PFPNet
PASSIVE FIRE PROTECTION NETWORK

Assessing the Suitability of Single Component, Acrylic-Based, Intumescent PFP Systems to Provide Passive Fire Protection in Hydrocarbon Facilities

Discussion Paper

Document No: PFPNet2021 - 001

Issue 1, April 2021

Disclaimer

PFPNet Limited is an industry group that is a not-for-profit, technical association.

In producing this document, every effort has been made to ensure the accuracy and reliability of the information contained within. However, PFPNet Limited, their employees, subcontractors, consultants, members, committees, or other assignees hereby expressly disclaim any liability or responsibility for loss or damage resulting from the use of any information or process disclosed in this publication, or for the violation of any authorities having jurisdiction with which this publication may conflict. No warranty or guarantee is given, nor is any representation, either express or implied, made with respect to the accuracy, completeness, or usefulness of the information contained herein

Any publication developed by PFPNet Ltd provides general guidance and the user must check the requirements of applicable local, national and international codes, standards and regulations. Where applicable, authorities having jurisdiction should be consulted.

Facilities requiring Passive Fire Protection (PFP) differ and they can change over time and users are solely responsible for assessing the needs of their specific equipment and premises in determining the appropriateness of applying this guidance. Users of this paper should not rely exclusively on the information contained herein which is intended to help inform and facilitate good engineering and operating practices and does not obviate the need for applying sound business, scientific, engineering, and safety judgment. Readers are encouraged to read widely, seek additional information and to consider the use of other practices if they so choose.

This paper does not negate or replace the duties of users to properly train and equip their employees, and others exposed, concerning health and safety risks and precautions, nor undertaking their obligations to comply with authorities having jurisdiction.

PREFACE

Facilities that extract, process, store and distribute hydrocarbon products, by the very nature of the materials involved, present fire hazards that pose risks to people, businesses and the environment. Effective fire hazard management is a key part of the safety and loss prevention activities for these facilities, and one mitigation measure that is used to manage the risks are passive fire protection (PFP) coatings. These systems are applied to structures and plant items and manage the consequences of a fire by insulating the steel to which they are applied from the fire and preventing a premature collapse.

A critical consideration is to select a PFP system that is durable over the facility lifetime so that it will not cause a loss of integrity to the item it is protecting, and will always provide the intended level of fire protection in the unlikely case that a fire occurs.

This paper discusses the importance of selecting a PFP coating material for use in a "hydrocarbon facilities" that been properly designed for, and then tested against, the environment and fire hazards to which it may be exposed.

Simon Thurlbeck, Director, PFPNet
April 2021

Endorsed by:

John Dunk, Director of PFPNet, Chair of the PFPNet Steering Committee
Robin Wade, AkzoNobel
Mike Ogles, Carboline
Dipak Mistry, Hempel
Andy Czainski, Jotun
Richard Holliday, PPG
Carl Burrell, Sherwin Williams

1. Long Term Integrity Performance of PFP Coating Systems

1.1. Background

Hydrocarbon facilities are often based in locations that experience extremes of environmental loads, both onshore and offshore, and on plants that generate high mechanical and thermal loadings. Furthermore, the process areas are often outside and exposed to the elements. Even what appears to be an enclosed process area is usually exposed to aggressive environmental, thermal and mechanical loading that is well beyond that in an internal, occupied, space such as an office or workshop.

These locations generate high moisture and humidity levels, high UV, environmental temperature cycling, elevated temperatures from plant items, high mechanical strains from process and thermal expansions, etc, and well as other hazards such as explosions or cryogenic spills, which themselves produce extreme environmental, thermal and mechanical loadings. It's not just the weather than can affect a PFP system.

PFP systems will be subjected to many years of exposure to these effects and, in reality, should not experience a fire on a well-designed and operated facility. In many respects, maintaining integrity of the coating and the steel is a higher priority than fire resistance because loss of coating integrity can ultimately lead to loss of plant integrity, with the potential for a fire.

These environmental, thermal and mechanical factors can affect the integrity and fire resistance performance of a PFP material if it is not designed to meet these threats. PFP materials such as epoxy intumescent or lightweight cementitious materials have been developed for use in hydrocarbon facilities and can resist the conditions the PFP will experience with the appropriate maintenance plan in place. They are developed to maintain their integrity for their intended facility lifetime so that they don't cause an integrity issue, such as corrosion, for the items to which they are applied. This is both dangerous and costly.

1.2. Demonstrating PFP Coating System Integrity

The integrity of PFP systems over the lifetime of the facility is demonstrated through durability testing against realistic harsh environmental, mechanical and thermal conditions. This testing provides confidence that the PFP system has the characteristics to resist the environment and will not become, or cause, an integrity issues, or experience a major reduction in its fire protection performance.

To achieve this, robust qualification testing of samples is carried out against simulated environmental, thermal and mechanical loadings using a combination of test standards that are relevant to the environment to which the PFP system is exposed, such as ASTM D 5894 , ISO12944 part 9, etc. These standards have been developed to be representative of specific environments, and qualification of the systems is made through observing how the PFP performs against these tests and ensuring this test environment simulates the environment in which the PFP system is expected to be exposed. Some standards give information regarding the maintenance of fire performance of a PFP system in specific environments but little information regarding corrosion resistance e.g. UL2431. These standards are valuable but should be used in combination with other standards which assess corrosion resistance and resistance to water logging.

1.3. Selecting the Correct PFP Coating System Integrity Characteristics

Epoxy intumescent PFP systems are robust systems that have been developed with high durability and resistance properties. Lightweight cementitious materials have been developed to use moisture as part of the fire-resistant process and, in combination with a robust anti-corrosive scheme, can withstand environmental threats. Both are suitable for hydrocarbon and other industrial facilities, with epoxy intumescent materials preferred for offshore environments. Importantly, when maintained correctly, both material types have been demonstrated to survive many years in harsh environments, subjected to operational stresses and, in some cases, real fires.

Traditional single-component, solvent or water-based, acrylic intumescent PFP materials have been used in the built environment (buildings, transportation hubs, stadia etc.) for many years. They have been developed to be durable when exposed to the typical environments and duties that are experienced in the built environment, which includes internal locations. If such a PFP system is to be installed in the high hazard areas of a hydrocarbon plant it must be evaluated for its ability to resist the external, heavy industrial, environment in which it will be used. This demonstration must be through the use of simulated environments and testing procedures that are shown to replicate those found in those heavy industrial environments.

Of course, there are many non-hazardous occupied buildings located on hydrocarbon facilities, and a PFP system developed for the external environmental exposures in the built environment can be a suitable solution if it has a proven durability performance for this situation. There are internal areas of buildings which are not exposed to aggressive environments, such as within offices and workshop areas, and here the PFP materials durability requirements will be significantly less onerous. But as far as possible we do not locate people in buildings in areas where the risk of hydrocarbon fires is high.

The issue comes when an aggressive industrial environment and duty is combined with direct exposure to a hydrocarbon fire and for this, specialised products are required which have the necessary, and proven, integrity resistance characteristics.

2. Fire Resistance Performance of Intumescent PFP Coating Systems

2.1. Hydrocarbon Fires

Hydrocarbon fires are described as pool fires or jet fires and hydrocarbon fires of any type are significantly more severe than cellulosic fires, which are typically found in the built environment. Hydrocarbon fires are hotter, reach their peak temperatures more rapidly, and can exert high levels of forces that can accelerate the erosion of the PFP material.

Single-component acrylic PFP materials which could be subjected to hydrocarbon fires after an extended period in aggressive, industrial environments, should be used with extreme caution. Fire testing of these materials is required to be undertaken after exposure to test standards that are relevant to the environment to which the PFP system as previously stated. For example, this need led to the development of UL2431 which includes durability testing to a wider range of threats posed by exterior environments. From July 2022, systems requiring a UL1709 listing will have to be compliant to UL2431.

Regardless of the fire test standard, the inclusion of representative and appropriate environments prior to fire testing represents best practice in establishing any possible degradation in fire resistance performance.

2.2. Hydrocarbon Pool Fires

Hydrocarbon pool fires are caused by a liquid release which forms into a pool, and the vapour above it ignites and burns. Fire resistance testing of PFP materials for use in hydrocarbon pool fires is typically through the use of specimens placed within a fire test furnace. The temperatures and received heat load levels (heat flux) reached within the furnace correspond to those measured in hydrocarbon pool fires. In addition, typical levels of turbulence in the hydrocarbon pool fire, which can damage an intumescent PFP through erosion when levels are high, are represented by a furnace test.

Furnace fire tests for testing materials in the built environment are based on time temperature relationships for cellulosic fires and are not as severe a test for materials as hydrocarbon pool fire furnace tests. Therefore, testing a material against only a cellulosic fire test standard and then using it where hydrocarbon pool fires are present, without also demonstrating hydrocarbon fire resistance performance, means that the material is being used incorrectly.

There are a variety of globally recognised hydrocarbon furnace tests standards in use (for example, UL1709, ISO834, EN1363-2, BS476 pt20) which represent hydrocarbon pool fires. There are differences in these test standards that can see variations in temperatures and turbulence experienced between the tests, with some more severe than others. Not all hydrocarbon furnace fire test standards are the same, and they are significantly different to cellulosic furnace fire tests .

There is also the emergence of national standards (e.g. GOST, GB 14907), which incorporate hydrocarbon fires by including furnace testing that uses a hydrocarbon time-temperature relationship.

A key consideration for the correct use of any PFP system when using any fire test standard is to ensure that the effects of environment and service conditions relevant to a hydrocarbon facility are also included in the assessment of suitability. The PFP must remain durable, provide good corrosion resistance performance, and perform as expected in a fire when called upon to do so at any point during its lifetime. This is achieved by combined durability testing and fire testing methods that are appropriate for a hydrocarbon facility.

2.3. Hydrocarbon Jet Fires

Jet fires are ignited releases of gas, or mixtures of liquid and gas, and are characterised by very high temperatures and very high levels of forces caused by the pressurised release. Jet fires are significantly different to pool fires and there are a range of PFP materials that are specifically designed to resist these fires. PFP systems developed for use in the built environment, such as one-component acrylic intumescent PFP materials, are highly likely to fail prematurely in a jet fire unless they are designed for jet fire resistance.

A PFP system that has been tested using a hydrocarbon furnace fire test should not be used in facilities where high pressure ignited jets of hydrocarbons are present, without also being tested to show how it behaves in a jet fire. The ISO 22899-1 jet fire standard has been developed for exactly this purpose, and subjects a specimen to temperatures, heat flux levels, and erosive forces that are representative of a hydrocarbon jet fire. In some facilities, the conditions can be even more severe than those in the ISO 22899-1 test, and a so-called “high heat flux” jet fire test should be used to demonstrate how effective a PFP system is in providing protection against these fires.

It is clear that, on facilities where hydrocarbon jet fires are present, materials that are developed for the built environment, and which have only been subjected to a hydrocarbon furnace fire test as proof of their fire resistance performance, should not be selected for use without jet fire testing also being performed.

3. Summary

The traditional PFP coating systems that provide passive fire protection in the process areas of facilities that extract, process, store and distribute hydrocarbons are epoxy Intumescent & lightweight cementitious products. These products have many years of performance track record and have demonstrated their long-term durability in industry-appropriate simulated ageing and weathering tests. A single-component acrylic intumescent PFP system may be suitable for internal occupied areas such as offices, workshops and amenity buildings, but if it is being considered for use in the process areas of a hydrocarbon facility, particularly where the fire hazards are hydrocarbon, it is essential that:

- The PFP system has been shown by suitable testing to have good durability against the environmental, mechanical and thermal loading conditions that are present in industrial facilities that could be located both onshore and offshore. Conditions and testing used for demonstrating durability of PFP systems in the built environment will, in many cases, not be suitable as they are less severe. Using testing suitable only for built environment use will lead to integrity problems, requiring high levels of maintenance, and a likely reduction in fire resistance performance if the material is required to function during a fire.

- Fire resistance testing to demonstrate fire resistance performance must be representative of the fire types present on a facility. Specifically, PFP systems must be resistant to these fire types after exposure to environments expected from oil and gas facilities. Materials designed and used for fire protection in the built environment should be subjected to more severe hydrocarbon fire testing standard to evaluate their performance against more representative, and challenging, fires. When hydrocarbon jet fires are present, hydrocarbon furnace fire testing is not an adequate demonstration of fire resistance performance. Testing should be carried out to a recognised hydrocarbon jet fire test standard.