Requirements for Fire Protection of Light Weight Floor Systems

**Act 1 Revisited**

Presented by: Bryan Heitzmann

Course Description

- This webinar will provide an overview of criteria that can be used to demonstrate the equivalence of alternatives to the 3/4-inch gypsum or 5/8-inch wood structural panel membrane that is required by Act 1 of 2011. This act eliminated sprinkler requirements, but required a protective floor membrane, the installation of which comes with its own set of challenges. This requirement has driven many builders to seek alternatives, which in turn has caused many code officials to struggle with approval. This webinar, which is an update and re-visit of a previous PHRC webinar, will clarify acceptable paths for demonstrating equivalence, will explore acceptable testing procedures that determine equivalence, and will provide an overview of applicable portions of Act 1 of 2011 and ASTM E 119 – Standard Test Methods for Fire Tests of Building Construction and Materials. The webinar will also explore changes/updates to demonstrating compliance using AC14 - Acceptance Criteria for Prefabricated Wood I-Joists.
Learning Objectives

Following completion of this webinar, participants will be able to:

- Understand what testing procedures are used and accepted when determining equivalency related to the International Building Code’s defined burn times of ½ inch drywall
- Explain the portions of Pennsylvania’s Act 1 of 2011 that relate to the elimination of the 2009 IRC’s required fire sprinkler systems, as well as, the requirement of protection of residential floor systems against fire
- Evaluate the literature of AC 14 (Acceptance Criteria for Prefabricated Wood I-Joists) to determine required burn times associated nominal 2 x 10 joists and how that relates to determining equivalency to prefabricated wood I-joists
- Compare ASTM tests that are commonly used for fire related testing and what variable each test is attempting to determine

Agenda

- Background Information
  - Act 1 of 2011
  - Fire protection requirements
- Equivalent Methods
  - How equivalency is determined
  - Using Act 1, the IBC, and AC14
- Testing Procedures
  - Appropriate tests and testing requirements used to determine equivalency
  - Potentially equivalent product types
- Conclusions

Background
Act 1 of 2011

- Effective April 25, 2011
- Removed the sprinkler mandate for one and two family dwellings
  - Townhouses still must have sprinklers
- Requires some floor assemblies to have fire protection
- Only required in new home construction
- Demonstrates political compromise

**Intent: Avoid structural failures causing risks to firefighters**

Act 1 of 2011

- Language of Act 1 describing floor protection is almost identical to R501.3 of the 2012 IRC

Note: Pennsylvania did not adopt 2012 IRC

Act 1 of 2011 – Floor Assemblies

- For floor assemblies not required to be fire-resistance rated*

  - The underside of the floor framing members shall be provided with:
    - 1/2-inch gypsum wallboard membrane
    - 5/8-inch wood structural panel membrane
    - Or “equivalent”

  - On underside of floor framing

* Fire-rated floors are required for stacked units which would far exceed the requirements of Act 1 of 2011
Act 1 of 2011 – Floor Assemblies

Fire protection of floors is not required for:

1. Floor assemblies located directly over a space protected by a NFPA13D/P2904, or other equivalent sprinkler system

2. Floor systems located directly over a crawl space
   • Must not be intended for storage
   • No fuel-fired appliances

3. Portions of the floor that:
   • Do not exceed 80 SF per story
   • Fire blocking in accordance with R302.11.1 installed along perimeter of unprotected portion

4. Floor systems:
   • Using dimensional lumber of ≥ 2 x 10
   • Floor systems of structural composite lumber ≥ 2 x 10 (e.g., LVL)
   • Or other floor assemblies approved by a municipal code official demonstrating equivalent fire performance

Equivalence

• The term “equivalent” is used two times in this portion of Act 1 of 2011

1. 1/2 inch gyp, 5/8 inch WSP, or equivalent

2. Floor assemblies using dimensional lumber or structural composite lumber ≥ 2x10, or other assemblies demonstrating equivalent performance

• Shows two possible paths for demonstrating “equivalence” for fire protected floors

Methods of Demonstrating Equivalence

1/2 Inch Drywall or 5/8 inch WSP
Equivalence - 1/2 Inch Drywall or 5/8 Inch WSP

How is equivalency determined per 1/2 inch gypsum wallboard or 5/8 WSP?

- L & I Advisory issued on 8/1/2011
  - IBC Section 721.6.2 provides a calculation methodology for establishing a fire-resistance rating of wood assemblies (in lieu of testing per ASTM E 119)
  - Table 721.6.2(1) lists burn times for gypsum board and wood structural panels
  - If a product can provide equivalent burn times to Table 721.6.2(1) for 1/2" gyp or 5/8" WSP, it would follow that it is equivalent.
    - Should be listed for intended use

Burn Times - IBC

Achieve ≥ 15-minute rating

- Table 721.6.2(1) times are based on:
  - Framing 16 inches o.c.
  - Edges supported
  - Long dimension perpendicular to framing
  - Joints finished

- Act 1 does not specify any of the above, so its provisions probably provide less than 15 minutes
  - Thus, a product providing 15 minutes is probably providing more protection

Equivalence - IBC

Question:

- How did 1/2" gyp. and 5/8" WSP achieve a 15 minute rating?
  - What does this mean?
  - How is this determined?
  - According to what test procedure?

Answer:

- Must look deeper into IBC section 721.6
721.6 Wood Assemblies. The provisions of this section contain procedures by which the fire-resistance ratings of wood assemblies are established by calculations.  

721.6.1 General. This section contains procedures for calculating the fire-resistance ratings of walls, floor/ceiling and roof/ceiling assemblies based in part on the standard method of testing referenced in Section 703.2.

**Testing - IBC**

**IBC Section 703.2**

- The fire-resistance rating of building elements, components, or assemblies shall be determined in accordance with test procedures set fourth in ASTM E119 or UL 263 or section 703.3 (Alt. methods for fire resistance) 
  - 703.3 states that the application of alt. methods must be based on acceptance criteria specified in ASTM E119 or UL 263

- Materials incorporated into the element or assembly must provide sufficient data to show that the fire-resistance rating is not reduced

- Materials used to protect joints/penetrations shall not reduce the required fire-resistant rating

**ASTM E119 – Test Objectives**

**ASTM**

- American Society for Testing and Materials
  - 12,000 ASTM standards are used around the world to improve product quality, enhance safety, facilitate market access and trade, and build consumer confidence.

**E119**


*Note: Underwriters Laboratories (UL) 263 is the same test
ASTM E119 – Test Objectives

Scope and Significance

• Intended to evaluate in terms of resistance and time, the ability of a test specimen to contain a fire, retain structural integrity, or both
  – Measures heat transfer through the test specimen
  – Assess the ability of the test specimen to withstand the transmission of flames and gasses hot enough to ignite combustible material
  – Assess the ability of the test specimen to carry load and withstand restraining forces during the fire-resistance test period

ASTM E119 – Test Procedure

• Test specimen is placed in a furnace and subject to certain temperatures over a certain time period
  – E119 does not provide specific construction details for the furnace unit, only a time and temperature relationship
  – Vertical and horizontal units exist
  – Most at least 16 ft long

ASTM E119 – Test Procedure

Control – Time/Temperature Curve

The furnace temperatures shall be controlled to follow a standard time/temperature curve. The points on the curve that determine the test characteristics are listed below:

<table>
<thead>
<tr>
<th>Temperature (°F)</th>
<th>Time (h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>100°F (38°C)</td>
<td>0</td>
</tr>
<tr>
<td>1050°F (566°C)</td>
<td>5</td>
</tr>
<tr>
<td>1100°F (599°C)</td>
<td>10</td>
</tr>
<tr>
<td>1150°F (621°C)</td>
<td>20</td>
</tr>
<tr>
<td>1200°F (654°C)</td>
<td>30</td>
</tr>
<tr>
<td>1250°F (677°C)</td>
<td>40</td>
</tr>
<tr>
<td>1300°F (704°C)</td>
<td>50</td>
</tr>
<tr>
<td>1350°F (738°C)</td>
<td>60</td>
</tr>
<tr>
<td>1400°F (754°C)</td>
<td>70</td>
</tr>
<tr>
<td>1450°F (780°C)</td>
<td>80</td>
</tr>
<tr>
<td>1500°F (815°C)</td>
<td>90</td>
</tr>
<tr>
<td>1550°F (851°C)</td>
<td>100</td>
</tr>
</tbody>
</table>

![E119 Time-Temperature Curve](image.png)
ASTM E119 – Test Procedures

• The assembly or member is placed in a furnace in the vertical (wall) or horizontal (floor) position

• If the specimen is intended to be load bearing, a specific load is then added

• The specimen is then subject to a controlled flame on one side, producing temperatures based on the time/temperature curve

ASTM E119 – Test Results

• Testing continues until one of the following failure modes is observed:
  1. Structural Collapse
  2. The temperature on the unexposed side of the assembly/membrane exceeds 250°F
  3. Cotton waste placed on the unexposed side of the assembly/membrane ignites

• Classification is reported by time, based on the duration of the test

Other Tests

ASTM E84

• Standard Test Method for Surface Burning Characteristics of Building Materials
  – Provides comparative surface flame spread and smoke measurements
  – Measures the rate of flame spread from a small ignition source along a specified length of the material
  – Measures amount of smoke produced
  – Compares results to a reference material – red oak
  – Does not measure heat transmission through an assembly or structural characteristics

• ASTM E84 is not an alternative to ASTM E119
Other Tests

**NFPA 286**
- Standard Methods of Fire Tests for Evaluating Contribution of Wall and Ceiling Interior Finish to Room Fire Growth
  - Room Corner Test
  - It determines the extent to which the interior finish materials may contribute to fire growth in a room and the potential for fire spread beyond the room under the particular conditions
  - Test indicates the maximum extent of fire growth in a room, the rate of heat release, and the time to flashover

*NFPA 286 is not an alternative to ASTM E119*

Resistive vs. Retardant

- Products tested according to ASTM E119/UL 263 are generally referred to as “fire resistive”
  - Ability to withstand combustion and delay the passage of flame

- Products tested according to ASTM E84, NFPA 286, or UL 1715 are referred to as “fire retardant”
  - Ability to delay the start of fire ignition or slow the spread of flame

Fire Resistive > Fire Retardant
Equivalence - 1/2 Inch Drywall or 5/8 Inch WSP

Conclusions

- According to Act 1 of 2011, underside of the floor framing members shall be provided with 1/2-inch gyp wallboard membrane, 5/8-inch WSP membrane, or equivalent
- L & I Advisory refers to Section 721.6.2 of IBC
- Burn times listed in IBC Table 721.6.2(1) are calculated per Section 703.2 of IBC
- IBC Section 703.2 states that fire-resistance ratings shall be determined using ASTM E119 or UL 263
- Therefore, burn times per ASTM E119/UL 263 equivalent to 1/2" gyp (15 mins) from table 721.6.2(1) demonstrates equivalency per Act 1 of 2011
- Municipal Code Official has final determination of equivalency

Methods of Demonstrating Equivalency

≥ 2x10 Dimensional or Structural Composite Lumber
Equivalence - ≥ 2x10 Dimensional or Structural Composite Lumber

• How is equivalency determined per ≥ 2x10 dimensional or structural composite lumber?
  – No guidance from Act 1 or L & I

• One approach:
  – ICC Acceptance Criteria for Prefabricated Wood I-Joists (AC14)

  • Section 4.4 provides a means for establishing equivalency to the
    wood floor assembly described in Ex. 4 to 2012 IRC Section R501.3
    – By extension, Act 1 of 2011

Acceptance Criteria 14

• Acceptance Criteria 14 (AC14)

• Updated by ICC Evaluation Service in July 2014

  • Section A4.3 – Fire Resistance Rated Construction
    • Sections A4.4.4 through A4.4.6

  • Section A4.4 – Fire Protection of Floors
    • Section A4.4.1 – Test Method through Section A4.4.3 – Member Design

Acceptance Criteria 14

A4.4 Fire Protection of Floors: Where recognition is sought for establishment of equivalent fire performance to the materials described in Exception 4 to Section R501.3 of the 2012 IRC, a test plan shall be submitted to ICC-ES staff for review prior to testing. At a minimum, the test plan shall meet the requirements and conditions of Sections A4.4.1 through A4.4.3.

Sections
• A4.4.1 – Test Method
• A4.4.2 – Test Specimen Design
• A4.4.3 – Member Design
Acceptance Criteria 14

A4.4.1 – Test Method

• A4.4.1.1
  – The test specimen shall be subject to an ASTM E119 exposure test
  – Temperatures exceeding those described in ASTM E119 procedure are allowed

• A4.1.1.2
  – Each framing member shall support a load corresponding to 50% of its full Allowable Stress Design (ASD) bending design load

• A4.4.1.3
  – Deflection must be measured and reported at center span of the center framing member

• A4.4.1.4
  – The test duration shall be defined as the time from start of test until structural member can no longer support the applied load

Updated language to most current version of AC14
Acceptance Criteria 14

A4.4.1 – Test Method

• A4.4.1.5 – Condition of Acceptance
  – The test shall equal or exceed the required minimum duration calculated using Chapter 16 of National Design Specification (NDS) for Wood Construction assuming:
    ▪ Unprotected 2x10 floor joists
    ▪ 3-sided fire exposure
    ▪ Nominal char rate of 1.5 inches/hr
    ▪ Bending strength to ASD ratio of 2.85
    ▪ Load corresponding to 50% of full ASD bending design load

Acceptance Criteria 14

A4.4.2 – Test Specimen Design

• Describe design criteria for test specimen

Acceptance Criteria 14

• A4.4.3 – Member Design
  – All components used in the manufacture of framing members shall be included in the test
    ▪ **Web holes shall be considered in test plan/member design

• **A4.4.4 – Corrosion Effects of Fire Protection
  – Corrosion effects of fire protective paints, coatings, and treatments shall be evaluated

**Updated language to most current version of AC14
Acceptance Criteria 14 – July 2014

• **A4.4.5 – Durability of Fire Protection Materials
  – Paints, coatings, or treatments shall be evaluated to ensure that field exposures to the elements do not affect their fire performance
  – Exposure conditions
    • Freeze/thaw including a 24-hour soak
    • UV testing
  • **A4.4.6 – Effects of Fire Protection on I-Joist Mechanical Properties
  – Paints, coatings, or treatments shall be evaluated to ensure that I-joist mechanical properties are not affected by fire protection materials

*Updated language to most current version of AC14

Equivalence – ≥ 2x10 Dimensional or Structural Composite Lumber

Conclusions

• ICC Evaluation Service Report for Prefabricated Wood I-Joists (AC14)

• Provides a means for establishing equivalency to the wood floor assembly described in Exception 4 to 2012 IRC Section R501.3, and by extension, Act 1 of 2011

• The test shall equal or exceed the required minimum duration calculated using Chapter 16 of National Design Specification (NDS) for Wood Construction

• The test specimen shall be subject to an ASTM E119 exposure test
Act 1 – Compliant Methods

≥ 2 X 10 nominal lumber

NFPA13D/P2904 Sprinkler System

*Fire protection of floors is not required for floor assemblies located directly over a space protected by a NFPA13D/P2904, or other equivalent sprinkler system.
1/2 Inch Gypsum Board - Bottom

1/2-Inch Gypsum Board Attached to Bottom of Flange

Or 5/8 Wood Structural Panel

1/2 Inch Gypsum Board - Sides

1. 1/2-Inch Gypsum Board Attached to Side of Flange

2. 1/2-Inch Gypsum Board Attached to Top

Coatings

Potentially Equivalent Products:
- Intumescent coatings
  - Liquid applied in shop or field that encapsulates material applied to and will swell to a thick rigid char when exposed to heat
  - Two types – soft char & hard char
  - The coated specimen must be tested in accordance with ASTM E119 to be considered "fire resistive" and equivalent per Act 1 when using the approaches described in this webinar
Other Products

Potentially Equivalent Products:

- Flame retardant sprays
  - Spray-on product
  - Can be applied to upholstery, drapes, wall coverings, timber, wood based products

- Fire resistance treated wood
  - Wood product impregnated with chemicals by a pressure process

**must demonstrate equivalency per IRC table 721.6.2 or AC14 to meet the floor protection requirements of Act 1 of 2011 when using the approaches described in this webinar**

Summary

- Demonstrating equivalency per Act 1 of 2011
  - 1/2-inch gypsum wallboard membrane or 5/8-inch wood structural panel membrane
  - ≥ 2x10 structural composite/dimensional lumber
  - Or "equivalent"

- **Approach 1**: Demonstrate equivalency to 1/2" gyp and 5/8" WSP through the IRC (15-minute rating)
  - Section 721.6.2
  - Table 721.6.2(1)

- **Approach 2**: Demonstrate equivalency to ≥ 2x10 structural composite or dimensional lumber through AC 14
  - Appendix A - section A4-A
Summary

• Equivalency is determined in accordance with test procedures set forth in ASTM E119 or UL 263

• Potentially equivalent products include:
  – Intumescent coatings
  – Flame resistive and flame retardant sprays,
  – Fire resistance treated wood

• Other testing procedures exist for testing specimens against fire, but equivalency per Act 1 of 2011 requires testing per ASTM E119/UL 263

Equivalence

Floor Protection/Resistant Membrane
(1/2" Gyp or 5/8" WSP)

L & I Advisory

Section 705.8.2
Table 705.6.1
Section 705.6

ASTM E119
UL 263

1.5 Joist units
3.5x6 Structural Composite System

Acceptance Criteria 3E
Appendix A
A4.4

ASTM E119