General Guidance on Testing, Assessment and Certification of PFP – Part 1

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Executive Summary

This Guidance Document provides an overview of the main features and processes involved in the testing, assessment and certification/approval of passive fire protection (PFP) products and systems. It colloquially known as the “TAC Guidance Document”.

PFPNet has separately published a “PFP Roadmap” to guide users through the stages necessary to define fire threats, identify items that require PFP and develop PFP specifications. The TAC follows from the Roadmap and provides a general understanding of PFP testing, assessment and certification.

The TAC Guidance Document is intended for anyone that is involved in the specification, design, manufacture, testing, assessment, certification and use of PFP products and PFP systems. The guide focuses on product performance testing and the approvals/certification process which is a wide-ranging subject too large to encompass in one volume. Therefore, the guidance is split into two parts:

Part 1 – this document - which provides an overview of the general process of testing, assessing and certifying PFP materials and systems.

Part 2 – which provides a detailed examination of the use of specific test standards and methods for each of the many different types of PFP available.

The TAC guide relates primarily to the use of PFP for the protection of critical structures, barriers and equipment from the effects of fire. However, it is recognised that hydrocarbon releases may involve other hazardous events that might have an adverse effect on PFP, such as explosion and cryogenic spillage. Therefore, testing to ensure performance against such hazards is also discussed.

About PFPNet

PFPNet is an independent, not-for-profit organisation funded by member subscriptions and dedicated to raising standards in the use of PFP in industries where hydrocarbon fuelled fires pose a threat to the safety of critical structures and equipment. It aims to achieve this through a focus on education, training, capturing and retaining existing knowledge, researching key topics, clarifying points of confusion and disseminating this to the membership, and to the industry at large – all with the aim of improving quality.

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Definitions and Abbreviations

Terminology	Role
ALS_{fire}	In Limit State Design, the limiting state for accidental load from fire.
Assessment	Within the PFP industry the term 'assessment' can refer to a number of processes: • The formal process that is conducted to assess all of the data from several fire tests on structural sections to derive a set of tables predicting PFP thickness against fire duration, steel section size and critical core temperature (CCT). The process is too complex to describe in detail here but for further information, commonly used processes are described in EN 13381. These are for PFP used in the building industry but have relevance in the oil and gas industry also • A project specific modification of a standard test may be required and the results interpreted (assessed) by a competent person to enable a decision to be made regarding suitability for the project requirement. • A project may have a requirement that has not been previously evaluated by testing but other similar test data is available. In such cases an assessment of the available data could be carried out by a competent person to establish an opinion in regard to the specific project requirement. The safety and reliability of such assessments relies entirely on the competence of the assessor and as such, assessors should be selected with great care.
Approval	When referring to PFP products and systems, an Approval is generally written consent by a regulatory body that a particular product (or system) complies with a defined set of criteria and is suitable for a specific end-use requirement. The approval may include a certificate. In the offshore oil and gas industry 'approval' generally refers to 'Type Approval' (from e.g. ABS, BV, DNVGL, Lloyd's Register, etc.). Other terms are also used. For example when a product has been accepted by UL, it is said to have 'UL listing' and such products are 'UL Approved' with the thickness and installation details listed being considered as certification. The TAC guide generally considers certification and Approval to be similar and in many cases the same.
Certification	The written assurance by a third-party of the conformity of a product to meet specified requirements. This would be issued

Definitions and Abbreviations

Terminology	Role
	by a competent body.
Competent Body	In highly regulated industries a competent body (or competent person) may be specifically identified, or be required, to meet a defined set of competency criteria. In less regulated industries a competent body (or person) could be someone with sufficient experience as judged by their peers.
Design Appraisal or Design Verification	Different names for documents issued by LR and DNVGL which are often used when Type Approval is not appropriate. Other Class organisations may use different terminology. Essentially theses are independent evaluations of technical information to assess the suitability of a particular solution to meet the design requirements of a project. They allow 'engineering judgement' to be made and examples of their use include situations where standard tests are not available, or where numerical modelling of data is to be considered, or where novel solutions are required to a new problem. Each Class organisation has its own guidelines on how they undertake these reviews and on what supporting information is required. The output from the review will be a formal document or report.
SCE and SECE	Safety Critical Elements (SCE) was used prior to the inclusion of environmental impacts within the UK Offshore Safety Case Regulations in 2015. After this, the term SECE was used to include the fact that these items may be both 'Safety and Environmentally Critical Elements'.
Test Report	A test report is a factual record of the test undertaken and the results obtained. It should not be confused with a conformance certificate or an approval of any sort.
Type Approval	Type Approvals certificates are issued by Class Societies such as ABS, BV, DNVGL, LR, etc. They certify that a defined system has been tested to recognised standards and achieved a required level of performance. The certificate also lists the limitations of approval and the design requirements to ensure the system is compliant when installed.
Witness Report	A witness report is simply a factual statement of what the witness observed during their attendance at a test, or other event such as PFP application. Often it does not include the detailed test results (as would a test report) but it may include a summary. In general, a witness report is not an approval or certificate of performance (or compliance).

1 Purpose and Scope of This Document

This document provides guidance on the basics of testing, assessment and certification/approval of PFP products that are used in industries that produce, process or use hydrocarbons.

PFPNet has separately published a “PFP Roadmap” to guide users through the stages necessary to define fire threats, identify items that require PFP and develop PFP specifications. This testing, assessment and certification guidance document, or “TAC Guide” follows on from the PFP Roadmap and provides a general description of the key points associated with the testing, assessment and certification of PFP products/systems.

The TAC Guide will aid those involved in the specification, design, manufacture, testing, assessment, certification and use of PFP products and PFP systems. The guide focuses on product performance testing and not on testing for quality control or assurance purposes as these are highly product specific.

The wide range of PFP materials and systems available and the multiplicity of tests required to demonstrate performance is too great for a single volume guidance document. Therefore, the guidance produced by PFPNet has multiple components:

Part 1 – this Guide

Provides an overview of the general process of testing, assessing and certifying PFP materials and systems. Part 1 focuses primarily on hydrocarbon fires but includes commentary on cellulosic fires where relevant to the hydrocarbons industries, such as inside offshore accommodation modules. Specifically, it covers:

- Methods for the assessment of test data and how they are used.
- The distinct types of approval and certification available and how these should be used for projects.
- Testing that would be useful but is not currently available.

Part 2 – which has multiple subcomponents

Provides a detailed description of the use of specific test standards and methods for each of the many different types of PFP systems available.

The TAC guide relates primarily to the use of PFP for the protection of critical structures, barriers and equipment from the effects of fire. However, it is recognised that hydrocarbon releases may involve other hazardous events that might have an adverse effect on PFP, such as explosion and cryogenic spillage. Therefore, testing to ensure performance against such hazards is also discussed.

Excluded from this guide are:

- The design, construction, testing and performance requirements of explosion resistant barriers (e.g. blast walls).
- The physics and chemistry of fires or explosions, which are very well covered in standard texts.
- Cellulosic fire testing as required in the built environment.
- Quality control testing.

Editorial Notes:

1. There are a wide range of PFP products and systems. In this guidance PFP products are considered to be individual items that are manufactured. Many PFP solutions are actually systems consisting of more than one product. In order to avoid repeatedly referring to 'products and systems' throughout this guide, the two terms are used interchangeably but 'system' will be the main term used to encompass both.
2. Where the reference for standard tests are given, the date of the standard is omitted unless the commentary made is specific only to that edition. Reader of this guide are expected to obtain the current version of any given standard prior to use.
3. There is a box at the start of each section that contains a summary of the key points and lessons from that section.

2 Performance Requirements and the Testing, Assessment and Certification Process

Key points

The performance requirements for PFP are driven by the performance requirements of the protected structure or equipment item.

PFP performance is demonstrated through testing, ideally to standard tests but bespoke testing may also be required.

Certification and other third-party approvals provide independent corroboration of claims made and allow users to select appropriate PFP systems, however, such certifications and approvals are not always required.

The testing and approvals process is multi-faceted and the flow chart in Figure 1 presents a typical example only.

Table 1 shows common roles of organisations but because many of these can fulfil more than one role they must be considered as typical examples only.

2.1 Process Overview and Indicative Flow Chart

Certain items of process equipment and many structures may be identified as critical to the safety of personnel, preventing damage to the environment or to minimising commercial loss. To protect critical items against the adverse effects of fire, Passive Fire Protection (PFP) may be selected.

Both the critical items and the PFP protection will have performance requirements defined in project documentation such as the PFP philosophy, strategy and specification. This will include the fire type, intensity, duration, the maximum temperature the protected item must not exceed, or maximum utilisation of the protected item in fire (ALS_{fire}); and any additional required performance against hazards other than fire.

The options available for identifying critical items, the various hazards and threats to their performance, along with the selection of PFP as a mitigation measure are all discussed in the PFPNet Roadmap.

The ability of the selected PFP to meet the defined performance requirements is demonstrated through testing.

The TAC guide is intended to cover the use of PFP at onshore and offshore facilities in different regional jurisdictions. Consequently, there is considerable variation in the testing, assessment and certification processes employed with the possibility of various 'start points' and routes through the process depending on the project and/or market requirement. These do not always follow the linear pattern shown in Figure 1 which, although a commonly used process route, should be viewed as indicative for many scenarios but not definitive for all.

Once suitable testing is complete a report will be written, and this may then be sent to an independent third-party for assessment and/or certification. However, there are occasions when projects will accept test reports directly from an accredited laboratory without the need for third-party assurance.

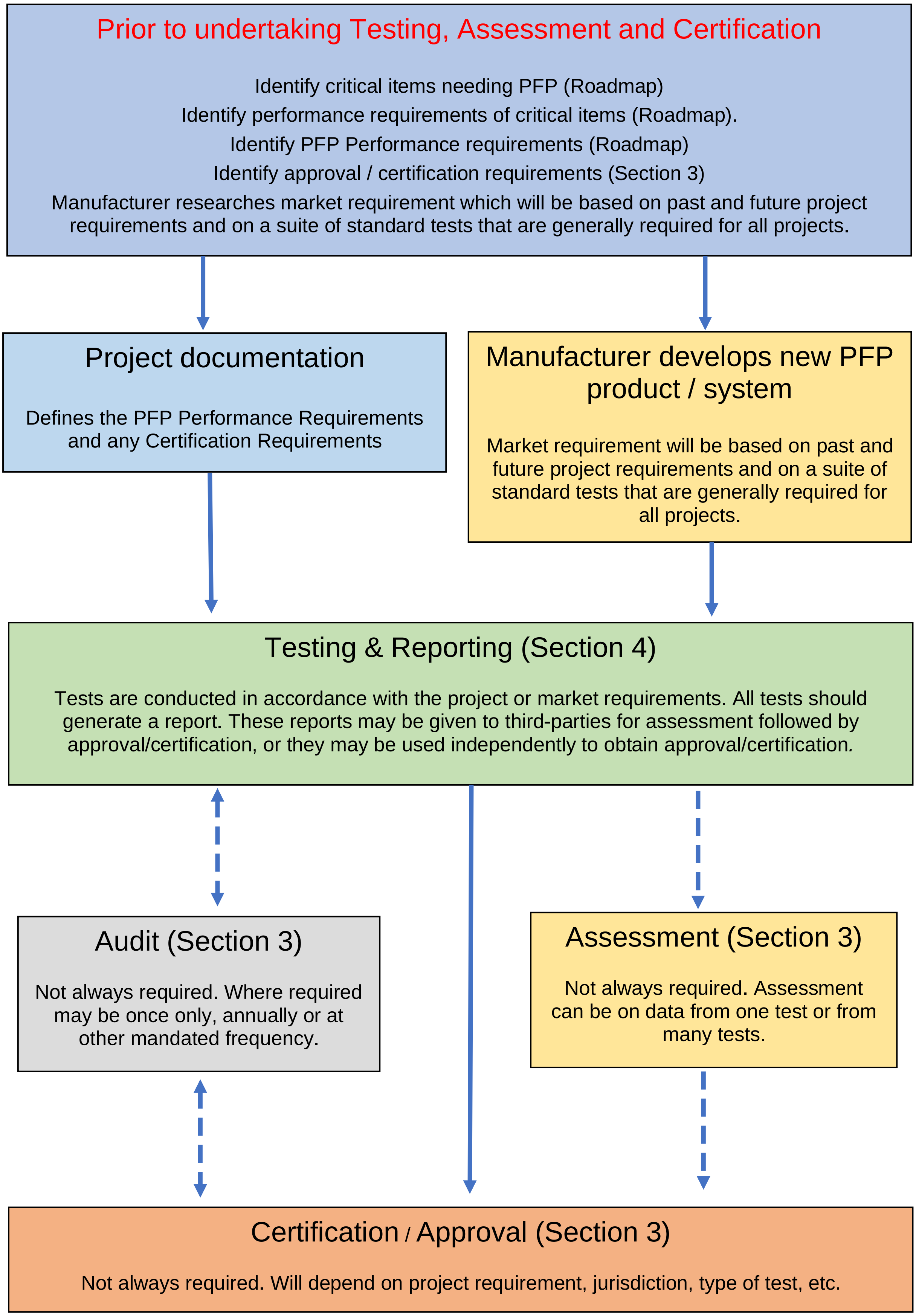

Figure 1 Major elements of the testing, assessment and certification process.

Some assurance processes will require detailed auditing of every stage, but others may not require any auditing at all. Others may fall somewhere between these two extremes. It is for these reasons that the assessment and audit boxes within Figure 1 are shown with dotted connections.

In reality the process is not as linear as shown in Figure 1 as testing is generally carried out in parallel with assurance requirements with final assurance coming after testing. A review of assurance requirements before testing and reporting can be very influential on the testing undertaken and the route through the TAC process. Consideration of the assurance requirements are helpful in understanding the testing required, third party verification of application and testing.

2.2 Roles of Organisations Involved in PFP Testing, Assessment and Certification

The roles of organisations involved can vary widely depending on factors such as the jurisdiction, the type of project and its requirements, etc. Some organisations fulfil more than one role and in many cases some of the stages are not required.

The following table reflects the most frequently encountered roles in the testing and approvals process.

Table 1 Typical roles of organisations

Organisation	Role
Owners, operators, specifiers, etc.	Define the performance requirements required for their projects. Select PFP systems that meet these requirements using an appropriate demonstration route. This may be via third-party certification, specific testing, assessments by third-parties, etc.
Manufacturers/ Marketers	Develop PFP products and systems. Submit these for testing and if required for approval and certification.
Testing Laboratories	Laboratories having recognised accreditation should be selected to undertake testing using recognised standards. They may also be required to undertake bespoke testing where necessary. Issue test reports that detail what was done and what results were obtained.
Standards Organisations **Examples include ISO, BSI, API, UL, FM, NFPA, ASTM, etc.**	Work with industry experts to develop and publish standards that define how tests shall be conducted. In some cases these may also define acceptance criteria, and may offer guidance on the applicability of the standard.

Assessment organisations **Examples include independent consultants, test laboratories, Class organisations and many others.**	These may be independent of the test laboratory and of the approval/certification organisation but in other cases they may be the same organisations. They review data from test reports to assess the applicability to specific project requirements. Assessments are not always required.
Certification Organisations **Examples include LR, DNVGL, UL, FM and many others.**	Evaluate results of tests and third-party assessments and may conduct their own assessments of the provided test data. Approve the scope for which the PFP systems are suitable. Provide confirmation via certification and approvals of PFP performance. These may be against standard test conditions or to bespoke test requirements. This provides PFP users with independent third-party assurances of PFP performance, enabling the selection of the most appropriate system to meet project performance requirements.

2.3 Items Typically Protected with PFP

Structural steelwork

The primary construction material and provides the integrity and strength for most offshore facilities, onshore process units and supports for pipes, vessels and valves. Steel reduces in strength as it gets hot, this reduction becomes significant at temperatures above 400°C. This loss of strength can lead to the collapse of structures critical to life safety; pipe racks and equipment supports may collapse leading to significant escalation potential.

Fire barriers

Fire barriers include walls/bulkheads/floors/roofs/decks and penetrations through these such as; doors, windows, ducting, fire dampers, pipe and cable transits.

Fire barriers provide compartmentation and separation of areas to minimise heat transfer, the spread of fire, smoke and toxic gases. They are typically used to protect occupied areas from process areas, shielding personnel from fires and allowing time to muster and escape. PFP is used to reduce the rate at which heat is transferred through the barrier from the fire-side to the non-fire side. Some barriers may be combined fire and blast barriers and here PFP will be used to provide thermal insulation, integrity and resistance depending on construction and rating. Any PFP used on fire and blast barriers needs to survive not only the blast overpressure, but also the displacement of the barrier.

Process vessels, tanks and their supports

These may fail due to the weakening effects of fire and this can lead to an escalation due to loss of containment. Tall vessels may topple and damage adjacent plant.

Pressurised vessels exposed to fire experience an increase in temperature leading to increased internal pressure, concurrent with a reduction in the strength of the vessel walls. If the vessel walls become too weak to contain the pressure, rapid catastrophic failure will occur, generating a sudden release of pressurised contents. If the contents are liquids at temperatures above their atmospheric boiling points the sudden release may cause a Boiling Liquid Expanding Vapour Explosion (BLEVE) resulting in a major escalation event. Note that a BLEVE can occur below the set-point of pressure relief valves.

Further information on fire protection of pressure systems can be found in Energy Institute Guidance on passive fire protection for process and storage plant and equipment, First edition, March 2017 [1].

Piping and pipe supports

Steel structures supporting piping can collapse due to the thermal effects of fire and result in escalation events due to loss of containment. Pressurised inventories contained within pipes can increase in pressure concurrent with wall weakening due to the thermal effects of fire leading potentially to rupture.

Risers and onshore pipelines and their supports

The threats to the integrity of risers and main import/export lines are the same as for piping but the potential consequences can be much more severe due to the large inventories, often at high pressures, the limited opportunity for isolation, the proximity of large numbers of personnel to the hazards, and the complexities of offshore escape, evacuation and rescue.

Valves (ESDV, BD, Isolation, etc.), actuators and accumulators

Main critical valves such those required for emergency shutdown (ESD), isolation and emergency depressurisation (EDP) are susceptible to premature failure in a fire with the potential for loss of control of emergency response systems and escalation. Valves, their actuators and their control lines and cables can fail or become inoperable at relatively low temperatures and often need PFP to provide sufficient thermal protection to allow emergency control activities to be completed successfully.

Critical control lines and cables

Cables, pneumatic and hydraulic control lines where valves do not have “fail safe” mechanisms may be protected with PFP to enable control for a defined time. There are other options to the use of PFP that may be preferred.

3 Assuring PFP Performance

Key points

Not all projects have a requirement for assurance. Where it is required there are numerous options ranging from highly regulated to minimal.

PFP assurance at the design stage differs to that at the manufacturing stage and at the site installation and in-service stages. This guidance deals with the design stage.

Witness reports are not formal approvals e.g. Type Approval. They do not typically include assessment of the results, nor do they elaborate on the applicability or range of validity of a product or its design.

It is essential that the PFP user reviews and understands the limitations of the approval or certificate and how these relate to the project design requirements, and where discussions on technical engineering judgement is required.

3.1 The PFP Assurance Route

3.1.1 General

For PFP performance characteristics requiring assurance, those relating to fire resistance are the most important but other performance characteristics may also need assurance. Examples include resistance to the effects of explosion, environmental durability and cryogenic spill resistance. It should also be emphasized that the fire resistance of the PFP may not be the same before and after these exposures. Changes in performance should be evaluated for survivability in fire and corrections applied if applicable and where appropriate.

It is common to think of assuring PFP performance in terms of third-party verifications but there is a wide spectrum ranging from little or no third-party involvement, to highly regulated scenarios where third-party assurance is essential. The variation in requirement stems from factors such as the regulatory authority, the location of the asset (onshore or offshore) and the entity that takes responsibility for the assurance, and this is considered with two hypothetical examples in 3.1.2 and 3.1.3 below.

3.1.2 PFP Requirements for an Onshore Facility

Consider an onshore facility located away from external populations and minimally manned, and where a fire risk analysis has shown that personnel not caught-up in the initial fire event can escape. Note that PFP does not prevent injury to those exposed to an initial event but is intended to prevent additional casualties by mitigating against escalation. In this example there is no regulatory requirement to use PFP and other mitigation measures are in place. PFP is therefore only required to protect the asset against property loss to meet facility insurance requirements. The facility PFP scheme is selected by the site owners and they submit this to their insurers for their agreement.

The above example is typical for many onshore facilities globally and the PFP specification would most likely be based on API 2218 which is a guide and not a standard. However, owners have responsibility to consider this guide carefully in placement of regulation Specifications based on API 2218 generally call for a PFP that has been tested to UL 1709 which is a fire test standard, however API 2218 allows the use of equivalent fire test standards such as EN1363-2 and ISO 834-3 and where jet fire risks are identified ISO22899-1 is cited.

Unlike many other organisations, UL not only publish the UL 1709 standard but they also carry out the fire testing, issue the test report and provide certification. In such cases 'assuring PFP performance' is based on the standard test conducted by the accredited laboratory without recourse to another body such as a Class Society.

Note that many onshore facilities incorrectly require UL1709 for items such as vessels where the standard is suitable for structural steel. The validity or otherwise of this requirement is covered in more detail in Part 2 of the TAC guidance document.

UL Approval (listing) entails not only testing to UL1709 but also durability testing to UL 2431.

A similar approvals process is operated by Factory Mutual (FM) who have their own standards that are not yet specific to hydrocarbon fire exposure. However, they will approve products for use that are tested to other standards recognised by them.

3.1.3 PFP Requirements for an Offshore Facility

For an offshore facility, personnel are generally confined within a relatively small area with hazardous inventories and processes occurring close to where they live and work. There is no easy escape from an offshore platform where there is generally a need to rely on boats and helicopter for evacuation.

Therefore, on offshore facilities, PFP is almost always installed to mitigate the risk to human life from fire events. Increasingly this now also extends to ensuring protection of the environment, but life safety is the predominant factor.

Typically, the offshore environment is also highly regulated with either legislation in place that demands specific fire protection aspects, or a safety case regime (as used in the North Sea) that mandates the use of measures to reduce risk to minimum levels, supported by documentation that upholds this contention.

For offshore PFP the supporting documentation invariably involves the submission of Type Approval certificates from Class Societies such as LR, DNVGL, ABS, etc. The Type Approval process is well defined and is the subject of the remainder of this section.

3.2 PFP Product and System Assurance at the Design Stage

3.2.1 The Stages of Product and System Assurance

Assurance requirements differ depending on the stage of the project lifecycle. Although the focus of this guide is the design stage, it is beneficial to mention the other stages to understand how they impact on the validity of assumptions made at the design stage. Typically, the stages are:

- Design - reference will be made to type approval certification, design verification and technical assessments – the subject of this Section 3.2.
- Manufacture and construction - installation procedures, verification of conformity and competence assessments would be relevant. See Section 3.3.
- Operation and service inspection and maintenance processes, along with verification of personnel qualifications would be relevant. See Section 3.4.

At the design stage organisations may produce an assortment of documents that record the performance characteristics of PFP. These documents will make available information that is valuable in supporting the design assessment. Such documents can originate from independent technical institutions; regulators and authorities, testing establishments and consultancies,

Historically, products used in the maritime industry on ships that operate internationally are approved and certified by Classification Societies such as ABS, BV, DNV GL, and LR. The process is well established and regulated and has been largely adopted for offshore oil & gas facilities with the result that for offshore installations, reference is mostly to certificates and approvals issued by the Classification Societies. Whilst the fires threats are different for sailing ships to floating production units and fixed platforms, the assessment and certification procedures are similar for PFP systems.

For onshore use, the above-mentioned documents are useful as they provide independent verification/certification but other documentation issued by national, professional or insurance associations may be required.

The majority of such documents are often referred to generically as "certificates" which is not always correct. To ensure a clear and common understanding it is important to emphasize the substantial difference between the assessment of materials in isolation, i.e. without relation to a particular case or project, and the type of evidence which is produced for a project specific requirement. This difference is discussed below.

3.2.2 Evidence of Assurance for the Industry: Certification and Type Approval

Type approval certificates are typically issued by Classification Societies. They are generally owned by the manufacturers of the PFP product or system but may be requested by re-sellers, or even users, e.g. a construction yard or a ship owner.

Type approval certificates confirm that an organization recognised by a Flag Administration, has assessed and approved a product. The certificate gives a summary of the key information from the assessment. For an oil and gas asset, testing undertaken will be appropriate to the specific application which may or may not utilise testing in accordance with the FTP code. Type approval certificates are issued against fire test procedures that are recognised by the organization issuing the certificate.

Type approval is normally issued by Class Societies for PFP used to protect items such as those listed below and indicated in Figures 2 and 3.

- Hydrocarbon fire protection systems (H class) for divisions (walls, bulkheads and decks)
- Hydrocarbon fire resistant (H class) doors and/or windows
- Hydrocarbon fire resistant (H class) penetration systems (for pipes and/or cables)
- Hydrocarbon fire resistant (H class) non-load bearing partitions and barriers
- Hydrocarbon fire protection systems for structural steel section
- Jet fire protection systems for divisions (walls, bulkheads and/or decks)
- Jet fire protection systems for penetrations (for pipes and/or cables)
- Jet fire resistant non-load bearing partitions and barriers
- Jet fire protection systems for structural steel section

- Dry-fit systems including enclosures, jackets, panels, etc. for fire hydrocarbon fire and/or jet fire on equipment items such as pipes, valves, actuators, flanges, assemblies, etc.
- Other PFP systems such as directly applied coatings, composites, etc. for hydrocarbon fire and/or jet fire on equipment items such as pipes, valves, actuators, flanges, assemblies, etc.

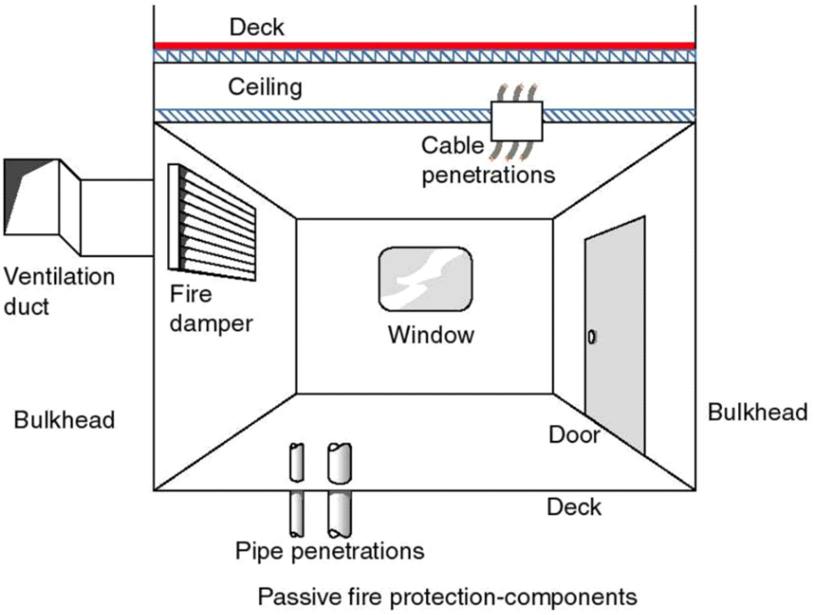

Figure 2 PFP components, internal space, examples (courtesy of IMO)

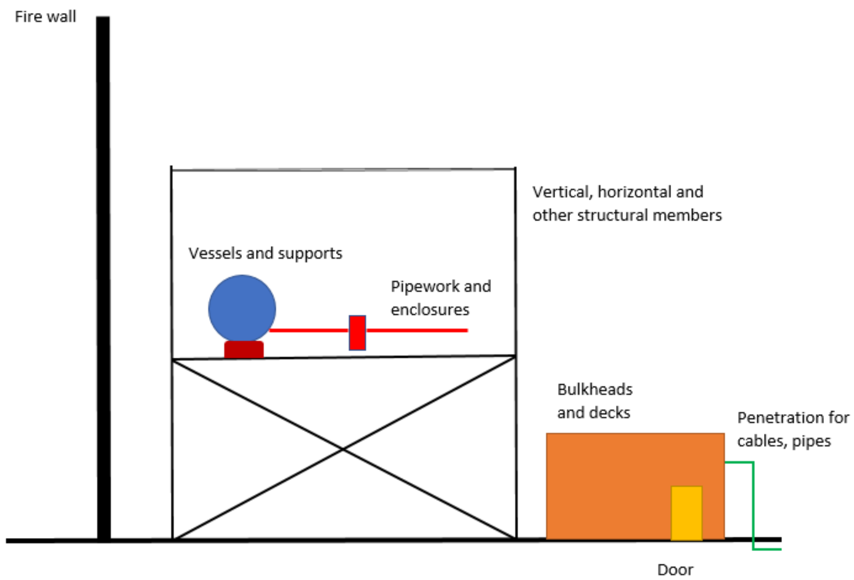

Figure 3 PFP components, external area examples

The above list is not exhaustive. It is based on a review of certificates currently available. Note that some items (e.g. Jet fire resistant doors, H-class fire dampers/ventilation ducts) are not included, either because of the lack of applicable test methods, or because they are deemed not significantly relevant to the hydrocarbon PFP market. The aim is to extend the list as soon as new standards become available and accepted by the industry.

Typically, test standards focus on the test method and rarely provide guidance on an approval process and there are cases where the available standards are not definitive for all types of PFP. This situation creates a degree of freedom for organisations providing the approval or certification to select the standard they consider most appropriate for their assessment and establish bespoke type approvals for products.

This can be perceived as an inconsistent approach, especially when approval is sought from more than one society. Ideally, the development or adoption of certain standards as best practices industry groups, jointly with the production of similarly, shared, type approval procedures, would minimise the opportunity for inconsistent or diverging interpretations going forward.

Equally, the adoption of a common structure for certificates that provide all the information required to enable all stakeholders to use them consistently and effectively would benefit the industry.

A sample certificate structure, containing what is considered to be necessary information, is proposed in Appendix A.

3.2.3 Certification and Approval other than Type Approval

At times scenarios may occur outside of the scope of the type approval - a deviation from an existing standard may be required, or project requirements may drive the need to generate a technical judgement based upon available data that the standards do not address. In these cases, a design approval document, design verification or independent validation may be required. They may also issue witness certificates to confirm the results of tests undertaken in accordance with proprietary, company specific or bespoke fire tests.

There is a risk that some organisations may produce design appraisals or witness certificates as though they were 'full' certificates. Design appraisal / verification documents are generally project specific outside of type approval and whilst these may have applicability to other projects, the issuing authority would normally require some involvement in ensuring continued applicability.

Witness certificates in particular should be clearly differentiated from type approvals, as they do not typically include assessment of the results, nor do they elaborate on the applicability or range of validity of a product or its design.

A technical assessment of the test data and witness report conducted by others such as test laboratories, consultants, etc. would still need to be reviewed and accepted by the authority on a project specific basis as part of a design assessment.

The use of the term "certificate" for such witness statements may be seen as confusing, if "certification" is seen as a record of full compliance with national or international standards. Generally these are only confirmation of specific data recorded during the test and of particular key elements in relation to conducting the test in accordance with the standard.

It is important therefore, that the receiver of the assurance documentation is fully aware of the nuances of the standard test, how the bespoke test differs from the standard test, and how a witness certificate differs from a formal approval certificate.

Where bespoke testing is used then specifiers of PFP should be aware that this should only be applied in the absence of a suitable test standard. Assessment of these tests may be restricted to a 'statement of opinion' based on the witnessing of a test, or on a review of the test report. This should not be viewed as a project specific design appraisal produced by Class Societies for project verification purposes.

3.3 Type Approval for Different Protected Items

3.3.1 General

The following sections provide an overview of the type approval certification requirements for each of the groups of items that are listed in section 3.2.2.

Certain requirements are applicable to all approvals and may require the certifying body to be involved in the production of test specimens, confirmation of the suitability of the test laboratory, and in the execution of the test. Activities will include survey and witness, design assessment and finally, issuance of the certificate. Ideally type approval certificates are issued to the manufacturer of the product but certificates may also be issued to companies who market the product. In the latter case additional documentation and assurance activities may be necessary to ensure clarity of ownership and traceability of manufacturing.

The following documentation would typically be required for type approval purposes:

- Request for type approval
- Description of the product/system and details of construction and/or composition (as applicable), together with specifications of materials used
- Drawings of product/system (or other equivalent documentation), for intended general applications, and of proposed test specimens (as applicable)
- Details of product designation, identification and marking
- Design details and supporting calculations (as applicable), including details of any software used for design purposes (if applicable)
- Proposed range of application and operational limitations, including details of any installation or construction procedure, or in-service or maintenance requirement or guidance
- Proposed testing program
- Fire test reports
- Other test reports and manufacturing records (if required)
- Documentation on in-service experience (if required)
- Survey and witness reports (as applicable)

Other documentation may also be required depending on the type of product or application under consideration. The type approval process is summarised in the flowchart given in Figure 4.

Stage 1
Application for Type Approval

Applicant should discuss requirements with certifying body to agree objectives, test program, deliverables and scope of the approval.

On completion of testing applicant formally requests approval and submits supporting evidence.

Stage 2
Preparation of test specimens and completion of test program

Certifying body may witness specimen preparation or may delegate to accredited test laboratory which will be agreed in advance.

Test conducted at a laboratory that is accredited and acceptable to the certifying body.

Tests may need to be witnessed by the authority or may delegate to accredited laboratory.

Laboratory issues test reports and these are submitted by the applicant with the approval application.

Stage 3
Assessment and issue of type approval

Applicant should discuss requirements with certifying body to agree objectives, test program, deliverables and scope of the approval.

On completion of testing applicant formally requests approval and submits supporting evidence.

Figure 4 Type approval process chart

3.3.2 H-Class Divisions (Walls, Bulkheads and Decks)

Testing methodologies and certificates for these systems are based on furnace testing using a hydrocarbon fire time/temperature curve, on specimens constructed in accordance with an applicable standard (e.g. 2010 IMO FTP Code Part 3, or ISO 20902-1).

The products in this category could be of various types, such as:

- Cementitious or fibre spray applied materials.
- Intumescent paint coatings.
- Ceramic or mineral wool type materials supplied in slabs or rolls and retained on the division by pins.
- Fire resisting boards or panels supported by appropriate structures.
- Composite system constructions using more than one of the above material types.

The certifying body will impose conditions that will be included in the certificate specific to PFP type and design, so they can be confident the 'as-built' construction conforms to the 'as-tested' arrangements. Imposed conditions may include requirements for application/installation, density, thickness, retention methods, reinforcement or joining arrangements.

The test standard for bulkhead and deck specimens generally includes details for the type and size of stiffeners to be used but these may not be representative of those used in an actual construction. For certain types of PFP the insulation details for stiffening and supporting structures may form part of the approval.

The PFP may have been tested on the unexposed or exposed side of the division, or both sides. The application may be approved for general use or restricted use, allowing the PFP to be specified for fire against either side of the division, or against the insulated side only. The detail of the certificate must be read and understood.

Limitation of approval for load bearing constructions, where the maximum allowable temperature of the structural core after specific durations, may or may not be stated depending upon the test standard being employed. Acceptability criteria in this case would include, in addition to integrity, the maximum temperature rise on the unexposed side only, so structural stability should be addressed separately. This would make type approval certificates for fire protection systems for divisions unsuited for use with stiffened panels or plating not forming a fire barrier between two spaces, such as saddles and supports. This is because the test method would not be representative of this fire scenario.

When insulation materials are combustible they may only be used for outdoor applications, or areas not normally manned. Smoke and toxicity requirements for such areas should be treated differently to internal areas and those that are normally manned.

The substrate (e.g. steel, aluminium alloys) used in testing is also relevant to the performance of the system and would limit the approval.

3.3.3 H-Class Doors and/or Windows

Furnace testing of door or window assemblies should be undertaken in line with the applicable standards. Doors may be hinged or sliding and can be single or double leaf. They may include hose ports or windows which may be of monolithic or multi-layer construction and may include mullions to provide more than one glazed panel. All these features will impact the extent of testing and the approval.

Based on the tests undertaken, typical conditions and limitations applicable for the certification of doors and windows would be related to:

- The maximum size, and possibly aspect ratio.
- Construction and hardware (frame, insulation materials, adhesives for doors, spacers for windows, gaskets, hinges, latching and locking mechanisms).

- Connections to the bulkhead or wall in which they are to be fitted (welding: continuous or not, single or double sided, bolting: size and spacing).

Insulation materials are required to be non-combustible and adhesives are required to have low flame spread characteristics.

Gaskets are often fitted in and around doors and when the gasket is installed in the door or frame such that it contributes to the fire integrity of the door (rather than externally or additionally to it), the gasket is normally required to be either non-combustible or the gasket should be included as part of the 'as-tested' construction to confirm it would not lead to failure.

3.3.4 H-Class Penetration Systems (for Pipes and/or Cables)

Testing of penetration systems should be undertaken in accordance with applicable standards which are fairly well established.

There is a very large range of materials and constructions for the different sealing systems as well as a wide range of possible combinations of penetration devices and sizes (e.g. single and multiple pipes and cables, steel sections, etc.). This means that a test program for type approval purposes is likely to include numerous options and specimens. The number and detail of these would normally be the result of agreement between the applicant, the certifying body, and occasionally, the fire testing laboratory.

As a general principle for approval; penetrations should not include visible openings to prevent the passage of smoke or combustion products. They should not be susceptible to damage due to vibration, over-pressure, under-pressure, minor impact, or movement of the division through which they are fitted (e.g. following ship motions or loading). Where appropriate, methods of construction should therefore include mechanical systems to ensure connection and prevent separation or loosening of systems made of different parts (e.g. blocks, collars).

Upon completion of the test program, it is common for type approval certificates for penetration systems to include many possible arrangements, to reference manufacturer's drawings, and have numerous conditions and limitations imposed such as:

- Maximum size of the penetration.
- Maximum and minimum size of the penetrating element.
- Type of penetrating element.
- Number of penetrations in a given sized area.
- Method of connection of the penetration device to the deck or bulkhead.

Particular care should be taken in the design, testing and approval of systems where fire insulation materials are necessary to achieve a certain fire rating, as this may lead to limitations with respect to the direction in which the penetration may be installed (e.g. fire on the insulated side only), or to the extent and type of insulation to be used. Any such limitation would then remain applicable to any project specific installation.

3.3.5 H-Class Fire Resistant Non-Load Bearing Partitions and Barriers

Some fire separation barriers are not load bearing with the load capacity provided by other structural elements to which the barrier is connected. Examples include cladding or panelling systems used in conjunction with a supporting structural frame. Other barriers may be self-supporting e.g. for internal divisions use.

Non-load bearing barriers often consist of thin sheet single, multi-layer or sandwich metal plating that provides the necessary integrity and stability, in conjunction with an insulating material such as mineral or AES wool. Alternatively, an intumescent coating or other coating may be used for outdoor applications.

As with load bearing divisions, furnace testing should be undertaken to prove fire performance for type approval purposes. Typical approval limitations may include:

- Maximum size of panel.
- Method of construction and assembling.
- Joint and connection details.

Additional care should be taken when evaluating the ability of such divisions to be fitted with penetrations, as penetration being normally tested and approved for use on load bearing divisions, they may not perform in the same manner in lighter constructions.

3.3.6 Hydrocarbon Fire Protection Systems for Structural Sections

Structural elements used in construction of facilities vary widely in terms of shape and size and to obtain approval it is necessary for the fire test program to reflect this range. Fire resistance testing of structural elements should also give confidence that the PFP design maintains the load bearing capacity of the element during fire exposure. Therefore, the fire test schedule should include testing of elements under load. International standards, national standards and guidelines such as UL 1709, ISO 834, EN-13381-4, EN 13381-8 and BS 476 are well established. In many cases these will define the testing protocol, the specimen selection process and the method for analysing the test data.

Type approval would identify the shape and range of section sizes tested as well as PFP material thickness at a prescribed range of fire endurance times such as 30, 60, 120 minutes, for specific limiting temperatures.

The PFP thickness will be related to a function based on the mass and exposed surface of the tested section, i.e. the section-factor (Hp/A, A/V or W/D). The Type Approval covers all surfaces being protected (commonly referred to as “4 sided”). Thickness does not apply to scenarios where one or more of the surfaces are left unprotected but where the steel section is exposed to fire on all surfaces. One common engineering practice is where the top-flange is left unprotected but where all surfaces are exposed to fire. Without an appropriate engineering and product evaluation of this specific case, type approval thickness should not be applied.

The type approval is valid only for the tested range of section factors (Hp/A, etc.). The calculations used to generate the data that is included in the Type approval certification is generally performed by an approved organisation. It is also possible for the calculations to be produced by the manufacturer and then verified by the approved organisation. In either case the test data and the assessment calculations are also reviewed by the certifying body.

Different approval bodies may use different standards when issuing type approval. It is important therefore, that the basis and limitations of each certificate are well understood. Other factors to consider in the applicability of the approval would include density, application or installation method, and construction detail.

The process can become quite complex when one is looking to gain test data and certification to a range of requirements and so this subject will be considered in subsequent parts of the TAC guidance.

3.3.7 Jet fire Protection Systems for Divisions (Walls, Bulkheads and/or Decks)

Jet fire testing in accordance with a recognised and suitable standard (generally ISO 22899-1), are required to assess the performance of the system.

For PFP coatings, the thickness for jet fire exposure is generally determined by adding a “Jet Fire Erosion Factor” to the type approval certificate thickness obtained from hydrocarbon furnace testing. Acceptance criteria is based on the time for the maximum single-point temperature rise to exceed a defined value.

3.3.8 Jet Fire Protection Systems for Structural Steel (I and Hollow Sections)

Jet fire testing should supplement hydrocarbon fire testing to confirm system performance. It should be noted that the standards mentioned above for hydrocarbon fire testing of structural sections do not extend to jet fire testing, and jet fire testing methods do not lend themselves to cover the range of sections which would be tested for hydrocarbon fires. Currently there is no accepted methodology for devising the test program or interpolating the results. For PFP coatings the thickness for jet fire exposure is generally determined by adding a “Jet Fire Erosion Factor” to the thickness required from hydrocarbon testing. The Jet Fire Erosion Factor for structural elements may not necessarily be the same as for divisions.

3.3.9 Jet Fire Resistant Non-Load Bearing Partitions and Barriers

Non-load bearing cladding or panelling systems may be capable of withstanding jet fires, and therefore have been mentioned separately from load bearing divisions. Similarly, jet fire testing should be conducted when seeking Type Approval, and, for coatings, that should be in addition to hydrocarbon furnace fire testing. Approval would typically be limited to a jet fire impinging on the same surface as that tested.

3.3.10 Jet Fire Protection Systems for Penetrations (Pipes and/or Cables)

Jet fire testing in accordance with a recognised and suitable standard (ISO 22899-1) is required to assess the performance of the system. As discussed earlier the wide range of penetration geometries and potential penetrating elements may require extensive testing programs if a wide range of approval is sought. Approval would typically be limited to a jet fire impinging on the same construction as that tested.

3.3.11 Dry-Fit Systems for Equipment, etc. (Hydrocarbon Fire and/or Jet Fire)

The wide variety of systems used to protect pipes, valves actuators, flanges, and similar items mean that it is impossible to cover them all in this document, but they include systems such as rigid enclosures, jackets, panels, etc. Similar construction cladding systems are also used for the protection of vessels and structural elements.

Although certified products are available there is actually no dedicated test standard or method for hydrocarbon or jet fire exposure. Typically such certificates are based on testing on divisions or assemblies, which may not be representative of the enclosure or cladding construction. Most products include one or more joints with various fixing and retention arrangements, and it is essential that these details are tested in the most onerous arrangement and they must be representative of the ‘end-use’ construction.

The testing of such arrangements will be covered in more detail in Part 2 of the TAC guidance document.

Additionally, the item being protected will have its own performance criteria that will affect the validity of the test data and the approval.

Although type approval remains a preliminary step, it is essential for this type of PFP that the design, construction and test method are fully detailed, and its applicability to the end use requirement fully understood. If the approval certificate does not have this level of detail then reference to the test report is additionally recommended.

Project specific solutions developed on the basis of certification should be assessed by a competent authority as suitable for the intended application at the design stage.

3.3.12 Other Systems for Equipment, etc. (Hydrocarbon Fire and/or Jet Fire)

There is a wide variety of systems that do not fit into the above categories and are used to protect pipes, valves actuators, flanges, and similar items. For example, a PFP coating applied directly to the surface of a valve would require an example of the assembly to be tested. It is not acceptable to simply use, for example, the data from a structural test.

3.4 Beyond Certification and Type Approval

3.4.1 PFP Assurance for a Project

Standard fire tests do not represent real fires but provide methods that enable the response to fire of candidate materials to be evaluated under agreed standard conditions. This enables the comparison of the performance of different products when exposed to a fire that can be consistently reproduced. Approval certification issued on that basis should therefore not be considered sufficient to prove that a product is adequate to meet the performance requirements of each and every project.

It is for this reason that Class Organisations may require design verification for each project so they can confirm that, for the application under consideration, there is reliable and traceable evidence demonstrating how the required performance has been achieved. An example of this can be seen on most Type Approval certificates where a phrase similar to the following may be seen… "*Application in each case to be approved by Class at the design stage*".

It is important to identify who is competent to perform such verification activity, and what process should be followed. The competency and activities required can vary significantly depending on the type of product, what is to be protected and how the product is installed. The necessary supporting information may often go beyond the contents of reference certificates and project specifications or drawings.

As examples:

- When assessing the suitability of a PFP coating on structural steelwork a review of thickness calculations and type approval certificates may suffice, however, assessing the suitability of the same material when applied to the supports of a hydrocarbon pressure vessel may require additional information such as the effect of the vessel temperature at the connected interface.

- For a more complex requirement such as the use of fire protection on pressure vessel walls a more detailed assessment may be needed, including the use of tools such as software modelling.

3.4.2 PFP Assurance During Manufacturing and Construction

It is normally a condition of type approval certification that PFP is manufactured in accordance with an acceptable quality control system such as ISO 9001, and that this is maintained throughout the validity period of the certificate (5 years in the case of Class organisations). The expectation would also be for manufacturer's production and quality systems to be periodically assessed by a competent organisation to confirm materials continue to conform to the tested and type approved prototype. Note that some approval/certification bodies carry out their own auditing of the manufacturing process.

Installation of the PFP would be expected to be in accordance with the 'as-tested' design and the manufacturer's requirements (including drawings where applicable). These details must form part of the review during the design approval process and be clearly referenced in the certificate (although it is recognised they may be updated by the manufacturer during the period of validity). This information should be made available and taken into consideration for any project specific assessment and in sub-supplier or survey documentation packages.

3.4.3 PFP Assurance In-Service

The type approval process (or project specific assessment) will assess and certify PFP performance when installed according to the approval documentation, and generally in the 'as new' condition. The process does not normally consider the performance of a PFP system during its lifecycle on site, and therefore does not take into consideration any reduction in performance over time.

Currently the owner or duty holder of the facility has the responsibility to ensure the selected PFP can meet the performance requirements throughout the expected life and operational conditions.

In the absence of agreed methods, the means by which this is achieved is open to interpretation and this is an area for improvement where industry can agree on the development of suitable tests and acceptance criteria.

4 Testing to Demonstrate Performance and Compliance

Key points

Testing is undertaken to demonstrate PFP performance and compliance to design specifications.

Both Reaction to Fire, and Fire Resistance tests may be required. Fire Resistance testing is the dominant type of testing for hydrocarbon fire protection.

This guide provides an overview of the testing that is required to assure performance of PFP in the hydrocarbon industries. Part 2 of the TAC guide will detail the individual test and how they are used.

The testing undertaken should be as representative of the project application as possible.

Performance testing is not restricted to fire testing. There may be a need to undergo other testing such explosion resistance, cryogenic spill resistance, weathering, etc.

4.1 Introduction

Testing is undertaken to demonstrate PFP performance and compliance to design specifications.

The primary role for PFP is the protection of critical items against the thermal effects of fire therefore this section will focus mainly on this aspect. Other hazards and required performance of PFP is covered in later sections.

Details of fire types are given in the PFPNet Roadmap but essentially for testing purposes the hydrocarbon fire protection industry recognises two very broad classifications:

Cellulosic fires

Fuelled by combustible cellulose-containing products such as wood and paper. Cellulosic fires are generally related to the use of PFP materials in buildings but also relevant to items such as decks and bulkheads in accommodation modules and other occupied units offshore where fire conditions are more representative of this time temperature furnace condition than that expected from hydrocarbon fire testing.

Hydrocarbon fires

Fuelled by combustible hydrocarbon products such as natural gas, condensate, LNG, oil, etc. Generally considered to be a threat from two types of release:

- Non-pressurised (i.e. ambient or very low pressure).

  Loss of containment of non-pressurised liquid inventory may form a pool of flammable inventory, which if ignited may result in a pool fire.

- Pressurised releases (i.e. moderate to high pressure).

  Loss of containment of pressurised inventory may result in a gas jet fire or a spray fire. Jet fires are highly directional, have high momentum and hence have the potential to rapidly heat impinged items and erode any protective PFP.

Fire scenarios are also possible that are a combination of these types of fires.

Note that methanol fires, hydrogen fires and tunnel fires and associated testing are not considered in this guidance document, however, much of the information will be relevant.

Fire testing is split into two broad categories:

- Reaction to fire.
- Fire resistance.

For industries associated with hydrocarbon fire threats the majority of fire testing conducted falls under the fire resistance category. A limited number of reaction to fire tests are conducted primarily for use on offshore modules where approvals from the marine classification societies are required.

4.2 Reaction to fire

4.2.1 General

Reaction to fire tests assess the contribution of material to the development and spread of fire. How a fire develops in the very early stages is of crucial importance to ensure safe evacuation.

Reaction to fire testing in the hydrocarbons industries are typically related to the use of materials in occupied spaces such as accommodation modules offshore where IMO Resolution MSC 307 (88) FTP 2010 Code [2] is the standard used. Onshore occupied buildings will normally come under relevant local building regulations although some tests may be similar.

FTP 2010 has several reaction to fire tests for materials used in ships, the majority of which are concerned with ceiling linings, textiles, bedding, floor coverings, etc. As these tests are not required for the assessment of PFP they are not discussed in this guide.

Reaction to fire tests tend to be smaller in scale than fire resistance tests and are carried out on the components of the PFP system. As well as FTP 2010 Code requirements, a relevant authority may require these or similar tests to be completed.

Required tests are normally conducted to evaluate ignition potential, flame spread, smoke generation and the development of toxic fumes. The most commonly required tests are discussed below.

4.2.2 Non-Combustibility Testing

For occupied spaces such as accommodation modules, PFP is required to be non-combustible. Where PFP is used that does not meet this requirement then it will be restricted for use in external areas only, or areas that are not normally manned. FTP 2010 requires combustibility testing to ISO 1182, where small strips of material are inserted into a cylindrical furnace at 750 °C and combustibility is assessed based on temperature rise in the furnace or the presence of flaming.

4.2.3 Surface Spread of Flame Testing

PFP and associated products such as topcoats may burn and contribute to the spread of flame from one area to another. To evaluate this, a number of similar standard tests are available which evaluate the distance flame will travel along a surface away from a heat source such as a flame or a radiant panel. For offshore FTP 2010 requires the use of ISO 5658-2. Other tests used for other jurisdictions include BS476-7 and ASTM E84.

4.2.4 Smoke and Toxicity Testing

Where PFP materials are combustible they may give off large volumes of smoke and in many cases toxic or asphyxiating gases. Although combustible PFP is precluded for use in occupied areas, the extensive use of PFP externally on an offshore facility could produce smoke and toxic fumes that may affect the ability for personnel to muster and evacuate, affecting breathing and/or visibility. It is required that material are evaluated appropriately for their specific end use. FTP 2010 requires a smoke and a toxic fume test according to ISO 5659-2 for materials used in internal occupied spaces. Test materials are exposed to a radiant cone heater in an enclosed space; the accumulation of smoke and toxicants are measured during well-ventilated combustion.

4.2.5 General Requirements for Specimen Preparation

Specimens shall be prepared, conditioned and presented for testing in accordance with the relevant method, and other relevant technical specification. For reaction to fire tests, the substrate can have a significant impact on the performance. It is therefore essential that the ‘as tested’ construction is representative of the end use application.

4.3 Hydrocarbon (Pool) Fire Resistance Testing

4.3.1 General

For the purposes of evaluating PFP intended for use in hydrocarbon pool fires, some tests are conducted in enclosed furnaces using standardised fire test curves. These time/temperature curves are used to control the test furnace, to provide an indication of the likely PFP performance if exposed to a real fire, e.g. tests conducted to UL1709, ISO 834, etc. A comprehensive list of fire test standards used in the hydrocarbon industries is provided in Appendix B.

There are also standard and non-standard fire tests that are conducted in the open. An example of a standard semi-open fire test is the ISO 22899-1 jet fire test and open LPG vessel fire test ISO 21843.

Standard fire tests do not replicate ‘real fires’. Real fires exhibit a wide range of properties depending on fuel, ventilation, confinement, etc., and jet fires depend additionally on inventory pressure, leak-hole size and shape.

Standard fire tests provide the means to evaluate PFP performance and the thermal response of the protected substrate over a defined period; and to compare one PFP against another to the same standard test. This allows PFP specialists to make informed choices as to the suitability of PFP systems for the protection of critical structural components and equipment.

Hydrocarbon fire resistance tests are generally conducted to evaluate:

- Loadbearing elements that do not fulfil a fire separating function such as structural steelwork: beams, columns, hollow-sections, channel, angle and elements fabricated from plate steel. Including supports for critical process equipment such as saddles and skirts.
- Loadbearing elements that also provide a fire separating function, with or without glazing, services and fixtures. These include bulkheads/walls; decks/floors/roofs.
- Non-loadbearing fire separating elements with or without glazing, services and fixtures. These include partitions; bulkheads/walls; decks/floors/ceilings; fire doors

and shutters and their closing devices; smoke control doors; penetration seals; service ducts.

- Critical process equipment such as valves, actuators and critical control systems, pressure vessels, etc.

Test specimens should be as representative of the end use application as possible, evaluating not only the PFP but also the method of construction, installation and where possible realistic imposed loads. Where it is not possible to test directly representative specimens, it may be necessary to test indicative specimens. Indicative specimens will be less informative than large scale testing and the data obtained from the test must be used with caution.

It is essential that the limitations of the test, the specimen and its construction, approval certification and their relevance to the end use be must be fully understood. One cannot assume that testing and certification for one set of conditions automatically confers suitability for every other scenario. Where there is sufficient difference between the tested construction and the end use application then additional testing may be required.

For example, if a separating element is likely to undergo a load induced deformation in a fire, then the appropriate fire resistance test would be one that imposes a similar load for it to be fully representative. Where that separating element is also at risk of exposure to jet fire, then additional jet fire testing would be appropriate.

4.3.2 Design of Specimen and Choice of Test Conditions

The dimensions of test specimens shall normally be full size, or in accordance with the test standard. Results obtained for a given span, height or width can generally be considered valid for a smaller span, height or width. For non-load bearing elements, heat transfer evaluations for span, height or width larger than tested are appropriate for project application within the scope of the section factor tested. However for load-bearing considerations, conservative limiting temperatures may be employed to account for scale.

Test results may be viewed as only applicable to real-world elements with identical constructional detail. However, test results generated by industry accepted test methodologies may be viewed as suitable for application to projects, subject to design verification.

Where the test exposes the specimen to a certain loading, e.g. a particular fire curve and/or a mechanical load, usually the outcomes of the test can be extended to less onerous load scenarios.

When choosing the required loading, a range of parameters may require testing unless the most severe case is known.

4.3.3 Fire Resistance Testing of Structural H-Section and Hollow Section Steel Columns and Beams

Fire testing of steel columns and beams (often referred to as elements of construction in various standards) is probably the most frequently used and widely known form of fire resistance testing. Such fire tests are conducted in furnaces that are controlled to defined standard fire test curves. This type of fire testing started many decades ago primarily for steelwork used in buildings where the ‘cellulosic’ fire test curve is used. For the hydrocarbon industries a ‘hydrocarbon’ curve is used. Hydrocarbon fire test curves produce higher peak temperatures than cellulosic fire test curves and reach the peak temperatures in a shorter time than cellulosic fire test curves. The test is therefore more onerous than for a cellulosic fire.

When testing steel columns and beams for hydrocarbon exposure there is little guidance as to what should be tested although the sections selected should be representative of those used in real projects. Despite this lack of formal guidance, the hydrocarbon industry has adopted an approach that is based on cellulosic testing for the building industry, as noted earlier. The method of testing, placement of thermocouples, etc. also adopts standards and guidance from the building industry.

In essence, a range of steel columns and beams of both open profile (e.g. H-section, angles, etc.) and closed profile (hollow tubes, rectangles, etc.) are tested that encompass the wide range of section sizes that will be encountered in real projects. . Unlike testing adopted for the built environment, loaded beam testing is only conducted to determine stickability at maximum thickness for spray applied PFP, and to determine correction factors to be applied in the event the loaded specimen gives poorer performance than the equivalent short section tested in the same fire test. Once the correction factors and maximum thickness are established, testing from column data determines the thickness to be applied for projects. In the process industries beams used to support concrete decks are rarely, if ever encountered.

The steel will have thermocouples attached using various methods as defined by the individual test standard. During the test the rise in steel temperature is monitored as the furnace temperature rises in accordance with the defined fire test curve.

Depending on the type of PFP being tested a range of different thickness of protection material may be evaluated. This data along with the steel temperature rise data will be assessed and then used to provide a set of tables that defined the required thickness against section size (A/V, Hp/A, W/D, etc.) for given critical core temperatures (CCTs) and fire durations.

4.3.4 Fire-Resisting Doors and Fire Door Furniture

Where a fire barrier has to be penetrated by a door these should be designed and tested to limit the spread of fire and products of combustion. There are essentially two types of fire resisting doors:

- Door assemblies - normally assembled on-site from components which have been fire tested (or assessed) as being capable of working together.
- Door-sets - consist of the door, its frame and hardware tested as a matched set of components.

To fulfil their mechanical and movement functions it is necessary to provide movement gaps. These gaps are protected against fire by the use of sealing strips that expand in a fire to seal-off the movement gap.

Fire-resisting doors are not effective unless they are closed. Self-closing devices ensure that fire-resisting doors re-close each time they are opened.

Fire-resisting doors, frames, self-closing devices and latch systems all require fire testing to ensure required fire performance. Substitute components shall not be used unless they have been assessed by a competent authority and suitably certified. Note that hardware does not have an independent fire test report but is included in the fire test report for the tested door-set.

4.3.5 Fire Shutters

Shutters are generally considered along with fire-resisting doors. They will generally be referred to as ‘a door, or shutter, for the passage of persons, air or objects, together with its frame and furniture (when closed) to resist the passage of fire and/or gaseous products of combustion and is capable of meeting specified performance criteria’.

4.3.6 Fire Barriers – Bulkhead/Wall, Deck/Roof/Floor

Compartmentation using decks and bulkheads (or other fire separation barriers) are a fundamental method for mitigating the spread of fire, smoke and hot gases from one area to another. Barriers may be load bearing or non-load bearing and require testing accordingly. The objectives of fire barriers are:

To prevent rapid spread of fire and products of combustion which may endanger occupants

To prevent a small fire growing to threaten occupants, people in the vicinity and first responders who may have to enter an area to affect a rescue.

In most fire separation barriers are designed to protect from fire on one side of the barrier and so testing would reflect that configuration. For separating elements that are required to be fire resisting from both sides, two specimens shall be tested (one for each direction) unless the separating element is fully symmetrical. Where fire-separating elements are tested with the PFP on one side only, it cannot be assumed the test is representative where the fire is from the other side or from both sides.

Asymmetrical fire separating elements may be tested from one side only if it is from the weaker side or the element is only to be classified for fire attack from one side.

4.3.7 Penetration Sealing Systems

Penetrations through barriers should be protected with suitably designed and tested solutions that ensure the fire-rating of the barrier is not reduced. This should be confirmed by manufacturers testing their design in a barrier test specimen.

When specifying and installing care should be taken to ensure the design complies with the ‘as tested’ construction. Apertures should be kept as small as possible and fire-sealed in such a way that relative movement of the service and the barrier will not disturb the penetration seal. Where penetrations such as steel pipes or structural elements pass through a fire barrier, it may be necessary to insulate along the length of the penetrating item to minimise heat transfer. If this insulation forms part of the fire test specimen then it must be considered part of the design and always implemented when installed on a project.

Specifiers must ensure that the intended penetration seal is tested, certified where required and installed in accordance with the construction detail used in the test.

4.3.8 Air Distribution Systems

The detailed design of ducts for air movement (ventilation, air conditioning, heating) is beyond the scope of this document, however, where air handling ducts pass through fire separating elements the integrity of those elements is maintained by using one of three basic methods:

- Protection using fire dampers.
- Protection using fire resistant enclosures.
- Protection using fire-resisting ductwork.

When utilising any of the above methods, care should be taken to ensure that adequate test evidence is available for the particular circumstances, or a valid independent assessment has been obtained.

4.3.9 Fire-Resisting Glazing Systems

In the MAH industries glazing is kept to a minimum for protection against fire and explosion. When glazing is used and where it penetrates a fire-resistant barrier then it must be tested.

Glazing requires mounting in an appropriate frame and should be tested together with all the correct components required by the glazed system.

4.4 Jet Fire Resistance Testing

Jet fires are highly directional releases of ignited gas or liquid. Where PFP is concerned, jet fires can be more damaging than pool fires because, in combination with high levels of total heat flux, the forces imparted by the high fluid velocity can penetrate and break apart materials. Where reactive coatings (e.g. intumescent) are concerned, jet fires can interfere with char development by inhibiting expansion or by separating layers before char stabilisation occurs, or simply eroding away char at a rate that is too fast for effective char stabilisation to occur.

There is currently only one industry-standard jet fire test, which is ISO 22899-1 (see figure 5). The standard consists of Part 1 which defines the test method and Part 2 (ISO-TR 22899-2) which is informative. Both parts of ISO 22899 are currently under review and the reader is encouraged to seek out the latest version.

Figure 5 ISO22899-1 jet fire test

The two main test configurations in ISO22899-1 are the structural and tubular samples. In structural jet fire tests, the jet is aimed into a 0.5 m deep, 1.5 m square box with a flange feature. The 0.5 m deep box provides a flame recirculation chamber necessary to achieve the desired heat flux values. In tubular tests, the jet is aimed onto a tubular section (diameter 350 mm) situated in front of the recirculation chamber. Penetration sealing systems and similar samples are mounted into a plate surrounded by the recirculation chamber.

Depending on the materials tested and their intended use, the standard jet fire test can be used as a standalone test or as a complimentary test. For preformed products such as pipe jackets, valve enclosures etc. it is used as a standalone test demonstrating jet fire resistance. For coatings materials it is used additionally to calculate a ‘jet fire erosion factor’ that is used to determine the extra material thickness required on top of the coating thicknesses determined from furnace testing using the hydrocarbon fire curve.

The ISO 22899-1 jet fire test has been characterised extensively and the maximum total heat flux obtained is generally accepted to be in the region of 300 kWm^2.

Although ISO 22899-1 jet fire testing has been widely accepted and used by the hydrocarbons industry over many years, there is opinion that it may not be onerous enough for some circumstances. Some guidance documents state that the maximum heat flux occurring in jet fires with large release rates can exceed 300 kW/m^2. The result of this has been the development of "high heat flux" (HHF) tests, and whilst there is no currently recognised national or international standard test, assessment reports by Class Societies have been issued.

Recent discussions have been held by Norwegian and UK based organisations including the relevant regulatory authorities to establish a common, standard treatment for high heat flux testing, and in time, to work towards develop an accepted test standard.

4.5 Process Vessel Fire Testing

The fire response of vessels containing pressurised liquids is influenced by the inventory composition and by the liquid fill level which will vary during normal use. Below the liquid level the temperature of the vessel wall will rise more slowly than above the liquid level. It is therefore difficult to assess the fire protection afforded by a PFP material from the standard suite of fire tests noted above and a limited number of tests for pressure vessels have been developed.

- Historically, a sponsored test programme called GASAFE was undertaken in France which involved various tests on PFP products, including testing on a pressure vessel and a jet fire evaluation. However, once the sponsored work had been concluded the programme closed. This meant that PFP materials not available at the time (or not included due to funding) cannot be tested to this scheme and the use of GASAFE as a measure of performance is generally not used.

- Over recent years, the most commonly used fire test for PFP systems for pressure vessels is that published by the BAM Institute to the German Federal Standard TRB 801 Nr 25 - Technical Regulations for Pressure Vessels Pressure Vessels for Non-corrosive Gases and Gas Mixtures. This test has become colloquially known as the "BAM test". The test is carried out on small LPG 'bullet tanks' that are part-filled with LPG and then exposed to a hydrocarbon fire using an array of gas burners with propane as the fuel source. This is an open fire and the temperatures achieved are less than those obtained in furnace tests running the hydrocarbon fire test curve listed in standards such as BS476, ISO834 and UL1709.

- In 2018, ISO 21843 was published for the testing of PFP materials on pressure vessels exposed to a hydrocarbon pool fire scenario. It requires that a small vessel is protected with PFP and filled with commercial LPG (typically to 20% by volume) and surrounded by an engulfing flame from propane burners. The engulfing flame must be shown to deliver heat flux of at least 90 kW/m^2 and temperatures (from a minimum of 13 directional flame thermometers) between 670 °C and 1070 °C (average 816 °C to 927 °C) on a calibration vessel test. The test is continued until a desired temperature rise, or pressure rise is observed (or until failure occurs). Due to the newness of the test, no established practice on how to widely apply the results exists. ISO 21843 contains a clause regarding the use of ISO 22899-1 jet fire test data for jet fire exposure on vessels. Note that there is an anomaly in ISO 21843 that makes it impossible to comply with the test method. As the standard cannot be amended and re-issued for some time, an equivalent British Standard is to be published in 2020 to address this anomaly.

Specification and use of PFP on pressure vessel walls is therefore still an area where available testing and guidance is limited, and engineering judgement with or without the benefit of software modelling is required.

4.6 Hose Stream Testing

NFPA 290 (and NFPA 58 Appendix H which is equivalent), evaluate the performance of PFP when exposed to a propane torch fire with and without a hose stream. Unlike ISO 21843, NFPA 290 does not test PFP on an actual pressure vessel. The test specimen is a plate, not smaller than 1.2 m square, nominally 16 mm thick and with thermal parameters equivalent to ASME pressure vessel steel. The propane torch is configured such that the velocity is 64 km/h at the exposed surface of the specimen, and the flame temperature is 1200 °C for the duration of the test. The erosive potential of the NFPA 290 propane torch is substantially lower than in the ISO 22899-1 jet fire. The hose stream is delivered through a defined nozzle size at a pressure of 2.07 bar. The hose stream is intended to simulate a firefighter hose stream impinging onto the tank to evaluate thermal shock and water erosion damage of PFP. A typical NFPA 290 test will run for 50 minutes comprising: 20 minutes torch, 10 minutes torch with hose stream, 20 minutes torch, although the duration of each stage may be altered, and test durations greater than 50 minutes may be evaluated if required

In addition to NFPA 290 there are other hose stream tests such as ASTM E2226-15b for building elements that are not bonded to steel. This could therefore include PFP panels and other jointed system that are ‘dry-fitted’ to a protected item.

All the hose stream tests have in common the need to direct a water stream from a firefighting hose onto a PFP test specimen either during or following a fire exposure test. The nozzle dimensions, the water pressure and stand-off distance will be defined as will the water-play duration and the manner in which the hose stream is directed at the specimen.

Such tests are intended to evaluate the survivability of PFP materials where the application of cold water onto hot PFP may cause shock-cooling effects or may erode or remove PFP post fire exposure.

4.7 Blast Testing

At the time of writing, there is no widely agreed test methodology for exposing materials to blast loads from gas explosions[1]. Some security industry standards exist but these focus on response to loads generated by high explosives, which result in higher overpressures and shorter durations than occur in gas explosions.

Currently most gas-explosion testing is carried out targeting conservative overpressures and whatever durations can be achieved, without reference to the response of the items exposed to the blast. There is currently an effort to develop a test standard focusing on deflection of the substrate as this is the major cause of impairment of PFP materials.

In general, PFP is not used to protect personnel or equipment from explosions but should an explosion event occur, then survival of the PFP would be necessary to provide the required fire protection performance. For these cases it is recommended that testing is undertaken to evaluate survivability.

[1] A new ISO standard is in progress, the first part of which, general methods, will be published during 2020. The reference for this series of standards will be ISO 23693.

4.8 Cryogenic Testing

Currently there are two international standards for cryogenic testing; ISO 20088 Part 1 covers cryogenic liquid spillage (immersion), Part 2 covers vapour exposure and Part 3 covers cryogenic liquid spray exposure. In all cases, liquid nitrogen is used as the cryogenic medium because although it has different properties to LNG, it safer to use, and can cool test samples to lower temperatures.

ISO 20088-1 consists of a 0.5m deep box with a central upright flange 0.25m high. The box is filled with liquid nitrogen until the flange is partially submerged. The box is identical to the structural box used in the ISO22899-1 jet fire test but orientated horizontally rather than vertically. Temperature change with time is recorded via thermocouples located on the underside of the box and inside the flange feature. Where cracking of the coating occurs, it is reported.

ISO 20088-2 concerns the exposure of a box type substrate (same as Part 1 but in the vertical orientation) to vapour from a cryogenic release. The vapour contains a small element of liquid from the pressurised release of cryogenic liquid.

In ISO 20088-3 uses a pressurised release of liquid nitrogen through a nozzle, impinging onto I-section and hollow section geometries. Localised cooling at the point of impingement is substantially greater than is achieved in Part 1 because the film of vapour between the fluid and the specimen surface is suppressed by the force of the jet. The standard is representative of cryogenic jet release with a hole-size of up to 20 mm and a release pressure up to 6 barg.

4.9 PFP Durability and Environmental Testing

When in service, PFP may be subjected to a variety of environmental exposure conditions, many of which can adversely affect fire resistance properties.

Exposure to water, high humidity or condensation can be a significant factor in the degradation of many types of PFP. High levels of UV radiation and excessively high or low temperatures may also contribute to the degradation of certain types of PFP, or components within a PFP system. The concern is that the PFP system is able to provide the required fire resistance even after several years of exposure to the environmental exposure conditions.

Exposure testing of PFP materials and systems should therefore be followed by a suitable fire test that compares the fire performance before and after exposure.

Whilst there is no substitute for ‘real life’ exposure, the time periods required for degradation to occur often means that accelerated weathering tests are required. It should be recognised that accelerated weathering tests have limitations and care should be taken to ensure that the selected test regime is appropriate to both the PFP type and the expected exposure environment.

Currently, the two main standards that evaluate the fire performance of PFP after a range of accelerated weathering exposures are Norsok M501 and UL2431.

Typical accelerated tests include:

- UV exposure cabinets for artificial sunlight exposure.
- Salt spray exposure for PFP used offshore and at coastal locations.
- Water immersion testing.

- Exposure to high humidity and condensation (with and without temperature variations).
- H_2S exposure for contaminated industrial atmospheres.
- Resistance to various chemicals to which a PFP may be exposed during its service life.
- Tests for corrosion (where a PFP coating is used and protection of the substrate for corrosion is of concern).

4.10 Physical, mechanical and thermal property testing of PFP

It is important to understand how PFP materials and systems behave when subjected to loads during service and from deviations to the normal loads under accidental conditions.

Typical testing that may be required depending on PFP type include:

- Compressive strength.
- Tensile strength.
- Flexural strength.
- Young’s Modulus.
- Torsional stability.
- Fatigue resistance.
- Density.
- Water content and water absorption with time (and temperature).
- Thermal conductivity.
- Specific heat capacity.
- Coefficient of thermal expansion.

4.11 Bespoke (ad hoc) Testing

There are many situations where standard tests are either not available or do not represent closely enough the project requirement or exposure case. Where this is the case it may be necessary to develop and use bespoke testing scenarios. Because a test is not a published standard does not necessarily make the test irrelevant. Bespoke testing is a valuable tool not only in the evaluation of candidate PFP systems but also in the development of standard tests. As an example, the ISO 22899-1 jet fire test was originally a bespoke test.

Where possible bespoke testing should be based on, or derived from, standard tests but this is not always possible.

As with all testing, it is important to understand the test conducted, how it relates to other test methods and how these and the results relate to the end use application.

Examples might include testing of PFP materials mounted on an unusual substrate, testing of items such as valves that contain polymers and are expected to fail at low temperatures, testing of damaged materials to determine the consequence of the damage, and the use of combination test methodologies where one hazard is followed by another (e.g. cryogenic exposure prior to jet fire).

4.12 Additional Notes on Testing

4.12.1 Temperatures

Given the wide range of fire tests it is understandable that varying practices exist for measuring temperature data. This is particularly true around the use of absolute temperature and temperature rise, neither of which should be confused with ambient temperature.

Absolute temperature refers to the actual measured temperature of a specimen, and may therefore be used to infer certain physical properties such as strength etc. Temperature rise is simply the temperature increase from an arbitrary starting point. The use of temperature rise terminology is convenient because it easily allows temperature data from tests to be compared, irrespective of differences in the specimen initial starting temperature. Of course, the specimen initial starting temperature is often close to the ambient temperature which can vary with local conditions.

The disadvantage of temperature rise terminology is that it ignores the fact that material properties change with temperature. This might be of relatively minor significance when the starting temperature is 5°C or 10°C at the start of the test but becomes much more relevant when a specimen has been prior exposed to another test – cryogenic exposure for example. When temperature rise terminology is employed, the starting temperature of the specimen and the rise from that value should be reported.

The reporting of average temperature and point temperature is also an issue for some confusion. Where the test conditions are not uniform – a jet fire test for example – it is essential to understand the temperature at individual locations across the specimen. Where heating is more uniform, furnace testing or testing against cryogenic pools for example, temperatures are often averaged across entire specimens or over certain features, for example the flange and the web of structural members in furnace testing.

It is important to understand how PFP is tested with regards to the starting and pass/fail temperature. Commonly used are average values from all test thermocouples, or the single value of the maximum thermocouple. There is the use of absolute temperature and temperature rise. For example, in jet fire testing it is the temperature rise of the maximum thermocouple that is mandated.

This may not be a significant factor when testing in temperate climates but it can be an issue where for example, vessel fire protection is required and the vessel is operating at an elevated temperature. Consider a process vessel that is operating at 120°C and needs to be protected with PFP to a limiting temperature of 300°C, a rise of 180°C. A certified PFP thickness may be based on testing from a starting temperature of 10°C to a failure temperature of 300°C. It cannot be assumed that the PFP thickness would be the same in both cases yet they both have the same limiting temperature. Thus when specifying PFP requirements it is essential to understand how the PFP was tested, the limitation of the test data and how these relate to the design fire protection requirements. It is not always the case that this level of detail is available from a certificate and a move to an agreed minimum set of information would be beneficial, alternatively the user or verifier may require access to the detailed test report.

4.12.2 Sampling and Test Witness Competency

The specimen to be tested must be representative of the end use construction and application of that construction when used in the field. Test results, approvals and certifications should detail the construction so that when considered for use, the person carrying out the evaluation is able to fully understand the way a PFP was tested and if that relates to the end use application.

Where a third-party witness attends a test of PFP materials it is beneficial for the witness to understand both the test method and the expected reaction to fire of the type of PFP under investigation as this will give the best chance for them to identify deviations from the standard test and understand the implications of these on the outcome of the test.

4.12.3 Acceptable Practice on Repeat Testing

Fire tests do not always provide the result that was expected before the test began and there are many reasons why this can occur; experimental concepts might be ill-conceived, specimen construction may be inadequate, component parts or raw materials may be substandard, etc. There is also an element of randomness inherent in fire testing.

Test sponsors have the right to conduct as many tests as they feel are necessary and there is no requirement to release fire test data to third parties if they do not wish to do so. This is an important aspect of PFP development, especially for new materials or systems and to prevent this may stifle innovation. However, it is not acceptable for a test sponsor to continually test the same product/system/construction over and over again until the desired result has been obtained, and to then ignore all the earlier unsuccessful attempts.

Where a PFP manufacturer requests third-party verification, the verifier should ensure, so far as is reasonably practicable, that they are aware of all relevant test data including previous unsuccessful attempts with the same configuration.

It is also unacceptable post-verification, for a PFP manufacturer to request a reassessment that ignores previous inadequate data for more favourable test data subsequently obtained, unless there has been a substantive change to bring about the improved performance. From the verifier's point of view, poor data should only by ignored if there is a valid reason, such as doubt about the validity of the test, or if the data can be proven to be statistical outlier.

4.12.4 Incorrect Use of Test Data when Specifying or Providing PFP for Use

There are a number of common cases where PFP test data (and/or certification) is used incorrectly. Some common misuse cases are:

- The use of approval certificates and test data from fire testing on structural section, or decks and bulkheads in isolation of any other test data, to determine the thickness of PFP required for the protection of process vessels walls based on equivalent Hp/A.
- The use of deck and bulkhead data/certification to determine PFP thickness of vessel saddles and supports.

When a vessel saddle is exposed to fire it is most likely to be fully engulfing and so the use of deck and bulkhead data is inappropriate. A plan view of a saddle would resemble a series of I-section linked together and it is best to use certified data developed for open-profile structural steel sections, based on a calculation of the Hp/A of the saddle.

The use of PFP to protect vessel skirts can, in many cases, present an untested scenario. This is because skirts can range in size from very small diameter to very large diameter, and there may be one or more access holes through which fire and thermal radiation can penetrate. Consequently, skirts may require fire protection on the outside only, or on both the inside and the outside depending whether the skirt opening is closed off. Where only the outer surface is exposed and where the skirt diameter is small, one can treat these in the same way as CHS. Unfortunately, as the diameter of the skirt increases this assumption may become less valid and there is currently no industry agreement at what diameter this transition becomes important for PFP specification.

5 Fire Ratings

Fire ratings are a ‘shorthand’ means for identifying either the performance of a PFP material obtained from testing, or the performance that is required in service. Ratings differ between test standards, classification standards and guidance, and from common usage over many years. This variety has resulted in confusion, and a discussion and recommendations are provided in Appendix C.

6 Conclusions

Fire testing of PFP systems for use in hydrocarbon industries can range from the relatively simple to the relatively complex depending on the scope of test data and approvals required. There is little guidance for many aspects of PFP testing and approval although there are many fire test standards and protocols. Test standards, protocols and guidance offer little direction as to how these tests relate to performance assurance, and the use of PFP to protect critical items of structure and equipment.

This guide, along with Part 2, documents the experience of practitioners within the hydrocarbon PFP industry to provide an overview of how the various parts of the testing and approval process are used, and to some extent how they may be abused.

The process of testing, assessment and assurance of PFP is not a linear process. It can start in several different places and progress in a number of different directions. In some instances, testing occurs before an approval is given. In others, the approval route that is agreed for a project may determine the testing that is undertaken. Additionally, not all projects require a third-party approval from an approval body or organisation. Some projects will accept a test report from an accredited test laboratory. National and local regulations will also have a bearing on what is accepted and what is not.

PFP must be capable of fulfilling its fire protection function for many years after its installed, and also when subjected to other accidental hazards that could occur concurrently, and which could damage it. It is therefore important to prove PFP performance not only in fires (by fire testing) but also against weathering, explosion, cryogenic spill and several other hazards where applicable, all of which require different testing approaches.

As well as protecting critical items against fire (fire resistance testing) it is also important that the PFP does not increase the intensity of a fire, cause the fire to spread, or create an additional hazard to personnel from toxic smoke and fume. To test for these criteria, reaction to fire testing is also undertaken in addition to fire resistance testing and may be used to determine if a PFP system should be excluded from a specific location – for instance excluding a material that produces toxic fumes from an occupied area.

In summary, part 1 of the PFPNet TAC guidance (this guide) is intended only to give an overview of the process of PFP testing, assessment and certification. Detail of the testing, assessment and certification for specific PFP systems (coatings, dry-fit systems, penetrations, etc.) are considered within part 2 of the PFPNet TAC guidance process.

7 References

1. Energy Institute Guidance on passive fire protection for process and storage plant and equipment, First edition, March 2017
2. International Maritime Organisation, Resolution MSC.307(88), International Code for Application of Fire Test Procedures, 2010, (2010 FTP CODE).

8 Useful Reading

1. Standards Norway, Norsok S-001 Technical Safety:2018
2. PFPNet Roadmap Document
3. The Offshore Installations (Offshore Safety Directive) (Safety Case etc.) Regulations 2015
4. HSE, Ian Bradley, A review of the applicability of the jet fire resistance test method to severe release scenarios, 2017.

Appendix A – Suggested Contents of Type Approval Certificate

No	Item
1	Name of the body issuing the certificate
2	Number and revision index of the certificate
3	Date of issue of the certificate
4	Date of expiry of the certificate, if applicable
5	Name of the organization under the authority of which the certifying body is authorised to issue the certificate, if applicable (e.g. a national authority, or national accreditation body)
6	Identification of the product, including name or trade name
7	Identification and details, including name and address/location. of the applicant, and of the manufacturer, if different
8	Type of passive fire protection product
9	Brief description of the approved product
10	Fire test procedure/national or international standard(s) according to which the product has been tested
11	A classification of the product in line with the procedure or standards in accordance which it has been tested, if included in them. If a classification system is used, which was not included in the testing standards, that should also be referenced
12	Type Approval procedure used for performing the approval (type approval procedure would typically be the certification body own one)
13	Full details of any approval documentation which form the basis of the approval (e.g. drawings, test and survey reports, technical assessments, manuals, including traceable references: number, date, revision index etc.)
14	A comprehensive description of the product and its components, of its method of construction and of the specimen(s) and conditions which has/have been tested
15	Any condition, restriction or limitation the certificate is dependent upon, or which should be taken into consideration when using the product as described in the certificate, addressing design, manufacturing and installation stages as appropriate (this would likely be an extremely important section of the certificate, as it should provide all sufficient and necessary information to confirm on a project specific basis that the material is being installed as to achieve the level of performance stated in the certificate: items which would be expected to be covered in this section would include, but may not be limited to:
16	Dimensional requirements or limitations
17	Design Verification activities to be performed on a project specific basis, to the satisfaction of the authority having jurisdictions over that, including list of required project specific documentation to be produced and submitted to the above authority, if applicable

No	Item
18	Manufacturing and installation requirements (e.g. quality control)
19	Details of any interpretation applied by the certifying body when performing the approval, if not covered by the type approval procedure identified above
20	Details of any additional test or performance characteristic of the product, beyond fire performance, which has been considered by the certifying body
21	Any additional information considered relevant for the users of the certificate by the certifying body
22	Identification, qualification and signatures of the certification body representative(s) who have prepared and checked the certificate

Note.

The inclusion of drawings and/or photographs within the certificate, as of details of the fire tests undertaken (e.g. temperature records or dimensional checks, observations) could also be helpful to the users of the certificate, and it is in general recommended. However, it is acknowledged such additions may show or contain confidential information and may represent a duplicate of contents of the approval documentation referenced in the certificate (e.g. test reports), which the owner of the certificate may or may not be willing to disclose to third parties, in case upon request.

Appendix B - Test Standards

Standards and guidance commonly used in the onshore and offshore hydrocarbon passive fire protection industry:

- API 2218, Fireproofing Practices in Petroleum and Petrochemical Processing Plants
- ASTM E84 - surface burning characteristics of building materials
- ASTM E-1529, Test Methods for Determining Effects of Large Hydrocarbon Pool Fires on Structural Members and Assemblies
- BS476-20 Fire tests on building materials and structures. Method for determination of the fire resistance of elements of construction (general principles)
- IMO Resolution MSC.307(88) - International code for application of fire test procedures (2010 FTP Code)
    - Part 1 Non-combustibility (ISO1182)
    - Part 2 Smoke and toxicity test (ISO 5659)
    - Part 3 Test for "A", "B" and "F" class divisions
    - Part 4 Test for fire door control systems
    - Part 5 Test for surface flammability (Test for surface materials and primary deck coverings)
    - Part 7 Test for vertically supported textiles and films
    - Part 8 Test for upholstered furniture
    - Part 9 Test for bedding components
    - Part 10 Test for fire-restricting materials for high-speed craft
    - Part 11 Test for fire-resisting divisions of high-speed craft
- ISO 834-1:1999 Fire-resistance tests - Elements of building construction - Part 1: General requirements
- ISO 1182, Non-combustibility
- ISO 12944-9, Corrosion protection of steel structures. Protective paint systems and laboratory performance test methods for offshore and related structures
- ISO20902-1, Fire test procedures for divisional elements typically used in oil, gas and petrochemical industries – Part 1 General requirements
- ISO 22899-1 Jet-Fire Resistance Test of Passive Fire Protection Materials
- ISO/TR 22899-2:2013
- ISO 5659-2 Plastics -Smoke generation Part 2: Determination of optical density by a single-chamber test
- NFPA 58 Appendix H, LPG gas code, Hose stream resistance test
- NFPA 290, Standard for testing PFP materials for use on LPG containers

- Norsok M501 – Surface preparation and protective coatings
- UL 2431 Standard for Safety for Durability of Fire Resistive Coatings and Materials
- UL 1709 Rapid Rise Fire Tests of Protection Materials for Structural Steel, Underwriters Laboratories; 5th Ed.

Standards used for building fire protection that have some applicability for the onshore and offshore hydrocarbon sector:

- ASTM E119 - Fire Tests of Building Construction and Materials
- ASTM E162 - Surface Flammability of Materials Using a Radiant Heat Energy Source
- ASTM E662 - Specific Optical Density of Smoke Generated by Solid Materials
- ASTM E2226-14, Application of Hose Stream
- BS 476 Part 4, Non-combustibility
- BS 476 Part 6, Fire propagation
- BS 476 Part 7, Surface spread of flame
- BS 476 -20 - Fire Resistance Tests. General principles
- BS 476 -21, Fire Resistance Tests - Loadbearing Elements
- BS 476 -22 Fire Resistance Tests – Non-Loadbearing Structures
- BS 476 -23, Fire test. Determination of the contribution of components to the fire resistance of a structure
- BS 476-24, Fire Resistance Smoke Extraction & Ventilation Ducts
- EN 1363-1 Fire Resistance Tests. General requirements
- EN 1363-2, Fire Resistance Tests. Alternative and Additional Procedures
- EN 1634-1, Fire Resistance Doors & Shutter Assemblies
- EN 1634-3, Smoke Leakage Doors & Shutter Assemblies
- EN 1365-1, -2, -3, -4, -6, Fire resistance for loadbearing elements
- EN 1366-3, -4, -7, Fire resistance tests for service installations
- EN 1366-2, -10, -11, Fire Resistance Dampers, cable systems & associated components
- EN 1366-1, -5, -8, -9, -12, Fire Resistance Smoke Extraction & Ventilation Ducts

- EN 12101-2, Fire Resistance Components for Natural Smoke & Heat Exhaust Ventilators
- EN 13501-1, -5, Fire classification of construction products & building elements
- EN45545-2, Fire protection on railway vehicles. Requirements for fire behaviour of materials and components.
- ISO 834-2, 3, 6 and 7
- ISO 3008, Fire Resistance Doors & Shutter Assemblies
- ISO 5658-2, Spread of flame - Part 2: Lateral spread in vertical configuration
- ISO 5660-1, Heat release, smoke production & mass loss rate - Part 1: cone calorimeter
- ISO 6944 Part 1, Fire Resistance Smoke Extraction & Ventilation Ducts
- ISO 9239-1 Reaction to fire tests for floorings
- ISO 10294, -5, Fire Resistance Dampers, cable systems & associated components
- ISO 11925-2 Reaction to fire tests. Ignitability
- ISO 11925-2, Ignitability of building products subjected to direct impingement of flame - Part 2: Single-flame source test
- NFPA 252, Fire Resistance Doors & Shutter Assemblies

Classification Society Rules for Offshore Facilities:

- DNV GL-OS-A101 Offshore Standard - Safety principles and arrangements
- DNV GL-OS-D301 Offshore Standard - Fire Protection
- LR Rules and regulations for the Classification of floating offshore units
- ABS Rules for building and classing facilities on Offshore installations
- IMO 2009 MODU Code

Appendix C - Fire Ratings

Fire ratings are a 'shorthand' means for identifying either the performance of a PFP material obtained from testing, or the performance that is required in service. Ratings differ between test standards, classification standards and guidance, and from common usage over many years. This variety has resulted in confusion and this Appendix seeks to clarify their use.

Historical fire rating nomenclature

The oldest and best-known shorthand fire rating is 'A-Class' decks and bulkheads on ships. The testing and requirements for these are defined in 2010 FTP Code. Although used mainly in the maritime industry, A-Class is also used in the offshore industry for accommodation modules and other occupied spaces.

For A-Class barriers the fire threat is considered to be 'cellulosic' and the protection time is given in minutes, e.g. an A60 barrier must restrict the temperature rise on the non-fire side to defined limits. A0 is a special case where the required insulation time is 0 minutes, i.e. no insulation is required as heat transfer across the barrier is not a concern.

In all cases the division must also maintain stability and integrity throughout the duration of the test which is 60 minutes.

- Stability refers to the load bearing capability of the division (including self-weight) and,
- Integrity refers to the capability of the barrier to remain in place and not distort such that the passage of flame, smoke or hot gases cannot occur.

Table C1 describes the A-Class ratings.

Table C1 Designation of A-rated Divisions in 2010 FTP Code

Designation	Limiting Temperature (LT) °C	Insulation time to LT (minutes)	Stability and Integrity**
A15	140/180	15	60
A30	140/180	30	60
A60	140/180	60	60
A0	Not defined	0	60

** For A-rated divisions with a steel core that are insulated on the exposed side only, and have no openings, then the test may be terminated when the limiting temperature is reached.

The hydrocarbons industry recognised that fire tests based on the 'standard' (cellulosic) curve were not sufficiently severe. The 2010 FTP test was adopted but the standard curve was replaced with the hydrocarbon fire test curve.

Additionally, where A-class divisions must retain stability and integrity for 60 minutes, H-class divisions are required to maintain stability and integrity for 120 minutes. Unlike the A-classification the fire resistance durations of H-rated divisions are not defined. Typically, the most common ratings include H60, H120 and H0.

Table C2 summarises the historical case for H-rated division classification criteria.

Table C2 Historical designation of H-Rated Divisions

Designation	Limiting Temperature (LT) °C	Insulation time to LT (minutes)	Stability and Integrity
H60	140/180	60	120
H120	140/180	120	120
H0	400*	0	120

*For certification purposes 400°C is typically taken as the limiting temperature for steel divisions offshore (200°C for aluminium).

Recent developments for hydrocarbon divisions

A new standard for divisions used offshore has recently been published (ISO 20902:2018). This retains a link to 2010 FTP but provides specific information on how to test decks and bulkheads for hydrocarbon fire purposes. It also comments on the possibility of testing 'corrugated' divisions which are commonly used offshore.

In ISO 20902 there is reference to the older method of using H-Class as per Table C2 above but the use of R, E I is recommended where:

R = Stability (Load Bearing Capacity) – this is the ability of the element under test when exposed on one or more sides to support the imposed load during the fire duration. For hydrocarbon divisions, ISO 20902 requires the critical temperature (CCT) to be added in parentheses, e.g. R60 (400°C).

E = Integrity – this applies to fire separation barriers as it is the ability to prevent the passage of flames and hot gases when exposed to fire on one side.

I = Insulation – this is the ability of the test specimen exposed to fire on one side to limit the temperature rise on the unexposed side below specified limits (e.g. 140°C average or 180°C maximum).

Note: Where no claim is made as to a specific rating type (R, E, I) it may be omitted from the description.

ISO 20902 defines the following structure to fire ratings:

Fire exposure type / protected element / Structural stability rating (R) / Integrity rating (E) / Insulation rating (I).

Two examples are:

1. ISO 834-1 (CF) / 5mm steel bulkhead with 50mm mineral wool unexposed face insulation / E120 / I60 (140°C average, 180°C point).

   Example 1 would be for a legacy rating for an A60 Bulkhead.

2. BS 476-20 App. D (HC) / 4.5mm steel deck / R120 (400°C) / E120.

   Example 2 would be for a legacy rating for an H0 Bulkhead.

Note that in these examples the designation of the fire test standard used (i.e. the fire test curve) is identified rather than just CF or HC, and where a rating type is not applicable it is omitted.

The use of REI in ISO 20902 is 'borrowed' from other ISO standards used in building fire protection. The advantage of REI is that it can be used for other items such as structural steel, vessels, valves, etc. This is discussed further in the recommendations section below.

Fire ratings for structural steelwork and other protected items

The terminology H60, H120 and H0 has specific meaning and relates to fire separation barriers but it is often (incorrectly) used whenever hydrocarbon fire resistance is required for a specified duration. For example, a specification may require 'H60 protection for a steel structure'. What is actually meant is that the exposing fire is a hydrocarbon pool fire ('H' in H60), with required protection time of 60 minutes.

However, this does not provide information about the maximum allowable temperature (CCT) because as noted above, H60 actually relates to an insulation value of 140°C average or 180°C maximum, on the unexposed side of a barrier. Structural steel does not provide separation and generally has a CCT of 400°C for offshore structures (higher for onshore steelwork).

A better method of nomenclature is to utilise the R/E/I system with a more explicit definition of requirement.

Other items such as vessels and valves will have completely different maximum allowable temperatures. The use of R/E/I along with a more explicit definition of the fire threat and protection requirement, provide a system suitable for all types of fires, protected items and PFP products and systems.

Fire ratings incorporating jet fire

Historically guidance for defining a rating for PFP tested to jet fire was that given in ISO 22899-2 and in ISO 13702.Again these legacy systems can lead to confusion and the ISO 20902 system is recommended.

Recommendations for fire ratings in the hydrocarbon passive fire protection industry

To avoid confusion and errors it is essential to have a rating system that is universally understood, accepted and which accurately reflects the performance requirements of the tested PFP.

PFPNet recommends that the detailed and descriptive rating system using REI is adopted for PFP protected items as it provides for an unambiguous description of the fire threats and the protection requirements. The recommended format is as follows:

Fire exposure type / protected element / Structural stability rating (R) / Integrity rating (E) / Insulation rating (I).

Ambiguity around nomenclature for jet fire and pool fire/jet fire combinations is a strong reason to fully describe the performance requirements of PFP, rather than rely on 'shorthand' rating methods. The only exception to this recommendation is the use of A-Class for the following reasons:

A-Class barriers are defined in 2010 FTP with the testing, approval and classification processes well understood and extensively used in the marine shipping industry. Classification Societies are a fundamental part of both ship and offshore asset verification and issue certification for fire protection performance in both sectors. It would be unreasonable for the hydrocarbon fire protection industry to recommend an alternative rating system for A-Class fire protection, especially given the relatively limited use of cellulosic fire testing in the hydrocarbons market sector.

Summary of recommendations for fire ratings

- **A-rated fire barriers** - continue with A-Classification system as described in 2010 FTP code.

  ISO 20902 also allows for the legacy H-Class to remain in use. This allowance is essential as it will take many years for "H-Class" to be discontinued in common use and will require Class Organisation to start to amend their certificates to reflect the rating system proposed by ISO 20902.

- **Divisions in hydrocarbon fire** - Implement the system proposed in ISO 20902 as follows:

  Fire exposure type / protected element / Structural stability rating (R) / Integrity rating (E) / Insulation rating (I).

- **Structural elements in hydrocarbon fire** - implement the use of R/E/I and a full description of the requirement/performance as follows:

  Fire exposure type / protected element / Structural stability rating (R) / Integrity rating (E) / Insulation rating (I).

- **Vessels, piping, valves and other items that require protection by the use of PFP -** implement the use of R/E/I and a full description of the requirement/performance as follows:

  Fire exposure type / protected element / Structural stability rating (R) / Integrity rating (E) / Insulation rating (I).

Incorrect use of fire ratings when specifying or providing PFP for use

Incorrect specification of PFP can arise because of the use of shorthand nomenclature (ratings) where these are not fully understood, or where there is ambiguity in use due to a lack of published guidance.

For example, a commonly requested rating is H120 pool fire resistance for a fire wall segregating two process areas, with no occupied rooms on the non-exposed side, where what is actually required is H0.

Both are 2-hour tests but the CCT for H0 is 400°C and for H120 is either 140°C average or 180°C maximum. The difference is the insulation time – both will provide stability and integrity for 120 minutes. The result of this can be a significant increase in PFP thickness (and therefore costs and weight).

If the specifier were to use the fully detailed nomenclature proposed above then this misunderstanding would not occur – see below using:

Fire exposure type / protected element / Structural stability rating (R) / Integrity rating (E) / Insulation rating (I).

- **H120 Bulkhead:**

  BS 476-20 App. D (HC) / 4.5mm steel bulkhead / E120 / I120 (140°C average, 180°C point).

- **H0 Bulkhead:**

  BS 476-20 App. D (HC) / 4.5mm steel deck / R120 (400°C) / E120

Similarly, misunderstandings occur with jet fires:

- **Example 1. Required fire performance = H60/J30.**

  Does this mean 60 minute hydrocarbon fire followed by a 30 minute jet fire (total fire duration 90 minutes), or 60 minutes hydrocarbon fire including 30 minutes jet fire (total fire duration 60 minutes of which 30 minutes is jet fire?

  Generally, it is taken as the latter case (i.e. total fire of 60 minutes) but one cannot be certain that this is what was intended by the specifier. The use of the fully detail REI system identifying the specific fire types and durations would remove ambiguity.

- **Example 2. Required fire performance = J60 for a steel bulkhead.**

  Does this mean that the bulkhead is impacted by a jet fire for 60 minutes and the non-exposed side must remain below 140°C average/180°C maximum, or does it mean that the steel can be allowed to reach 400°C at the end of a 60 minutes exposure period? The use of the fully descriptive naming convention will remove ambiguity.