



THE PROTECTION OF STRUCTURAL STEEL IN HYDROCARBON FIRES





Over the past 20 years, UL 1709, Rapid Rise Fire Tests of Protection Materials for Structural Steel, has grown in importance across the worldwide petrochemical industry for evaluating the protection of structural steel from the effects of hydrocarbon-based fires, such as those experienced in chemical, oil and gas production and distribution facilities. The standard requirements are applicable in many parts of the world, particularly in those countries that actively reference guidance documents for the petrochemical industry published by the American Petroleum Institute (API).

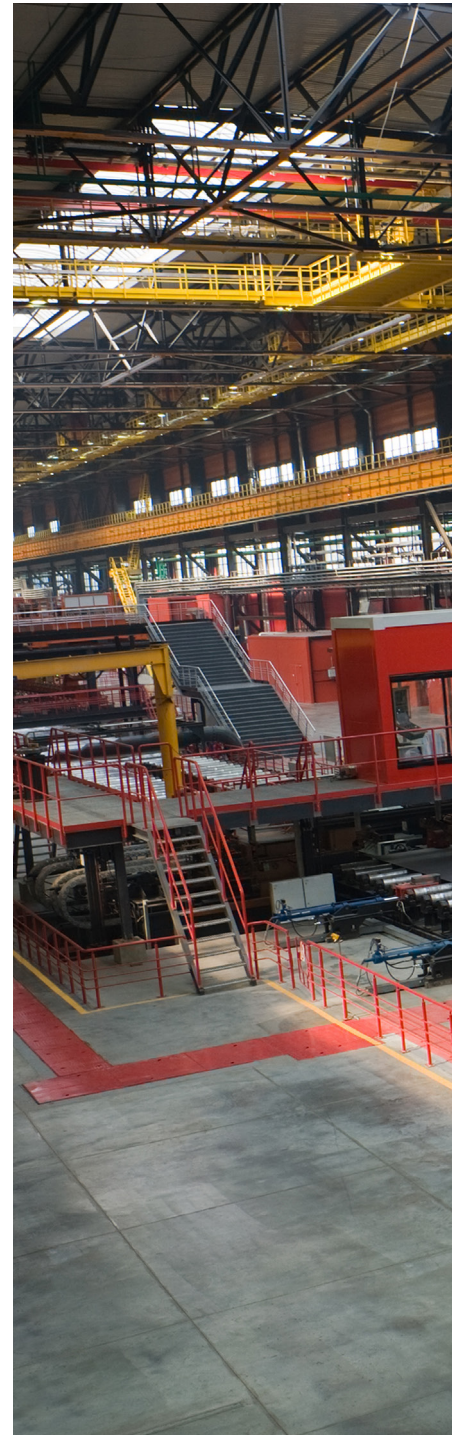
However, depending on the installation, national legislation and industry guidance can often impose requirements on passive fire protection (PFP) materials for structural steel that differ from the testing methods found in the current version of UL 1709. This divergence between the requirements of UL 1709 and those of other applicable requirements and codes can create confusion for manufacturers, usually leading to additional, and sometimes duplicative, testing, as well as delays in product certification.

In order for UL 1709 to remain relevant to the needs of the petrochemical industry and continue to adequately address known safety risks, UL is currently revising UL 1709 and, in addition, has produced a more holistic certification category for the fire resistance of structural steel against hydrocarbon fires.

Scheduled to be published in 2015, UL 1709 5th Edition is expected to update legacy testing requirements for PFP materials to include newer environmental conditioning tests, and variations in steel section sizes that are covered by the test standard. As well as mandatory UL 1709 requirements, the new certification category includes optional requirements for additional performance characteristics, such as exposure to fire via high- pressure jets and environmental durability. The expanded

certification scheme will provide greater flexibility in the appropriate selection of structural steel PFP materials for use in petrochemical plants and facilities.

This UL white paper offers an overview of UL 1709 and a preview of the anticipated changes in UL 1709 5th Edition. The paper begins with background on the codes and standards applicable to structural steel PFP materials used in petrochemical applications. The paper then discusses the requirements of UL 1709 and identifies specific areas being addressed in the current revision. The white paper concludes with information on UL's expanded certification scheme for PFP materials applicable to structural steel in petrochemical applications.





The Role of Passive Fire Protection for Structural Steel

Passive fire protection (PFP) systems and materials are an essential requirement for structural steel used in plants and facilities that process or handle hydrocarbon materials such as petroleum and natural gas. Fires fueled by hydrocarbons can quickly achieve temperatures in excess of 1000°C, which can compromise the strength and integrity of unprotected steel and lead to the spread of the fire and premature collapse of the structures they support. Effective PFP materials for structural steel can potentially save lives in a hydrocarbon-based fire or explosion by providing valuable additional time for the evacuation of workers and the initiation of first responders. Such products may also assist in preventing structural collapse due to fire.

PFP materials typically used to protect structural steel found in petrochemical plants and facilities include, but are not limited to:

- **Cementitious products** - Includes cement and concrete, as well as lightweight materials such as mineral fiber, vermiculite or perlite. In hydrocarbon fires, these products have relatively low thermal conductivity, slowing the transmission of heat to the underlying structural steel.
- **Intumescent and epoxy coatings** - These spray-on or trowel-on products form an insulative char when exposed to heat, helping to insulate steel from the high temperatures of hydrocarbon fires.
- **Blanket systems** - The thermal insulation of structural steel can also be achieved through the use of blanket systems and thermal wraps constructed of various materials.
- **Mineral and fiber board systems** - These are commonly rigid type materials that are constructed around the profile of the structural steel thus providing the thermal protection required.

The selection of a specific type of PFP material should be based on application-dependent factors. These include the type of facility being constructed, the types of hydrocarbon products being processed, and anticipated environmental exposures. Additional considerations in selecting a suitable PFP material could include product weight, ease of installation or application and product appearance.

PFP Regulations, Codes and Standards for Hydrocarbon Applications

The wide range of applicable PFP safety and performance considerations has led to a plethora of regulations, codes and standards applicable to PFP materials used to protect structural steel from the effects of hydrocarbon fires. These include:

- National regulations in many industrialized countries such as Germany, France, Russia, China, and others
- Industry codes such as those developed by the American Petroleum Institute (API), including:
 - API Recommended Practice 2218, Fireproofing Practices in Petroleum

In high risk facilities, PFP systems and materials are used in conjunction with active fire protection systems such as sprinkler systems, fire curtains and other fire defense systems. This combination enhances overall safety by reducing dependence on a single protection system that could be rendered inoperable in the event of an explosion or other circumstance.



and Petrochemical Processing Plants (Third Edition, July 2013)

- API Publication 2510/2510a, Fire-Protection Considerations for the Design and Operation of Liquefied Petroleum Gas (LPG) Storage Facilities (Second Edition, December 1996)
- API Standard 2510 (Eighth Edition, May 2001)
- Testing standards, including:
 - UL 1709, Rapid Rise Fire Tests of Protection Materials for Structural Steel
 - Factory Mutual Approval Standard for Fire Protection of Steel Framing Members for High Hazard Occupancies, Class #4970 (January 1980)
 - ASTM E1529, Standard Test Methods for Determining Effects of Large Hydrocarbon Pool Fires on Structural Members and Assemblies (2013)
 - NFPA 58 Annex H Procedure for Torch Fire and Hose Stream Testing of Thermal Insulating Systems for LP-Gas Containers
 - NFPA 290, Standard for Fire Testing of Passive Protection Materials for Use on LP-Gas Containers
 - BS 476 series of standards on fire tests on building materials and structures
 - ISO 834 series of standards on fire resistance tests
 - EN 1363 series of standards on fire resistance tests
 - IMO Resolution A.754(18)

However, because the selection of a specific PFP material depends on the intended application and the types of fires and environmental conditions to which structural steel will be exposed, individual regulations, codes and standards may fail to fully address all of the safety and performance considerations appropriate for a given application.

Take, for example, testing requirements in Russia for the fire resistance of structural steel. Mandatory PFP certification is based on that country's GOST R 53295 standard, Fire Retardant Compositions for Steel Constructions—General Requirement-Method for Determining Fire Retardant Efficiency. Testing under GOST R 53295 is conducted to temperatures generally observed in fires associated with cellulosic materials, which are considerably lower than temperatures associated with hydrocarbon fires. Therefore, GOST-certified PFP materials may provide protection thicknesses and resistance levels that are inadequate for use in hydrocarbon applications.

For manufacturers of PFP materials, these and similar issues result in a complex and often confusing testing and certification process. In addition, the absence of a single, flexible and transparent testing and certification scheme complicates the specification process for developers of petrochemical facilities, who must conduct their own due diligence to determine the suitability of specific PFP materials.

About UL 1709

UL 1709, Rapid Rise Fire Test of Protection Materials for Structural Steel, was first published in 1989. The standard was originally developed to provide fire testing requirements suitable for materials exposed to the rapidly rising high temperatures typically observed in high intensity, hydrocarbon-based fires. The 4th Edition of UL 1709 was published in June 2011 and has been approved as an American National Standard by the American National Standards Institute (ANSI).

In brief, UL 1709 describes test methods for two types of exposure, as follows:

- **Full-scale fire exposure**—Full-scale fire exposure testing is intended to evaluate the thermal resistance of PFP materials applied to full-scale structural steel columns, and the ability of PFP materials to withstand fire exposure.
- **Small-scale fire exposure**—Small-scale fire exposure testing is intended to evaluate the ability of PFP materials applied to small-scale structural steel columns to withstand fire exposure as well as a variety of environmental conditions. Durability is assessed using tests similar to those found in UL 2431, Durability of Spray-Applied Fire Resistive Materials.

Under the fire test methods described in UL 1709, PFPs are subjected to temperatures of 1093°C (2000°F) within five minutes of the beginning of testing and throughout the remaining duration of testing. These rapidly rising temperature conditions are more suitable



for evaluating the performance of PFP materials used in structures subject to hydrocarbon-based fires, and are significantly more intense than those found in cellulosic-based fires.

Toward UL 1709, 5th Edition

UL is currently revising UL 1709 to address a more complete range of safety and performance considerations for structural steel PFP materials used to protect against hydrocarbon fires in petrochemical plants and facilities. Targeted for publication in 2015, UL 1709 5th Edition will include a number of new test methodologies to address PFP material performance characteristics for different sizes and types of structural steel. The revision is also expected to set higher thresholds for environmental exposure performance.

In addition to establishing a revision to UL 1709, UL has developed a certification category for PFP materials used to protect structural steel in petrochemical plants and facilities; the category will include tests to evaluate optional performance characteristics over and above UL 1709. This new certification is classified as BYFH - Fire Resistance Hydrocarbon. These optional characteristics are expected to cover high-pressure fires, alternative multi-temperature performance, optional fire exposure conditions, and additional environmental durability.

Here is a brief summary of the key items that will be included in the new certification category:

- **Different steel failure temperatures**—The revised standard will deal comprehensively with different

steel failure temperatures to provide structural steel design engineers with the flexibility to address varying load utilization requirements. This will also aid in performance-based design approaches for structural steel protection. The existing steel failure temperatures remain as the baseline for certification while the different steel failure temperatures will be an optional secondary method and deliverable.

- **Different steel sizes and thicknesses**—Certification will provide the possibility of testing and certifying variations in steel section size which was not possible before.
- **Jet fire testing**—The new certification program is expected to include jet fire testing as an optional performance characteristic. Jet fire testing simulates the impact of high pressure flammable hydrocarbon gas on steel structures. In jet fire testing, heat flux, flame velocity

and erosive power are more critical than temperature. Therefore, the certification program will specify testing and performance characteristics consistent with these additional criteria.

- **More stringent environmental performance thresholds**—Minimum passing performance for environmental exposure tests will be increased from 75% to 85% to better distinguish PFP material environmental quality.
- **Additional fire exposure conditions**—The new hydrocarbon certification category will allow for testing against alternative fire test methods and fire exposure conditions as an optional performance characteristic over and above UL 1709.
- **Multi-temperature analysis of PFP coatings**—The purpose of this analysis is to identify the thickness of PFP coating material necessary to keep a specific steel substrate below a specific temperature for a specific duration. The





multi-temperature analysis is expected to be an optional performance characteristic under UL 1709.

The UL 1709 Certification Process

Certification of PFP materials to the mandatory and optional characteristics of the certification category will follow the path employed by UL for other certification in this area. That certification path includes the phases described below.

- **Pre-Testing**—In this phase, UL personnel witness production of the PFP material samples at the manufacturer's production facility. This activity provides an opportunity to record the material formulation and manufacturing process for future use. It also enables UL personnel to identify specific batches of PFP materials as samples to be subject to testing, allowing for error-free traceability and transparency in the sample selection process.
- **Testing**—In the testing phase, UL personnel witness the application of the PFP material samples to structural steel samples. Key details, such as substrate surface preparation, material properties, PFP thicknesses and application techniques, are recorded by laboratory personnel for later use in product certification documentation.

Following the sample preparation, the prepared test samples remain with UL until scheduled testing is conducted. During this interim period, key characteristics of the PFP material, such as thickness and density, are continuously monitored.

During scheduled testing, column

samples are tested individually in a furnace specifically designed for the task and according to the testing protocols detailed in the standard. Once testing has been completed, UL engineers perform an analysis of the test results to determine whether mandatory performance requirements have been met.

If the testing results meet all conditions of acceptance, UL publishes the certification results and requirements in UL's Fire Resistance Directory and on its online database of certified products. If applicable, the certification also includes information on optional performance characteristics evaluated during the testing.

- **Post-Testing**—Before a manufacturer is permitted to apply the UL Mark to their product, a UL field representative conducts an initial inspection of samples from bulk PFP material production to determine whether the material formulation is consistent with the material samples originally tested. Periodic post-testing surveillance is also required to maintain certification. In addition, manufacturers must obtain approval from UL for raw material and process changes that could affect PFP material performance.

The UL 1709 certification process provides for the thorough evaluation of both mandatory and optional performance characteristics of PFP materials used to protect structural steel in petrochemical plants and facilities. PFP materials whose scope of performance has been certified to UL 1709 can more easily be compared side-by-side with other PFP materials,

UL 1709's flexible certification scheme can also enable PFP manufacturers to develop customized testing plans to meet specific regulatory requirements or customer preferences. Finally, the certification's follow-up inspection requirements provide assurances regarding the continuing quality and performance of PFP materials.



providing buyers and specifiers with the information necessary to choose protective materials that are suitable for their specific requirements.

Conclusion

UL 1709 remains a leading standard in the evaluation by testing of PFP materials used to protect structural steel from the effects of hydrocarbon fires. The anticipated changes in the mandatory and optional performance testing under UL's hydrocarbon certification category are likely to strengthen the

standard's importance and facilitate UL 1709 certification around the world. The addition of UL's new Hydrocarbon certification scheme will also provide PFP manufacturers with greater flexibility in meeting international regulations and industry codes, as well as customer specifications and application-specific requirements.

UL is an independent product safety certification organization that has been testing products for more than 120 years. UL tests more than 19,000 types

of products annually, and more than 20 billion UL marks appear on products each year. Worldwide, UL's family of companies and its network of service providers include 62 separate laboratories, and testing and certification facilities.

