FIRE PROOFING OF STEEL SUPPORTING STRUCTURES IN OIL & GAS INDUSTRY

OISD – STD – 164

Oil Industry Safety Directorate
Government of India
Ministry of Petroleum & Natural Gas
8th Floor, OIDB Bhavan, Plot No. 2, Sector – 73, Noida – 201301 (U.P.)
Website: www.oisd.gov.in
Tele: 0120-2593800, Fax: 0120-2593802
FIRE PROOFING OF STEEL SUPPORTING STRUCTURES IN OIL & GAS INDUSTRY

Prepared by:

FUNCTIONAL COMMITTEE ON
FIRE PROOFING OF STEEL SUPPORTING STRUCTURES IN OIL & GAS INDUSTRY

OIL INDUSTRY SAFETY DIRECTORATE
GOVERNMENT OF INDIA
MINISTRY OF PETROLEUM & NATURAL GAS
8th FLOOR, OIDB Bhavan, Plot No 2
Sector-73, Noida - 201301 (Uttar Pradesh)
Website: www.oisd.gov.in
Preamble

Indian petroleum industry is the energy lifeline of the nation and its continuous performance is essential for sovereignty and prosperity of the country. As the industry essentially deals with inherently inflammable substances throughout its value chain – upstream, midstream and downstream – Safety is of paramount importance to this industry as only safe performance at all times can ensure optimum ROI of these national assets and resources including sustainability.

While statutory organizations were in place all along to oversee safety aspects of Indian petroleum industry, Oil Industry Safety Directorate (OISD) was set up in 1986 Ministry of Petroleum and Natural Gas, Government of India as a knowledge centre for formulation of constantly updated world-scale standards for design, layout and operation of various equipment, facility and activities involved in this industry. Moreover, OISD was also given responsibility of monitoring implementation status of these standards through safety audits.

In more than 25 years of its existence, OISD has developed a rigorous, multi-layer, iterative and participative process of development of standards – starting with research by in-house experts and iterating through seeking & validating inputs from all stake-holders – operators, designers, national level knowledge authorities and public at large – with a feedback loop of constant updation based on ground level experience obtained through audits, incident analysis and environment scanning.

The participative process followed in standard formulation has resulted in excellent level of compliance by the industry culminating in a safer environment in the industry. OISD – except in the Upstream Petroleum Sector – is still a regulatory (and not a statutory) body but that has not affected implementation of the OISD standards. It also goes to prove the old adage that self-regulation is the best regulation. The quality and relevance of OISD standards had been further endorsed by their adoption in various statutory rules of the land.

Petroleum industry in India is significantly globalized at present in terms of technology content requiring its operation to keep pace with the relevant world scale standards & practices. This matches the OISD philosophy of continuous improvement keeping pace with the global developments in its target environment. To this end, OISD keeps track of changes through participation as member in large number of International and national level Knowledge Organizations – both in the field of standard development and implementation & monitoring in addition to updation of internal knowledge base through continuous research and application surveillance, thereby ensuring that this OISD Standard, along with all other extant ones, remains relevant, updated and effective on a real time basis in the applicable areas.

Together we strive to achieve NIL incidents in the entire Hydrocarbon Value Chain. This, besides other issues, calls for total engagement from all levels of the stake holder organizations, which we, at OISD, fervently look forward to.

Jai Hind!!!

Executive Director

Oil Industry Safety Directorate
FOREWORD

Oil Industry in India is more than 100 years old. Over the years a variety of practices have been in vogue because of collaboration/association with different foreign companies and governments. Standardisation in design, operating and maintenance practices was hardly in existence at a national level. This lack of uniformity, coupled with feedback from some serious accidents that occurred in the recent past in India and abroad, emphasised the need for the industry to review the existing state of art in designing, operating and maintaining oil and gas installations.

With this in view, the Ministry of Petroleum and Natural Gas in 1986 constituted a Safety Council assisted by the Oil Industry Safety Directorate (OISD) staffed from within the industry in formulating and implementing a series of self regulatory measures aimed at removing obsolescence, standardising and upgrading the existing standards to ensure safer operations. Accordingly, OISD constituted a number of functional committees comprising of experts nominated from the industry to draw up standards and guidelines on various subjects.

The present document on ‘Fire Proofing of Steel Supporting Structures in Oil & Gas Industry’ was prepared by the Functional Committee on Fire Proofing. This document was prepared based on the accumulated knowledge, experience of industry members and various national/international codes and practices.

This document will be reviewed periodically for improvements based on the new experiences and better understanding.

Suggestions from industry members may be addressed to:

The Coordinator,  
Functional Committee on  
‘Fire Proofing of Steel Supporting Structures in Oil & Gas Industry,’  
Oil Industry Safety Directorate  
8th FLOOR, OIDB Bhavan, Plot No 2  
Sector-73, Noida - 201301 (Uttar Pradesh)
NOTE

OISD (OIL INDUSTRY SAFETY DIRECTORATE) publications are prepared for use in the oil and gas industry under Ministry of Petroleum & Natural Gas. These are the property of Ministry of Petroleum & Natural Gas and shall not be reproduced or copied and loaned or exhibited to others without written consent from OISD.

Though every effort has been made to assure the accuracy and reliability of the data contained in these documents OISD hereby expressly disclaims any liability or responsibility for loss or damage resulting from their use.

These documents are intended to supplement rather than replace the prevailing statutory requirements.
FUNCTIONAL COMMITTEE OF FIRST EDITION
ON
FIRE PROOFING IN OIL & GAS INDUSTRY

<table>
<thead>
<tr>
<th>NAME</th>
<th>DESIGNATION</th>
<th>ORGANISATION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LEADER</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shri B. K. Raut</td>
<td>DGM (SMMS)</td>
<td>E.I.L</td>
</tr>
<tr>
<td><strong>MEMBERS</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shri R. P. Saxena</td>
<td>DGM (M)</td>
<td>MRBC, ONGC</td>
</tr>
<tr>
<td>Shri S.G. Subramoney</td>
<td>CH.MGR, (PROJECTS),</td>
<td>HPCL</td>
</tr>
<tr>
<td>Shri S. Neelakantan</td>
<td>SR.MGR(ENGG.SERVICES)</td>
<td>MRL</td>
</tr>
<tr>
<td>Shri B. K. Singh</td>
<td>SR. INSPI. MGR</td>
<td>IOC</td>
</tr>
<tr>
<td>Shri H.C. Mehta</td>
<td>SR. MGR. (LPG-OPER)</td>
<td>HPCL (MKTG)</td>
</tr>
<tr>
<td>Shri U. V. Mannur</td>
<td>MGR (LPG – ENGG)</td>
<td>IOC (MKTG)</td>
</tr>
<tr>
<td>Shri B.S.M. Krishna</td>
<td>MGR (ADV ENGG-CIVIL)</td>
<td>BPCL</td>
</tr>
</tbody>
</table>

**MEMBER COORDINATOR**

Shri K. R. Soni
ADDL DIRECTOR (ENGG) OISD

In addition to the above, several other experts from Industry contributed in the preparation, review and finalisation of this document.
## FUNCTIONAL COMMITTEE OF SECOND EDITION
ON
FIRE PROOFING OF STEEL SUPPORTING STRUCTURES IN OIL & GAS INDUSTRY

<table>
<thead>
<tr>
<th>NAME</th>
<th>ORGANISATION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>LEADER</strong></td>
<td></td>
</tr>
<tr>
<td>Shri P. P. Lahiri</td>
<td>Engineers India Limited.</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>MEMBERS</strong></td>
<td></td>
</tr>
<tr>
<td>Shri P. K. Dewari</td>
<td>IOCL - BGR</td>
</tr>
<tr>
<td>Shri O.P. Khokhar</td>
<td>IOCL (PIPELINES)</td>
</tr>
<tr>
<td>Shri G. Deka</td>
<td>Numaligarh Refinery (NRL)</td>
</tr>
<tr>
<td>Shri R. K. Sachdeva</td>
<td>IOCI (REF)</td>
</tr>
<tr>
<td>Shri Joydeep Mazumdar</td>
<td>IOCL (MKTG)</td>
</tr>
<tr>
<td>Shri V. Suresh Kumar</td>
<td>BPCL (KR)</td>
</tr>
<tr>
<td>Shri M.N. Nagaraja</td>
<td>BPCL (MR)</td>
</tr>
<tr>
<td>Shri J R Divekar</td>
<td>HPCL (REF)</td>
</tr>
<tr>
<td>Shri G.K. Dey</td>
<td>CHT</td>
</tr>
<tr>
<td>Shri Suvir Singh</td>
<td>CBRI, ROORKEE</td>
</tr>
</tbody>
</table>

**MEMBER COORDINATOR**

Shri Y.P. Gulati
OISD

In addition to the above, several other experts from industry contributed in the preparation, review and finalisation of this document.
## CONTENTS

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>SUBJECT</th>
<th>Page No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>INTRODUCTION</td>
<td>01</td>
</tr>
<tr>
<td>2.0</td>
<td>SCOPE</td>
<td>01</td>
</tr>
<tr>
<td>3.0</td>
<td>DEFINITION</td>
<td>01</td>
</tr>
<tr>
<td>4.0</td>
<td>OBJECTIVES OF FIRE PROOFING</td>
<td>01</td>
</tr>
<tr>
<td>5.0</td>
<td>AREA WISE APPLICATION</td>
<td>03</td>
</tr>
<tr>
<td>6.0</td>
<td>FIREPROOFING MATERIALS AND SYSTEMS</td>
<td>07</td>
</tr>
<tr>
<td>7.0</td>
<td>INSTALLATION OF FIREPROOFING SYSTEMS</td>
<td>09</td>
</tr>
<tr>
<td>8.0</td>
<td>METHODS OF APPLICATION OF FIREPROOFING</td>
<td>11</td>
</tr>
<tr>
<td>9.0</td>
<td>QUALITY CONTROL IN APPLICATION OF FIRE PROOFING</td>
<td>13</td>
</tr>
<tr>
<td>10.0</td>
<td>PERIODIC INSPECTION AND MAINTENANCE</td>
<td>14</td>
</tr>
<tr>
<td>11.0</td>
<td>REFERENCES</td>
<td>15</td>
</tr>
</tbody>
</table>

## LIST OF ANNEXURES TO THE DOCUMENT

<table>
<thead>
<tr>
<th>Annexure -I</th>
<th>FIRE SCENERIOS AND FIREPROOFING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annexure -II</td>
<td>TESTING OF FIRE PROOFING MATERIALS</td>
</tr>
<tr>
<td>Annexure - III</td>
<td>PARTIAL DIRECTORY OF FIRE TEST LABORATORIES</td>
</tr>
<tr>
<td>Annexure - IV</td>
<td>TEST RATINGS- STRUCTURAL STEEL FOR OIL INDUSTRY</td>
</tr>
<tr>
<td>Annexure - V</td>
<td>TYPICAL DETAILS – CEMENT CONCRETE</td>
</tr>
<tr>
<td></td>
<td>FIREPROOFING - SOLID ENCASEMENT</td>
</tr>
<tr>
<td>Annexure - VI</td>
<td>TYPICAL DETAILS OF COVER PLATES FOR WEATHER</td>
</tr>
<tr>
<td></td>
<td>PROTECTION</td>
</tr>
<tr>
<td>Figure – 5.1 to 5.6</td>
<td>TYPICAL DETAILS DEPICTING FIREPROOFING REQUIREMENTS</td>
</tr>
</tbody>
</table>
FIRE PROOFING OF STEEL SUPPORTING STRUCTURES IN OIL & GAS INDUSTRY

1.0 INTRODUCTION

This standard provides technical details, including inspection and maintenance requirements, for selection and application of fire proofing in Oil and Gas Industry.

Only passive fire proofing systems have been covered in this standard and details of active systems such as automatic water deluge, which are used to protect pressure vessels, processing structures, equipment etc., are excluded. Passive fire protection shall be used along with active fire protection systems like water deluge sprinkler systems etc.

2.0 SCOPE

This standard provides minimum requirements of passive fire proofing for steel supporting structures of on-shore installations for exploration & production, refineries, petrochemicals and marketing installations.

This standard is not applicable to offshore installations.

The standard also covers technical details of materials used for fire proofing, fire rating, selection and application methods for different areas, methods of application of fire proofing materials, quality control measures and inspection during application of materials, including periodic inspection and maintenance of fire proofing. Active fire protection system and its effects are beyond the scope of this standard.

3.0 DEFINITIONS

i) Fire Proofing: Fire proofing is an insulation that provides a degree of fire resistance to protect substrates of vessels, piping and structures for a predetermined time period against fire.

ii) Fire-Exposed Envelope: A fire-exposed envelope is the three-dimensional space into which fire potential equipment can release flammable or combustible fluids that are capable of burning long enough and with enough intensity to cause substantial property damage.

iii) Fire Rating is the duration of fire test exposure to which a component or construction assembly is exposed and for which it meets all the acceptable criteria as determined by relevant standard.

iv) Flammable (or inflammable) product: Any product which when tested in a specified manner will ignite when mixed with air on contact with a flame and will support combustion.

v) Shall indicate that the provision is mandatory.

vi) Should indicate that the provision is recommendatory as per good engineering practices.

vii) Substrate is the underlying layer being protected by a fireproofing barrier layer.

4.0 OBJECTIVES OF FIRE PROOFING

4.1 General

Fireproofing is considered as one of the most effective means of protecting the steel structures. One of the options available to mitigate damage caused by fire is fireproofing of structures. It offers protection against the adverse thermal effects of fire for a limited period and limited degree of exposure. It should never be considered as a replacement for active fire fighting.

The main objective of fireproofing of steel supports and structures is to prevent the escalation of fires to an unacceptable level by providing a protection for a limited period of time until full fire protection capabilities can be deployed. Fireproofing is done to maintain the integrity and stability of the structure to its design functional objectives in order to prevent injury to personnel working within or
outside the industry premises due to release of large quantities of flammable products and/or toxic materials.

Application of fireproofing will delay an eventual collapse of steel structures and allow it to happen in gradually controlled manner with visible signs. This helps in timely isolation of the affected equipment and carrying out safe fire fighting and rescue operations.

Refrigerated or cryogenic liquefied gases exert an intense cooling effect when escaping to atmosphere, which may expose unprotected steelwork to severe embrittlement and failure due to fracture. One of the most effective and well proven means of protection against such hazards is fireproofing.

4.2 General application criteria

4.2.1 Fire protection

Fireproofing shall be applied to the steel supporting structures, whose sudden failure would lead to endangering the lives of operating personnel, escalation of the incident or unacceptable environmental pollution. Only the steel structures located within the fire exposed envelope shall be considered for fireproofing.

Fire proofing is normally not provided for the following:

i) Top surfaces of the beams, which support floor plates, gratings or equipment.

ii) All the stairways, walkways and platforms etc which are designed for live loads.

For all the steel stanchion or supports requiring resistance against mechanical damage at the lower end, fire proofing should preferably be made of reinforced cement concrete or otherwise suitable means should be provided to protect the fire proofing from mechanical damage. The height of such fire proofing shall be a minimum of 1.8 M from the grade level. However, at higher levels, alternative fireproofing materials can be used.

4.2.2 Cold splash protection

Steel structure members which are under the danger of embrittlement due to cooling effect of the product released through potential sources of leaks should be protected against cold splash.

4.3 Resistance against fire and cold splash

4.3.1 General

The criteria for judging a material's thermal performance in a fire exposure should be actual fire tests on a sufficiently large enough scale to realistically determine the behaviour of both the material and the installation design. Test environments should closely match the fire exposure expected in an end-use situation. In the case of the hydrocarbon processing industry, this could be anything from free burning pools of liquid to high pressure jets of hot hydrocarbons. Therefore, it is imperative to test materials in as severe an environment as possible.

4.3.2 Resistance against fire

The length of time during which a steel structure needs to maintain its integrity depends on local circumstances such as type of plant, availability of fire-fighting services, and risk of escalation.

Due to high severity of hydrocarbon fire in comparison to cellulose type fire, all the fireproofing systems for hydrocarbon fires shall meet the high rise hydrocarbon fire curve criteria mentioned under UL1709 fire resistance tests for the duration of predicted fire exposure. (A brief write up about testing of fireproofing materials is attached as ANNEXURE-II to this document.)

50 mm thick cement concrete cover of grade or proportion as specified at clause no 8.8.1 of this document, meets the above hydrocarbon fire requirement. Systems based on other types of fireproofing materials shall be referred as ‘other than cement concrete fireproofing systems’ as per the scope of this standard. To establish fire rating of alternative materials appropriate tests or calculations can be done. Results of the tests performed on new materials shall be as good as those of the cement concrete.

"OISD hereby expressly disclaims any liability or responsibility for loss or damage resulting from the use of OISD Standards/Guidelines."
4.3.3 Resistance against cold splash

The fireproofing system should be able to withstand the atmospheric boiling temperature of the product while the temperature of the steel structure should not fall below its embrittlement temperature. To meet the above cold splash protection, 50 mm thick cement concrete cover should be provided.

4.4 Design considerations

4.4.1 Extent of fireproofing

The extent of the fireproofing around equipment and structures shall be based strictly on the detailed fire assessment study and the same should be clearly indicated on layout and construction drawings.

4.4.2 Type of fireproofing

The type of fireproofing material and its construction/application method should be clearly specified. If necessary, heat transfer calculations should be made to determine the fireproofing thickness for different \( \frac{H_p}{A_{\text{Net}}} \) ratios of sections to be protected, the need for reinforcement and the need for insulation. Reinforced and/or precast cement concrete can also be considered as an alternative to fireproofed structural steel.

Note 1: \( H_p \) is the exposed perimeter and \( A \) is the cross sectional area of the substrates.

4.4.3 Structural members to be fireproofed

Structural members or bracings within a fire exposed envelope which are required for reducing the effective buckling length of the stanchions shall be fireproofed. Structural members serving only a windbracing function shall not be fireproofed.

5.0 AREAWISE APPLICATION

Determination of fire proofing needs involves a three step procedure that establishes:

a) The location of fire-hazardous areas or fire-exposed envelopes,

b) The size of the fire-exposed envelope, and

c) The rating or thickness of fire proofing material that needs to be applied within each of the fire-exposed envelope.

5.1 FIRE POTENTIAL EQUIPMENT CLASSIFICATION

Fire-potential equipment includes types of hydrocarbon-handling equipment that can release appreciable quantities of flammable fluids.

5.1.1 High Fire Potential Equipment:

a) Fired heaters that charge liquid or mixed phase hydrocarbons, under the following conditions:

i. Operation at temperatures and flow rates that are capable of causing coking within the tubes.

ii. Operation at pressure and flow rates those are high enough to cause large spills before the heater can be shut in.

iii. Charging of potentially corrosive fluids.

iv. Incorporation of a high level of automation and complex peripheral equipment such as combustion air preheater.

“OISD hereby expressly disclaims any liability or responsibility for loss or damage resulting from the use of OISD Standards/Guidelines.”
b) Pumps that handle flammable and combustible liquids at or above their flash point or autoignition temperatures, at high pressure, or at high flows. In some cases, maintaining seals without serious leaks may be difficult because of the liquid being pumped.

c) Reactors that operate at high pressure or are apt to produce exothermic or runaway reactions.

d) Compressors along with related lube-oil system. Compressors do not have a high liquid - fire potential; however, they can generate a fire-exposed envelope if the likelihood exists that there will be a prolonged release of gas and intense fire in the vicinity of important structural supports.

e) Heat exchangers handling high temperature fluids at high pressure.

f) Pressure vessels handling light hydrocarbons e.g. C2, C3 and C4 (Reflux).

5.1.2 Medium Fire Potential Equipment:

a) Accumulators, feed drums, and other vessels that may leak as a result of broken instrumentation, ruptured gaskets, or other apparatus.

b) Tower that may leak as a result of broken gauge columns or gasket failure on connected piping and bottom reboilers.

5.1.3 Low Fire-Potential Equipment:

a) Pumps that handle excluded class Note 2 liquids below their flash points.

b) Piping that is within battery limits and has a concentration of valves, fittings, and flanges.

c) Heat exchangers that may develop flange leaks.

Note 2: Liquids having flash point of 93°C and above.

5.2 SIZE OF FIRE-EXPOSED ENVELOPE:

A frequently used frame of reference for a fire-exposed envelope is one that extend 20-30 feet (6.1-9.1 meters) horizontally and 30-40 feet (9.1-12.2 meters) vertically from a source of liquid fuel.

The following conditions within the fire-exposed envelope can either limit or extend the envelope’s reference dimensions:

i. The source & volume of the leak.

ii. Pressure and possible leak rates.

iii. The surface drainage area and capacity of the drainage system.

iv. The fuel's burning rate.

v. The fuel's heat of combustion.

5.3 FIREPROOFING INSIDE PROCESSING UNITS:

5.3.1 Multilevel Equipment Structures:

a) When structures support fire-potential equipment, fireproofing shall be used for the vertical and horizontal steel support members from the grade up to the highest level at which the equipment is supported (see Figure 5.1).

b) Elevated floors and platforms that could retain significant quantities of liquid hydrocarbons shall be treated as though they were on the ground floor level, for the purposes of calculating vertical distances for fireproofing. (See figure 5.6)

c) For the structures supporting non-fire potential equipment, fireproofing shall be provided for the vertical and horizontal steel members from grade up to and including the level that is nearest to a 30-foot (9.1 meter) elevation above grade if the collapse of unprotected structural supports could result in substantial damage that would involve nearby fire-potential equipment (see Figure 5.2).

"OISD hereby expressly disclaims any liability or responsibility for loss or damage resulting from the use of OISD Standards/Guidelines."
d) Fireproofing shall be used for knee and diagonal bracing that contributes to the support of vertical loads or to the horizontal stability of columns if it is located within the fire-exposed envelope. Knee and diagonal bracing that is used only for wind, earthquake, or surge loading need not be fireproofed (see Figure 5.1).

e) When reactors, towers, or similar vessels are installed on protected steel or reinforced concrete structures, fireproofing materials shall be used for protection of supporting steel brackets, lugs, or skirts (see Figure 5.1). The insulating effect of the fireproofing material must be considered in the design of supports for vessels that operate at high temperatures. Because of the size and importance of large vessels such as reactors, regenerators, and vacuum towers that are mounted on high support structures, fireproofing should be provided for the entire exposed support system regardless of its height.

f) Except for the upper surface of the top flange, fireproofing shall be provided for beams that support equipment in fire-exposed areas.

g) The earthing lugs shall be kept clear of the fire protection.

5.3.2 Support For Pipe Racks:

a) When a pipe rack is within a fire-exposed envelope, fireproofing shall be used for all vertical and horizontal supports upto and including the first level (see Figure 5.3.).

b) If a pipe rack carried piping handling hydrocarbon that has a diameter greater than 6 inches at levels above the first horizontal beam or hydrocarbon pumps are installed beneath the rack, fireproofing shall be provided upto and including the level that is nearest to a 30-foot (9.1 meter) elevation (see Figures 5.3 and 5.4.) Wind or earthquake bracing and non-load bearing stringer beams that run parallel to piping need not be fireproofed.

c) If air fin-fan coolers are installed on top of a pipe rack, fireproofing shall be used for all vertical and horizontal support members on all levels of the pipe rack including support members for the air fin-fan coolers, regardless of their elevation above grade.

d) Fireproofing shall be provided for knee and diagonal bracing that contributes to the support of vertical loads. Knee or diagonal bracing that is used only for wind or earthquake loading need not be fireproofed.

e) Frequently, the layout of piping requires that auxiliary pipe supports be placed outside the main pipe rack. These supports include small laterals pipe racks, independent stanchions, individual T columns, and columns with brackets. Whenever these members support piping with a diameter greater than 6 inches or important piping such as relief lines, blowdown lines, or pump suction lines from accumulators or towers, fireproofing shall be provided.

f) A fireproofed catch beam or bracket shall be given beneath larger piping (greater than 6 inches) that is supported by exposed steel spring hangers or rods. Sufficient clearance should be provided between the bracket or beam and the pipe to permit free movement.

5.3.3 Air fin-fan coolers in a fire exposed envelope:

a) Supports of grade level air fin-fan coolers handling liquid hydrocarbons shall be fireproofed.

b) Fireproofing shall be provided for the structural supports of all air-cooled exchangers handling flammable or combustible liquids at an inlet temperature above their auto ignition or above 315°C, whichever is lower.

c) In case of the air-cooled exchangers located above vessels or equipment containing flammable materials; all the supports located within a 6m – 12 m radius of such vessels or equipment regardless of their height, shall be fireproofed. (See figure 5.5)

5.3.4 Tower & Vessel Skirts:

"OISD hereby expressly disclaims any liability or responsibility for loss or damage resulting from the use of OISD Standards/Guidelines."
a) Fire-proofing shall be used for the exterior surfaces of skirts that support tower and vertical vessels. Consideration should also be given for fireproofing interior surfaces of skirts if there are flanges or valves inside the skirt. Interior surfaces of skirts need not be fireproofed if there is only one manway opening through the skirt and its diameter is not greater than 2 feet (0.6 meter). Openings other than the single manway can be closed with removable steel plate at least 1/4 inch (6.4 millimetres) thick. The effect of draft through vent openings and space that surrounds pipe penetrations in the skirt should be minimised.

b) Fireproofing shall be used for brackets or lugs that are used to attach vertical reboilers or heat exchangers to towers or tower skirts.

c)  

5.3.5 Leg Supports For Towers & Vessels:

If the towers or vessels are elevated on exposed steel legs; fireproofing the leg supports to their full load-bearing height shall be used.

5.3.6 Supports for Horizontal Exchangers, Coolers, Condensers, Drums, Receivers and Accumulators:

Fireproofing should be given for steel saddles that support horizontal heat exchangers, coolers, condensers, drums, receivers, and accumulators that have a diameter greater than 30 inches (0.76 meter) if the vertical distance between the concrete pier and the shell of the vessel exceeds 18 inches (0.46 meter).

5.3.7 Fired Heaters:

a) Fireproofing shall be used for all supports for fired heaters in hydrocarbon service. Heaters are often supplied with short, steel legs that are set on reinforced concrete piers. These legs shall be fireproofed from the concrete piers up to the point where the steel columns are welded to the steel floor plate of the firebox.

b) If structural supports are provided by horizontal steel beams beneath the firebox of an elevated heater, fireproofing shall be used for the beams unless at least one flange face is in continuous contact with the elevated firebox.

c) For common chimneys or stacks handling flue gas from several heaters; structural support for ducts or breeching between heaters and stacks shall also be fireproofed.

d) When fired heaters in other than hydrocarbon service, such as steam superheaters or catalytic cracking-unit air heaters, are located within a fire-exposed envelope, fireproofing shall be provided for their support members if a collapse would result in damage to adjacent hydrocarbon-processing equipment or piping.

5.3.8 Electrical power and Instrument cables:

a) Cables in trays, racks or ducts which are critical (e.g. cables feeding emergency shutdown and emergency depressuring valves) shall be protected from fire damage, unless they are designed to fail safe during a fire exposure. Fire proofing requirements of such cables shall be as per API-2218.

b) The need to protect other electrical, instrument or control systems not associated with control or mitigation of fire should be based on the risk assessment.

5.3.9 Pneumatic and hydraulic instrument tubing:

Pneumatic and hydraulic instrument lines which are critical (e.g. tubing for emergency shutdown and emergency depressuring valves) shall be protected from fire damage, unless they are designed to fail safe during a fire exposure. Fire proofing requirements of such lines shall be as per API-2218.

5.3.10 Emergency valves within a fire exposed envelope:

Emergency valves and valve actuators located in a fire exposed envelope meeting the following criterion shall be fireproofed:

a) The valve is important to shutting down the unit safely.

"OISD hereby expressly disclaims any liability or responsibility for loss or damage resulting from the use of OISD Standards/Guidelines."
b) The valve is for depressurising the equipment

c) The valve is used for isolating the fuel feeding the fire.

Examples of these valves are isolation valves in piping to pumps that are fed from large towers, accumulators or feed surge drums.

Fireproofing of such valves shall be done as specified in API-2218.

5.4 FIREPROOFING OUTSIDE PROCESSING UNITS:

5.4.1 Pipe Racks:

a) Fireproofing shall be provided for pipe rack supports outside processing units if they are located within a fire-exposed envelope. Bracing for earthquakes, wind or surge protection and stringer beams that run parallel to piping need not be fireproofed.

b) If important pipe racks run within 20-30 feet of open drainage ditches or channels that may contain oil waste or receive accidental spills, either fireproofing should be considered for the pipe rack supports as described in (5.3.2 (b)) as above, or the ditch should be covered.

5.4.2 Storage Spheres/ Vessels & its Supports:

Fire proofing protects the LPG vessel by reducing the heat input to the vessel and also by controlling the rate of rise of vessel wall temperature. Fireproofing provides protection in case water supply is interrupted.

a) Fire proofing of all LPG vessels, their supports and connected/ nearby pipelines shall conform to the requirements stipulated in OISD-STD-144.

b) Fireproofing shall be provided on the aboveground portion of the vessel’s supporting structures. The fireproofing shall cover all support members required to support static load of the full vessel. Fireproofing shall not encase the points at which the supports are welded to the vessel.

5.4.3 Horizontal Pressurised Storage Tanks:

Horizontal pressurised storage tanks should preferably be installed on reinforced concrete saddles. Fireproofing shall be given for exposed steel tank supports that are more than 18 inches (0.46 m) high, measured at the lowest point of the tank shell.

5.4.4 Flare Lines:

Supports of flare lines shall be fireproofed if they are within a fire-exposed envelope or if they are within 20-30 ft distance from the open ditches/drainage channels, likely to receive large accidental spills of hydrocarbons.

6.0 FIRE PROOFING MATERIALS AND SYSTEMS

6.1 General

Passive fire proofing materials & systems should conform to the following parameters:

a) It should fulfil its protection role by limiting the temperature of substrate to be within the guaranteed maximum temperature over a specified time period.

b) The fire protection should not fail at the end of this specified period, but should continue to offer a reasonable measure of protection beyond this period.

c) It should have system integrity so that the protection remains in place during a fire, and can withstand both the thermal stresses and impingement of fire water from hoses/monitors. Test checks as necessary should be carried out.

d) The fire protection must be non-corrosive to the substrate and be compatible to environmental conditions. It must not in itself become a hazard in a fire condition whether by spalling, spreading flame, or producing toxic fumes.

"OISD hereby expressly disclaims any liability or responsibility for loss or damage resulting from the use of OISD Standards/Guidelines."
e) Selection of the fire proofing system must take into account the weight limitations imposed on the strength of steel supports to be fireproofed especially for existing installations.

f) The materials should have adequate adhesion, strength and durability.

g) The fire proofing system should be adequate for the desired fire rating.

h) The fire proofing material/coating should be resistant to weather effects such as chalking and erosion. Top coat, wherever provided, must be resistant to solar ultra violet radiation.

6.2 Fire rating criteria for material selection

The following factors should be considered in selecting the fire rating of the material to be applied:

a) The source volume of leak.

b) The time required to block flows and backflows of fuel that may be released.

c) The time required to apply adequate and reliable cooling water from fixed monitors, fixed water spray systems, and hand hose lines.

d) The time required for the area’s drainage system to remove a spill.

e) The layout of the equipment, particularly if congestion exists.

f) The physical properties of material that may be spilled.

g) The fuel’s burning rate.

h) The fuel’s heat of combustion.

i) The severity of operating conditions, particularly the temperature if the material being handled is above its auto ignition point.

j) The importance of the unit to continued plant operations and earnings.

k) Availability & proximity of fire fighting resources in and around the plant and time required for evacuation of personnel.

Further, the fire rating for LPG storage vessels shall be as per OISD-STD-144 whereas for all other areas, it should be as per API - 2218.

6.3 Fire Proofing Materials

Materials normally used for fire proofing are

a) Dense cement concrete

b) Light weight concrete

c) Mastic (Intumescent/Subliming) etc.

Prior to use, these materials should be checked to relevant specifications.

6.3.1 Dense cement concrete

Dense cement concrete shall be of grade M20 conforming to IS: 456 or equivalent.

This traditional material has been used for decades as fire proofing. Tough and dense, (approx. density 2200-2400 Kg/cum) they provide long term protection in most environments.

In areas of high maintenance activity, where fire proofed structures could be subject to impact and abrasion, concrete fire proofing offers good mechanical resistance.

When applied to columns where water could penetrate between steel and concrete, it shall be weather proofed with a caulking bead or other approved mastic application.

6.3.2 Lightweight Concrete

This concrete is made of light weight aggregates such as vermiculite, mica, perlite and cements. Dry densities range from 640 to 960 kg/cum. Lightweight materials are normally sprayed on but they may be troweled or formed in place using light reinforcing mesh.
Insulating concrete, fire proofing cements and plasters made with lightweight or special aggregates, may be used when weight becomes a limiting factor in the design.

Finished lightweight concrete normally require top coat for weather protection when used in extreme climates.

6.3.3 Intumescent / Subliming mastic coatings

Intumescent/subliming coatings are used in appropriate applications. Specific attention should be given to the possibility of a fume or smoke hazard arising from exposure of intumescent coatings to fire.

Intumescent coatings provide protection by expanding during heating and forming an insulation layer of char. These materials are durable, light weight and also provide long term corrosion protection to steel. However, they need stringent surface preparation.

Subliming coatings consist of two components applied with reinforcement. They absorb large amount of heat in the event of fire and they change directly from solid to gaseous state.

It is important to include mesh reinforcement in these systems for two reasons. Firstly the thermal expansion characteristics are thereby modified to come nearer that of the steel substrate. Secondly the mesh holds the coating in place during a fire when it's bond to the primer eventually fails, to achieve satisfactory protection in jet fires, the thickness of the coating needs to be increased by reinforcing the same with suitable wire mesh.

Mastic fire proofing materials shall be applied by spraying or troweling. Surface preparation for application of a paint primer shall be in accordance with manufacturer’s recommendations.

Mastic fire proofing materials have a density of approximately 960 to 1290 kg/m³.

Intumescent and subliming mastic coatings shall be sealed in accordance with the manufacturer’s recommendations for possible extreme weather conditions. In locations where there is exposure to high levels of ultraviolet radiation (from sunlight), premature ageing should be considered.

UV protection can be provided by applying a thin top coat of aliphatic polyurethane.

6.3.4 Specialist Applications

There are certain structures or vessels, which might be subjected to thermal shock conditions. Refrigerated vessels and furnace burner supports where the burner is integral with the furnace are some of these. For these types of special applications, composite arrangements of alternate layers of thermal insulation and a passive fire proofing should be done.

Irregular shapes such as flanges, valves, pipes, cable trays, etc., present difficulties in application techniques and create conflict with the access requirements for routine maintenance. The problem is suitably addressed with the availability of other than concrete fireproofing systems including preformed and/or sculptured sections, designed boxes, etc. Applicability of these systems shall conform to the necessary requirements mentioned in clause no 7.2.2 of this document.

6.3.5 Asbestos

Fireproofing systems/materials shall not contain asbestos.

7.0 INSTALLATION OF FIREPROOFING SYSTEMS

7.1 General

The standard fireproofing material for all systems is cement concrete. Alternative systems using proprietary materials herein referred to as ‘other than cement concrete systems’ are also available. These systems can be preferred for existing structures whose strength or space limitations do not allow the use of cement concrete.

*OISD hereby expressly disclaims any liability or responsibility for loss or damage resulting from the use of OISD Standards/Guidelines.*
7.2 Fireproofing systems

7.2.1 Cement concrete fireproofing systems

Dense cement concrete shall be of grade M20 conforming to IS:456 or equivalent. Solid encasement of the structural member is the usual method of application. (Refer to Annexure V)

In case of application of cement concrete in the operating units, only metallic shuttering shall be used.

The minimum required thickness of fireproofing cement concrete is 50 mm.

7.2.2 Other than cement concrete fireproofing systems

Other than concrete fireproofing systems should meet the following requirements:

a.) It shall be asbestos free;

b.) System provider should furnish test results carried out by independent laboratories demonstrating that the system is adequate for the proposed application and its thickness shall have the required resistance against hydrocarbon fires;

c.) It should be reliable in service and should provide desired life-span with reasonable maintenance, taking into account all possible variations in ambient temperature and humidity;

d.) When exposed to damp conditions, the system should not initiate or sustain any long-term pernicious effects, such as corrosion of the painted steel work.

e.) Installation of the system shall be carried out by specialists, strictly as per the approved procedures of the manufacturer.

7.3 Preparation for fireproofing

The entire steel surface to be fireproofed should be cleared of all loose dirt, oil and grease etc for better adhesion of the fireproofing to the steel.

All the steel members, new as well as existing ones; which need to be fireproofed should be suitably primed for corrosion protection.

The primer should be compatible with the fireproofing to be applied.

Mesh reinforcement type, fixing and overlaps etc. shall be as per the manufacturer’s recommendations.

7.4 Installation of fireproofing

All the other than concrete fireproofing systems shall be applied in accordance with the instructions of the manufacturer.

For concrete surfaces weatherproofing is not needed, however, for proprietary systems, a flexible membrane may be required as per the prevailing local circumstances.

Joints between exposed steel work and fireproofing should be caulked to prevent water from entering the system at this point.

The top of fireproofing should be protected by cover plates continuously welded to the steel structure in order to prevent ingress of rainwater between the members and the fireproofing. Typical details of cover plates are given in ANNEXURE- VI.

During the course of application of fireproofing, proper care should be taken to protect the surface from heavy rain, frost and extreme weather conditions etc.
Fireproofing shall not be carried out when the ambient air temperature and/or the temperature of the surface to be fireproofed is 10-Deg C or below.

Provision should be made for adequate ventilation during and after application, until the materials are dry. However, in extremely dry and hot conditions, appropriate measures should be taken to keep vermiculite-containing systems moist until set.

The fireproofing should be resistant to frost damage after its proper setting, wherever necessary.

Approved welding procedure by a competent authority should be followed if the fixing of such systems to surfaces necessitates the welding of certain fixtures to the surfaces.

8.0 METHODS OF APPLICATION OF FIRE PROOFING

8.1 General
The process of fire proofing application consists of but not limited to, attaching pins for retention of metal/fabric mesh reinforcement, abrasive blasting where required, priming with appropriate and approved primer system, installation of reinforcing mesh, masking where necessary, mixing, spraying, trawelling and levelling, rolling top coating if required, and demasking.

8.2 Qualification of applicators
The application shall be performed by qualified applicator having training, equipment and experience. Supervisory or lead personnel involved with the application shall be or have been trained by the manufacturer of fire proof coating material and its application. Applicator shall submit written verification of such training in case of proprietary products.

8.3 Safety precautions
The applicator shall follow standard industrial hygiene practices for the handling of chemical coatings and shall confirm to applicable codes of practice and regulations. Necessary Personal Protective Equipment as detailed in OISD-STD-155 should be used.

8.4 Storage of material
Materials should be stored at site in accordance with the manufacturer’s recommendations, since some materials are temperature sensitive and others must remain upright in their containers for the proper sealing. Material should not be used if its shelf life has exceeded.

8.5 Sample preparation
Prior to actual production work, a sample area will be coated with fire proof coating following all pertinent procedures and specifications. This sample should be typical of the work to be done. This sample or sample area will then be approved by the Client's Representative, Applicator's Representative, Consultant's representative and any other party as defined and required by the contract, for quality of surface finish and adherence to procedures.

8.6 Work start-up
Applicator will obtain a release from the Client for a given area to start on.

8.7 Environmental conditions
Environmental conditions are important for every aspect of the Application System.

Environmental conditions/ specifications for blasting where required and priming are as per manufacturer or relevant standard, which include but are not limited to ambient temperature, substrate temperature, relative humidity and dew point. Environmental conditions/ specifications for the system provided by the manufacturer of fire proof coating, these conditions shall be recorded for each system since conditions can vary considerably depending on location. Environmental conditions should be recorded daily. Where water is required to be added, it should be clean, potable and of a quality suitable for use in blending with fireproofing coatings.

“OISD hereby expressly disclaims any liability or responsibility for loss or damage resulting from the use of OISD Standards/Guidelines.”
8.8 Application details for specific fire proofing materials

8.8.1 Dense Cement Concrete

The entire steel surface to be fireproofed shall be cleared of all loose dirt, oil and grease etc for better adhesion of the concrete to the steel.

A typical composition of dense cement concrete should be M20 as per IS: 456 with gravel size as passing through 10 mm sieve.

Dense concrete can be formed in place to the required thickness using steel reinforcement.

In the case of gunniting (pneumatical application) the ratio of the mix shall be one part of cement and four parts of sand. Cement, sand and water quality shall be as per IS: 456.

8.8.2 Lightweight concrete

A) Substrate preparation

Prior to the application of fireproof coating, structural steel should be suitably primed after appropriate surface preparation.

B) Mesh retaining pins

Pins should be fixed to the structural substrate at maximum 400 mm centres on a staggered pitch. Stud fixing may necessitate local removal of the priming system, which should be reinstated to the original paint specification after the fixing of pins. Welding need not be done for fixing pins on pressure vessels as the same can be fixed using other techniques.

C) Mesh reinforcement

Reinforcing mesh (made of GI/SS) should be attached to previously installed pins using suitable arrangements.

The mesh should be pulled away from the substrate so as to lie substantially within the centre of the final fireproof coating thickness.

Mesh shall be overlapped at all joints and no more than three mesh thicknesses are permitted at any one joint. Cut ends may be twisted together to make a more secure joint. Alternatively, galvanised wire ties at 150 mm centres may be used.

For pressure vessels where pins are not permitted, reinforcing mesh should be attached to a system of floating rings and tensioning wires to construct a monolithic reinforcement.

D) Fireproof coating

The light weight concrete shall be mixed in accordance with the Manufacturer's Instructions for application and spray applied in the minimum number of coats or by using trowel to the required thickness as per Manufacturer's recommendation. The coating should generally be float finished to close down the texture.

E) Water shedding

Where water-shedding cowls are not provided, top surfaces and all terminations of fire proof coating against steel must be sloped and floated to shed water.

A 'U' shape shall be cut at the concrete steel junction to receive mastic sealant.

F) Top Coating - Weather Barrier

After the concrete coating has been allowed to cure and dry for at least five days, suitable top coat as recommended by manufacturer may be applied, if required.

G) Sealing of concrete Coating/Steel junctions

Suitable flexible sealant e.g. Polysulphide based or Silicone rubber based should be applied in the groove.
All sealants must be suitable for use with a concrete mixture and be weather resistant and remain flexible.

8.8.3 Mastics

A) Mesh retaining pins

Pin Installation wherever required, shall be done in accordance with the procedure outlined in the Manufacturer’s Application Manual. Embedded mesh reinforcement shall be used based on manufacturers’ recommendation.

B) Substrate preparation

Substrate preparation shall be done in accordance with product requirements. The blast finish/profile shall be accepted prior to priming.

C) Priming procedure

Priming of substrate shall be done in accordance with paint manufacturer’s application guideline. The primers approved by material manufacturers only shall be used.

D) Mesh reinforcement

Meshing of substrate shall be done in accordance with the procedures outlined by mastic material manufacturer’s application manual.

E) Masking

Any surfaces or equipment in the spraying areas which do not receive mastic must be masked off, using polyethylene or equivalent. Regardless of the structural configuration being worked on, overspray is always a concern.

F) Intumescent/Subliming coating

Solvent based or Solventless application of Intumescent / Subliming Materials shall be done in accordance with the procedure outlined by the Intumescent/ Subliming Materials Manufacturers Application Manual upto the required thickness.

G) Surface finish and inspection

Surface finish is a visual standard for sprayed Intumescent/Subliming Material, which includes various structural configurations. Visual inspection should be performed to ensure that there is no exposed mesh, debonding at terminations or bubbles below the finish surface layer.

Physical inspection would consist of drilling holes in the Intumescent/ Subliming Material to determine actual thickness, tapping with a hammer to detect possible hollow areas or delamination between sprayed layers of coating not visible.

9.0 QUALITY CONTROL IN APPLICATION OF FIRE PROOFING

9.1 Introduction

Quality control during application is of prime importance. Satisfactory performance of the fireproofing material over its expected lifetime depends on the user’s and the applicator’s knowledge of materials and application techniques and on continuous inspection by qualified plant personnel.

Attention to the following points will ensure a quality job:

9.1.1 Qualified personnel

Both the user and the applicator should have a detailed knowledge of the characteristics of the fireproofing material and the application techniques that are necessary to achieve the desired degree of fire resistance. The applicator should be qualified as per Clause no 8.2

9.1.2 Mock-up application

The contractor/applicator is required to provide a sample of the finished work so that there is no misunderstanding about the desired texture, smoothness and soundness of the finished coating. Before start of the application job, mock-up application should be carried out over 1Mx1M surface area to ascertain the skill of the applicator.

9.1.3 Surface preparation

“OISD hereby expressly disclaims any liability or responsibility for loss or damage resulting from the use of OISD Standards/Guidelines.”
Substrate surfaces must be cleaned so that they are free from oil, grease, liquid contaminants, rust, scale and dust. If a primer is required, it must be compatible with the fire proofing material.

9.1.4 Application

It is to be ensured that the materials must be applied in accordance with the manufacturer’s recommendations for dry thickness and use of reinforcing materials. Thickness of material must be ensured as some of the mastic coating shrinks as much as 30 per cent when cured.

9.1.5 Curing

Some materials require a controlled curing period to develop full strength and prevent serious cracking in the future. Hence, proper curing is to be ensured.

9.1.6 Random core sample check

Random core samples should be taken after application to verify coat thickness, proper bonding, and voids. Defects, if any, should be rectified properly.

9.1.7 Supervision

Fire proofing shall be supervised by competent personnel having appropriate knowledge and experience backed with test results. These persons shall inspect the process at its various stages and maintain an inspection check list for stage wise approvals of the same. Following minimum stages shall be included in the inspection check list

i) The condition of the steel surface to be fire proofed.

ii) The quality and placing of the reinforcement mesh.

iii) The quality and application of fire proofing material.

iv) The joints between fire proofing and the steel work which are exposed to weather.

v) Weatherproofing.

10.0 PERIODIC INSPECTION AND MAINTENANCE

10.1 Deterioration during service life

As fireproofing materials age, problems can develop that affect the usefulness of the coating and weaken the protected structural supports.

Any fireproofing material is subject to a certain amount of degradation over time. However, some applications have been known to fail completely at a rapid rate. Some failure may be caused by materials that are improperly selected but in most cases the failure results from poor applications.

Cracking or bulging of the surface of the material is the first sign of a problem. If the problem is not corrected, moisture, chemicals, corrosive vapour, and marine condensation can enter and lead to corrosion of both the substrate and the reinforcement materials.

Weathering or the use of the wrong top coat can cause the fireproofing to become permeable to moisture and vapour. This permeability can lead to serious corrosion and deterioration.

Loss of bonding to the substrate seriously affects the material’s performance and may be caused by moisture penetration, corrosion, the use of an improper primer on the substrate, or poor preparation of the substrate before the fireproofing is applied.

The weathering effects of sunlight and chemical environment have been known to affect some mastic materials to the extent that they lose a significant amount of their insulating ability due to development of cracks, disbonding, and peeling off top coat.

10.2 Inspection

To reduce the risk of structural failure from hidden corrosion or the risk from fire because of fireproofing loosened or damaged by underlying corrosion, all fireproofed surfaces should periodically be inspected and tested as per schedule prepared by the owner based on local environmental conditions and criticality of the equipment. An inspection and testing program should include the following steps:

a) Survey the coating for surface cracking.

"OISD hereby expressly disclaims any liability or responsibility for loss or damage resulting from the use of OISD Standards/Guidelines."
b) Selectively remove small sections of fireproofing to examine conditions at the face of the substrate and the surface of reinforcing wire.

c) Visually check for the loss of fireproofing materials as a result of mechanical abuse.

d) When the fireproofing material is applied, coat and set aside several pieces of structural steel for periodic fire testing over the expected life of the coating.

In the event of a fire, the affected area of coating should be thoroughly examined; including substrate if required and necessary repairs should be carried out.

10.3 Maintenance

Maintenance of fire proof coatings should be done in as under:

a) When cracks are wider than hairline, the opening should be cleaned out and filled with new material according to the manufacturer’s instructions.

b) If top coat is required to prevent moisture from penetrating, it must be renewed at intervals recommended by the manufacturer.

c) Loss of bonding to the substrate may be noticed when the surface bulges or if an abnormal sound is given off when the surface is tapped with a light hammer. In areas that have evidence of bond failure, fireproofing should be removed, and the substrate should be thoroughly cleaned and properly primed before new material is applied.

d) Whenever rust stains are observed on the external surface of fire proof coating, the integrity of coating as well as the condition of substrate should be established by chipping the affected area.

11.0 REFERENCES

i) UL-263: Fire tests of Building Construction and materials

ii) UL-Subject 1709: Structural steel Protected for Resistance to Rapid Temperature rise fires

iii) ASTM E119: Method for fire test of building construction and Material

iv) ASTM –E1529: Standard test methods for determining effects of large Hydrocarbon pool fires on Structural members and assemblies.

v) API 2218: Fireproofing Practices in Petroleum and Petrochemical Processing plants

vi) API-2510: Design and construction of LPG installations

vii) API-2510A: Fire-Protection consideration for the design and operation of LPG storage facilities

viii) OISD-STD-144 Vol. IV: Safety and Fire protection in LPG Bottling Plant operations


x) IS : 456: Plain and Reinforced Concrete - Code of Practice
ANNEXURE- I

FIRE SCENARIOS AND FIREPROOFING

Pool and jet fires

In a hydrocarbon industry the leaks from various potential sources of leakage (PSL) e.g. small bore connections on piping and equipment, flange joints, pump mechanical seals, expansion joints etc under different ambient conditions and the type of product handled; can form a liquid pool or be dispersed as either an aerosol liquid cloud or as a vapour cloud. Ignition of these leaked products shall either result in a pool fire or a torch fire. These fires continue to sustain till the source feeding these leaks is completely stopped.

It is observed that liquid pools are normally formed by all hydrocarbon products containing Pentane and also butanes/butenes at sub zero ambient temperatures. Further it is also seen that refrigerated/cryogenic liquefied gases may form liquid pools in case of their accidental release while they are handled at or near their atmospheric boiling points. Particularly this may happen during a prolonged release of these gases, when the vaporization rate caused by heat pick-up from the surroundings does not match the rate of release. Pool fires possibilities shall be taken into account for above categories.

As the pressurized liquefied gases disperse in the form of an aerosol liquid jet or as a vapour jet upon their accidental release, they shall not result in pool fires. Similarly vapor release shall also disperse as a jet. Hence, ignition of an aerosol liquid jet or a vapour jet shall lead to a torch fire which may cause impinging flames with high radiation intensities. The length and width of jet flames is dependent on factors like size of the hole, wind speed and direction and the pressure at the upstream of the leakage point.

Maximum efforts should be made to protect the supporting steel structures from torch fires by proper location selection and orientation of the supporting structure with regard to PSL and/or by providing fire shields near the PSLs or the surfaces of the structures to avoid direct impingement. If the supporting structures protection against torch fires is not possible or practicable then fire proofing of these structures should be done as per the relevant fire exposed envelope.

For the most part, liquid and gaseous hydrocarbon fires are characterized by highly luminous flames resulting from hot carbon particles (soot). Because of limited mixing with oxygen, combustion gases are fuel-rich and produce nearly continuous radiation in the infrared region making the hot gas and soot particles behave as a grey body radiator. Petrochemical fire temperatures reach as high as 130deg C (240Deg F) but average 100deg C (185deg F) because of various factors including radiational cooling of the fire ball, winds and geometry. Free burning fires normally do not achieve the theoretical combustion temperatures for the fuels involved. During fires with high pressure fuel sources, convection plays a larger role and can even be the primary mode of heat transfer. Jet fires are characterized by high convective inputs.
Annexure II (Page 1 of 2)

TESTING OF FIRE PROOFING MATERIALS

Fire resistance testing is one of the very important steps in assessing the fireproofing rating of any material prior to its use for fireproofing purpose. No fire test method can be termed to be typical of a real fire situation and so, there is no single correct or best fire test method. Standardized testing simply provides a frame of reference for relative comparisons of fireproofing materials and designs. In the 70s, ASTM E119 Fire Test of Building Construction Materials was the only internationally accepted standard for investigating the performance of fireproofing materials. This test method, however, was designed to measure the fire performance of walls, columns, floors, and other building members in solid fuel fire exposures. It does not simulate the high intensity of liquid hydrocarbon-fuelled fires. The slope of the time/temperature heating curve for the typical solid fuel fire is significantly different than that of the more instantaneous and intense liquid hydrocarbon fire. Wood, for example, burns fairly slowly. Volatilization of the fuel from the surface is slow and wood can form a char which provides some protection. Liquid hydrocarbons volatilize quickly to feed a fire, and there is no protective char formation. In recognition of this, several of the major oil companies developed their own outdoor hydrocarbon pool fire tests. These tests were more representative of the threat posed to refineries and petrochemical plants but reproducibility was not very good.

UL 1709 Rapid Rise Fire Tests of Protection Materials for Structural Steel and ASTM E1529 Standard Test Methods for Determining Effects of Large Hydrocarbon Pool Fires on Structural Members and Assemblies were first issued in the early 90s. Both tests involve a test furnace which develops an average temperature of 2000°F (1093°C) within the first 5 minutes of the test. The principal difference is that UL 1709 involves a total heat flux of 65,000 BTU/ft²-hr (205 kW/m²), whereas the ASTM E1529 heat flux is 50,000 BTU/ft²-hr (158 kW/m²). Temperature is an important parameter but heat flux is considered as a better measure of the amount of heat stress being placed on a material (how fast heat works on a material). Although the temperature is the same, the higher heat flux of UL 1709 makes it a more severe test. A comparison of standardized fireproofing test procedures is placed in tabular form as below.

<table>
<thead>
<tr>
<th>Fireproofing test Standards</th>
<th>UL1709</th>
<th>ASTM E1529</th>
<th>ASTM E 119 UL 263</th>
</tr>
</thead>
<tbody>
<tr>
<td>Testing environment</td>
<td>Rapid rise fires</td>
<td>Effects of large hydrocarbon pool fires on exterior structural members</td>
<td>Structural material for building interiors</td>
</tr>
<tr>
<td></td>
<td>Exterior Petrochemicals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Heat flux in BTU/ft²-hr</td>
<td>65000 (5000)</td>
<td>50000 (2500)</td>
<td>(11000)*</td>
</tr>
<tr>
<td>After Five Minutes</td>
<td>65000 (5000)</td>
<td>50000 (2500)</td>
<td>(11000)*</td>
</tr>
<tr>
<td>One Hour</td>
<td>65000 (5000)</td>
<td>50000 (2500)</td>
<td>(11000)*</td>
</tr>
<tr>
<td>Temperature after</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Three minutes</td>
<td>2000±200°F</td>
<td>&gt; 1500°F</td>
<td>1000°F</td>
</tr>
<tr>
<td>Five minutes</td>
<td>2000±200°F</td>
<td>2000±150°F</td>
<td>1550°F</td>
</tr>
<tr>
<td>Thirty Minutes</td>
<td>2000±200°F</td>
<td>2000±150°F</td>
<td>1550°F</td>
</tr>
<tr>
<td>One hour</td>
<td>2000±200°F</td>
<td>2000±150°F</td>
<td>1550°F</td>
</tr>
</tbody>
</table>

“OISD hereby expressly disclaims any liability or responsibility for loss or damage resulting from the use of OISD Standards/Guidelines.”
Annexure-II (Page 2 of 2)

BRIEF DESCRIPTION ABOUT UL 1709 TESTING METHOD

There are a number of fire test laboratories in North America and Europe (For partial directory refer Annexure III). These laboratories conduct fire tests according to defined standards and depending upon performance, a rating is determined for the particular type of test run. A rating is given in time units with temperature limits imposed on the protected part of the test assembly. Annexure-IV list some of the important ratings used in the Hydrocarbon processing industries for structural and personnel protection of stationary materials.

The oldest and most widely used independent testing organization is Underwriters Laboratories, Inc. (ULI) in USA. ULI provides fire test and manufacturing follow-up services for many products on a non-profit basis. ULI was the first testing organization to standardize the high rise fire test as UL 1709 and offer it as one of their services. Other testing laboratories now conduct similar tests.

In the case of the UL 1709 test, the furnace temperature is brought up to 1093deg C (2000deg F) within 5 minutes and held within a tolerance of this level for the duration of the test. Tests are usually run on a light column designated as a W10X49, but they can be run on lighter or heavier sections. Less material is required to protect heavier members, so the user should be careful to determine which member was tested. Steel temperatures are measured beneath the protective material at 4 levels with 3 thermocouples per level. Failure criteria for columns are:

When the average of all thermocouples at any level reaches 538 deg C (1000deg F) or;

If any individual thermocouple reaches 649 deg C (1200deg F).

Environmentally exposed materials are tested against control material to determine the effect on fireproofing performance. A loss in performance of 25% or more in any of these tests prevents a material from receiving an external use rating. Even though these evaluations are helpful in determining material suitability for industrial use, the aging tests are accelerated and small losses in performance may turn into significantly larger ones over long periods of time. However, this test program is an important tool in rating and monitoring potential fire protection materials for outdoor use.

After successful completion of the test, a listing or rating is offered, which in the case of ULI, is printed in an annual Fire Resistance Index under X or XR classifications for columns for the hourly period tested. Listings in the X classification are for designs tested to the ASTM E-119 cellulosic fire environment whereas those in the XR classification have been tested to the UL 1709 high intensity fire environment. XR ratings (listings) include mandatory additional testing for environmental aging such as freeze thaw cycling, salt fog, high humidity, and SO2 / CO2 exposures. For X classifications, environmental testing is optional.

While, UL -1709 is the minimum requirement for a fire proofing material, materials being used for pressurized storage vessels must have preferably undergone independent tests successfully on such type of vessels.

"OISD hereby expressly disclaims any liability or responsibility for loss or damage resulting from the use of OISD Standards/Guidelines."
## PARTIAL DIRECTORY OF FIRE TEST LABORATORIES

<table>
<thead>
<tr>
<th>Name of the laboratory/Institute</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Federal Institute for Material Research and Testing (BAM)</td>
<td>Berlin, Germany</td>
</tr>
<tr>
<td>Factory Mutual Research Corp.,(FM)</td>
<td>Norwood, MA, USA</td>
</tr>
<tr>
<td>Loss Prevention Council (LPC)</td>
<td>Borehamwood, Herts, England.</td>
</tr>
<tr>
<td>Southwest Research Institute (SWRI)</td>
<td>San Antonio, TX, USA</td>
</tr>
<tr>
<td>TNO</td>
<td>Delft, Netherlands</td>
</tr>
<tr>
<td>Underwriters Laboratories Inc.,(ULI)</td>
<td>Northbrook, IL, USA</td>
</tr>
<tr>
<td>Warrington Fire Research Center</td>
<td>Warrington, Cheshire, England.</td>
</tr>
<tr>
<td>Health &amp; Safety Executive</td>
<td>Buxton</td>
</tr>
<tr>
<td>U. S. Department of Transportation (DOT)</td>
<td>USA</td>
</tr>
</tbody>
</table>
# ANNEXURE - IV

## TEST RATINGS - STRUCTURAL STEEL FOR OIL INDUSTRY

*(STATIONERY MATERIALS)*

<table>
<thead>
<tr>
<th>RATING</th>
<th>NORMAL CONFIGURATION</th>
<th>TEST ENVIRONMENTAL TEMP.</th>
<th>CRITERIA TO BE MET</th>
<th>TEST TYPE</th>
</tr>
</thead>
<tbody>
<tr>
<td>UL 1709</td>
<td>W 10 X49 Column 9&quot; high</td>
<td>1093 deg C (2000 deg F)</td>
<td>Protected steel must not exceed 538 deg C (1000 deg F)</td>
<td>High intensity or high rise fire curve. Gas fired furnace</td>
</tr>
<tr>
<td>BAM 90 min. for pressurised LPG tanks (Germany)</td>
<td>Horizontal 485 M³ Tank with 6.4 mm wall thickness and 50% filled with Propane</td>
<td>600-900 deg C (1112 - 1652 deg F)</td>
<td>250 deg C (482 deg F) maximum wall temperature, measured in the ullage space not adjacent to the liquid. Maximum internal pressure of approximately 20 bars.</td>
<td>Pressurised Propane jets in a series surrounding the tank.</td>
</tr>
<tr>
<td>GESIP (France)</td>
<td>Loaded vessel + Flame impingement and + Hose Stream</td>
<td>1000 deg C 1100 deg C</td>
<td>Protected steel must not exceed 427 deg C (800 deg F)</td>
<td>Simulated Pool fire furnace test H/C</td>
</tr>
<tr>
<td>H.S.E. (U.K.)</td>
<td>Loaded vessel</td>
<td>Pool fire (H/S) 1100 deg C</td>
<td>427 deg C</td>
<td>Pool fire</td>
</tr>
</tbody>
</table>

"OISD hereby expressly disclaims any liability or responsibility for loss or damage resulting from the use of OISD Standards/Guidelines."
ANNEXURE V

TYPICAL DETAILS - CONCRETE FIREPROOFING - SOLID ENCASEMENT

"OISD hereby expressly disclaims any liability or responsibility for loss or damage resulting from the use of OISD Standards/Guidelines."
ANNEXURE VI

TYPICAL DETAILS - COVER PLATES FOR WEATHER PROTECTION

Stanchions

Cover plates to be continuously welded

6 mm steel plate - shop-welded

3 mm steel plate - field-welded

All plates to be supplied by the manufacturer of the steel structure

Supporting Beams

3 mm steel cover plate - field-welded after installation of fireproofing

Cover plates to be continuously plug welded

20 x 5 mm flat Jolly shop-welded

Centre-to-centre distance 600 mm

GAIL INDIA LIMITED
Fig. No. 5.2: Structures supporting non fire potential equipment in fire exposed area

Note: — shows Fire Proofed Structures
Figure 5.3: Pipe rack without pumps in a Fire Exposed area

Note: shows Fire proofed Structures

"OISD hereby expressly disclaims any liability or responsibility for loss or damage resulting from the use of OISD Standards/Guidelines."
Figure No. 5.4: Pipe racks with large Fire-Potential Pumps installed below

Note: shows Fire Proofed Structures

“OISD hereby expressly disclaims any liability or responsibility for loss or damage resulting from the use of OISD Standards/Guidelines.”
Figure 5.5 - Pipe rack supporting air fin-fan coolers in a fire exposed envelope.

"OISD hereby expressly disclaims any liability or responsibility for loss or damage resulting from the use of OISD Standards/Guidelines."
Figure 5.6: Structures supporting fire potential and non fire potential equipment in a fire exposed envelope