reach flashover vary and are unknown when emergency personnel reach the scene. Reliance upon test results from these relative tests for the purpose of estimating available safe response time for fire service personnel is inappropriate.