# *Fire Protection of Structural Steel...*

## For Dummies

*By Jim DeStefano, P.E.*

There has been a lot of talk in recent years about structural engineers becoming more involved in the specifying and inspecting of fireproofing systems for structural steel. The collapse of the World Trade Center towers has focused public attention on some of the inadequacies in the way fireproofing of structural steel has been treated in the past.

There has also been a lot of debate over the adequacy of Building Code requirements for fireproofing, but the problem is not the codes, it is improper application and enforcement of the code provisions. When the prescriptive fire protection requirements are correctly implemented, they result in a very fire safe building.

Some fire protection engineers have proposed mandating performance based fire protection rather than prescriptive requirements. Although performance based requirements would make a lot more work for fire protection engineers, they will probably result in more complicated and less understood code provisions. This is not likely to improve the fire safety of buildings.

The problem is that architects who are typically charged with specifying fire protection systems have not taken much interest in them. Fire protection is not something that enhances the architectural design of a building and is often viewed as a necessary evil. As a result, fire protection specifications are often vague and inadequate.

It has been argued that architects do not often have adequate technical training in fire protection systems, and that structural engineers could do a better job. Of course structural engineers don't learn much about fire protection in school, but they are often better than architects at figuring out technical stuff when they are presented with all of the facts. So here are the facts — this stuff is really not that hard to understand.

Fire protection systems are classified as passive, active, or manual. Passive fire protection consists of building materials that insulate structural elements from the heat of a fire, such as spray fireproofing, masonry encasement or rated ceilings. Active fire protection systems are systems that are intended to extinguish a fire, such as a sprinkler system. Manual fire protection systems are those intended to aid fire fighters, such as standpipes. This article will deal only with passive fire protection of structural steel using spray fireproofing.

*Fireproofing thickness gauge*

The current politically correct term for spray fireproofing is "Spray-Applied Fire Resistive Material (SFRM)." In this article the term "spray fireproofing" will be used — there is no need for fancy language and acronyms, it only confuses people.

### What materials are available?

The most common spray fireproofing materials are low-density fiber or cementitious sprays. The fiber spray is less costly than the cementitious spray, but does not adhere as well to steel and is easily dislodged. These materials have a gypsum based binder and are not suitable for wet locations or exposed locations where the fireproofing can be dislodged, such as parking garages.

There are medium-density and high-density products available which contain Portland cement, and are far more durable and water resistant than the low-density products. They are also considerably more expensive.

For architecturally exposed steel there are intumescent paints available. These usually require several coats to obtain the required thickness. The high cost of intumescent paints limits their use to projects where it is important to architecturally expose the structural steel.

### What fire rating do I need?

The Building Code defines 5 general construction classifications for buildings, with sub categories within each. You (or the Architect) must pick one of the construction classifications for your particular building project. Structural steel framed buildings are typically either Type 1 or Type 2 construction (Type 1 and Type 2 require that the structural elements be non-combustible). The Building Code stipulates maximum building height and floor area for each construction classification and use group (Table 503 of the IBC). The code allows increases to the height and area limits if the building is sprinklered, or has more than 25% of the perimeter accessible to fire trucks. The trick is to pick a construction classification for your building that has the lowest fire ratings required for the building elements.

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practical solutions

Once you know your construction classification, Table 601 of the IBC defines the fire ratings required for each building element, floor construction, roof construction, columns, etc.. This part is real easy.

There are no fire ratings tabulated for brace elements that resist only wind or seismic lateral loads. This is based on the assumption that it is unlikely that a hurricane or earthquake will strike while the building is on fire.

The code does require that beams which brace a column must have the same rating as the column that they are bracing. Similarly, beams that support a wall around a stair must have the same rating as the wall.

*Flutes of metal deck have not been completely filled over beam*

## Is it an assembly or just a beam?

Fire ratings are listed as restrained assemblies, unrestrained assemblies and unrestrained beams. If you are attempting to achieve a fire rated floor or roof, you are dealing with an assembly. If you are fire rating a beam that braces a column or supports a rated wall, you are dealing with an unrestrained beam. Since an unrestrained beam requires a thicker application of fireproofing than a restrained floor assembly with the same fire rating, beams that frame into a column will typically require thicker fireproofing than adjacent beams that frame into a girder.

## It is restrained or unrestrained?

There is considerable confusion and misinformation about what constitutes a restrained assembly. Restrained assemblies require less fireproofing thickness than unrestrained assemblies with the same fire rating.

In the context of fire rated assemblies, the term "restrained" has a different meaning from that commonly used by structural engineers.

A building fire is often limited to a small area of a building and only heats up the structural steel immediately above the fire. If there is surrounding floor or roof construction that is capable of restraining the thermal expansion of the structural steel in the vicinity of the fire, the assembly will perform better and is considered to be restrained.

There is a table contained within the ASTM E119 standard (Table X3.1) that gives guidance in evaluating if an assembly is restrained or unrestrained. If steel beams are welded, riveted, or bolted to other steel beams, the assembly is considered restrained. If steel beams or joists are supported on bearing walls, then single spans and end bays are considered unrestrained. It is clear that structural steel construction is almost always restrained.

It is not uncommon for a product salesman to encourage architects and engineers to treat all assemblies as unrestrained. This allows them to sell considerably more fireproofing material for a project. Some local

*Fireproofing should be applied to bare unpainted steel*


*Application of fireproofing*

building codes such as the California code actually stipulate that all assemblies must be treated as unrestrained.

## Which UL design should I use?

The Underwriters Laboratory (UL) publishes a directory that lists the fire rated assemblies, beams, columns and walls that they have tested. UL is not the only testing laboratory that performs fire tests, but they are the most prolific. There are other laboratories such as Factory Mutual that also list fire test results.

Fire tests are defined in ASTM E119. A full size mock-up is placed in a test furnace and subjected to a fire with a prescribed time-temperature curve. The time period to failure is recorded for the test. Since actual building fire conditions are different from an E119 test, an assembly with a 2 hour rating will not necessarily survive a real fire for 2 hours. The E119 test is a good method of rating the relative fire resistance of different building elements, but it is not a good predictor of an element's actual duration in a real fire.

Each listing in the UL directory describes in great detail all of the significant components of the test specimen, such as beam size, type and thickness of fireproofing, type, size and gage of metal deck, thickness of concrete slab and type of concrete aggregate. Your building construction must match all of the components of the test specimen for the UL test that you reference. This requires some tedious reading through the UL directory to find a test that is similar to the construction of your project.

## What thickness should the fireproofing be?

The UL test will indicate the fireproofing thickness that is required for a given fire rating. This thickness is valid only for the beam size that was used in the test. For instance, UL test D739 was based on a W8x28 steel beam. Unless your project has been designed with all of the beams being W8x28s, you will need to adjust the fireproofing thickness for each beam size used.

There is a simple formula that is used to calculate the required fireproofing thickness based on the ratio of beam weight to heated perimeter. This is referred to as W/D, where W is the weight per foot in pounds and D is the heated perimeter in inches (not beam depth). You don't actually have to do this calculation yourself, instead you should require the fireproofing contractor to submit W/D calculations for approval along with a schedule of fireproofing thickness for each beam and column size on the project.

Just to keep everybody confused, some references will base the thickness calculations on the ratio of cross sectional area to heated perimeter. This is referred to as A/P, where A is the area in inches squared and P is the heated perimeter in inches (note that they have changed from D to P).

## What about surface preparation?

Spray fireproofing is intended to be applied over bare, unpainted steel. A light coating of rust will actually improve the adhesion of the fireproofing. If for some reason the steel has been painted, things get more complicated. Unless you can substantiate that the fireproofing will have adequate adhesion to the paint, you must take additional steps such as applying a bonding agent to the steel or securing metal lath to the beam prior to fireproofing.

Many fire rated assemblies require the underside of the metal deck to be spray fireproofed along with the beams. Often galvanized metal deck will have a light film of oil on its surface that needs to be removed by solvent cleaning. Fireproofing manufacturer's specifications will often say that the cleaning of the metal deck will be *by others*. Your spec should indicate who is responsible for the solvent cleaning, since it is not likely that the Ironworkers will be doing it.

## What Special Inspections are required?

Spray fireproofing is subject to Special Inspections under chapter 17 of the IBC. Testing is required of the fireproofing thickness, bond/adhesion and density. The code requires that one thickness test be performed for every 1,000 square feet of rated floor or

*Fireproofing mixer and pump*

roof assembly, and for 25% of the individually rated beams and columns. Previously, one test for every 10,000 square feet was customary. One thickness test consists of averaging several thickness measurements taken on a prescribed pattern. This adds up to a lot of testing.

Thickness testing can be performed by an engineering technician with some training, and does not need to be delegated to a testing agency. Thickness gages are relatively inexpensive. Conversely, performing bond/adhesion testing is very messy and is best left to a testing agency.

In addition to testing, the fireproofing application requires inspection. Some of the common inspection tasks are as follows:

1. Making sure the flutes of the metal deck have been completely filled above beams.
2. Reviewing cold weather protection methods and temporary heating of the work area.
3. Ensuring there is adequate ventilation to prevent mold from growing in the fireproofing.

## How do I get paid to specify fireproofing?

A common complaint amongst structural engineers is that architects are unwilling to pay additional fees to have the structural engineer assume responsibility for specifying fireproofing. This is true, if you include spray fireproofing in your scope of services you probably won't get a bigger fee for doing so. Of course, once you have learned how to specify fireproofing and have developed your standard specification, it really does not take very long to do. At the most, it is a couple of hours of additional work.

The real payoff comes with Special Inspections. If you provide Special Inspection services for your project, there are considerable fees generated for inspecting and testing the thickness of the fireproofing. It is well worth the effort invested in preparing the specification if you will be performing inspections.▪

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