This publication will look at the requirements for dampers, firestopping and the joint systems that help protect openings and penetrations so that a fire-resistance-rated and/or smoke-resistant building assembly can perform as intended and maintain its rating.

Chapter 7 of the *International Building Code* (IBC) provides detailed requirements for fire-resistance-rated construction, including structural members, walls, partitions and horizontal assemblies. Other portions of the code tell us when certain fire-resistance-rated elements are required or what level of protection they must provide. Chapter 7 specifies how fire-resistance-rated and/or smoke-resistant building elements are to be constructed and how openings and penetrations of such elements are to be protected. Openings and penetrations in a fire-resistance-rated and/or smoke-resistant assembly create a potential weak link or hole that could dramatically reduce the assembly's effectiveness, or render it completely ineffective, if they are not properly protected.

This publication is written to address the requirements in both the 2015 and 2012 editions of the IBC. The main body of the book is written to cover the 2015 code. Where a section reference has been changed from the 2012 edition, the 2015 section number will be shown in italics. The code user can then reference Appendix B, where a table provides a cross-reference of section numbers so that the user can determine where the comparable provision was located in the 2012 code. Where there are technical changes between the 2015 and 2012 code, a note has been included at the end of the paragraph directing the reader to additional discussion within Appendix B that will explain the code change and the effect it may have on applying the provision. It is hoped that this method of noting differences between the two editions of the code will make this document useful to more people and provide greater assistance in understanding the distinctions between the 2012 and 2015 requirements.

To begin, it is important to understand how fire-resistance-rated and/or smoke-resistant assemblies are tested and expected to perform. By understanding what the assembly is trying to do, it will provide guidance on what type of opening protection is required and help to show the importance of properly installing fire and/or smoke dampers, penetration firestop systems and fire-resistant joint systems.

As stated in IBC Section 703.2, fire-resistance ratings are established for building elements, components or assemblies by using

the test procedures specified in ASTM E 119 or UL 263, which are essentially equivalent. This code section also includes the following three requirements, which will be discussed in detail later:

- Section 703.3 and the methods listed within it may be used as an alternate means for determining fire resistance.
- When incorporating materials, systems or devices that were not tested as a part of the fire-resistance-rated assembly, sufficient data must be made available to the building official to show the required fire-resistance rating has not been reduced.
- Materials and methods used to protect joints and penetrations shall not reduce the fire-resistance rating of an element, component or assembly.

The ASTM E 119 and UL 263 tests evaluate the ability of an assembly to contain a fire, maintain its structural ability, or both, over the period of time for which it will be rated. The tests also measure and evaluate heat transfer (temperature rise) through membrane elements that protect structural framing to help ensure the assembly can serve its purpose, and measure heat transfer through the entire thickness of the assembly to ensure that hot-surface ignition cannot occur on the protected side. These tests are conducted using the time-temperature curve shown in **Figure 1**. The temperatures used in the test standard are not intended to be indicative of any specific fire type but are intended to provide a consistent reproducible means so that various building elements, components and assemblies can have their performance evaluated and compared to both the test and to each other.

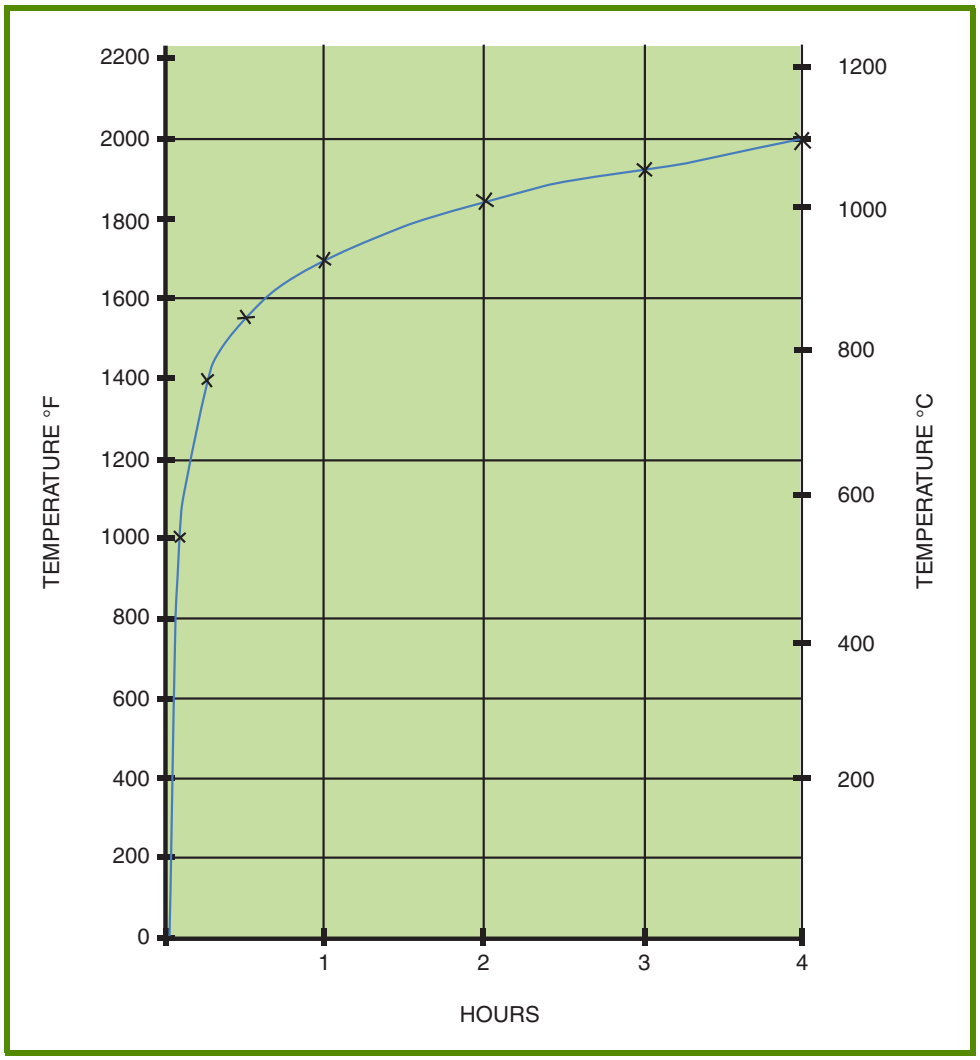

Figure 1
Time-temperature Curve

The average test furnace temperatures used in the tests are:

1,000°F at 5 minutes
1,400°F at 15 minutes
1,550°F at 30 minutes
1,700°F at 60 minutes
1,850°F at 120 minutes
1,925°F at 180 minutes
2,000°F at 240 minutes

As a part of the fire tests, thermocouples are placed at a number of locations on the unexposed side of a wall assembly, on the upper

floor or roof surface of a horizontal assembly, and at various places on the steel or structural elements within an assembly. The rating period is established once the fire breaches the assembly to the unexposed side or when the thermocouples reach certain limitations. The temperature end point limits are as follows:

Temperature rise on the unexposed surface:

250°F average
325°F at any one point

Temperature of steel components within horizontal assembly (beams and structural steel in floors and roofs) general limits:

1,100°F average
1,300°F at any one point
[Note: Standard contains additional criteria and limitations]

Temperature of steel components within horizontal assembly (steel deck in floors and roofs) general limits:

1,100°F average
[Note: Standard contains additional criteria and limitations]

Prestressing steel and reinforcing steel in concrete floors, roofs or beams:

800°F average for prestressing steel
1,100°F average for reinforcing steel

When using alternate test for steel columns:

1,000°F average at any level
1,200°F at any one point

These required performance criteria for rated assemblies are shown in **Figures 2, 3** and **4**.

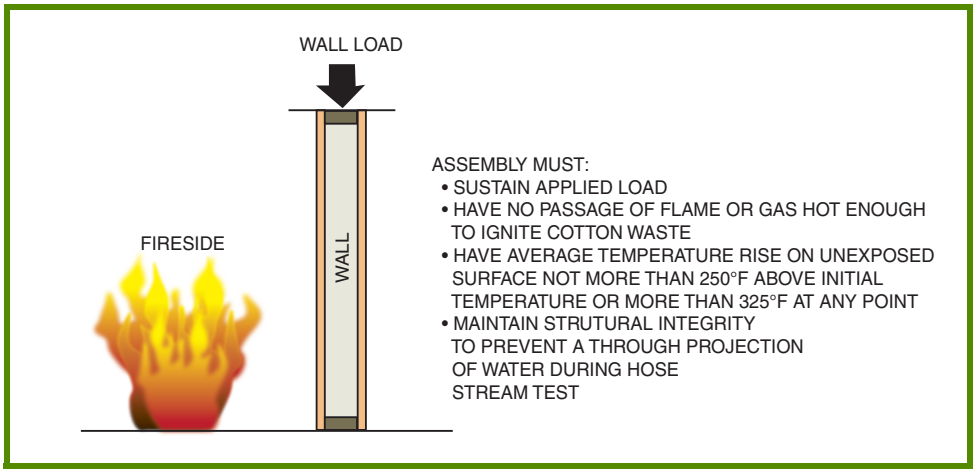

Figure 2
Wall Assembly Fire Test

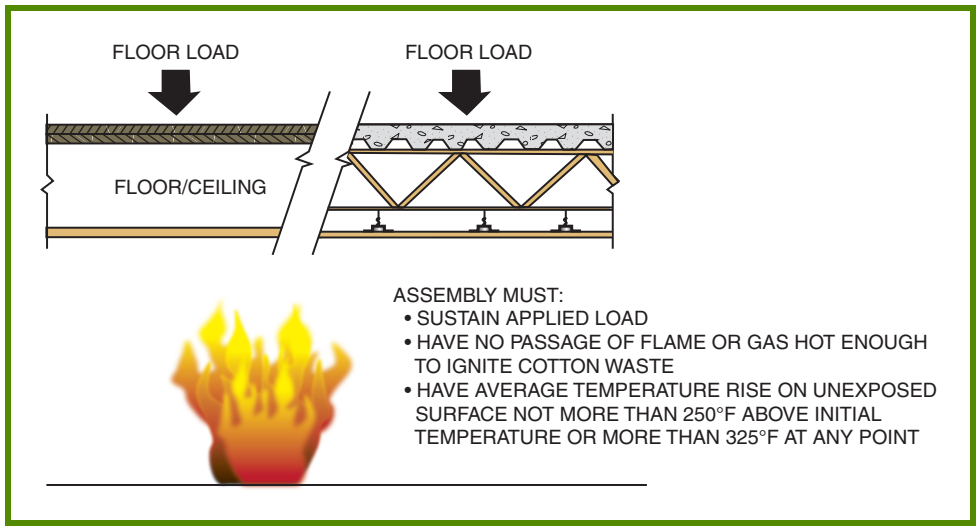

Figure 3
Horizontal Assembly Fire Test

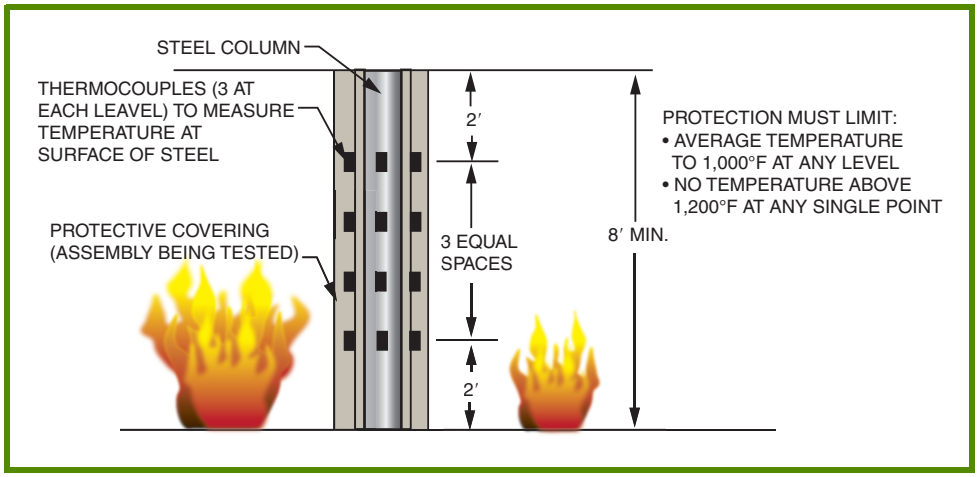

Figure 4
Column Assembly Fire Test

Understanding the performance criteria for fire-resistance-rated and/or smoke-resistant assemblies is important since it gives the code user a better appreciation of the level of protection that these assemblies provide. It also shows that openings and penetrations remove or diminish some of this protection. Therefore it is important that these weakened points be protected, matching assembly ratings prior to the penetration or joint occurring so the assembly can continue to serve its intended purpose. The protection of these openings and penetrations are the focus of this book so that code users and building occupants can be assured that fire-resistance-rated and/or smoke-resistant assemblies do perform their intended function and can minimize or prevent the spread of fire and smoke and the potential for structural failure.

When reviewing the code's requirements related to fire-resistance-rated and/or smoke-resistant assemblies, knowing a bit about each of the specific test standards and the distinction between a fire-resistance rating and a fire-protection rating are important aspects to understand. Each of the specific test standards used in the evaluation of the assemblies, components or penetrations has its own pass/fail criteria used to determine compliance or acceptance in meeting the requirements of the standard. As this book gets into each of the sections (dampers, firestopping and fire-resistant joint systems), the test standards being used and the criteria being evaluated will be discussed.

For now, perhaps the easiest way to understand the distinction and importance between a fire-resistance rating and a fire-protection

rating is to simply look at the fire-resistance rating requirements found in the ASTM E 119 standard for a wall assembly and those of the fire-protection rating for a door (NFPA 252 or UL 10C) or for a fire damper (UL 555). The purposes of the wall assembly are: a. To support any applied structural load; b. To limit flames or hot gases from reaching the unexposed side and spreading the fire to the area on the opposite side; c. Limiting the temperature rise on the unexposed side so combustible materials on the unexposed side (such as furniture, draperies, papers, etc.) are not ignited by the hot surface; and d. To maintain its structural integrity. The purposes of a fire-protection rating are generally to limit the direct passage of flames, but not to limit the temperature rise on the unexposed side, and, again, to maintain its structural integrity. This difference can most easily be seen where a metal fire door or a metal fire damper is placed in the opening of a fire-resistance-rated wall. While the wall must insulate and limit the temperature rise on the unexposed side to a point where combustibles cannot be ignited, the door or damper must only plug the opening so no direct flames may pass through—yet the door or damper themselves may become glowing red hot on that unexposed side.

The best analogy of this situation is that of the little Dutch boy placing his finger in the dike to stop a leak. The dike is doing the main work and is holding back the water. When a small hole or leak opens up, the Dutch boy places his finger into the hole and stops the leak. The boy is not really doing a large amount of work but is simply plugging that one hole so that the dike may continue to do its job of holding back the sea. The fire-resistance-rated and/or smoke-resistant wall or floor, like the dike, is truly doing the work. The boy's finger, like the door, firestop system or damper, simply needs to plug the hole so that the integrity of the wall is not breached.

By focusing on the dampers, penetration firestop systems and joint systems, this book will hopefully make the code requirements easier to understand and apply so that the fire-resistance-rated assemblies may continue to do their job and protect the buildings and people within them. Unless these breaches (openings, penetrations, joints) and other features of fire-resistance and smoke-resistant assemblies are properly protected, we are not getting the level of building safety we expect.

Before getting into the details of the code requirements, it might be helpful to review some of the definitions that will be applicable to these provisions and may assist in understanding the application or

limitations of the requirements. These terms are defined within Chapter 2 of the code and are simply listed here so that readers may be aware of the terms and can review them if necessary.

TERMS	
Annular space Approved Approved agency Automatic Building official Ceiling radiation damper Ceramic fiber blanket *(See Appendix B, Item 1 for discussion related to changes between the 2012 and 2015 editions of the code.)* Combination fire/smoke damper Concrete Corridor damper *(See Appendix B, Item 2 for discussion related to changes between the 2012 and 2015 editions of the code.)* Damper Detector, heat Draftstop Dwelling unit Exit Exit access Exit, horizontal *(See Appendix B, Item 3 for discussion related to changes between the 2012 and 2015 editions of the code.)* Exit passageway Exterior wall F rating Fire alarm signal Fire area Fire barrier Fire damper Fire door Fire door assembly Fire partition Fire protection rating Fire resistance Fire-resistance rating Fire-resistant joint system Fire-separation distance	Fire wall Fire blocking Firestop, membrane-penetration Firestop, penetration Firestop system, through-penetration High-rise building Horizontal assembly Horizontal exit *(See Appendix B, Item 3 for discussion related to changes between the 2012 and 2015 editions of the code.)* Joint L rating Labeled Listed Membrane penetration Membrane-penetration firestop Membrane-penetration firestop system Mineral fiber Mineral wool Open parking garage Owner Penetration firestop Risk category Roof deck Shaft Shaft enclosure Sleeping unit Smoke barrier Smoke damper Smoke detector Smoke partition Special inspection Splice Story T rating Through penetration Through-penetration firestop system