UL's guide to steelwork fire protection

Fire resistance and external exposure characteristics

Empowering Trust™

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Preface

Fire protection - Building codes rely on fire protection features to safeguard people from fire and other hazards attributed to the built environment and to provide safety to fire fighters and emergency responders during emergency operations. One aspect of this protection is based on maintaining the structural integrity of the building during fires using a fire safety concept or engineering approach. The overall fire safety in a building includes requiring fire-resistance-rated fire walls, fire barriers, fire partitions, smoke barriers, shaft enclosures and horizontal assemblies as well as complementary 'active' fire protective systems to be provided to limit the spread of fire. It also includes requirements designed to limit the movement of smoke and toxic gases through the building using smoke barriers and partitions. This passive protection is an integral part of the overall safety scheme included in the codes.

An important aspect of maintaining a building's structural integrity is protecting the steelwork used to support the floors, walls, roofs and other building systems that are provided to allow the building to be functional. Various products are used to protect the steelwork such as boards, cementitious or fibrous sprays and intumescent coatings. Some of these materials have reactive properties which provide an increased level of insulation when exposed to elevated temperatures.

UL certifies a wide range of products that are covered by steelwork protective requirements in building codes. These products and materials, and the applications for which they are certified, are covered in detail in this guide. Since some of the products are also certified for use during the erection process and may be exposed to weather elements or intended for long-term use in an external environment, these applications are also covered in this guide. Boards, sprays and intumescent coatings that have been certified by UL are not listed by name or brand in this guide; up-to-date Listings (Certifications) can be found on **UL Product iQ™**.

We developed this guide for use by code and inspection authorities, architects, contractors, installers and other interested parties. It is intended to aid in understanding the basic components of fire protection for structural steelwork, in association with the applicable codes and standards to facilitate safe, code-compliant installations.

Our guides are updated as necessary due to new product developments, changes in the codes or the need for clarification. To confirm the current status of any UL Guide, please contact UL.

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1. Introduction

Use of this guide

This guide is intended to assist regulatory authorities, designers and installers in determining the suitability of fire protective products and systems for structural steelwork in a particular installation and use.

Products are Listed or Classified by UL under an appropriate product category. A four-letter Category Code Number, or CCN (shown in parentheses), following every category title in this guide is the UL product category code designation. A list of fire protection for structural steelwork product categories evaluated by UL, along with the applicable standard(s), can be found in Appendix A.

Each UL CCN provides a direct link to the Guide Information for the product category. The Guide Information includes the scope of the products covered, information relating to limitations or special conditions applying to the product, the requirements used for the investigation of the products, general installation and use information, certification requirements and information on product markings and the UL Mark to be used on the product. Guide information is available in UL Product iQ™ at **https://iq.ulprospector.com**.

The product markings identified in this guide do not include every possible marking that could be provided either on a product or in its installation or operation instructions. The purpose of these markings is to provide you with an indication of the type of text and location of markings that address features that may be critical in determining if a product is certified and / or if it is installed correctly. Refer to the specific Guide Information for the product category for additional marking information.

This guide was produced independently by UL with non-financial and editorial input from the following companies:

- AkzoNobel (International Paints Ltd.)
- Carboline
- GCP-Applied Technologies
- Hilti AG
- Hempel
- Industrias Sylpyl SA de CV
- Isolatek International
- Jotun Paints
- PPG
- Promat
- Rudolf Hensel GmbH
- Sherwin Williams
- Tremco-Illbruck

Information on listing versus classification

Most codes and regulations require the certification of these products to be applicable to safety-related standards. They may also require these products to be certified to performance standards. Products that are certified to safety-related standards are evaluated with regard to all reasonably foreseeable safety-related hazards, including fire, electrical shock and mechanical hazards. Such products are termed “UL Certified” or “UL Listed.” Some products that are evaluated to a limited range of hazards, or for use under specific conditions, are termed “UL Classified.”

It is important to distinguish the difference between ”UL Certified,” ”UL Listed” and ”UL Classified” and the relation that these terms have with the term “listed” as used in various codes. The term “listed” in the codes generally indicates that the product is required to be evaluated in accordance with the appropriate standard(s) by an independent third-party certification organization, such as UL. The term “listed” in the codes should not be confused with the term “UL Listed” as explained above. It is important to recognize that not all certification agencies make this distinction in their certification services.

It is also important to distinguish products that are tested and certificated by UL to the ANSI/UL 263 standard and those products that are tested outside of UL to the ANSI/UL 263 standard. Some material manufacturers who claim UL certification may have conducted a test to the ANSI/UL 263 standard at other third-party laboratories. Other authorities may employ certification schemes that differ from UL’s. This is further evidence of the importance of the UL Classification Mark. Only UL may issue a UL Certification Mark. One way of checking the validity of the test and certification is by visiting the current **online certifications database**.

UL Mark considerations

There are several UL Marks that can be used with fire protection for structural steelwork. General information on each of these Marks is provided below. Each has its own specific meaning and significance. The only way to determine if a product has been certified by UL is to look for the UL Mark on the product container or on the product itself. It is also important to make sure the mark/certification is fit for purpose; for example, a certification mark for surface burning will not satisfy the code requirements for fire resistance, even though it is a certified product.

The UL Mark on a product or its container means that UL has tested and evaluated representative samples of that product and determined that they meet the requirements in the applicable standard(s). Under a variety of UL programs, certified products are periodically checked by UL at the manufacturing facility to determine that they continue to comply with the standard(s).

The UL Marks may only be used on or in connection with products certified by UL and under the terms of a written agreement between the manufacturer and UL.

UL Listing Mark

This is one of the most common UL Marks. It shows that the product that has been produced under UL's Listing and Follow-Up Service program in accordance with the terms of UL's Service Agreement and bears the UL Listing Mark as the manufacturer's declaration that the product complies with UL's requirements.

UL Classification Mark

This Mark appears on representative samples of products that UL has evaluated but only with respect to specific properties, a limited range of hazards, or suitability for use under limited or special conditions. The UL Classified Mark includes the UL symbol, the word "Classified", a statement of the scope of evaluation, the product or category name, and a control number assigned by UL.

UL-EU Mark

This Mark is used to denote compliance with UL's European certification requirements. If a product carries this Mark, it means UL found that representative samples of this product met the requirements of the relevant (harmonized) European Product Standard (hEN), European Assessment Document (EAD) or UL's own requirements based on a hEN or EAD. The UL-EU Certification Mark includes the UL-EU symbol, the abbreviation "EU", the product or category name, and a control number assigned by UL.

Post installation inspections

Sprayed Fire-Resistive Materials (SFRMs) and Intumescent Fire-Resistive Materials (IFRMs) are designed to maintain the structural integrity of steel, and in some cases other structural items such as concrete, under fire conditions and to maintain safe conditions for a specified period of time.

These materials are a vital component in the modern building design of structures such as schools, hospitals, residential and office buildings, and petrochemical and manufacturing plants, where structural steel is the key element in supporting the load of the structure and its contents.

In the event of a fire, should the SFRM or IFRM fail to protect the ability of the steel to carry the design load, it is possible that a premature failure of the building or assembly therein may occur thereby jeopardizing the safety of the inhabitants, first responders or adjacent properties.

Industry standards and test methods have been developed to validate that the installed SFRMs and IFRMs conform with the project specifications, local building code requirements, manufacturer's recommended installation procedures and minimum UL design guidelines for the material and system being installed. Deviation from any of these items could result in a greater magnitude of loss due to fire and the nullification of the UL certification.

Standard industry practices

Standard industry practices that may be of assistance during the installation process are as follows:

- ASTM E1513, Standard Practice for Application of Sprayed Fire-Resistive Materials (SFRMs)
- ASTM E2924, Standard Practice for Intumescent Coatings

2. Codes and standards

Model codes

Fire protection products for structural steelwork have been investigated for installation, inspection and maintenance in accordance with the following model codes, among others:

- The International Building Code (IBC)
- The NFPA 101 Life Safety Code
- The NFPA 5000 Building Construction and Safety Code

Among other things, these codes specify the locations in which these products are to be installed, the ratings required for each installation, the standards with which the products must comply and the related installation standards.

Product safety standards

In many cases, installation codes require products to comply with UL Standards for Safety, such as the UL Standard for Safety for Fire Tests of Building Construction and Materials, ANSI/UL 263. These are safety standards that include a comprehensive set of construction and/or performance requirements that products must comply with to be certified (listed) by a product certification organization such as UL.

Manufacturers may use UL safety standards to design their products, so they comply with the applicable certification and building code requirements. Product testing and certification organizations such as UL use these standards to evaluate the products and determine their compliance with the product standards.

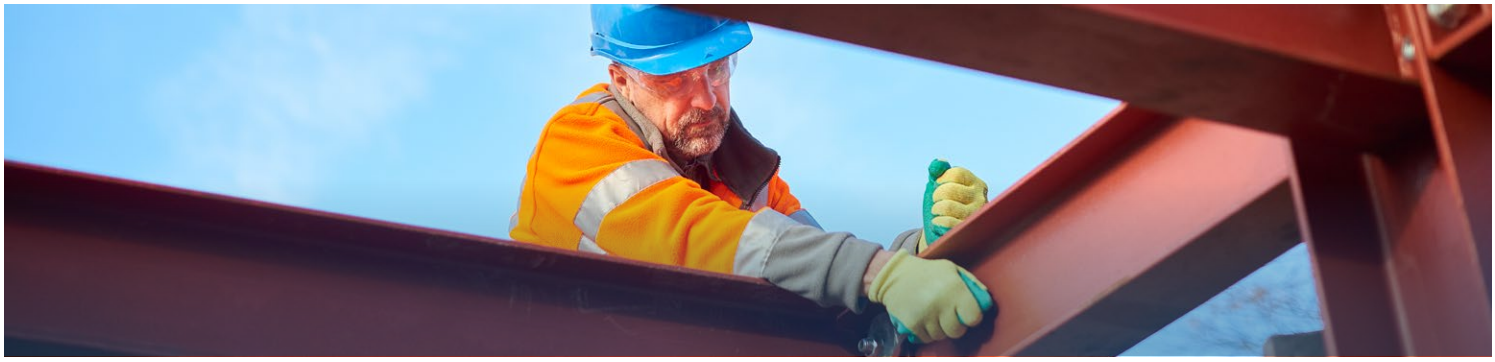
When UL determines that a product complies with all applicable product safety standards, the manufacturer is authorized to apply a UL Certification Mark (Listing or Classification) during production of the product. The standards used to investigate UL Certified products are identified in the product category guide information found in the UL Product iQ Directory at https://iq.ulprospector.com. The product safety standard may also be marked on the product or indicated in the manufacturer's installation instructions.

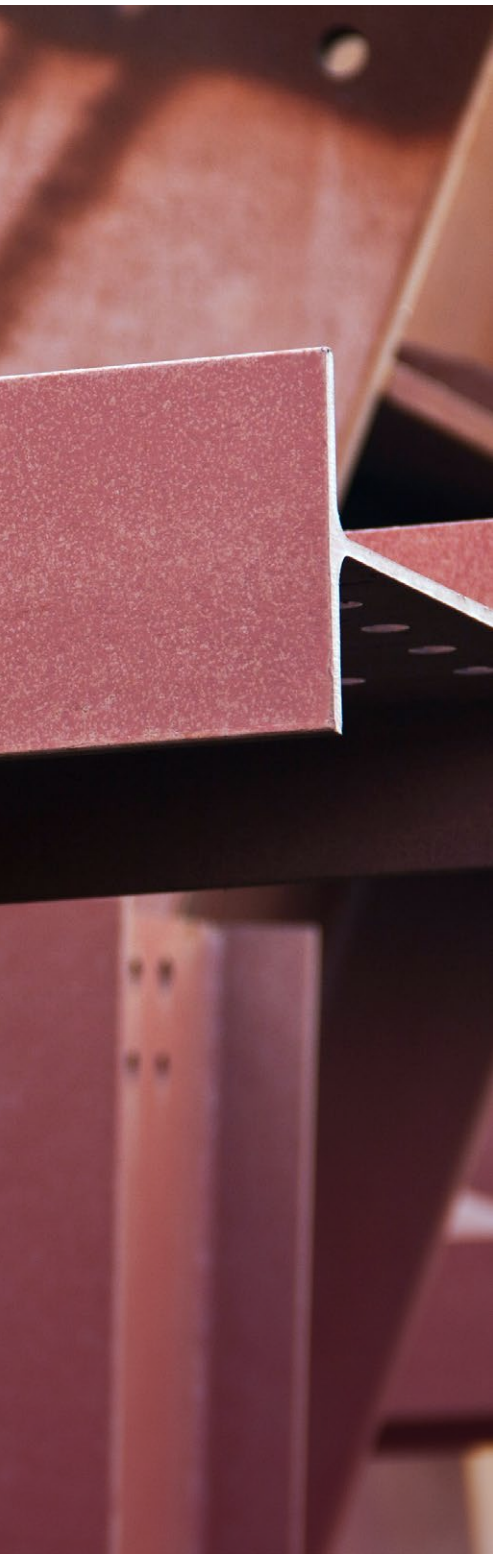
When an installation code or specification requires a product, system or assembly to comply with a UL Standard, designers, contractors and code authorities are encouraged to look at the certification mark on the product and the corresponding guide information to identify the product safety standard used during the investigation.

Installation standards

There are two ASTM practices that can be specified in addition to the manufacturer's general installation instructions. These are ASTM E1513 – Standard Practice for Application of Sprayed Fire-Resistive Materials (SFRMs) and E2924 – Standard Practice for Intumescent Coatings.

These practices are intended for use by the material specifiers, general contractor, applicator or any individual group requiring information regarding the application of SFRMs or Intumescent Coatings.





3. Fire protection products for structural steelwork

Many different products and technologies in the marketplace today have been developed to provide fire protection for structural steel and fire resistance rated assemblies. For the most current compilation of UL Certified products and technologies for steel protection it is best to consult the UL fire resistance directory. This section is intended to describe the more common types of products and technologies used today but is not intended to be an allinclusive list.

Boards

Rigid board materials are a solution used to overcome a wide range of challenges including out-of-sequence construction phases, space constraints, cold weather conditions and construction roof traffic. Rigid board materials provide an alternative fire protection method when spraying is not practical due to unique construction or building conditions. These materials may be used regardless of temperature, substrate conditions or in lieu of sprayapplications when the introduction of water is not practical.

Sprays

Spray-applied fire-resistive materials (SFRMs) are composed primarily of binding agents such as cement or gypsum and often contain other materials such as mineral wool, quartz, perlite, bauxite or vermiculite. SFRMs are available as a wet or dry spray formula and application. The SFRMs are generally delivered as a dry powder in a bag, which is then mixed with water in the field. They are typically sprayed but some can also be trowel applied. SFRMs are used to passively delay (or prevent) the failure of steel and the spalling of concrete in structures that are exposed to the high temperatures found during a fire. SFRMs thermally insulate the structural steel members and concrete to keep them below the temperatures that cause failure and / or spalling.

Reactive coatings

Intumescent coatings, which react, expand and insulate when exposed to high temperatures, offer designers the ability to showcase exposed structural steel. These coatings allow designers and architects to obtain a smooth, aesthetically pleasing and durable finish, along with the required fire protection. These are occasionally referred to as Intumescent Fire-Resistive Material (IFRM). These products can be applied to the structural steel utilizing traditional painting methods such as spraying, rolling or brushing.

4. Environmental exposure considerations for fire protection products for structural steelwork

Construction where the steelwork is exposed to harsh environmental conditions, such as external environments, swimming pools and parking garages, requires fire protection that is capable of handling and withstanding these environments. The consequences of not applying proper fire protection may result in poor long-term performance of the installed material. It is important to select the correct fire protection material type, taking into consideration the environment in which it is being installed. Various environmental conditions are simulated in UL 2431, and this Standard may be helpful when selecting the appropriate fire protective systems including any topcoat if required for such exposed situations.

Topcoats are often considered part of the fire protective system and, where required, are critical to the overall fire protection performance. UL certifies topcoats as part of CCN XKXC2, 'Topcoats for Use in Fire-resistive Applications – Component'. The topcoat materials covered under this category are intended for use as components of complete fire-resistive coating systems rather than for separate use in the field. Therefore, the final acceptance of the topcoat material is dependent upon its use in the complete fire protective system.

Fire resistive material is classified within the categories shown in Table 1, extracted from UL 2431.

Classification category	Application
I-A	Outdoor, Heavy Industrial
I-B	I-B Outdoor, General Use
II-A-1	Indoor, Concealed, Controlled Temperature and Humidity Environment
II-A-2	Indoor, Concealed, Elevator Shafts
II-A-3	Indoor, Exposed Non-Controlled Temperature and Humidity Environment

The characteristics evaluated in UL 2431 are as follows:

Outdoor location exposures

- Temperature stability
- UV
- High humidity
- High speed air erosion
- Salt spray
- Combination wet/freeze/dry cycling
- Industrial atmosphere CO_2 / SO_2
- Specific chemical exposure (optional)
- High-impact resistance
- Vibration

Indoor location exposures

- Temperature stability
- UV
- High humidity
- Air erosion
- Impact resistance
- Vibration

5. Fire protection products for structural steelwork selection and installation

There are many aspects to a well-developed fire protection strategy; both 'passive' and 'active' measures are often used to provide the fire safety strategy in a building. This section highlights the importance of following specifications and guidance that have been established for specific fire resistive materials based on years of testing and evaluations. In addition, this document intends to bring clarity and guidance to some inconsistencies in how listings, particularly those under UL's certification, are interpreted within certain markets.

For all types of passive fire protection, careful consideration should be given to the building code, specification and application to ensure that the intended fire protection is provided. Careful consideration is needed concerning thickness, along with controls for mixing and application. A poor application may result in an undesirable finish and added costs to remediate, not to mention potential unknown fire performance.

In common with all fire protection products, it is important that the products are appropriate to the respective building codes. There are many possible test methods under which the products may have been tested and a comparison must be made between what the respective building code requires and the test standard that has been used to evaluate the products.

SFRMs and IFRMs are very specialized products and require a high level of understanding as they are often mixed on-site and require careful monitoring of the mixing/application properties to ensure they are being applied correctly.

There have been many anecdotal examples where the incorrect test method has apparently been used to justify use against an alternative test standard. This is often the case with 'mixing up' North American and European test standards that require different testing methods and cannot be interchanged. For example, UL 263 cannot be substituted for EN 13381. In addition, it is important to understand that the intent of SFRMs, boards, mats and intumescent materials for steel protection goes far beyond simply protecting the steel from flame spread or combustibility to UL 723 (ASTM E84) or ASTM E136.

A final consideration, once the appropriateness of the test standard is addressed, is to ensure that the information submitted by the manufacturer is independently verified and ideally covered under a third-party certification scheme that is verifiable online and in compliance with the respective code. This ensures the submitted data has not been modified, and the appropriate information is provided.

For many years UL has been at the forefront of testing and certifying fire resistive products and constructions. These evaluations include initial tests of fire resistance performance in accordance with ANSI/UL 263, *Fire Tests of Building Construction and Materials* (also commonly referenced ASTM E119) and long-term durability. In addition, UL certifications in common with the requirements of third-party certification schemes involve a follow-up program to assist manufacturers in assuring that the manufactured product performance remains unchanged from the products tested and originally certified. As a result, the UL certification scheme and the associated UL Mark are recognized internationally as an independent product certification that reliably covers manufactured products.

Figure 3 – Steelwork Fire Protected by SFRM Coating System
Photo courtesy of GCP Applied Technologies

The most relevant UL design guide information for fire resistive construction is found within the current printed UL Fire Resistance Directory in UL Product iQ under the Fire Resistance Ratings (BXUV) Guide Information section. This is a comprehensive summary of information relevant to the application of ANSI/UL 263 fire testing results. There is a wide variety of different fire resistive products evaluated to ANSI/UL 263 (including boards, sprayed fire-resistant materials, wraps, and mastic and intumescent coatings). This summary also covers a wide range of construction groups, such as flooring-ceiling assemblies, roof-ceiling assemblies and vertical partitions as well as structural elements.

Intumescent (Reactive) coatings are a family of coatings that provide fire resistance to a steel substrate such that the steel may maintain its structural integrity for the duration of the fire rating. They contain certain ingredients which, in a fire situation, cause the coating to bubble, char and swell (i.e., to 'intumesce'). This swelling process provides an insulating layer (often referred to as "a char") that protects the substrate from the effects of fire exposure for a specified period of time. There are hundreds of separate designs within UL's product category for mastic and intumescent coatings (CDWZ) from many manufacturers, all of which are listed on the UL website.

The BXUV guide information does make some statements about these coatings that are worth emphasizing and further explaining. Firstly, it states that: *"The mastic and intumescent coating average thickness should not exceed the maximum thickness published in the individual designs."*

Intumescent protection is being increasingly used to fire protect structural steelwork in new and refurbished buildings due to the low thicknesses and decorative nature of the product. In common with other types of fire protection, specification and application requires care to ensure the intended fire safety will be provided.

This is a very important statement as it covers a number of possible scenarios. A product may be tested at a higher maximum thickness for a listing for columns (X or Y series designs) than would be used on a listing for beams (N series designs) or a listing for a floor assembly (D series designs). Mastic and intumescent coatings should not be used on beams at film thicknesses beyond the maximum published thickness covered in the certification for a horizontal design (for example, beam or floor-ceiling) as the material has not been tested under load at higher thicknesses.

The intumescent process results in char that has material properties different from the unreacted, virgin material. It is imperative that a specified and applied thickness is within the range of thicknesses given in the certification for any given configuration (that is, size, shape and orientation) of the steel member.

Evidence has shown that it is not always safe to extrapolate an intumescent coating thickness beyond the maximum certificated value. In extreme cases, adding extra thickness may actually result in a situation where the intumescent foam is unable to support its own weight, meaning delamination or excess cracking may occur and a poorer level of fire performance may be achieved. In the worst case, it could lead to no fire protection being provided.

A second statement within the BXUV guide information addresses column designs relative to W/D ratio, where W is the weight of the beam per lineal foot and D is the perimeter of protection material at the interface between the steel section and the protection material: *"The minimum column size and configuration of the steel member is specified in the (X and Y series) designs. The same hourly rating applies when a steel section with an equal or greater W/D is substituted for the specified column size of the same configuration."*

A similar statement is also present to cover beam designs. The above statement indicates that it is possible to cover a larger steel section that has a greater heat sink than the lowest W/D listed steel section, by using the minimum listed thickness, without any reduction. This approach is conservative and has been generally accepted. However, the application using a thickness specified for a larger steel section to cover a smaller steel section that has a lower W/D than is listed is not acceptable, as the section will likely be under-protected. Increasing the dry film thickness of the fire protection is an unknown and, as explained above, this does not always provide the extra protection required. Consequently, this could negatively impact the system's ability to perform as needed in a fire event.

Listings prepared by UL indicate that material thickness tables are applicable to the minimum size of the steel member specified. Substitution of a steel member for a heavier weight (greater W/D) using the same specified coating thickness is acceptable, however substitution for a lighter weight (lower W/D) steel member is not acceptable. Other substitution rules stated in this section must also be followed.

Lastly, within the BXUV design guide there is a method to calculate for alternate coating thicknesses for slender steel sections based on steel size and hourly ratings. However, this is **only applicable for the use of Spray-Applied Fire-Resistive Materials** (UL Category CHPX) in X or Y series designs. The design guide clearly states that this method cannot be used for mastics and intumescent (Reactive) coatings (UL Category CDWZ). This is in part due to the fact that SFRMs are "steady state" inert materials that do not react in the same manner in a fire situation as an intumescent coating does. Therefore, it is entirely acceptable to develop a known formula to increase the level of protection with an SFRM whereas this is not possible with a reactive coating.

In summary, it is important to understand the allowances and limitations for products specified within the UL designs, because deviation without using proven and established methods is likely to have negative impacts on the fire resistance performance and life safety. It is also important to ensure that the correct test method has been used as the basis for the testing of the steelwork protection as stated in the respective building code.

Guidelines referenced within the UL Fire Resistance Directory have been proven by many years of testing, research, observation and study. Adjusting these guidelines without the proper technical competence and analysis is discouraged. Users of products covered by any third-party certification, including UL listings, should confirm that the ultimate end use of the product and construction is in line with that covered by the scope of the listing and the relevant design guides, all of which can be accessed from the UL website.

Figure 2 - Fire Protected External Steelwork.
Project: Torri Esso – Rome,
Architect: Julio Lafuente.
Photo courtesy of Etex Group.

6. Cellulosic and hydrocarbon fires

Cellulosic fires

UL 263 - "Fire Tests of Building Construction Materials," and ASTM E119 - "Standard Test Methods for Fire Tests of Building Construction and Materials," were developed to simulate building fires, often referred to as 'cellulosic fires.'

This heating regime was developed to simulate the type of fires that occur in commercial buildings, such as office buildings, hospitals and schools, with a simulated exposure based on a post flashover room fires utilizing wood, cotton and paper-based combustibles.

At five minutes into the fire test, the temperature within the furnace reaches 1,000°F. The temperature gradually increases during the test and, at four-hours, the temperature within the furnace reaches 2000°F.

This is considered to be the 'standard' time/temperature heating regime for buildings. However, for installations which include oil, gas and petrochemicals fuels, an alternative 'Hydrocarbon' time/temperature regime may be more appropriate to evaluate the protection materials.

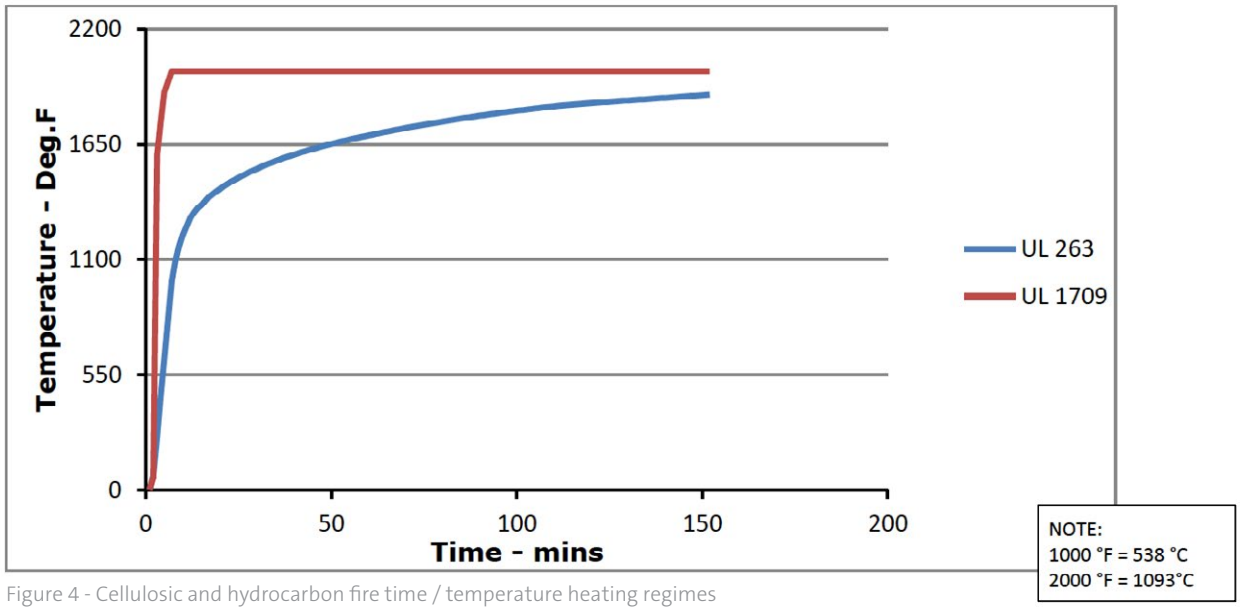


Figure 4 - Cellulosic and hydrocarbon fire time / temperature heating regimes

As might be expected for the evaluation of products in installations such as those processing hydrocarbon fuels, a test method employing greater energy input than a typical building fire condition is more appropriate. ANSI/UL 1709 – "Standard for Rapid Rise Fire Tests of Protection Materials for Structural Steel" is specifically designed to simulate fires using hydrocarbon fuels.

ANSI/UL 1709 has grown in importance in the petrochemical industry for the hydrocarbon fire protection of structural steel. It is currently considered the 'default' standard around the world.

ANSI/UL 1709 was developed specifically to evaluate products subjected to hydrocarbon fires and is widely accepted as the means of evaluating steelwork protection in many regions internationally.

7. Specific areas of guidance

It is understood that there are numerous scenarios where conditions exist that are non-conforming in nature and are not specifically addressed in the UL Fire Resistance Directory. For these scenarios, we offer the following guidance for consideration. Authorities having jurisdiction should be consulted in all cases as to the particular requirements covering the installation and use of UL Listed or Classified products, equipment, systems, devices and materials.

Topcoats

For reactive coatings, topcoats can be a critical part of the overall fire protective system as they often add additional protection. However, it is possible that the incorrect topcoat and/or topcoat thickness could interfere with the reaction of the coating, thus interrupting the fire performance. Reactive coatings are generally thin-film intumescent coatings but may also be Epoxy coatings (often referred to as thick-film intumescents).

UL certifies topcoats as part of the XKXC2 Category as a Recognized Component (R.C.). Only topcoats REQUIRED as part of the fire protective system MUST be certified. Such products should be appropriately labelled to show certification. This is always a requirement for externally exposed intumescent coating systems.

NON-REQUIRED topcoats are not part of the Certification program (e.g. no follow up inspection, no listing and no reference in the UL directory, etc.).

NON-REQUIRED topcoats are to be approved for use by the Authority Having Jurisdiction (AHJ) and supported by the Passive Fire Protection (PFP) manufacturer.

For intumescent coatings, reapplication of outer, protective or decorative topcoats, resulting in multiple additional layers, can result in the excessive thickness of topcoats which may compromise the intended fire performance of the fire protective system.

> ***Statement:***
> ***"Epoxy Mastic and Intumescent Coatings Certified to CDWZ, that are certified without a reference to a topcoat may have aesthetic topcoats applied without detriment to the system performance. Where topcoats are not listed in the design/ certification, topcoats are to be used at the discretion of the manufacturer of the fire resistive coating and the AHJ. When such topcoats have been deemed acceptable by the manufacturer of the fire resistive coating and the AHJ, it should be understood that such products are not under UL Certification and have not been evaluated for their impact to the fire resistance rating."***

For SFRMs, UL allows for surface coatings such as water-based latex, vinyl acrylic, urethane or chlorinated rubber coatings to be used as a topcoat on UL Classified materials. If used, the coatings are intended for surface coloring only. Their application must be controlled so that the coatings do not saturate the SFRM and thus influence the bond between the SFRM and the steel substrate. Unless specifically indicated, these systems have not been investigated for exterior use. The flame spread index of the surface coating shall be less than 200 as determined by the test method in ANSI/UL 723 (ASTM E84 and NFPA 255). Surface Burning Classifications are contained in the UL Building Materials Directory.

Non-traditional shapes

Non-traditional shapes such as steel angles, channels and tees, unless otherwise specified in the UL system or design, have not been evaluated and therefore the statement below applies.

> ***Statement:***
> ***"For non-traditional shapes such as steel angles, channels and tees it is typical industry practice to utilize a thickness based on a UL design of similar orientation and use. The thickness would be derived from the W/D or HpA (see Glossary) of the Non-traditional shape provided it is subjected to the same exposure limitations listed in the Wide Flange or HSS design. In some cases, an additional factor of safety, as proposed by the manufacturer may be added provided the thickness does not exceed design limitations or maximum listed thickness in the design."***

Flat plates

Connection plates, stiffeners and similar elements are ordinarily treated with the same fire protection thickness as the primary steel member to which they are attached.

The lack of re-entrant detail on large flat plates means that the adherence (stickability) of the material may be compromised under fire conditions and therefore the certification, including the maximum area of the plate, should be available for the plate being protected to ensure that the dimensional areas are not exceeded. In some cases, mechanical attachment or additional adhesives or coatings may be necessary prior to the application following the suggested design guidelines in which the thicknesses are derived. For example, certain SFRMs require lath, disks with washers and/or adhesives prior to the application. These are generally used for cellular decking protection for large flat surfaces or steel sizes that exceed specific web or flange dimensions. The manufacturer of the PFP must be consulted to determine whether or not dimensional limitations are being exceeded.

Horizontal hollow sections used as beams

Flexurally, loaded horizontal hollow beams should be based upon a loaded hollow beam test. Therefore, only those designs that specify a hollow section are supported by UL for their fire resistance rated performance.

Non-UL Listed data to "top-up/extrapolate" beyond the listed data

UL Listings are based upon ANSI/UL 263 test data and accepted evaluations using this test data. Ideally, the listing will cover the necessary scope for any given project. However, due to the high number of possible variations for fire protection, the product listing is unlikely to cover every possible scenario and therefore additional data may be necessary. For conditions where there is no alternative option, due to time or cost restraints or the lack of an alternate product, a manufacturer must be clear on which aspects of the project scope are outside the scope of the UL design listing. The manufacturer, project decision makers and AHJ should agree on the acceptable criteria for the additional data. Extrapolated thicknesses that are beyond the scope of the published UL design without additional supporting test data are not considered acceptable. Additionally, extrapolated material thicknesses that are beyond the published UL design are not recognized by UL and are considered outside the scope of the UL Certification.

Beam and floor/roof listings (N & S, D, E, G, J, & P series letter designations)

The summarized form of the test assembly is identified by an alphanumeric UL design number. The prefix letter designates the group of construction, the first number designates the type of protection, and the other numbers and letters identify the particular assembly.

The prefix letters representing the various groups of constructions utilizing assemblies and steel beams are shown in Table 2 below:

Table 2 - Prefix letters representing the various groups of constructions types

Prefix	Construction Type
N	Beam designs for floor-ceiling assemblies
S	Beam designs for roof-ceiling assemblies
D or E	Floor-ceiling designs - concrete with steel floor units and beam support
G	Floor-ceiling designs - concrete and steel joists
J or K	Floor-ceiling designs - precast and field poured concrete
P	Roof-ceiling designs

For example, a D700 series design is a floor-ceiling assembly utilizing concrete and steel floor units with a structural support entirely protected with spray applied fire resistive material. A D600 series design is the identical construction entirely protected with intumescent coating material.

It is important to distinguish the difference between an assembly that contains a full representation of the floor or roof construction and a listing indicating just a partial representation of an assembly. Assemblies will determine a protection method on both the deck (if necessary) and the supporting beams and joists. These are identified in the D, G, E, J and P Series letter designations. The other type of assembly is a partial representation of the floor or roof construction. These systems only determine protective material thicknesses on the supporting beams and joists and are commonly used for beam substitutions.

Beam substitutions are permitted to utilize an N or S Series beam in a D, G, E, J or P Series assembly. The N or S series design must contain the same UL Classified Fire Resistive Material and must be substituted into assemblies that have similar or greater capacity for heat dissipation from the beam than the capacity for heat dissipation in the N or S series design.

For example, an N Series floor beam or joist can be substituted into a D, G, E, or J Series Floor/Ceiling Assembly. However, a substitution cannot be made from an N Series floor beam or joist into a P Series roof/ceiling assembly as the roof assembly does not have the equivalent or greater capacity for heat dissipation compared to the segmented floor assembly.

Other substitution rules apply and can be found in the BXUV Guide Information section of the UL Fire Resistance Directory.

Thermal and structural restraint

From an engineering perspective, the most prevalent forms of steel framed construction are structurally restrained to some extent. However, it is also important to determine if the same assembly is considered “Thermally Restrained” at elevated temperatures as defined by ANSI/UL 263 and would be able to support the design load.

Thermal elongation of heated steel members causes additional thermal restraint forces in steel-framed construction. Guidelines for “considerations of restraint for common construction” are provided in Table C1.1 of ANSI/UL 263.

In a true thermally restrained assembly, the beams must be able to resist the additional axial forces placed upon them by thermal expansion of the beams against the test frame and continue to support the design load.

Within a restrained floor/roof assembly, as outlined by ANSI/UL 263, the supporting restrained steel beams and associated design have a rating less than the same restrained steel beams tested as part of the restrained floor/roof assembly and rated as part of the assembly rating itself. The beams are capable of failing thermally after one hour or half the duration of the rating period (whichever is greater) has been a exceeded, while still allowing for the assembly to support the design load and prevent failure of the supporting floor or roof. Restrained steel beams, as outlined in ANSI/UL 263, can also be tested as individual restrained beams and rated as individual restrained beams.

For a beam or a floor/roof assembly to be considered restrained in building construction, several criteria must be met and can generally only be determined by the structural engineer, a registered design professional, as commonly required by Model Building Codes. These criteria are outlined under the “Restraint Conditions” section within the BXUV Guide Information section of the UL Fire Resistance Directory. Restrained construction should be identified on the construction documents, as commonly required by Model Building Codes.

Cellular beams

Cellular beams (i.e. solid beams) which include holes within their web behave differently from traditional beams in fire situations and as such need particular evaluation. The use of N and D designs based on non-cellular beams is not acceptable for cellular beams as this has not been investigated and may be unsafe. The use of a UL design specific to cellular beams should be followed, if available.

Attachments

Many services require hangers, straps, or bracing in the fastening of pipes, cables and other miscellaneous non-structural items. These attachments may be directly clamped or welded to the structural steel.

The user should be aware that heat transmission from unprotected steel sections to adjoining protected steel sections can result in additional temperature rise on the protected steel sections. The fire protection system manufacturer should be consulted for guidance on addressing this issue.

In the absence of specific guidance and barring any local jurisdictional or code guidelines for overspray of fire protection materials onto non-structural or unprotected structural attachments, it has been a generally accepted practice in the industry to extend the protection scheme along the adjoining section a minimum distance of 18 inches (450mm) beyond the attachment point onto the non-structural attachments, unless there is specific evidence to support alternative distances. For example, horizontal joist bracing calls for a distance of 12 inches (300 mm overspray).

In some cases, additional 'coatback' protection may be recommended and/or protection of the entire attachment to the termination point. These conditions may be scenarios where structural attachments, which have been deemed to be otherwise unprotected, are attached to steel members that are protected.

UL Statement:
"The user should be aware that heat bridging from unprotected sections adjoining protected sections can cause additional temperature rise in the protected sections. The fire protective system manufacturer should be consulted for guidance on addressing this issue. In the absence of specific guidance the user should be aware that standard practice in many parts of industry has been to extend protection along the adjoining section "coatback" for 18 inches (450mm) when the adjoining cross sectional area exceeds 4.65 inches square (3000mm2) per 3 feet or per linear metre."

Multi-temperature analysis

Multi-Temperature Analysis (MTA) is a data analysis method described in UL 1709 5th Ed., dated Feb 24, 2017, Appendix B. The methodology allows for additional analysis of test data to multiple limiting temperatures and may be publish by UL in the form of an adjunct table linked to the traditional certification design. These limiting temperatures are different from those prescribed in the Conditions of Acceptance of ANSI/UL 263 and ANSI/UL1709 (1000 °F average and 1200 °F individual for columns, and in UL 263, for beams, 1100 °F average and 1300 °F individual). The MTA may be used to provide information for conditions in which a performance based design approach is implemented and/or where the specifier or other party has requested alternate limiting temperatures. It should be noted that the limiting temperatures used in the MTA, and the material thicknesses derived from them, may not meet local prescriptive requirements mandated by building codes or other Authorities Having Jurisdiction. The publication by UL of an MTA does not on its own imply compliance with any code, standard or regulatory requirement. It is up to the AHJ to determine applicability and appropriate use of the MTA. Note: While not specifically written into ANSI/UL 263, the same basic MTA methodology may be used in conjunction with ANSI/UL 263 test data.

Appendix A – UL certification product categories for steelwork fire protection

UL certifies steelwork fire protection products under the following product categories. Click the category code links to view UL guide information for that product category. The guide information also has links to manufacturers whose products are certified under that particular category. To view all UL certifications (e.g. Listings and Classifications) visit UL Product iQ at https://iq.ulprospector.com.

Category Name	Cellulosic Fire Test Standard	Hydrocarbon Fire Test Standard	Environmental Exposure Test Standard	UL Category Code
Epoxy Mastic and Intumescent Coatings	UL 263	UL 1709	UL 2431	CDWZ
Spray-applied Fire-resistive Materials	UL 263	UL 1709	UL 2431	CHPX
Hydrocarbon Fire Protection		UL 1709	UL 2431	BYFH
Topcoats	UL 263	UL 1709	UL 2431	XKXC2
Mineral and Fiber Boards	UL 263	UL 1709		CERZ
Mat Materials	UL 263	UL 1709		CEAV
Building Units	UL 263	UL 1709		BZXX
Sprayed Reactive Intumescent Coatings Certified to the ASFP Yellow Book	BS 476: Part 20/21			CDXA
EAD 350140-00-1106 - Renderings and rendering kits for fire resisting applications				
EAD 350142-00-1106 - Fire protective board, slab and mat products and kits	EN13381-4/8			ENCF
EAD 350402-00- 1106 - Reactive coatings for fire protection of steel elements				

Appendix B – Glossary

AHJ – Authority Having Jurisdiction

ANSI – American National Standards Institute

ASTM – ASTM International, formerly American Society for Testing and Materials

Cellular Beam – Horizontal member with holes cut/fabricated in web.

CCN – Category Code Number: A four-letter code (shown in parenthesis) following every category title in this guide is the UL product category code designation.

HpA (ratio) – A is the cross sectional area of the beam and Hp is the heated perimeter of protection material at the interface between the steel section and the protection material.

IFRM – Intumescent Fire-Resistive Material

MTA – Multi-Temperature Analysis

NFPA – National Fire Protection Association

PFP – Passive Fire Protection

SFRM – Spray-applied Fire-Resistive Material

W/D (ratio) – W is the weight of the beam per lineal foot, and D is the perimeter of protection material at the interface between the steel section and the protection material.

If you would like to discuss anything within this guide with UL's steelwork fire protection experts, please contact us at: steelworkfireprotection@ul.com

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