Exploration & Production

GENERAL SPECIFICATION

SAFETY

GS EP SAF 337

Passive fire protection: Basis of design

03	10/2009	Complete review and update. Change of title
02	10/2005	Addition of EP root to document identification
01	10/2003	Change of Group name and logo
00	04/2001	Old TotalFina SP SEC 221
Rev.	Date	Notes

Contents

1. Scope

1.1 Purpose

The purpose of this General Specification is to set out COMPANY's philosophy and requirements for the design, selection and use of Passive Fire Protection (PFP) systems for onshore and offshore installations.

This specification also sets out COMPANY's requirements for the qualification of Passive Fire Protection (PFP) systems.

1.2 Applicability

This General Specification is not retroactive. It applies to new facilities and major modifications or extensions of the existing installations.

This specification applies to onshore and offshore installations, in particular to:

- primary structure members and indoor structure members;
- enclosures involved in Emergency Response or Escape, Evacuation and Rescue;
- enclosed process areas and outdoor partitions (living quarter external faces, external fire walls, etc.);
- process and storage, vessels and tanks;
- pipes, risers and top ESDVs, valves and local instrumentation.

The present document does not cover the fire rating requirements for internal partitions in buildings (refer to GS EP SAF 221).

For Quality Assurance and Quality Control refer to GS EP COR 353.

2. Reference documents

The reference documents listed below form an integral part of this General Specification. Unless otherwise stipulated, the applicable version of these documents, including relevant appendices and supplements, is the latest revision published at the EFFECTIVE DATE of the CONTRACT.

Standards

Reference	Title
ISO 834-1:1999	Fire-resistance tests - Elements of building construction – Part I: General requirements
ISO 13702:1999	Petroleum and Natural Gas Industries - Control and Mitigation of Fires and Explosion on Offshore Production Installations – Requirements and Guidelines
ISO 14692-2:2002	Petroleum and natural gas industries – Glass-reinforced plastics (GRP) piping – Part 2: Qualification and manufacture
ISO 22899-1:2007	Determination to the resistance to jet fires of passive fire protection materials – Part 1: General requirements
UL 1709	UL Standard for Safety Rapid Rise Fire Tests of Protection Materials for Structural Steel, third edition (including revision of 2007)

Professional Documents

Reference	Title
API PUBL 2218	Fireproofing Practices in Petroleum and Petrochemical Processing Plant, second edition, 1999
API PUBL 2510A	Fire Protection considerations for the Design and Operation of Liquefied Petroleum Gas (LPG) Storage Facilities, second edition
API RP 14G:2007	Recommended Practice for Fire Prevention and Control on Fixed Open-type Offshore Production Platforms
API STD 2510	Design and construction of LPG Installations, eighth edition
IMO Resolution A.753 (18)	Guidelines for the application of plastic pipes on ships, adopted on 4 November 1993
IMO Resolution A.754 (18)	Recommendation on fire resistance tests for "A", "B" and "F" class divisions, adopted on 4 November 1993
IMO SOLAS	International Convention for the Safety Of Life At Sea (SOLAS), 1974 and subsequent amendments
NFPA 33	Standard for Spray Application Using Flammable or Combustible Materials, 2007
OTI 95634	Offshore Technology Report – Health and Safety Executive - Jet-fire resistance test of passive fire protection materials, 1996
UKOOA	United Kingdom Offshore Operators Association – Fire and Explosion Hazard Management Guidelines, March 1995

Regulations

Reference	Title
Arrêté du 21 novembre 2002 (French Legislation)	Arrêté relatif à la réaction au feu des produits de construction et d'aménagement (modifié par les arrêtés du 13 août 2003 et du 18 septembre 2006)

Codes

Reference	Title
Not applicable	

Other documents

Reference	Title
Not applicable	

Total General Specifications

Reference	Title
GS EP COR 230	External laminated glass fibre/resin based coating for risers of sea line
GS EP COR 353	Design and application of passive fire protection coatings
GS EP PLR 100	Submarine pipeline systems
GS EP SAF 221	Safety rules for buildings
GS EP SAF 253	Impacted area, restricted area and fire zones
GS EP SAF 261	Emergency Shut-Down and Emergency De-Pressurisation (ESD & EDP)
GS EP STR 102	Design of offshore topside structure

3. Terms and definitions

There are three types of statements in this specification: "shall", "should" and "may". They shall be understood as follows:

Shall Is to be understood as mandatory. Any deviation from a "shall" statement requires a derogation approved by the COMPANY.

Should Is to be understood as strongly recommended to comply with the requirements of the specification. Alternatives shall provide a similar level of protection and this shall be documented.

May Is used where alternatives are equally acceptable.

For the purpose of this document, only the following terms and definitions apply:

Boiling Liquid Expanding Vapour Explosion (BLEVE)
Sudden rupture due to fire impingement of a vessel and/or system containing liquefied flammable gas under pressure. The pressure burst and the flashing of the liquid to vapour creates a blast wave and potential missile damage, and immediate ignition of the expanding fuel-air mixture leads to intense combustion creating a fireball (UKOOA :1995).

Emergency De-Pressurization (EDP)
Control actions undertaken to depressurize equipment or process down to a pre-defined threshold (generally 7 barg or 50% of design pressure) in a given period of time (generally 15 minutes) in response to a hazardous situation (COMPANY from ISO 13702:1999).

Emergency Response (ER)
Action taken by personnel on or off the installation to control and/or mitigate a hazardous event (ISO 13702:1999).

Escape, Evacuation and Rescue (EER)
General term used to describe the range of possible actions including escape, muster refuge, evacuation, escape to the sea and rescue/recovery (ISO 13702:1999).

Fire rating
Time during which a structure or component will provide prescribed resistance to transmission of heat, passage of flame, smoke and toxic gases and structural failure (COMPANY).

Glass-fibre-reinforced epoxy (GRE)
Epoxy resin-based composite that is reinforced with glass fibre (COMPANY from ISO 14692-2:2002).

Glass-fibre-reinforced plastic (GRP)
Polymeric resin-based composite that is reinforced with glass fibre. (COMPANY from ISO 14692-2:2002).

Passive Fire Protection (PFP)
Coating, cladding arrangements or a free standing system which in the event of fire will provide thermal protection to the substrate to which it is attached or to the protected area and does so independently of a requirement for human, mechanical or other intervention to initiate a response (COMPANY from ISO 13702:1999).

Pool fire
Combustion of flammable or combustible liquid spilled and retained on a surface (ISO 13702:1999).

4. General requirements for Passive Fire Protection

4.1 Objectives

The aim of PFP is to minimize the spread of fire, its duration, the damage caused, and more specifically:

Safety to life:

- to protect personnel on the installation against hydrocarbon fire and jet fire;
- to protect part of the escape routes, evacuation and rescue means, as necessary.

Mitigation:

- to protect equipment, critical components and structure members;
- to prevent any explosion or delaying the event of BLEVE on pressure vessels;
- to minimize fire escalation;
- to provide a degree of protection to assist the Emergency Response (ER) activity.

PFP shall also be considered for the protection of equipment whose failure in case of a local fire could cause extensive damage to the environment and assets.

Additional PFP requirements shall be implemented, as follows:

- Non-flammable materials shall always be used in new facilities.
- Particular attention shall be paid when selecting cables within continuously, permanently and normally manned rooms/enclosures. Cables shall be "Zero Halogen" type.
- Electrical overload protection systems shall be carefully adjusted in order to limit the risk of fire by cable overheating.
- Potential fire areas shall be segregated into volumes as small as possible: cable floors from the cabinets, cable floors and cabinets from the room, etc.

4.2 Functional requirements

4.2.1 General

The performance of PFP (in terms of fire resistance), is the period of time (in minutes) during which the PFP protects the structure or the equipment before the first critical behavior is observed. Attention shall also be paid to other criteria such as pre-fire-durability, reaction in a fire, installation requisites, weight, and certifications of PFP materials.

4.2.2 Performance criteria

PFP systems shall be certified. A list of laboratories and certifying authorities agreed by the COMPANY is given in **appendix 1**. No PFP material shall be used without certificates.

In terms of fire rating, structures, partitions and equipment, PFP systems shall satisfy three main criteria throughout a prescribed time of exposure to heat:

a) Stability: the structure shall fulfill its load-bearing capacity throughout the fire exposure period.

b) Integrity: the partitions shall prevent spread of flames and hot fumes throughout the fire exposure period.

c) Insulation: the unexposed side of the partitions shall not reach surface temperatures in excess of a certain level throughout the fire exposure period.

4.2.3 Standard fires

Three standard fires shall be considered.

4.2.3.1 Cellulosic-Fire (CF)

A CF has a slow flame temperature rise after ignition. The standard CF temperature vs. time curve shall be that of the reference documents IMO Resolution A.754 (18), ISO 834-1:1999 and IMO SOLAS. With T0 = 20°C

Table 1: temperature rise

t (min)	0	5	10	20	30	60	120
T (°C)	20	576	678	781	841	945	1049

Typical radiation value 5 minutes after ignition is 50kW/m^2.

4.2.3.2 Hydrocarbon-Fire (HF)

A HF has a rapid flame temperature rise after ignition. The standard HF temperature vs. time curve shall be taken from UL 1709 or ISO 834-1:1999 or an equivalent procedure approved by the COMPANY (DGEP/HSE/SEI).

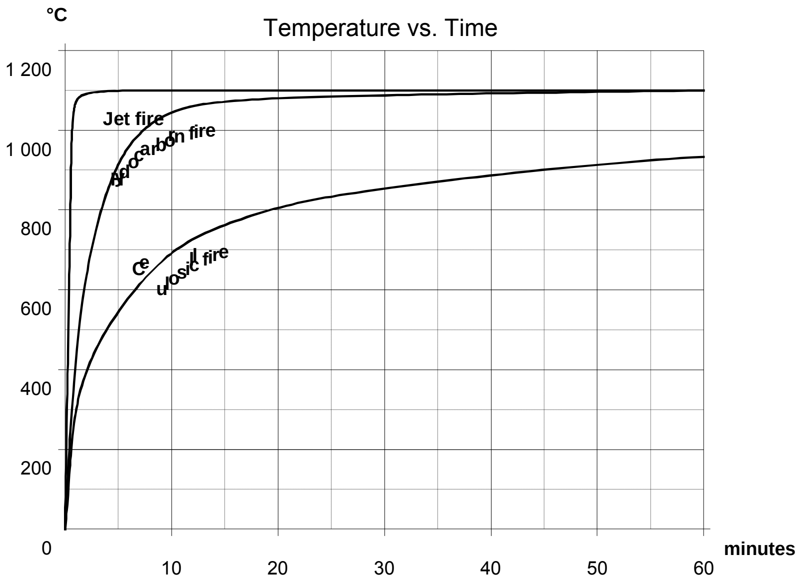
The heat flux is 205kW/m^2 ± 15 kW/m^2 after 5 minutes. The typical temperature value 5 minutes after ignition is between 1037°C and 1149°C.

4.2.3.3 Jet-Fire (JF)

A JF is a turbulent diffusing flame, resulting from the combustion of a steady release of pressurized liquid or gaseous fuel. They are the most severe fire scenarios that PFP materials could be required to withstand, considering the effect of erosion and also the significantly higher rate of burning due to turbulent fuel/air mixing.

The Jet Fire test shall be conducted as described in OTI 95634 or ISO 22899-1:2007 or similar COMPANY approved procedure.

In particular, the jet fire test shall deliver 0.3 kg/s ± 0.05 kg/s flow rate of propane fuel under controlled condition, as described in OTI 95634 and ISO 22899-1:2007.



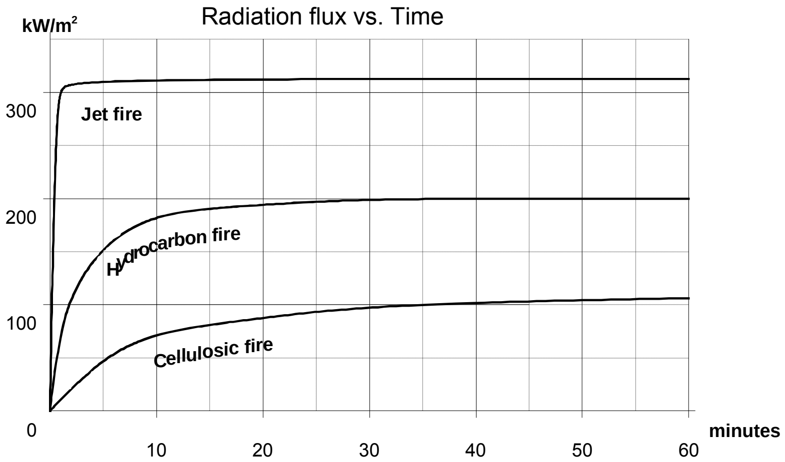


Fig 1: standard fire curves (Temperature and radiation flux vs Time)

4.2.4 Maximum allowable temperatures

4.2.4.1 Reinforced concrete structures

The mechanic resistance of reinforced concrete structures is appreciably weakened (due to dilatation of bar iron) at 400°C. At 800°C, concrete risks complete destruction. The critical temperature shall be assumed at 450°C.

4.2.4.2 Steel structures

The critical temperature for steel shall be specified as 800°F giving 427°C, at which the steel departs from linear elastic behavior to plastic deformation in a standard tensile test.

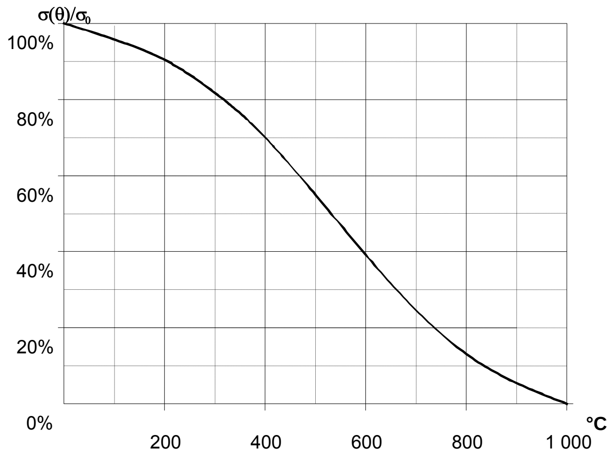


Fig 2: resistance of steel vs Temperature

4.2.4.3 Other materials (structure)

The critical temperature for other materials than steel is specified as the temperature at which yield strength is reduced to the maximum allowable stress under operating loading conditions.

4.2.4.4 Equipment

The maximum surface temperatures given in the following table shall be used as default values in determining the PFP requirements for critical equipment, which may require a protection in order to allow it to fulfill its function in an emergency. The PFP requirements shall be listed in the Safety Concept.

Table 2: maximum surface temperatures

Equipment	Maximum surface temperature (°C)
Steel processing equipment and piping (vessels, columns, exchangers, etc.) likely to contain gaseous, liquid or liquefied hydrocarbon	< 350
Riser sections, pipelines and ESDV's	< 200
Riser supports	< 400
Fire pumps, essential generator	< 200

4.2.5 Duration of the protection

The PFP system shall provide protection for a specified period of time, given in minutes, during which it has been continuously exposed to fire. Unless otherwise specified in the Safety Concept, the default values shall be such so as to provide the following protection:

4.2.5.1 Safety to life

- Escape of personnel from a fire zone: < 5 minutes
- Escape from high-occupancy buildings: refer to GS EP SAF 221
- EER: 120 minutes

4.2.5.2 Mitigation

- EDP completed: 60 minutes
- ER duties in non-hazardous areas: 60 minutes
- ER duties in hazardous areas: 120 minutes
- Hydrocarbon inventory that cannot be EDP: 120 minutes

4.2.5.3 Asset production

As per Statement of Requirements, Safety Concept or technological risk management studies.

4.2.6 Partitions

Fire rating for partitions (ceiling, walls, floors, decks, etc.) and bulkheads and decks shall be based on standard ratings as per table 3 that gives the average temperature reached by the cold face (non-exposed to fire):

Table 3: Fire rating for partitions

				Insulation (cold face maximum temperature)		
Fire rating	**Fire Curve**	**Stability (min)**	**Integrity (min)**	**Duration (min)**	**Average (°C)**	**Spot (°C)**
A-0	CF (1)	60	60	0	None	None
A-30	CF (1)	60	60	30	140	180
A-60	CF (1)	60	60	60	140	180
B-0 (4)	CF (1)	30	30	0	None	None
B-15 (4)	CF (1)	30	30	15	140	180
B-30 (4)	CF (1)	30	30	30	140	180
H-0	HF (2)	120	120	0	None	None
H-60	HF (2)	120	120	60	140	180
H-120	HF (2)	120	120	120	140	180
J-0	JF (3)	120	120	0	None	None
J-15	JF (3)	120	120	15	140	180
J-60	JF (3)	120	120	60	140	180

Note 1: Cellulosic-Fires as per ISO 834-1:2002 and IMO SOLAS
Note 2: Hydrocarbon-Fires as per UL 1709
Note 3: Jet-Fires as per OTI 95634 or ISO 22899-1:2007
Note 4: B-class **is not** supposed to avoid the spread of gas or fumes.

4.2.7 Structure

Fire rating for structure members is defined by the material critical temperature, the worst type of fire the structure shall withstand, and the period of time during which the structure shall not exceed the critical temperature (i.e. shall maintain its stability).

There is no integrity requirement. This is not a standard definition. The fire rating shall be written as T/XF/t, with: T critical temperature, XF: type X of fire, and t: specified period of time. The fire rating of structures shall be as per table 4:

Table 4: Fire rating for structures

				Insulation (cold face maximum temperature)		
Fire rating (2)	**Fire curve**	**Stability (min)**	**Integrity (min)**	**Duration (min)**	**Average (°C)**	**Spot (°C)**
T/CF/60	CF (1)	60	NA	60	T	T
T/CF/120	CF (1)	120	NA	120	T	T
T/HF/60	HF (1)	60	NA	60	T	T
T/HF/120	HF (1)	120	NA	120	T	T
T/JF/60	JF (1)	60	NA	60	T	T
T/JF/120	JF (1)	120	NA	120	T	T

Note 1: same definitions as in table 3, **section 4.2.6**

Note 2: T can take different values (e.g. 427, 350 or 200°C), refer to **chapter 6.**

4.2.8 Other properties

The following list is intended to provide technical guidance about other requirements which shall be evaluated prior to the selection of a PFP material.

- **Pre-fire durability:**
  - Normal: adherence to substrate, ageing, weather resistance, resistance to hosing, low-level heat resistance.
  - Mechanical: vibration, flexure of substrate, abrasion/erosion, impact.
  - Resistance to chemicals such as acids, bases, salts, solvents.
- **Anti-corrosion capabilities and guarantee** (including chemical interference with substrate): as described in GS EP COR 353.
- **PFP ageing:** as per design life for installation.
- **Explosion resistance (overpressure):** the PFP provided on equipments and structures shall be required to resist blasts up to the level that the structure/equipment is designed for.
- **Fire performance** (spread of flame, response to thermal shock, resistance to water deluge, smoke development and toxic gas production).
- **Installation requisites** (surface preparation, compatibility with substrate, top coating requirement, mode of installation/application, coat back, applicator qualification, health hazard during application, environmental conditioning).

4.3 Risk analysis

4.3.1 Company's Policy

The decision to install PFP and the specification of the type of PFP to be implemented shall be made after a fire risk analysis and an assessment of consequences have been carried out, in order to determine the degree of protection required for the duration of the hazard.

If such analyses are not carried out, the default PFP extent values and associated ratings shall be applied.

In any case, the following rules shall apply:

- PFP requirements for safety to life shall always be implemented, regardless of the local specificities.
- PFP requirements for the protection of the environment shall be implemented.
- PFP requirements for asset protection shall be implemented as per the asset policy in the Safety Concept.

4.3.2 Assumptions

Unless otherwise specified in the Safety Concept, or not applicable, the need and the ratings for PFP are based on the following assumptions:

- The installation has been properly split into fire zones (refer to GS EP SAF 253). Only one single fire is occurring at a time and the fire is restricted to one single zone. Simultaneous double fire occurrence is not envisaged.
- An ESD system has been implemented and is operative without any failure. However, the ESD system response time (including ESDV closure time) shall be considered.
- The automatic active protection systems, if any, are initiated without failure upon demand and without delay. However, the piping in the relevant fire zone could be unserviceable as a consequence of fire or explosion.
- Process shutdown systems are implemented and operative without failure. However, and contrarily to the ESD system, it shall not be assumed that all SDV's shall close when instructed to do so by the process shutdown system.
- The emergency depressurization system, in the fire zones adjacent to the fire zone on fire, operates correctly without failure upon demand. The emergency depressurization system in the fire zone where the incident has occurred could be inoperable as a consequence of fire or explosion (in particular due to damage on the flare header).
- When human action or decision are necessary, it shall be assumed that trained operators initiate pre-determined procedures without failure or delay, but cannot take correct decisions in the first five minutes following a catastrophic event.

4.4 Implementation requirements

In addition to the functional requirements defined above in **sections 4.2** and **4.3**, particular attention shall be paid to the configuration of PFP devices that can affect significantly their performances. The following topics shall be taken into consideration.

4.4.1 Fire hazard evaluation

Location and types of fire-hazard areas shall be first identified, all factors which include quantities, pressures, temperatures, and the chemical composition of potential fuel sources taken into account.

Most of the equipment to be considered for fireproofing shall be located in areas subject to some form of hazard evaluation procedure. This evaluation shall be based on API PUBL 2218 i.e. on qualitative “fire-potential” categories to assist in hazard determination. This division of equipment into high, medium, low, and non-fire-potential, has been proven useful in determining fireproofing needs. These categories are based on experience, which shows that some types of equipment have a higher fire potential than others, based on historical incident frequency and/or severity. These fire potential definitions are intended to include most types of hydrocarbon-handling equipment that can release appreciable quantities of flammable fluids.

As a general rule, COMPANY implements a 5 m^3 threshold for liquid hydrocarbons.

Although classified as non-fire-potential equipment, water supply lines to active fire protection equipment within the envelope shall be considered for fireproofing protection if analysis shows they are vulnerable.

4.4.2 Height of flames of a pool fire

As a general rule, in case of flammable liquid pool fires, a fire protection from surface level to 7.5 m height shall be considered as a minimum to maintain stability and integrity of the vertical structure members and to ensure protection of tanks and vessels, either horizontal or vertical. In addition, a particular study shall be carried out to assess whether some horizontal bending structure members, higher than 7.5 m above grade, shall be protected or not, in particular if the structure has the ability to retain a pool fire. In any case, the first layer of horizontal structure shall be protected. This fire height shall be from any level on which a spill can accumulate and be sustained.

4.4.3 Pool fire diameter

Fire area is determined by making reference to API PUBL 2218 as 9 m fire radius as a default value for a pool fire. For further guidance on dimensions of a fire-scenario envelope, reference may also be made to the following table:

Table 5: fire scenario envelope as per API PUBL 2218

Hazard Concern	Horizontal	Vertical
A fire-scenario source of liquid fuel release - general	6 to 12 m	6 to 12 m
Fire-potential equipment	6 to 12 m	Up to highest level supporting equipment
Non-fire-potential equipment above fire potential equipment	6 to 12 m	Up to the level nearest to 9m above grade
LPG vessels as potential source of exposure	Pipe supports within 15 m or within the spill containment area	Up to the level nearest to 9m above grade
Fin-fan coolers on pipe racks within fire-scenario envelope	6 to 12 m	All support members up to the cooler
Rotating equipment	6 to 12 m from the expected source of leakage	6 to 12 m
Tanks, spheres, and spheroids containing liquid flammable material other than LPG	Extension to the dike wall, or 6 m from the storage vessel, whichever is greater.	6 to 12 m or as specified for the equipment of concern
Marine docks where flammable materials are handled	30 m horizontally from the manifolds or loading connections	From the water surface up to and including the dock's surface

4.4.4 Penetrations

Penetrations through a partition (cables, ducts, pipes, doors and windows, etc.) shall be specified for the same grade of fire resistance as the equipment they pertain to or the function they serve.

4.4.5 Supports

Supporting features (safety critical cable trays and supports, HVAC duct supports, piping supports, etc.) shall be specified for the same grade of fire resistance as the equipment they pertain to or the function they serve.

4.4.6 Jet Fire

Extent rating of PFP shall be provided in the Safety Concept based on the fire risk analysis.

4.4.7 Clearance for intumescence development

Clearance shall be provided around active PFP materials to enable the complete development of their intumescence during the specified protection duration time. As a default value, the minimum clearance shall be assumed as 100 mm. The operability of escape doors shall not be affected by intumescence development.

4.4.8 Cut-out for PFP application

A particular attention shall be paid to apply PFP coating on the structural members connected to the protected items. Therefore, a cut-out value shall be provided during Basic Engineering and confirmed during the Detail Engineering studies in accordance with the requirements of GS EP STR 102, GS EP PLR 100 and GS EP COR 353. The cut-out default value is taken at 450-500 mm.

5. Different fire proofing materials

5.1 General

The fireproofing materials that are most commonly used in the petroleum industry can be sorted into two main groups: active and inactive insulation. Active insulation undergoes chemical and physical changes when exposed to fire, while inactive insulation does not. Active insulation is achieved by epoxies, reacting to a fire either by intumescences, or by sublimation. In this section, PFP materials are sorted out as follows:

- Epoxies: see **section 5.2**
- Cementitious coating: see **section 5.3**
- Fibres and pre-fabricated panels/boxes: see **section 5.4**
- Glass Reinforced Plastic: see **section 5.5**
- Others: see **section 5.6**

Fibers absorbing moisture in wet environments and carcinogenic fibers (e.g. asbestos) are forbidden.

Two different material types of PFP, which work in different ways, are commonly applied to structures on offshore installations:

- Cementitious PFP
- Epoxy Intumescent PFP

5.2 Epoxies

Epoxy type PFP materials provide active insulation either by intumescence or by sublimation (see **note 1** for information). They are generally available in multiple-part mixtures for spray application. However, they can be purchased in pre-fabricated panels to be bolted in place (see also **section 5.4**).

- **Intumescent materials:** undergo a physical and chemical change expanding several times their applied volumes and forming a low-thermal conductivity char that absorbs heat.
- **Subliming materials:** the direct change from solid to vapour (and possibly smoke and fumes) absorbs heat.

Epoxies can be used offshore for structural members (external jacket members above splash zones), external decks and roofs, underside decks, equipment enclosures and pipe work.

They have a superior performance to fire and jet fire and a superior resistance to explosions, corrosion and impact. They react with fire and release chemical toxics and, therefore, shall not be used in enclosed areas where personnel could be present and need to stay, or pass through in a fire situation. Some examples of Epoxy Intumescent PFP Products are given in **appendix 2, table 9.**

Note 1: Intumescent PFP started as epoxy resin-based corrosion coatings but have had their capabilities extended for fire protection. By their nature they, therefore, provide excellent corrosion resistance properties. The key to successful durability of epoxy intumescent materials is at the application stage, so that they are bonded correctly to a properly prepared substrate. When applied correctly, the materials provide excellent adhesion, impact, abrasion, and vibration resistance properties with inherent reliability. An epoxy intumescent fire protection material comprises a resin binder which supports the active pigments which cause the material to swell, forming a char when subject to fire. On completion of the reactions, it is the char that provides an insulating layer and provides fire protection. In thick film intumescents, which are required to resist hydrocarbon fires in an offshore environment, the swelling can be a factor of between 4 and 8 times the original solid thickness. Once the char is established, thermal insulation is provided although the char is steadily eroded. Intumescents should be used with a reinforcement material which is intended to make sure the char stays in place during the intumescence process. This is particularly important given the erosive forces associated with jet fires. The original epoxy intumescent materials used a pin and steel mesh system, often with the mesh coated for corrosion resistance. Modern materials now adopt a fibre scrim which does not directly fix the material to the substrate. With modern materials, the epoxy intumescent bonds directly onto the substrate (which should be coated in a primer prior to application of the PFP). When used with a suitable primer, a sealing coat, and a topcoat, the material is highly watertight as a system, providing excellent protection to the substrate.

5.3 Cementitious coatings

PFP materials of cementitious type provide inactive insulation (see **note 2** for information). They are generally mixed as a slurry and spray-applied. However, they can be purchased in pre-fabricated panels which can be bolted in place (see also **section 5.4**).

Cements are incombustible and easy to maintain. However, they have a weak resistance to explosions, are susceptible to corrosion and may cause corrosion of steelwork. Furthermore, the installation of reinforcement cages is labour intensive activities.

There are two main categories of cementitious PFP: the first one is based upon inorganic cements, and the second upon magnesium oxy-chloride cement but shall not be used in COMPANY's installations. Inorganic cements used for PFP are cements either with magnesia or Portland type, enhanced or not with vermiculite.

Fire protection works out in two steps: the cement dehydrates at 100°C and then, for higher temperatures, it acts as an insulation barrier. Vermiculite improves resistance to high temperatures. Examples of inorganic cement based products are given in **appendix 2, table 09**.

Cementitious PFP can be applied onshore onto structural members (inside modules), EER and ER equipment and enclosures, equipment enclosures, pressure vessels and supports. They are prohibited for offshore use.

Reinforced concrete PFP applications shall not be used on flexible structures and shall also be limited to dry applications given their porosity and susceptibility to freeze/thaw cycles.

Note 2: Cementitious PFP is a cement/vermiculite mixture which can be sprayed or trowelled into place. Vermiculite is a mined mineral which is subjected to a heating process known as exfoliation. As exfoliation occurs, millions of microscopic gaps are created in the particles which give them insulation and water retention properties. The expansion that results can be of the order of 20 times the original size. This makes vermiculite lightweight, air entraining and water absorbent. It is also environmentally friendly, chemically neutral and virtually sterile after exfoliation. During a fire, the entrained water generates steam, maintaining the material surface at 100°C, the typical moisture content for cement material has a range of 5-15% by volume. When the water has all boiled off then the material acts as a thermal barrier but the temperature rises above the 100°C mark. The material should be used with a topcoat, a surface primer, and a reinforced mesh. They may also be used with a water repellent primer between the cement material and the topcoat although early installations of the material did not use this layer.

5.4 Fibres and pre-fabricated panels/boxes

Fibres are of two main types: ceramic or mineral. They are generally available under the form of prefabricated panels/ boxes supported by rigid steel or cement slab or can be purchased alone to form blankets (see **section 5.6**). Pre-fabricated panels/ boxes can use other PFP materials, such as epoxies, cementitious coatings or composites.

Fibers and pre-fabricated panels have a good resistance to blast and chemicals, and are light in weight. They are maintenance-free and can be easily removed. However, fibers and prefabricated panels exhibit some disadvantages that hinder their applications where there is direct exposure to hydrocarbon fires. Therefore, they may only be used for protection from cellulosic fires outside the restricted area or as internal enclosures for equipments, buildings and the outside of enclosures in dry climates.

Panels with organic binders shall be prohibited for indoor use.

5.5 Glass Reinforced Plastic (GRP)

GRP is a polymeric resin-based composite that is reinforced with glass fibre. Typical resins are epoxy, polyester, vinyl ester and phenolic. Thermoplastic resins are excluded. These kinds of composite materials are mainly used and recommended for pipings and risers' PFP.

Special grade of GRP (as defined in GS EP COR 230) is commonly used by the COMPANY as PFP for riser sections in the splash zone.

GS EP COR 230 defines the minimum requirements for the characteristics of the applicable products and methods of applying a laminated resin/ glass fibre-based coating.

This coating is intended as external protection applied in plant and onsite for welded field joints. The type of resin shall be adapted to the maximum operating temperature.

5.6 Other PFP materials

5.6.1 Introduction

Other PFP materials, not pertaining to epoxy, fibres and pre-fabricated panel categories, are available. They can be sorted out as follows:

- Fibres blankets: see **section 5.6.2**
- Gums: see **section 5.6.3**
- Silicones: **see section 5.6.4**
- Polyurethane foam: **see section 5.6.5**

5.6.2 Fibres blankets

- Light in weight and cheap.
- Moisture absorption compels to a vapour barrier and limits outdoor use.
- Cannot be exposed directly to a hydrocarbon fire and require a protection casing.
- Easy inspection if the protection casing is removable.

5.6.3 Gums

- Light in weight and easy to install in complex shapes.
- Superior resistance to explosion and chemical aggressions.
- Especially suitable for protection of penetrations and cable trays.

5.6.4 Silicones

- Same as for gums.

5.6.5 Polyurethane foam

- Effective thermal insulator, but rapid time ageing.
- Releases hydrogen cyanide when heated up, and is prohibited in the presence of personnel.

5.7 Thickness requirements

The thickness of PFP is the responsibility of the SUPPLIERS because it depends on the PFP type, the material to be protected and the fire protection required. The PFP SUPPLIER shall provide the test certifications (including a full test report) in accordance with the following rules to confirm the thickness of PFP for the required fire rating and/or fire protection level.

5.7.1 Partitions and structures

The data sheets for the various PFP coatings should describe their characteristics and application techniques to enable the correct thickness of coating for any given fire resistance period to be chosen for any steel section, given its Hp/A, without recourse to individual assessment.

For structures fireproofing, the first step to determine the thickness is then to calculate the Hp/A factor. Each piece of steel has some ability to absorb heat. The greater the area of steel exposed to fire, the greater the amount of heat that can affect the strength of the steel. Therefore a shallow thick section has a greater ability to resist fire than a deep thin section and this ability is expressed as the steel section's Hp/A factor, where Hp is the perimeter of section exposed to fire (m), and A is the cross sectional area of the steel member (m^2) (see examples given in appendix 4). A section with a high Hp/A factor heats up more rapidly than one with a low Hp/A factor, and so may require a higher protection specification to achieve the same level of fire resistance. The second step to determine the thickness is to find the correct thickness of the material from tables using the Hp/A values. Although structural steel sections have their own specific Hp/A factor, thickness values varies depending on the type of fire protective material specified and also whether the material is used on a horizontal or vertical section.

For partitions, thicknesses in table 6 are default values given in mm of PFP material, exclusive of steel. Partitions have self-integrity but are not bearing other loads than themselves.

Table 6: default values for PFP thickness on partitions

	Epoxies		Cementitious coatings		Fibre panels	
Fire rating	**Vertical**	**Horizontal**	**Vertical**	**Horizontal**	**Vertical**	**Horizontal**
A-0	NA	NA	8	10	25	30
A-30	NA	NA	16	18	30	35
A-60	9	10	25	27	35	40
H-0	6	6	13	13	35	40
H-60	12	14	25	35	70	80
H-120	16	20	40	45	80	90

For structures, the resistance of a structure to fire is dependent of its shape. Table 7 provides orders of magnitude for normalized I shape beams for Hp/A factors ranging from 50 to 200 m^{-1}. Thickness is given in mm of PFP material.

Table 7: default values for PFP thickness on structure

	Epoxies				Cementitious coatings				Fibre panels			
	Hp/A (m^{-1})				Hp/A (m^{-1})				Hp/A (m^{-1})			
Fire rating	**50**	**100**	**150**	**200**	**50**	**100**	**150**	**200**	**50**	**100**	**150**	**200**
400/CF/60	4	5	6	7	NA	NA	NA	NA	(1)	(1)	29	(1)
400/CF/120	8	10	12	14	NA	NA	NA	NA	(1)	(1)	52	(1)
400/HF/60	5	7	9	11	20	26	30	32	20	37	50	60
400/HF/120	10	13	17	20	35	40	44	(2)	42	74	100	120

Note 1: no data available.

Note 2: the required thickness is not practicable.

5.7.2 Piping and vessels

For piping and vessels, the required PFP thickness shall be given in accordance with fire tests conducted following the SUPPLIER's requirements and required fire rating, as given in the certificate, and with COMPANY's approval.

As a general rule, fireproofing materials should not be considered for thermal insulation even if in some particular cases, these thermal insulation materials could provide some fire protection (if properly installed and protected). Specifically, some fireproofing materials may be limited to operating (non fire) temperatures as low as 160°F (70°C). Suitable material for the substrate's normal range of operating temperatures should be selected by carefully reviewing the SUPPLIER's data sheets for possible thermal restrictions.

5.8 Typical response of PFP materials

The temperature vs. time response curve may become a criterion for PFP material selection, in particular when exposure to fire is associated with an emergency depressurization curve, or for the protection of LPG storage tanks to prevent the BLEVE effect.

Figure 3 provides typical response curves for different types of PFP materials in a same 427/HF/60 rating for a beam of structure having Hp/A = 160 m^{-1} with the following thicknesses:

- Epoxy, intumescent: thickness about 10 mm
- Cement, inorganic, with vermiculite: thickness about 25 mm
- Cement, inorganic, without vermiculite: thickness about 30 mm
- Fibres pre-fabricated panels: thickness about 50 mm
- GRP on pipe (max OD = 500 mm): thickness about 35 mm – with a 350/JF/90 rating: see the red curve.

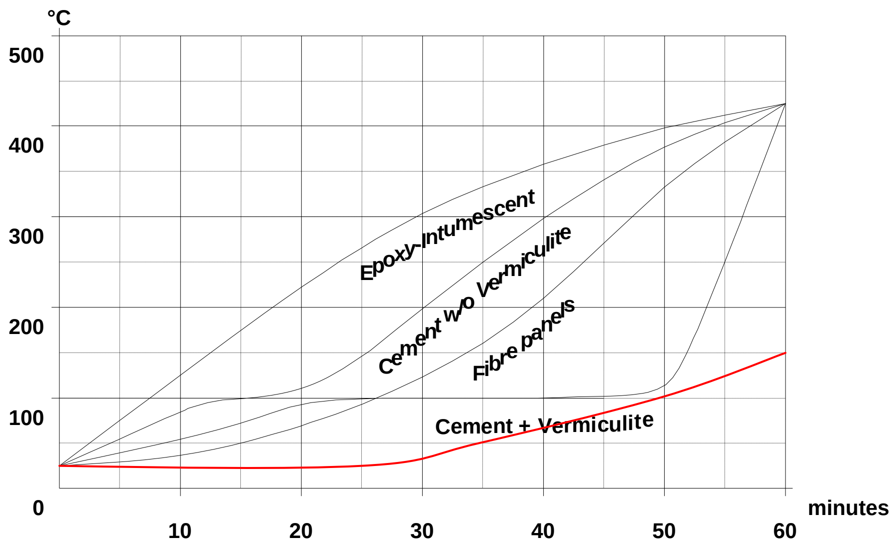


Fig 3: cold side temperature for different PFP materials

It can be noted that the response curves are quite different:

- The PFP performance of intumescent epoxy upgrades with time and temperature, as intumescence develops.
- Inorganic cement without vermiculite tends to control the temperature ranging from 100°C to 300°C; its performances decrease when the water content is exhausted.
- The addition of vermiculite enlarges the plateau where temperature is controlled around 100°C.
- Fibres pre-fabricated panels have no active insulation response; after a short lag the cold side temperature increases in a linear manner.

6. Applicability to typical examples

The purpose of this section is to propose, for typical examples, the default fire ratings to be applied if the risks analysis is not carried out.

6.1 Primary structure members

6.1.1 Requirements

Unless stipulated otherwise in the asset protection section of the Safety Concept, only structures supporting ER and EER equipment and risers and their associated ESDV's shall be, as a general rule, protected by PFP, in accordance with the requirements and criteria given in **sections 6.1.1.1; 6.1.1.2; 6.1.2** and **6.1.3** as follows.

6.1.1.1 Onshore

ER and EER systems shall preferably be designed in such a way that a supporting structure is not necessary. If this were not feasible the same requirements as those valid for the offshore environment shall apply.

6.1.1.2 Offshore

PFP applied onto structures supporting ER and EER equipment, risers and ESDV's is not sufficient to ensure their integrity over the required period of time if the **offshore installation main structure** is not capable of withstanding the effect of a fire for at least as long. Furthermore, PFP shall be envisaged where the collapse of a structure engulfed by fire can endanger life of personnel escaping or performing ER duties and/or affect the surrounding environment.

It is assumed, in the development that follows, that the offshore installation main structure can indeed resist as long as structures supporting specific equipment. If this were not the case, then a specific study shall be carried out at the preliminary engineering stage to determine the maximum duration required to achieve evacuation, and PFP shall be applied (onto structure exposed to fire) so that their fire resistance capability be sufficient to last as long as necessary for evacuation, but no longer. Normally, there are no further requirements, unless otherwise specified in the Safety Concept for asset protection purposes.

6.1.2 Applicability

6.1.2.1 Compulsory

- Structure supporting EER facilities (temporary refuges, muster areas, embarkation posts, telecommunication mast if exposed to fire) and ER facilities (elevated flares, emergency station, active-fire-fighting means).
- Structure supporting risers and ESDV's.
- Structure supporting equipment likely to fall down onto ER or EER facility and/or risers and ESDV's.

6.1.2.2 Optional

- Structure supporting facilities, as per asset protection section in the Safety Concept.

6.1.3 Default fire ratings

- Critical temperature: 427°C (steel).
- Fire rating:
  - In restricted area: HF or JF
  - Outside restricted area: CF.
- Duration:
  - EER or ER in hazardous areas: 120 minutes
  - Emergency depressurization: 60 minutes
  - ER or EER in non-hazardous areas but in restricted area: 60 minutes
  - Structures supporting risers and ESDV: 120 minutes
  - Asset protection as per the Safety Concept

6.2 Indoors structure members and partitions

6.2.1 Requirements

The same basic requirements set out for main structure members (see above **section 6.1**) apply in this case but only to structure members located indoors or in enclosed areas.

Intumescent material shall not be used inside enclosed areas.

On the other hand, indoors structure members are normally protected against wet environments and the selection of fibre materials generally becomes a feasible option.

6.2.2 Applicability and default fire ratings

It is the same as in **sections 6.1.2** and **6.1.3**.

6.3 Enclosures involved in ER or EER

6.3.1 Requirements

PFP shall be installed on premises which are involved in ER or EER operations, for as long as necessary for the situation to be brought back under control (ER), or the evacuation to be completed (EER). The occupancy in these premises is high or very high during an emergency and it is of utmost importance that PFP materials do not release any toxic gases or smoke.

6.3.2 Applicability

6.3.2.1 Compulsory

- ER: control room, emergency switch gear room, emergency centre, telecommunications room (if applicable), fire water pump enclosures.
- EER: temporary refuge, muster areas, embarkment posts.

6.3.2.2 Optional

- None.

6.3.2.3 Default fire ratings

- EER or ER in hazardous areas: H-120 or J-60

  It shall be assessed, on a case by case basis, if J-15 is not sufficient considering the presence of an automatic EDP system, theoretically capable of getting rid of the hydrocarbon inventory in 15 minutes.

- ER or EER in non-hazardous areas but in restricted areas: H-60 [(1) and (2)]
- ER outside the restricted area: A-0
- Within an enclosure whose external walls are H- or J-class, internal partition between ER and other equipment shall be A-60 if the hazard is cellulosic fire (e.g. partition between control room and electrical room) or H-60 if the hazard is hydrocarbon fire (e.g. partition between control room and diesel driven fire pumps).

Note 1: it is assumed that jet fire is not a threat in restricted areas but outside the hazardous areas, at least where ER or EER devices have been located.

Note 2: H-0 may be selected instead of H-60 if the location of the facility to be protected renders unlikely exposure to continuous hydrocarbon fire.

6.4 Enclosed process areas

6.4.1 Requirements

Enclosed process areas shall be provided with an adequate PFP system where it is required that a fire **inside the enclosure** cannot propagate quickly out doors. Different solutions can be selected for vertical partitions, ceilings, decks and floors. For the combination cases, where it is also necessary to protect the enclosed equipment from a fire located outside, refer to **section 6.5**.

6.4.2 Applicability

6.4.2.1 Compulsory

- Any enclosure located in hazardous areas and containing a fuel source, such as enclosed separation and gas compression units in rough environments or gas turbine diesel engines or gas engines enclosures.
- Enclosures containing a fuel source and outside hazardous areas, but within the restricted area and close to ER or EER facilities.

6.4.2.2 Optional

- Other enclosures containing a fuel source, within the restricted area, and close to the equipments that shall be protected from the effect of a fire as per the asset protection philosophy.

6.4.3 Default fire ratings

- Away from the main escape routes, flare headers and the ER facilities: H-0 or J-0
- Close to a main escape route, a flare header or an ER facility: H-0 or J-15

6.5 External Partitions

6.5.1 Requirements

PFP applied onto external partitions shall be as per the requirements of the certifying authorities, if applicable. For the combination cases, PFP may be applied inside or outside as per the requirements of this section and **section 6.4**.

6.5.2 Applicability

6.5.2.1 Compulsory

- Main decks that are required to be fire barriers
- Protection between fire zones.

6.5.2.2 Optional

- The external side of enclosures containing equipment to be protected from an outside fire, as per the asset protection section in the Safety Concept.

6.5.1 Default fire ratings

H-60 or J-15 in hazardous areas and/or where the risk of hydrocarbon fire exists within the restricted area; A-0 everywhere else unless a specific requirement prevails (e.g. garbage incinerator).

6.6 Pressure vessels containing LPG

6.6.1 Requirements

The main objective of PFP is to prevent the BLEVE effect that may occur on overhead LPG storage vessels.

All pressure vessels containing LPG shall be protected with PFP.

Fireproofing of pipe supports within 15 m of the LPG vessel, or within the spill containment area, is also mandatory.

Reference shall be made to API STD 2510 for the calculation of the required PFP thickness. Table 8 gives guidance for the UL 1709 fire-resistance rating for the selected equipment.

Table 8: level of fireproofing protection in a fire-scenario envelope

Equipment	Protection level
LPG vessels if not protected by fixed water spray systems	Fireproofed equivalent to 1.5 hours in UL 1709
Pipe supports within 15m or in spill containment area of LPG vessels, whichever is greater	Fireproofed equivalent to 1.5 hours in UL 1709
Critical wiring and control systems	15-to-30-minute protection in UL 1709 temperature conditions

6.6.2 Applicability

There is no optional requirement. Compulsory requirements are as follows:

- All LPG storage pressure vessels, regardless of their storage capacity.
- All pressure vessels containing more than 120 m^3 propane or 500 m^3 heavier than propane and likely to be exposed to a fire from an adjacent storage, a nearby process unit or the pressure vessel piping itself.
- The supporting legs of the LPG sphere/ bullet shall be fireproofed.

6.6.3 Default fire ratings

- 350/JF/60 where there is one single storage pressure vessel **and** where the other sources of fuel are at a sufficient safety distance or can be depressurized in case of an emergency.
- 350/JF/120 where there are several storage pressure vessels or other fuel sources nearby that cannot be depressurised.

6.7 Process vessels

6.7.1 Requirements

PFP may be imposed by local regulations and/or by process considerations such as the necessary time to achieve depressurization (when existing) or the absence of an emergency depressurization system in the case of simple and low-risk installations.

6.7.2 Applicability

6.7.2.1 Compulsory

- All process vessels that are not (or cannot be: e.g. slug catchers) depressurized but that should be Emergency De-Pressurized (EDP'd) in case of an emergency, according to the criteria set forth in GS EP SAF 261.
- All process vessels that are not covered by GS EP SAF 261 (size, design pressure, inventory) but that are located close enough to an ER or EER equipment to affect the said equipment in case of an incident.

Fireproofing is required on the supports (saddles, legs and skirts) of all process vessels within the fire scenario envelope that contain and could release flammable/ combustible, or toxic materials.

6.7.2.2 Optional

- Vessels that can be exposed to fire as per the asset protection in the Safety Concept.

6.7.3 Default fire ratings

- 350/HF/60 or 350/JF/15, depending upon the type of threat the vessel is exposed to, as a base case.
- 350/HF/120 or 350/JF/60 for process vessels likely to become a threat to ER or EER equipment.

6.8 Piping

6.8.1 Requirements

Piping (including piping supports) shall be fire proofed when it is attached to a capacity or a vessel which is, itself, fire proofed and not depressurized in case of an emergency, or when a sufficient hydrocarbon inventory is trapped in pipework that is not depressurized in case of an emergency. Additionally PFP shall be applied to piping systems that can be exposed to fire and that are used for emergency response.

6.8.2 Applicability

6.8.2.1 Compulsory

- Piping systems connected to a vessel, like the ones mentioned in **section 6.7** and either an ESDV or a block valve, a control valve, a SDV, a PSV, etc. downstream of which pressure does not exceed back pressure during an EDP.
- Flare headers, sub-headers and BDV outgoing lines, in places where they can be exposed to a fire and that shall remain serviceable for a duration that exceeds their inherent capacity to resist the effect of a fire. The purpose of this is to avoid escalation when performing an EDP from a fire zone where a fire has occurred.
- Parts of the fire water network, especially if made of GRE or Cu-Ni alloy, in places where it is exposed to a fire and that shall remain serviceable for a duration that exceeds their natural capacity to resist the effect of a fire.

6.8.2.2 Optional

- ER related piping systems (relief network, fire water network, other if applicable) that shall keep full integrity in the perspective of resuming normal operation immediately after the emergency response.
- PFP applied to flare network and fire water networks, if any, shall be such that it suffices to maintain their operational status over the period of emergency response; it is not required that these systems retain full integrity after the emergency response.

6.8.3 Default fire ratings

As a general rule, PFP applicable to piping shall be specified for the same duration of protection for the equipment they are attached to or the function they serve. The recommendations conveyed below are, therefore, default values that can be adjusted to match the installation's specific conditions:

- 350/HF/120 or 350/JF/60 (1), for systems containing hydrocarbon - If JF rating is required, it is assumed that the jet fire shall not last longer than the time it takes to perform emergency depressurisation (typically 15 to 20 minutes) and that sufficient protection is provided afterwards to cope with subsequent hydrocarbon fire for a duration of 120 minutes.
- 350/HF/60 or 350/JF/60, for flare lines and headers
- T/HF/60 or T/JF/60, depending upon the type of threat the pipework is exposed to, for fire water mains with T equal to 350°C if steel pipework, or T equal to the maximum allowable temperature for other materials.

6.9 Pipelines, risers and ESDV's

6.9.1 Requirements

All connections (risers, etc.) to the facilities, either incoming upstream of battery limit ESDV's, or outgoing downstream of battery limit ESDV's, that can be exposed to a fire and cannot be depressurized (EDP), shall be protected with PFP.

The PFP systems shall ensure the integrity of the protected part. Maintenance and inspection tasks shall be carried out during all field's lifetime. PFP application on risers shall be carried out in plant.

6.9.2 Applicability

6.9.2.1 Compulsory

- Offshore, all risers routing flammable products to and from a facility, including riser clamps/hang-offs, from below the Lowest Astronomical Tide (LAT) minus 3 meters or the annual swell trough, whichever is the greater, and up to (inclusive of) ESDV and its actuators.

6.9.2.2 Optional

- Onshore, all incoming/ outgoing hydrocarbon pipelines from (inclusive of) ESDV to grade or, if above-ground pipeline, sufficient distance to protect the pipeline against the effects of a fire on other units, including receiving facilities.

6.9.2.3 Default fire ratings

- 200/HF/120 or 200/JF/60, depending upon the type of threat the pipeline is exposed to, for onshore pipelines and associated ESDV's.
- 200/JF/120, for offshore risers and associated ESDV's.

6.10 Valves and local instrumentation

6.10.1 Requirements

PFP shall be used onto valves and instruments where they are attached to a process vessel, or a piece of piping that is, itself, fitted with PFP. Refer to **sections 6.7** and **6.8.**

6.10.2 Applicability

All appurtenances connected to piping or process vessels.

6.10.3 Default fire ratings

Same as piping or vessel it is attached to.

6.11 Refrigerated tanks for Liquefied Natural Gas (LNG)

They shall be subject to a particular project specification.

6.12 Bulkheads and decks

In case of offshore application, the minimum fire integrity of bulkheads and decks inside the hull and accommodations shall be in compliance with IMO SOLAS Part C -Regulation 9 Chapter II-2.

All bulkhead penetrations shall be fireproofed at the same level protection as the bulkheads themselves.

6.13 Health and Safety precautions

Operations involving spray application of flammable and combustible materials shall comply with NFPA 33.

Some PFP materials and most of their associated primers and topcoats contain low flash point solvents or substances hazardous to human health or the environment. All substances or chemicals shall be assessed in terms of health and environmental effects.

A risk assessment shall be made prior to all delivery and all PFP preparation and application work. Suitable control measures, including low-storage temperature, natural or forced ventilation requirements, respiratory protective equipment, adequate clothing and eyes protection, etc. shall be provided and their use enforced to reduce the risks as low as practicable. In case welding is required on a face opposite to a face protected with PFP, PFP shall be removed during the work and reinstalled afterwards.

Appendix 1 Test reports laboratories and certifications

I. Test reports

The performances of the PFP materials proposed by the SUPPLIER shall be tested by a third party laboratory agreed by the parties involved. The tests results shall be certified by the authorities.

Third party laboratories agreed by the COMPANY:

Australia

- Australian Army Proof and Experimental Establishment, Graytown, Victoria, Australian Maritime Agency.

Europe

- GESIP/GEIE program GASAFE (European Economic Interest Grouping): fire tests program on LPG spherical storage tanks amended by consortium and eligible by French Instruction.

France

- CNPP laboratory: in-situ tests
- CSTB laboratory
- CTICM laboratory, "Laboratoire Métallurgique"
- SERCOVAM laboratory.

Germany

- "Bundensanstalt für Materialforschung und Prüfing" (BAM) laboratory.

Great Britain

- British Gas, Faverdale Technology Centre (FTC)
- Fire Research Station and Building Research Establishment, Cardington
- Health and Safety Laboratories (HSL): Jet-Fire tests
- Spadeadam: in-situ, full size Jet-Fire tests, Shell Research UK
- Southwest Research Institute (SWRI): Jet-Fire tests
- Warrington Fire Research Centre (WFRC).

Netherlands

- Netherlands Shipping Inspection.

Norway

- Norwegian Maritime Directorate (NMD)
- SINTEF: Jet-Fire tests.

USA

- Department of Transportation

- Factory Mutual Corporation (FMC)
- Underwriters Laboratories (UL).

II. Certifications

Third party Authorities agreed by the COMPANY:

- American Bureau of Shipping (ABS)
- Bureau Veritas (BV)
- Der Norske Veritas (DNV)
- Germanischer Lloyd’s
- Lloyd’s Register of Shipping (Lloyd’s)

Appendix 2 List of PFP materials

Table 9: examples of SUPPLIERS and products recommended by the COMPANY

SUPPLIER	Products
ADVANCED INSULATION SYSTEMS LTD. (ALDERLEY)	Contratherm JF 120
INTERNATIONAL COATINGS	Chartek 7 Chartek 8 Chartek 1709
MANDOVAL	Mandolite 990
CARBOLINE	Thermolag 3000 Thermolag 3000/3002 Nullifire System E Pyrocrete 241
PPG	Pittchar XP
LEIGHS PAINTS	Firetex M90

These products shall only be used for the application for which they are guaranteed and in the strict conditions of their certification. This is not an exhaustive list.

Appendix 2

Table 10: examples of PFP products classification (this is not an exhaustive list)

Product	Application	Partition fire rating	Structure fire rating
System E	Structural steel bulkhead	H0 H60 H120	427/HF/120
	Structural steel deck	H0 H60 H120	427/HF/120
Chartek 7	Structural steel		427/JF/120 427/HF/180
Chartek 8	Structural steel deck	H0 H60 H120	350/HF/120
	Structural steel bulkhead	H0 H60 H120	350/HF/120
	Structural steel I section		350/HF/120
Chartek 1709	Structural steel		427/HF/120
Contratherm JF 120	Structural steel planar steelwork		350/JF/120 427/JF/60
Contratherm JF 120	Structural steel tubular section		350/JF/60
Thermolag 3000/3002	Structural steel I section	J0 J15 J60	350/JF/30 350/JF/60
Thermolag 3000	Horizontal partition and deck	H0 H60 H120 deck	
	Wall and bulkhead	H0 H60 H120 bulkhead	
Pittchar XP	Structural steel bulkhead	H60-H120 deck H60-H120 bulkhead	350/HF/120
	Structural steel I section		427/HF/120
	Structural steel jet fire protection		350/JF/60
Pyrocrete 241	Structural Steel I sections		427/JF/120
Firetex M 90	Structural Steel I sections		427/JF/60
	Structural Steel Hollow Section		427JF/90
	Fire walls Deck	H0 H60 H120	427/JF/60 350/JF/60 350/JF/60
	Fire walls Bulkheads	H0 H60 H120	427/JF/60 350/JF/60 350/JF/60
	Planar Steelwork		427/JF/60
Ocean Coating 477	PFP for GRP pipings		

Appendix 3 GRP fire tests

These tests may be carried out on GRP only or on GRP with PFP coating, or on other synthetic materials. SUPPLIERS shall be responsible for PFP selection, application and performances during all the installation's lifetime.

Electrical conductivity of GRE pipes is required in hazardous areas: the GRE pipe manufacturer shall provide detailed specifications regarding conductivity for the acceptance of the pipe.

Table 11: piping class and fire endurance tests

FLUID SERVICE	CURRENT PIPING CLASS	Selected Fire endurance tests				Chapter ISO 14692-2:2002	IMO Resolution A.753 (18)
Firewater wet system	B90	SF	JF	EB	30	E.4.5	
		SF	HF	EA	30	E.4.5	
Firewater dry system	B94 (1)	DF	JF	EB	30	E.4.3	
		DF	HF	EA	30	E.4.3	
Cooling water	B90	ST	IF	EB	30	E.4.4	Level 3
Seawater	B90	ST	IF	EB	30	E.4.4	Level 3
Open drains	B91	DE	HF	EA	30	E.4.2	Level 2

Note 1: new class B94

For FPSO, BV rules states that GRE pipes to be used in machinery spaces cat "A" shall be able to withstand the fire endurance as stated in BV rules and IMO resolution A.753 (18), i.e. in all cases a 60 minutes endurance test; whereas a combination of other GRE pipe endurance class level such as L3 type with a suitable fire protection cover may be considered. Nevertheless, this combination shall give results equivalent to class L1 type fire endurance (DE/HF/EA/60) and a certificate shall be issued proving such compliance.

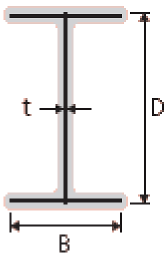
Table 12: terms for fire endurance tests taken from ISO 14692-2:2002

Service (fluid or fluid state)		Fire type		Integrity/duration	
DE	Dry or empty	JF	Jet Fire	EA	Capable of maintaining test pressure without leakage during or after test
DF	Initially dry/empty for a minimum of 5 min followed by flowing water (linear velocity ≤1m/s)	HF	Hydrocarbon Pool Fire	EB	No leakage during the test except for a slight weeping that could be accepted. Capable of maintaining the test pressure after cooling without significant leakage, i.e. not exceeding 0.2 l/min for a minimum of 15 min.
ST	Stagnant water	IF	Impinging flame	EC	Minimal or no leakage (≤ 0.5 l/min) during the fire test. Capable of maintaining the test pressure after cooling with known leakage (leakage rate per metre of pipe to be quantified in each case).
SF	Initially stagnant for a minimum of 5 min followed by flowing water (linear velocity ≤1m/s)	CF	Cellulosic Fire	ED	Leakage permitted (≥ 0.5 l/min) during the fire test. Capable of maintaining the test pressure after cooling with known leakage (leakage rate per metre of pipe to be quantified in each case).

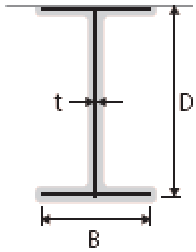
Appendix 4 Example of a Hp/A calculation

Using a 457 x 191 x 67 kg/m serial size steel section for which actual dimensional values are:
A (area) = 0.00854m^2
B = 189.9 mm
D = 453.6 mm
t = 8.5 mm
Note that the cross-sectional area can be obtained by dividing the weight of the section per linear metre by the weight of 1m^3 of steel (7850kg). Thus, 67 ÷ 7850 = 0.00854 m^2.
If the protection follows the profile of a section, as would occur with sprayed coatings and paints, the following Hp/A factors shall result.

Example 1: Profile protection, 4 sides exposed
Hp = 4B + 2D - 2t
Hp = 4 x 189.9 mm + 2 x 453.6mm - 2 x 8.5 mm
Hp = 759.6 + 907.2 - 17.0 = 1649.8 mm (1.650 m)
Therefore, Hp/A = 1.650 m ÷ 0.00854 m^2 = **193.2 m^{-1}**

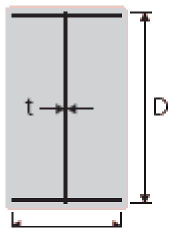


Example 2: Profile protection, 3 sides exposed
Hp = 3B + 2D - 2t
Hp = 3 x 189.9 mm + 2 x 453.6 mm - 2 x 8.5 mm
Hp = 569.7 + 907.2 - 17.0 = 1459.9 mm (1.460 m)
Therefore, Hp/A = 1.460 m ÷ 0.00854 m^2 = **171.0 m^{-1}**



If the same section to be protected is 'boxed', whether enclosed with boards or filled with a solid sprayed coating, the following Hp/A factors shall result. Note that whilst the cross-sectional area does not change, the exposed surface to be protected does.

Example 3: Boxed protection, 4 sides exposed
Hp = 2B + 2D
Hp = 2 x 189.9 mm + 2 x 453.6 mm
Hp = 379.8 + 907.2 = 1287 mm (1.287 m)
Therefore, Hp/A = 1.287 m ÷ 0.00854 m^2 = **150.7 m^{-1}**



Example 4: Boxed protection, 3 sides exposed
Hp = B + 2D
Hp = 189.9 mm + 2 x 453.6 mm
Hp = 189.9 + 907.2 = 1097.1 mm (1.097 m)
Therefore, Hp/A = 1.097 m ÷ 0.00854 m2 = 128.5 m-1