UL Solutions' guide to steelwork fire protection

Fire resistance and external exposure characteristics

UL Solutions

Safety. Science. Transformation.™

Contents

Preface

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 firefighters 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 protection 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 that provide an increased level of insulation when exposed to elevated temperatures.

UL Solutions 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 Solutions 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 safer, code-compliant installations.

Our guides are updated as necessary due to new product developments, changes in the codes or the need for clarification. This is our current to date 2023 guide.

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.

The UL Certification process can have different marks result as a part of the process, e.g., Classified, Listed or Certified. A four-letter Category Code Number, or CCN (shown in parentheses), following every category title in this guide, is the UL Solutions product category code designation. A list of fire protection for structural steelwork product categories evaluated by UL Solutions, along with the applicable standard(s), can be found in Appendix A.

Each 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 Solutions with nonfinancial 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 Certified or Listed vs Classified

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 used under specific conditions are termed as UL Classified, but please note that an Enhanced UL Certification Mark can also be used.

Distinguish between the differences of 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 and certified in accordance with the appropriate standard(s) by an independent third-party certification organization, such as UL Solutions. The term “listed” in the codes should not be confused with the term “UL Listed” as explained above. Recognize the importance that not all certification agencies make this distinction in their certification services.

Distinguishing products proves important between testing and certifying by UL Solutions to ANSI/UL 263, the Standard for Fire Tests of Building Construction and Materials, and those products that are tested outside of UL Solutions 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 Solutions. This is further evidence of the importance of the UL Mark. Only UL Solutions may authorize the use of the UL Mark. One way of checking the validity of the test and certification is by visiting Product iQ.

UL Mark considerations

Several UL Marks apply to fire protection products 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 Solutions is to look for the UL Mark on the product container or on the product itself. Making certain your Mark/certification fits its intended purpose is important, 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 Solutions has tested and evaluated representative samples of that product and determined that they meet the requirements of the applicable standard(s). Under a variety of UL Solutions programs, certified products are periodically checked by UL Solutions 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 Solutions and under the terms of a written agreement between the manufacturer and UL Solutions.

UL Listed Mark

This is one of the most common UL Marks. It shows that the product that has been produced under the U.S. and Canada Safety Certification Program in accordance with the terms of UL Solutions' Service Agreement and bears the UL Listed Mark as the manufacturer's declaration that the product complies with applicable standards.

UL Certified Mark

The UL Certified Mark covers both UL Listed Marks and UL Classified Marks. The UL Mark is the single most accepted Certification Mark in the United States and appears on 22 billion products annually. The UL Certified Mark exists in both an enhanced and not enhanced format. The Enhanced UL Certification Mark offers more information, letting you clearly and quickly demonstrate compliance and provide instant access to certification information on a customizable web page, accessed by a QR code on the mark.

UL Classified Mark

This Mark appears on representative samples of products that UL Solutions has evaluated 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 Solutions.

UL-EU Mark

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

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 Solutions' 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, such as ANSI/UL 263, the Standard for Fire Tests of Building Construction and Materials. These safety Standards 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 Solutions.

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 Solutions use these Standards to evaluate products and determine their compliance.

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

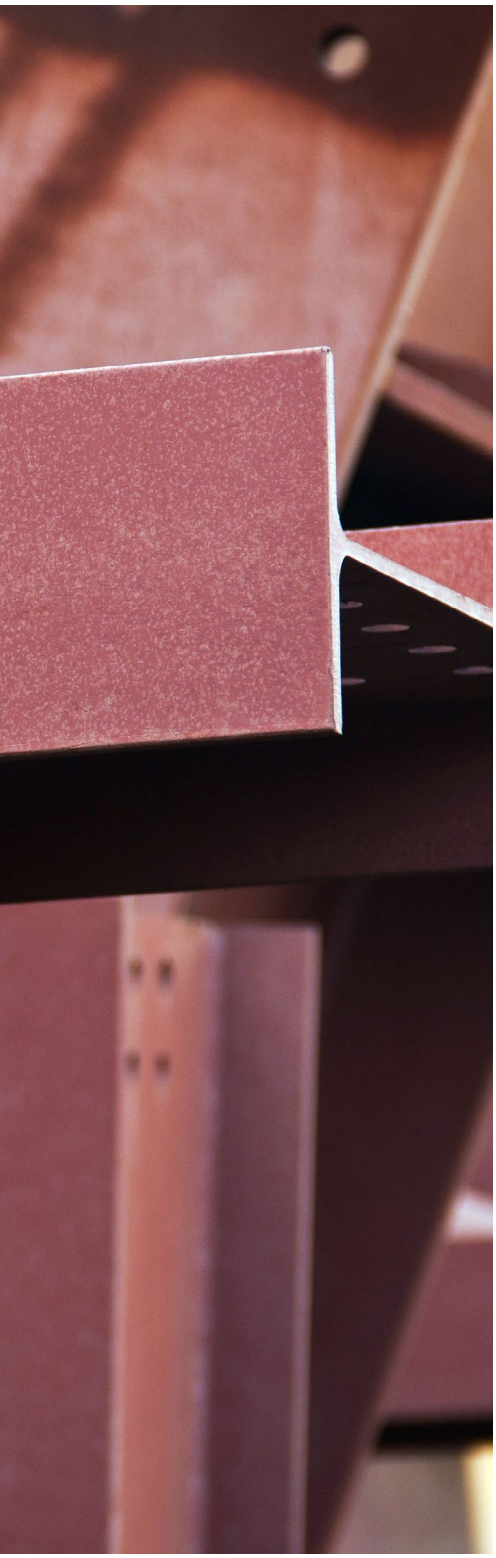
When an installation code or specification requires a product, system or assembly to comply with a UL Standard, designers, contractors and code authorities are encouraged to look at the certification Mark on the product and the corresponding guide information to identify the product safety standard used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

Installation standards

Two ASTM Standards can be specified in addition to the manufacturer's general installation instructions, including:

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

These standards 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, consult Product IQ. This section is intended to describe the more common types of products and technologies used today but is not intended to be an all-inclusive 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 spray applications 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, occasionally referred to as intumescent fire-resistive material (IFRM), allow designers to obtain a smooth, aesthetically pleasing and durable finish, along with the required fire protection. 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 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. Selecting the correct fire protection material type proves important, taking into consideration the environment in which the material is being installed. Various environmental conditions are simulated in UL 2431, the Standard for Safety for Durability of Fire Resistive Coatings and Materials, 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 Solutions 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 Carbon dioxide (CO_2) Sulfur Dioxide (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 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.

Many anecdotal examples can show where the incorrect test method has apparently been used to justify 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, the Standard for Test for Surface Burning Characteristics of Building Materials, (ASTM E84) or ASTM E136.

Once the appropriate test standard is determined, give a final consideration to ensuring 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 Solutions 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 (also commonly referenced as 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 1 – Steelwork Fire Protected by SFRM Coating System
Photo courtesy of GCP Applied Technologies

The most relevant UL Solutions design guide information for fire resistive construction is found on Product iQ under the Fire Resistance Ratings (BXUV) Guide Information section. The BXUV Guide Information serves as a comprehensive summary of information relevant to the application of ANSI/UL 263 fire testing results. A wide variety of different fire resistive products can be evaluated to ANSI/UL 263, including boards, sprayed fire-resistant materials, wraps, and intumescent Fire-resistive Materials. This summary also covers a wide range of construction groups, such as floor-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, that protects the substrate from the effects of fire exposure for a specified period of time. The UL Solutions website contains lists featuring hundreds of separate designs from many manufacturers within the UL Solutions product category for intumescent Fire-resistive Materials (CDWZ).

The BXUV Guide Information does make some statements about these coatings that are worth emphasizing and further explaining. Firstly, it stated that: *"The Intumescent Fire-resistive Material 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.

As a highly important statement, this 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). intumescent Fire-resistive Materials 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, i.e., 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 Solutions 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, the BXUV design guide contains a method to calculate alternate coating thicknesses for slender steel sections based on steel size and hourly ratings. However, this **applies only to the use of Spray-Applied Fire-Resistive Materials** (UL Category CHPX) in X or Y Series. The design guide clearly stated that this method cannot be used for intumescent Fire-resistive Materials (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 the allowances and limitations of products specified within UL Solutions should be understood, as deviation without using proven and established methods is likely to have negative impacts on the fire resistance performance and life safety. Also 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 BXUV Guide Information 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 Solutions 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, the Standard for the Standard for Fire Tests of Building Construction and 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 fire utilizing wood, cotton and paper-based combustibles.

At five minutes into the fire test, the temperature within the furnace reaches 1,000 degrees Fahrenheit. The temperature gradually increases during the test and, at four hours, the temperature within the furnace reaches 2,000 degrees Fahrenheit.

These tests have come to be seen as the standard time/temperature heating regime for buildings. However, for installations that include oil, gas and petrochemicals fuels, an alternative hydrocarbon time/temperature regime may be more appropriate to evaluate the protection materials.

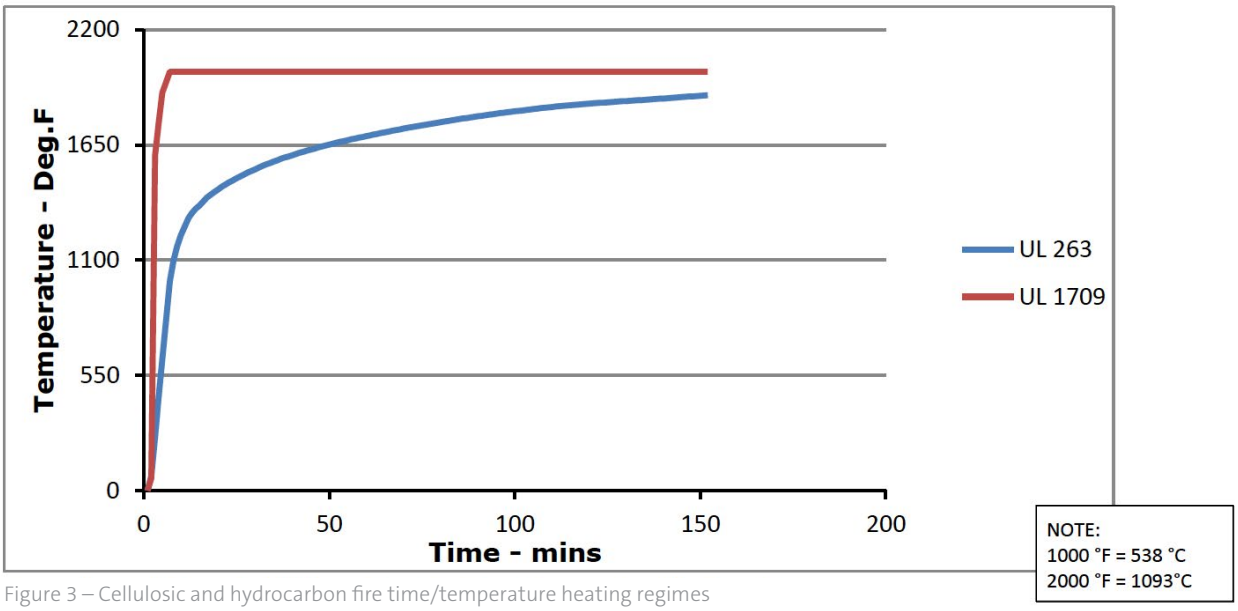


Figure 3 – Cellulosic and hydrocarbon fire time/temperature heating regimes

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, the 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 a worldwide standard.

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

Our experts understand that numerous scenarios with conditions can exist that are non-conforming in nature and are not specifically addressed in BXUV Guide Information or in the individual designs on Product iQ. For these scenarios, we offer the following guidance for consideration. Code authorities 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 Solutions 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 labeled 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 Product iQ, etc.

Non-required topcoats are to be approved for use by the code authority 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.

UL Solutions statement:
"Epoxy Intumescent Fire-resistive Materials 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 code authority. When such topcoats have been deemed acceptable by the manufacturer of the fire resistive coating and the code authority, 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 Solutions 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 Product iQ.

Non-traditional shapes

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

UL Solutions 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 Solutions design of similar orientation and use. The thickness would be derived from the W/D or Hp/A (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 from 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

Flexural 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 Solutions 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 Solutions design listing. The manufacturer, project decision makers and code authority should agree on the acceptable criteria for the additional data. Extrapolated thicknesses that are beyond the scope of the published UL Solutions design without additional supporting test data are not considered acceptable. Additionally, extrapolated material thicknesses that are beyond the published UL Solutions design are not recognized by UL Solutions 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 Solutions design number. The prefix letter designates the group of construction, the first number designates the type of protection, and the other numbers 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 construction 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.

Distinguishing between an assembly that contains a full representation of the floor or roof construction and a listing indicating a partial representation of an assembly is important. 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 on Product iQ.

Thermal and structural restraint

From an engineering perspective, the most prevalent forms of steel framed construction are structurally restrained to some extent. Consider if the same assembly is considered "thermally restrained" at elevated temperature 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 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 on Product iQ. 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 Solutions 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 (450 mm) 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 Solutions 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 (450 mm) when the adjoining cross sectional area exceeds 4.65 inches square (3,000 mm²) per 3 feet or per linear meter."

Multi-temperature analysis

Multi-temperature analysis (MTA) is a data analysis method described in UL 1709 6th Ed., dated Aug. 8, 2022, Appendix A. The methodology allows for additional analysis of test data to multiple limiting temperatures and may be published by UL Solutions 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/UL 1709 (1,000 degrees F average and 1,200 degrees F individual for columns, and in UL 263, for beams, 1,100 degrees F average and 1,300 degrees 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 code authorities. The publication by UL Solutions of an MTA does not on its own imply compliance with any code, standard or regulatory requirement. It is up to the code authority 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.

If you would like to discuss anything within this guide with our steelwork fire protection experts, please contact us at UL.com/Contact-us.

Appendix A – UL certification product categories for steelwork fire protection

UL Solutions certifies steelwork fire protection products under the following product categories. Click the category code links to view 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 Product iQ at https://iq.ulprospector.com.

Category name	Cellulosic Fire Test Standard	Hydrocarbon Fire Test Standard	UL Category Code
Intumescent Fire-resistive Materials	UL 263	UL 1709	CDWZ
Spray-applied Fire-resistive Materials	UL 263	UL 1709	CHPX
Hydrocarbon Fire Protection		UL 1709	BYFH
Topcoats	UL 263	UL 1709	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	EN13381-4/8		ENCF
EAD 350142-00-1106 - Fire protective board, slab and mat products and kits			
EAD 350402-00- 1106 - Reactive coatings for fire protection of steel elements			

Environmental Exposure Test Standards:

All products investigated to UL 1709 are required to have environmental testing conducted in accordance with UL 2431.

For products investigated to UL 263, consult the guide information on Product iQ for any required and/or optional environment testing.

Appendix B – Glossary

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.

Hp/A (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 like to discuss anything within this guide with our experts, please contact us at: UL.com/services/structural-steel-fire-protection-testing-and-certification

UL Solutions

UL.com/Solutions

BE22CS758433