FIRE PROTECTION FACILITIES

FOR

PETROLEUM REFINERIES & OIL/GAS PROCESSING PLANTS

Oil Industry Safety Directorate
Government of India
Ministry of Petroleum & Natural Gas
FIRE PROTECTION FACILITIES
FOR
PETROLEUM REFINERIES AND OIL/GAS PROCESSING
PLANTS

Prepared by
COMMITTEE ON FIRE PROTECTION

OIL INDUSTRY SAFETY DIRECTORATE
7th Floor, New Delhi House 27-Barakamba Road
New Delhi - 110001
NOTES

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 and 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 only to supplement and not to replace the prevailing statutory requirements.

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

The oil industry in India is over 100 years old. Variety of practices have been in vogue because of collaboration / association with different foreign companies and governments. Standardisation in design philosophies & operating and maintenance practices at a national level was hardly in existence. This 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, Oil Industry Safety Directorate (OISD) was established in 1986 staffed from within the industry for formulating and implementing a series of self regulatory measures aimed at removing obsolescence, standardising and upgrading the existing standards to ensure safer operations. OISD constituted a number of committees comprising of experts nominated from the industry to draw up standards and guidelines on various areas of concern.

The present document on 'Fire Protection Facilities for Petroleum Refineries & Oil/Gas processing plants' is First Revision of the document prepared by the Committee on 'Fire Protection' which was originally published in 1991. Attempts have been made to incorporate the latest technological changes, experience gained in its implementation during last 4-5 years and relevant changes in the light of various national and international codes and practices.

It is hoped that the provision of this document, if implemented objectively will go a long way in improving the safety in the oil & gas industry.

This document will be reviewed periodically for improvements based on the new experiences and better understanding. Suggestions from users/industry members shall be addressed to:

The Co-coordinator
Committee on 'Fire Protection'
Oil Industry Safety Directorate
7th Floor, New Delhi House
27-Barakhamba Road
New Delhi 110001

“OISD hereby expressly disclaims any liability or responsibility for loss or damage resulting from use of the OISD Standards/ Guidelines/ Recommended Practices.”

III
FUNCTIONAL COMMITTEE

(First Edition - March, 1991)

<table>
<thead>
<tr>
<th>Name</th>
<th>Designation / Organisation</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. M.M.Kapoor</td>
<td>Engineers India Limited</td>
<td>Leader</td>
</tr>
<tr>
<td></td>
<td>(w.e.f. 1.1.95)</td>
<td></td>
</tr>
<tr>
<td>R.P. Bhatla</td>
<td>Engineers India Limited</td>
<td>Leader</td>
</tr>
<tr>
<td>(upto 31.12.94)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. A.A. Raichur</td>
<td>Hindustan Petroleum Corporation Limited</td>
<td>Member</td>
</tr>
<tr>
<td>3. S. Neelkanthan</td>
<td>Madras Refineries Limited</td>
<td>Member</td>
</tr>
<tr>
<td>4. P.J. Joshuva</td>
<td>Cochin Refineries Limited</td>
<td>Member</td>
</tr>
<tr>
<td>5. Sunil Kumar</td>
<td>Indian Oil Corporation Limited</td>
<td>Member</td>
</tr>
<tr>
<td>6. V.P. Vaidhya</td>
<td>Hindustan Petroleum Corporation Limited</td>
<td>Member</td>
</tr>
<tr>
<td>7. S.N. Mukharjee</td>
<td>Bharat Petroleum Corporation Limited</td>
<td>Member</td>
</tr>
<tr>
<td>8. A.K. Das</td>
<td>Bongaigaon Refineries &amp; Petrochemicals Ltd.</td>
<td>Member</td>
</tr>
<tr>
<td>9. R.P. Saxena</td>
<td>Oil &amp; Natural Gas Corporation Ltd.</td>
<td>Member</td>
</tr>
<tr>
<td>10. H.K. B. Singh</td>
<td>IBP Co. Ltd.</td>
<td>Member</td>
</tr>
<tr>
<td>11. Vijay M. Ranalkar</td>
<td>Oil Industry Safety Directorate</td>
<td>Member</td>
</tr>
</tbody>
</table>

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

"OISD hereby expressly disclaims any liability or responsibility for loss or damage resulting from use of the OISD Standards/ Guidelines/ Recommended Practices."
FUNCTIONAL COMMITTEE
(Second Edition - March 2007)

<table>
<thead>
<tr>
<th>Name</th>
<th>Organisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>LEADER</td>
<td></td>
</tr>
<tr>
<td>Shri Arvind Kumar</td>
<td>Engineers India Limited, New Delhi</td>
</tr>
<tr>
<td>MEMBERS</td>
<td></td>
</tr>
<tr>
<td>Shri A.A. Raichur</td>
<td>Hindustan Petroleum Corporation Limited, Mumbai.</td>
</tr>
<tr>
<td>Shri S. P. Garg</td>
<td>GAIL (India) Limited, Pata (UP).</td>
</tr>
<tr>
<td>Shri G. B. Tolmore</td>
<td>Indian Oil Corporation Limited, New Delhi.</td>
</tr>
<tr>
<td>Shri G. C. Kundu</td>
<td>Indian Oil Corporation Limited, Panipat.</td>
</tr>
<tr>
<td>Shri S.N. Mukherjee</td>
<td>Bharat Petroleum Corporation Limited, Mumbai.</td>
</tr>
<tr>
<td>Shri P. K. Bora</td>
<td>Bongaigaon Refineries &amp; Petrochemicals Ltd,</td>
</tr>
<tr>
<td></td>
<td>Bongaigaon.</td>
</tr>
<tr>
<td>Shri A.K. Das</td>
<td>Kochi Refineries Limited, Kochi.</td>
</tr>
<tr>
<td>Shri K. V. Singh</td>
<td>Hindustan Petroleum Corporation Limited, Vizag.</td>
</tr>
<tr>
<td>Shri J.P.K.Hepat</td>
<td>Chennai Petroleum Corporation Limited, Chennai.</td>
</tr>
<tr>
<td>Shri D. K. Varshney</td>
<td>Oil Industry Safety Directorate, New Delhi.</td>
</tr>
<tr>
<td>MEMBER COORDINATOR</td>
<td></td>
</tr>
<tr>
<td>Shri P. Kulshreshtha</td>
<td>Oil Industry Safety Directorate, New Delhi.</td>
</tr>
</tbody>
</table>

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

“OISD hereby expressly disclaims any liability or responsibility for loss or damage resulting from use of the OISD Standards/ Guidelines/ Recommended Practices.”
FIRE PROTECTION FACILITIES FOR
PETROLEUM AND OIL/GAS PROCESSING PLANTS

SECTION DESCRIPTION

1.0 Introduction
2.0 Scope
3.0 Definitions
4.0 Fire Protection philosophy
4.1 General considerations
4.2 Design criteria
5.0 Fire Water System
5.1 Basis for Firewater system
5.2 Firewater Flow Rate
5.3 Header Pressure
5.4 Firewater Storage & Make up
5.5 Firewater Pumps
5.6 Firewater Distribution Network
5.7 Hydrants and Monitors - Details
5.8 Material Specifications
5.9 Fixed Water Spray System
5.10 Fixed Water Sprinkler System
6.0 Foam Systems
6.1 Types of Foam
6.2 Low Expansion Foam
6.3 Foam Conveying Systems
6.4 Floating Roof Tank Protection using foam
6.5 Fixed Roof Tank Protection using foam
6.6 Floating cum Fixed Roof Tank Protection using foam
6.7 Dyke Area/Spill Fire Protection using foam
6.8 Foam Application Rate
6.9 Duration of Foam Discharge
6.10 Foam Quantity Requirement
6.11 Foam Compound Storage
7.0 Clean Agent based Protection System for Control room Satellite Rack room
and computer room
8.0 Carbon Dioxide Systems
9.0 Dry Chemical Extinguishing System
9.1 Recommended use of Dry chemical extinguishing system
9.2 Design of Dry Chemical Extinguishing System
10.0 Modernization plan for firefighting equipments
11.0 First Aid Fire-fighting & other Equipment
11.1 Criteria to determine the Quantity needed
11.2 Other fire fighting Equipment
12.0 Mobile Fire-fighting Equipment
12.1 Fire Tenders
12.2 Other Mobile Equipment
12.3 Other Fire Fighting Equipment
13.0 Storage of Fire Fighting Agents
14.0 Detection system and Alarm
14.1 Areas to be covered with detectors

"OISD hereby expressly disclaims any liability or responsibility for loss or damage resulting from use of the
OISD Standards/ Guidelines/ Recommended Practices."
<table>
<thead>
<tr>
<th>SECTION</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>15.0</td>
<td>Communication System</td>
</tr>
<tr>
<td>16.0</td>
<td>Inspection &amp; Testing of Fire Protection System</td>
</tr>
<tr>
<td>16.1</td>
<td>Fire water tank, reservoirs &amp; foam tanks</td>
</tr>
<tr>
<td>16.2</td>
<td>Fire Water Pumps</td>
</tr>
<tr>
<td>16.3</td>
<td>Fire Water Ring Main</td>
</tr>
<tr>
<td>16.4</td>
<td>Fire Water Spray System</td>
</tr>
<tr>
<td>16.5</td>
<td>Fixed Foam System</td>
</tr>
<tr>
<td>16.6</td>
<td>Clean Agent based Extinguishing System</td>
</tr>
<tr>
<td>16.7</td>
<td>Mobile Fire Fighting Equipment and Accessories</td>
</tr>
<tr>
<td>16.8</td>
<td>DCP / CO2 / Foam type Fire Extinguishers</td>
</tr>
<tr>
<td>16.9</td>
<td>Communication System</td>
</tr>
<tr>
<td>16.10</td>
<td>Detectors</td>
</tr>
<tr>
<td>17.0</td>
<td>Fire Fighting Organisation</td>
</tr>
<tr>
<td>18.0</td>
<td>Fire Protection Training</td>
</tr>
<tr>
<td>19.0</td>
<td>Mutual Aid</td>
</tr>
<tr>
<td>20.0</td>
<td>Fire Emergency Procedures</td>
</tr>
<tr>
<td>21.0</td>
<td>Fire Station/Control Room</td>
</tr>
<tr>
<td>22.0</td>
<td>Passive Fire Protection Measures / Other Safety measures</td>
</tr>
<tr>
<td>23.0</td>
<td>Fire Protection system Audit</td>
</tr>
<tr>
<td>24.0</td>
<td>References</td>
</tr>
</tbody>
</table>

**ANNEXURES**

I  Example for calculation of Fire Water Flow Rate  
II Example for calculation of Foam Compound Requirement  
III Broad specifications for Fire Fighting Equipment  
IV Fire Training Ground - Facilities  
V Arrangement of Mutual Aid  
VI example of fire case in a large Floating Roof Tank after sinking of floating roof  
VII System of automatic actuated rim seal fire detection and extinguishing system for external floating roof tanks storing Class- A petroleum  
VIII Brief description of fire-fighting foam  
IX Explanatory Note for Implementation
1.0 INTRODUCTION

Even though petroleum refineries and oil/gas processing installations are generally located in remote areas, experience shows that residential/industrial units come up in close proximity with the passage of time. Hence, these installations which store, process and handle large quantity of flammable materials, pose threat to surroundings as well, in addition to their own safety. Such conditions, therefore, necessitate the introduction of in-built fire protection facilities.

It is impractical and prohibitively costly to design fire protection facilities to control catastrophic fires. Usual requirement of an effective fire protection system is to prevent emergencies from developing into major threat to the installations and surroundings.

The requirement of fire fighting facilities, described in the following chapters is based on the consideration that the fire fighting services from city fire brigade and/or from other neighbouring industries will not be available.

2.0 SCOPE

i) This standard covers the design criteria and details of the various fire protection facilities to be provided in petroleum refineries and oil/gas processing plants.

ii) This standard also covers the facilities located within the refineries and oil/gas processing plants which includes:
- LPG storage, handling and bottling plants,
- Marketing & Pipeline Terminals with their loading / un-loading/ pumping and handling facilities

iii) This standard does not cover the facilities located outside the premises of Refineries & gas processing plants such as LPG mounded storage, handling & bottling plants, LNG storage Petroleum Depots, Terminals, Lube Blending plants & Pipeline Installations located out side.

However, this standard shall be applicable to those of above mentioned facilities located outside the premises under the same management and in close proximity to the refineries & gas processing plants. For such cases, common firewater storage and pumping facilities should be considered.

Otherwise, to protect the facilities located outside the following OISD standards shall apply:
- Petroleum Depots, Terminals, AFS, Lube Blending plants & Pipeline Installations --- under OISD-STD-117.
- Central Tank Farm (CTF) --- OISD-STD – 117.
- Group Gathering Station (GGS), Oil Collecting Stations (OCS) --- under OISD-STD-189.

3.0 DEFINITIONS

i) PETROLEUM REFINERY
A plant where crude oil is received and processed to produce various intermediates and finished products.

ii) OIL/GAS PROCESSING PLANT
A plant where oil/natural gas is collected and processed to produce Oil/LPG and other petroleum fractions. Drilling activities and facilities upstream of the Christmas tree of a well are not covered under this definition.

iii) LPG BOTTLING PLANT
A plant where LPG is stored and filled into cylinders. Receipt and despatch of LPG by rail, road and pipeline are also considered under this definition.

iv) PETROLEUM DEPOTS, TERMINALS AND OIL & GAS INSTALLATIONS
These include locations where Petroleum crude/Products/LPG are received by tanker, pipelines, tank wagons and tank trucks and stored or blended in bulk and despatched by
tankers, pipelines, tank wagons, tank trucks, portable tanks or containers. Lube oil installations including lube blending plant / Grease manufacturing plants and can-filling facilities also form part of such installations.

v) INSTALLATION

For the purpose of this Standard, installation includes all the facilities as listed in 3(i) to 3(iv) which are located in a Refinery or Oil/Gas Processing Plant.

vii) FLASH POINT:

The minimum temperature at which the liquid gives so much vapour that this vapour, when mixed with air, forms an ignitable mixture and gives a momentary flash on application of a small pilot flame under specified conditions of test.

viii) CLASSIFICATION OF PETROLEUM PRODUCTS

a) General Classification of Petroleum Products:

Petroleum products are classified according to their closed cup FLASH POINTS as follows:

Class 'A' Petroleum: Liquids having flash point below 23 degrees C.

Class 'B' petroleum: Liquids having flash point of 23 degrees C and above but below 65 degrees C.

Class 'C' petroleum: Liquids having flash point of 65 degrees C and above but below 93 degrees C.

Excluded Petroleum: Liquids having flash point of 93 degrees C and above.

Liquefied gases including LPG, do not fall under this classification but form a separate category.

b) Classification for heated products:

At locations where the handling temperatures are higher than the flash point of the product in circumstances where product handled is artificially heated to above its flash point, class 'C' product shall be considered as Class 'B' product.

ix) CLASSIFICATION OF FIRES

Class A Fires: involve combustible materials of organic nature, such as wood, paper, rubber and many plastics, etc., where the cooling effect of water is essential for extinction of fires.

Class B Fires: involve flammable liquids, petroleum products, or the like, where a blanketing effect is essential.

Class C Fires: involve flammable gases under pressure including liquefied gases and energised electrical equipment where it is necessary to inhibit the burning gas at a fast rate with an inert gas, powder or vapourising liquid for extinguishment.

Class D Fires: involve combustible materials such as magnesium, aluminum, zinc, sodium, potassium. The burning metals are reactive to water and water containing agents, and in certain cases carbon dioxide, halogenated hydrocarbons and ordinary dry powders. These fires require special media and technique to extinguish.

x) Shall: indicates provision that is mandatory in nature.

xi) Should: indicates that provision is recommendatory as per good engineering practices.

xii) Clean Agent: electrically non-conductive, volatile or gaseous fire extinguishants that does not leave a residue upon evaporation and meets the requirements given in the latest NFPA 2001 on clean agent fire extinguishing systems in line with environmental consideration of Kyoto and Montreal Protocols & latest MoEF regulations.

xiii) GPM denotes US gallons (1GPM=3.785 LPM)

4.0 FIRE PROTECTION PHILOSOPHY

The Fire Protection Philosophy is based on Loss Prevention and Control. It considers that a hydrocarbon processing plant carries inherent potential hazard. A fire in one part/section of the plant can endanger...
other sections of plant as well. If fire breaks out, it must be controlled / extinguished as quickly as possible to minimise the loss to life and property and to prevent further spread of fire.

4.1 GENERAL CONSIDERATIONS

The size of process plant, pressure and temperature conditions, size of storage, plant location and terrain determine the basic fire protection need. Layout of an installation shall be done in accordance with OISD-Standard-118 on Layouts to ensure adequate fire fighting access, means of escape in case of fire and also segregation of facilities so that the adjacent facilities are not endangered during a fire.

Material of construction for infrastructure facilities shall conform to National Building Code (NBC) / statutory regulations.

The following fire protection facilities shall be provided depending upon the nature of the installation and risk involved.

- Fire Water System
- Foam System
- Clean Agent Fire Protection system
- Carbon Dioxide System
- Dry Chemical Extinguishing System
- Detection and Alarm system
- Communication System
- Portable fire fighting equipment
- Mobile fire fighting equipment
- First Aid Fire Fighting Equipment.

4.2 DESIGN CRITERIA

The following shall be the basic design criteria for a fire protection system.

i) Facilities shall be designed on the basis that city fire water supply is not available close to the installation.

ii) Fire protection facilities shall be designed to fight two major fires simultaneously any where in the installation.

Fire water requirements shall be as per guidelines given in Annexure-I.

iii) All the tank farms and other areas of installation where hydrocarbons are handled shall be fully covered by hydrant System.

4.2.1 Fixed Water Spray on storage Tanks

i) Class Petroleum storage in above ground tanks shall have fixed water spray system, whether floating roof or fixed roof.

ii) Class 'B' Petroleum storage tanks of following dimensions shall be provided with fixed water spray.
- Floating roof tanks of diameter larger than 30 M.
- Fixed roof tanks of diameter larger than 20 M.

4.2.2 Semi-fixed Foam system for Storage

i) Semi-fixed Foam system shall be provided for the following tanks:
- Floating roof tanks storing Class 'A' and Class 'B' petroleum products.
- Fixed roof tanks storing Class 'A' and class 'B' petroleum products.
- Fixed roof tanks storing class 'C' petroleum products, of diameter larger than 40 M.

4.2.3 Automatic Actuated Rim seal Protection System for External Floating roof tanks:

Automatic actuated rim seal fire detection and extinguishing system shall be provided on all existing as well as new external floating roof tanks storing Class A petroleum.

Only those Rim seal protection systems, which use the linear heat hollow metallic tube type detectors with foam based extinguishing media, either for existing/ new or for replacements of existing detection system when due, shall be used. These detection systems shall be certified by any of the international certifying agencies like UL, FM, VdS.
or LPC to ensure that those systems are used which meet with highest international standards of safety certification.

(Refer Explanatory Note for Implementation in Annexure-IX).

The minimum requirement for design of the system is given in Annexure VII. This shall be in addition to the water spray and semi-fixed foam system on all the floating roof tanks storing class-A products.

4.2.4 Automatic Water Spray for Pressurised storages including LPG / Hydrogen

i) LPG and hydrogen Pressure storage vessels shall be provided with automatic water spray system.

ii) Automatic water spray system shall be provided in LPG bottling stations, LPG loading/unloading gantries and LPG pump and compressor areas in all new refineries and for existing refineries this conversion to automatic shall be done in phased manner.

4.2.5 Water Spray System in Process Unit

i) Water spray system shall be provided for hazardous locations and equipment in process unit areas. Some of these areas are:
- Un-insulated vessels having capacity larger than 50 m³ and containing class A or B flammable liquid.
- Vessels inaccessible to fire tender/ mobile equipment, fire hydrants
- Pumps handling petroleum products class 'A' under pipe racks.
- Pumps handling products above auto-ignition temperature under pipe racks
- Air fin coolers in hydrocarbon service located above pipe racks / elevated location.
- Water spray rings for columns of height more than 45 M shall be provided

4.2.6 Water Spray for Electrical Installation

Water spray requirement with mode of operation to be considered in line with provisions of OISD-STD-173. The water to be used should be clear and non-saline.

4.2.7 Clean Agent (Halon substitute) for Control rooms & Satellite Rack Room (SRR)

Selection of Clean Agent and design of Fire protection system for process control rooms, computer rooms, SRR and pressurized rooms shall follow the Standard on “Clean Agent Extinguishing systems NFPA Standard 2001 (Edition 2008 and the latest) including its safety guidelines with respect to “Hazards to Personnel”, electrical clearance and environmental factors in line with environmental considerations of Kyoto & Montreal Protocols and latest MoEF regulations. Clean Agents like inert gas, Fluoro-ketone can be used as fire suppressant in Control rooms & SRR and Computer/Server rooms. (For areas to be covered with clean agent refer OISD STD 163).

4.2.8 Loading / unloading Gantry

Oil loading/unloading Tank Truck & Tank Wagon Gantries shall be provided with water spray and/or foam system. In case automatic fixed water spray system is provided in TW gantry, the gantry may be divided into suitable number of segments (each segment having min. length of 15 m length & width of 12 m) and three largest segments operating at a time shall be considered as single risk for calculating the water requirement. Accordingly, a provision shall be made to actuate the water spray system from a safe approachable central location i.e. affected zone and adjoining zones.

5.0 FIRE WATER SYSTEM

Based on the site requirement, water shall be used for fire extinguishment, fire control, cooling of equipment and protection of equipment as well as personnel from heat radiation. For these purposes water in appropriate form should be used such as straight jet, water fog, water mist, water

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

12
curtain, water spray, deluge/ sprinkler, for foam making etc.

Fire water system shall comprise of fire water storage, fire water pumps and distribution piping network along with hydrants and monitors, as the main components.

5.1 BASIS

In line with the design criteria given at 4.2 (ii), the fire water system in an installation shall be designed to meet the fire water flow requirement for fighting two fires simultaneously or single fire for largest floating roof tank roof sinking case, whichever requiring largest water demand.

5.2 FIREWATER FLOW RATE

Two of the largest flow rates calculated for different sections as shown below shall be added and that shall be taken as design flow rate. An example for calculating design major fire water flow rate is given in Annexure-1.

i) Fire Water flow rate for tank farm shall be aggregate of the following:
- Water flow calculated for cooling a tank-on-fire at a rate of 3 lpm/m² of tank shell area.
- Water flow calculated for all other tanks falling within a radius of (R+30) M from centre of the tank on fire at a rate of 3 lpm/m² of tank shell area.
- Water flow calculated for all other tanks falling outside a radius of (R+30) M from centre of the tank on fire and situated in the same dyke area at a rate of 1 lpm/m² of tank shell area.
- Water flow required for applying foam into a single largest cone roof or floating roof tank (after the roof has sunk) burning surface area of oil, by way of fixed foam system, where provided or by use of water/foam monitors. (Refer section 6.8 for foam rates).
- Fire water flow rate for supplementary stream, shall be based on using 4 single hydrant outlets and 1 HVLR (1000GPM) simultaneously. Capacity of each hydrant outlet as 36 m³/hr and of each monitor as 228 m³/hr shall be considered at a pressure of 7 kg/cm².

ii) Fire water flow rate for LPG sphere storage area shall be aggregate of the following:
- Water flow calculated for cooling LPG sphere on fire at a rate of 10.2 lpm/ m² of sphere surface area.
- Water flow calculated for all other spheres falling within a radius of (R+30) metre from centre of the sphere on fire at the rate of 10.2 lpm/ m² of surface area.
- If the water rate as calculated above works out to be more than 2000 m³/hr the layout of the spheres should be reviewed.
- Water flow for supplementary stream shall be considered as 372 m³/hr as indicated under item (i).
- The spheres should be laid in two separate groups with each group limited to a maximum of 6 vessels. The groups shall preferably be separated by a distance of (R+30) metre.

iii) Water flow required for applying foam into a single largest cone roof or floating roof tank (after the roof has sunk) burning surface area of oil, by way of fixed foam system, where provided or by use of water/foam monitors. (Refer section 6.8 for foam rates).

iv) Water flow rate requirements for fire fighting in other major areas shall be calculated based on criteria in terms of lpm/ m² given in section 5.9.

5.3 HEADER PRESSURE

The fire water system shall be designed for a minimum residual pressure of 7.0 kg/cm² at the hydraulically remotest point of application at the designed flow rate at that point.

"OISD hereby expressly disclaims any liability or responsibility for loss or damage resulting from use of the OISD Standards/ Guidelines/ Recommended Practices."
The fire water network shall be kept pressurised at minimum 7.0 kg/cm²g at all the time.

5.4 STORAGE & MAKE-UP WATER

5.4.1 FIREWATER STORAGE

Water for the hydrant service shall be stored in any easily accessible surface or underground lined reservoir or above ground tanks of steel, concrete or masonry. The fire water storage should be located as far away as possible (not less than 60 M) from hazardous areas to avoid any damage in case of fire/explosion. The effective capacity of the reservoir above the level of suction point shall be minimum 4 hours aggregate working capacity of main pumps (excluding standby pumps). Where rate of make up water supply is 50% or more, this storage capacity can be reduced to 3 hours aggregate working capacity of main pumps. Storage reservoir shall be in two equal interconnected compartments to facilitate cleaning and repairs. In case of aboveground steel tanks there shall be minimum two tanks each having 50% of required capacity.

Large natural reservoirs having water capacity exceeding 10 times the aggregate fire water requirement can be left unlined.

In addition to fire water storage envisaged as above, emergency water supply in the event of depletion of water storage shall be considered. Such water supplies can be connected from cooling water supply header and/or treated effluent discharge headers. Fire water supply shall be from fresh water source such as river, tube well or lake. Where fresh water source is not easily available, fire water supply can be sea water or other acceptable source like treated effluent water. In case sea water or treated effluent water is used for fire fighting purposes, the material of the pipe selected shall be suitable for the service.

5.4.2 MAKE UP WATER

Suitable provisions shall be kept for make up firewater during fire fighting time. Provision should be made to divert water from various sources like ETP, Process Cooling Water, river, ponds etc. to the fire water system.

5.5 FIREWATER PUMPS

Firewater pumps shall be used exclusively for fire fighting purposes.

5.5.1 Type of Pumps

Fire water pumps shall be of the following type:

i) Electric motor driven centrifugal pumps
ii) Diesel engine driven centrifugal pumps

The pumps shall be horizontal centrifugal type or vertical turbine submersible pumps.

Each pump shall be capable of discharging 150% of its rated capacity at a minimum of 65% of the rated head. The shut-off head shall not exceed 120% of rated head, for horizontal pumps and 140% in case of vertical turbine type pumps.

Number of diesel driven pumps shall be minimum 50% of the total number of pumps (inclusive of standby pumps). Minimum 50% of total flow requirement should be available through diesel driven pumps all the time. Power supply to the electric driven pumps should be from two separate feeders.

5.5.2 Capacity of main Pumps

The capacity and number of main fire water pumps shall be fixed based on design fire water rate, worked out on the basis of design criteria as per section 5.2. The capacity of each pump shall not be less than 400 m³/hr or more than 1000 m³/hr. All pumps should be identical with respect to capacity and head characteristics.

5.5.3 Standby pumps

i) When total number of Working pumps work out to be one or two, 100% standby pumps shall be provided.

ii) When total numbers of working pumps are more than two, 50%
standby pumps shall be provided.

iii) In cases where two sets of firewater storage and pumps are provided, the number of pumps at each location shall be according to hydraulic analysis of piping network.

5.5.4 Jockey Pumps

The fire water network shall be kept pressurised at minimum 7.0 kg/cm² g by jockey pumps. 2 Jockey pumps (1 working plus 1 standby) shall be provided. The capacity of the pump shall be sufficient to maintain system pressure in the event of leakages from valves etc. The capacity of jockey pumps shall be 5% minimum and maximum 10% of the design fire water rate. Its head shall be higher than the main fire water pumps. Auto cut-in / cut-off facility should be provided for jockey pumps.

5.5.5 Power Supply for Fire Water Pumps

i) A direct feeder dedicated only to fire water pumps shall be laid from the sub-station to ensure reliable power supply. The direct feeder line shall not run along with other HT cables.

ii) The diesel engines shall be quick starting type with the help of push buttons located near the pumps, or at remote location.

iii) Each diesel engine shall have an independent fuel tank adequately sized for 6 hours continuous running of the pump.

iv) Main fire water pumps shall start automatically and sequentially with pressure switches/PLC on fire water mains. The system shall ensure auto start of the standby pump in case a pump in sequence failed to take start.

5.5.6 Location of pumps

Firewater pumps shall be located as far away as possible (not less than 60 M) from hazardous areas to avoid any damage in case of fire/explosion. The location and inter-distances for firewater pump house and related facilities shall follow OISD-STD-118.

5.6 DISTRIBUTION NETWORK

5.6.1 Looping & Maintainability

The fire water network shall be laid in closed loops as far as possible to ensure multi-directional flow in the system. Isolation valves shall be provided in the network to enable isolation of any section of the network without affecting the flow in the rest. The isolation valves shall be located near the loop junctions. Additional valves shall be provided in the segments where the length of the segment exceeds 300 M.

For ease of maintenance, Firewater pumps should be segregated in two groups by providing an isolation valve on common discharge header of pumps.

Flushing connections with isolation valves should be provided at suitable locations in the firewater ring main.

For branch piping, an isolation valve shall be provided at the take-off point.

Permanent connection shall not be taken from fire water line / system for purposes other than fire protection/ fire prevention.

5.6.2 Criteria for above / underground network

The firewater network piping should normally be laid above ground at a height of atleast 300 mm above finished ground level. However, the fire water network piping shall be laid below ground level at the following places. Pipes made of composite material shall be laid underground.

i) Road crossings.

ii) Places where the above ground piping is likely to cause obstruction to operation and vehicle movement, and get damaged mechanically.

iii) Where frost condition warrants, the ring main system shall be laid underground beneath the frost layer.
5.6.3 Protection for underground pipelines
Where the pipes are laid underground the following protections shall be provided:

i) The main shall have at least one meter earth cushion in open ground and 1.5 metre earth cushion under the roads. In case of crane movement areas, pipes should be protected with concrete/steel encasement.

ii) The mains shall be provided with protection against soil corrosion by suitable coating/wrapping.

iii) Pipe supports under the pipe line shall be suitable for soil conditions.

5.6.4 Protection for above ground pipelines
Where the pipes are laid above ground, the following protection shall be provided:

i) The firewater mains shall be laid on independent sleepers by the side of road. These shall not be laid along with process piping on common sleepers.

ii) The mains shall be supported at regular intervals not exceeding 6 metre. It should be supported at every 3 M for pipes less than 150 mm diameter.

iii) The system for above ground portion shall be analysed for flexibility against thermal expansion and necessary expansion loops shall be provided wherever called for.

5.6.5 Hydraulic Analysis & Sizing of Firewater Network

i) The hydraulic analysis of network shall be done. Also whenever fire water demand increases due to addition of plant & facilities or extensive extension of network, fresh hydraulic analysis shall be carried out.

ii) Fire water distribution ring main shall be sized for 120% of the design water rate. Design flow rates shall be distributed at nodal points to give the most realistic way of water requirements in an emergency. Several combinations of flow requirements shall be assumed for design of network. For large water requirement for floating roof tank (Annexure-VI), the network around tank farm shall be suitably designed.

5.6.6 Fire hydrants
Fire water hydrants shall be provided on the fire water network (Ref. Section 5.7 for details). Each of these connections shall be provided with independent isolation valves. Refer item 5.7.1 for further details on hydrants.

5.6.7 Fixed water monitors
Fixed water monitors shall be provided on the fire water network (Ref. Section 5.7 for details). Each of these connections shall be provided with independent isolation valves.

5.6.8 Layout

i) Fire water mains shall not pass through buildings or dyke areas.

ii) Hydrants / monitors shall not be located inside the dyke area.

5.7 HYDRANTS & MONITORS - DETAILS
5.7.1 Hydrants

i) Hydrants shall be located keeping in view the fire hazards at different sections of the premises to be protected and to give most effective service. At least one hydrant post shall be provided for every 30 M of external wall measurement or perimeter of unit battery limit in case of hazardous areas. Hydrants protecting utilities and non plant buildings can be spaced at 45 M intervals. The horizontal range and coverage of hydrants with hose connections shall not be considered more than 45 M.

ii) The hydrants shall be located at a minimum distance of 15 M from the periphery of storage tank or
hazardous equipment under protection. For process plants, location of hydrants shall be decided based on coverage of all areas. In the case of buildings, this distance shall not be less than 5 M and more than 15 M from the face of building. Provision of hydrants within buildings shall be in accordance with Standard IS Standard-3844.

iii) Hydrants / Monitors shall be located along road side berms for easy accessibility as far as possible.

iv) Double headed hydrants with two separate landing valves on 4" stand post shall be used. All hydrant outlets shall be situated at a workable height of about 1.2 metre above ground level.

v) Fire hydrants around the tank should be provided with 4" size pumper connection.

vi) Hydrants / Monitors shall be located with branch connections and not directly over main header for easy accessibility.

5.7.2 Monitors

i) Monitors shall be located at strategic locations for protection of cluster of columns, heaters, gassifiers, etc., and where it is not possible to approach the higher levels. A minimum of 2 monitors shall be provided for the protection of each such area. Water monitors for protection of heaters shall be installed so that the heater can be isolated from the remainder of the plant in an emergency.

ii) Monitors shall be located to direct water on the object as well as to provide water shield to firemen approaching a fire. The monitors should not be installed less than 15 M from hazardous equipment.

iii) Field adjustable variable flow monitors shall be installed at critical locations. These shall be UL/FM listed / approved. The requirement of monitors shall be established based on hazard involved and layout considerations. The location of monitors shall not exceed 45 M from the hazard to be protected. Monitors should be painted with luminous color for ease of identification during emergency.

5.7.3 Dry/Wet Risers with hydrants should be provided on each floor of technological structures.

5.7.4 Fixed Remote / Manual operated High Volume Long Range Water cum Foam Monitors

Remote / Manual operated high volume long range water cum foam monitors (Capacity 1000 GPM & above) shall be variable flow type with flow adjustable manually in the field, with foam induction to monitor being possible from minimum 60 m distance from the monitor and shall be provided in

i) Tank farm area.

ii) Inaccessible areas such as column, reactor, compressor house etc in critical units like CCRU, DHDS, HCU, Hydrogen, FCCU, DCU, CDU etc

iii) Critical equipments at higher locations (above 45 mtrs.)

The basic water cum foam monitors shall be UL/FM listed / approved. The electrical or hydraulic remote control mechanism shall be in line with Hazardous Area Classification.

Following criteria shall be followed for installation of variable flow foam-cum-water monitors in tank farm area:

a) Remote/ manual operated variable flow monitors shall be installed in such ways that all the tanks in the installation are within the horizontal range of foam throw.

b) Number and capacity of monitor shall be provided in such a way that foam application rate from the monitors meet requirement of foam application rate (8.1 LPM/m²) for

"OISD hereby expressly disclaims any liability or responsibility for loss or damage resulting from use of the OISD Standards/ Guidelines/ Recommended Practices."
For determining the total foam solution requirement, potential foam loss from wind and other factors shall be considered.

(Refer Explanatory Note for Implementation in Annexure-IX).

5.7.5 Hose Boxes

Provision of hose boxes should be given at critical locations for housing hoses and nozzles.

5.7.6 Water cum Foam monitors for Gantry area

Tank Wagon & Tank Lorry loading/unloading gantry area shall be provided with alternate water cum foam monitors having multipurpose combination nozzles for jet spray & fog arrangement and fire hydrants located at a spacing of 30 M on either sides of the gantry. These monitors shall be UL/FM listed/ approved variable flow type.

(This is in addition to water spray requirement given in 4.2.8.)

5.8 MATERIAL SPECIFICATIONS

All the materials required for firewater system using fresh water shall be of approved type as indicated below.

i) Pipes: Carbon Steel as per IS: 3589/ IS: 1239/IS:1978 or Composite materials as per API 15LR/API 15 HR or its equivalent shall be used.

In case saline water/ treated effluent water is used, the fire water main of steel pipes shall be, internally cement mortar lined or glass reinforced epoxy coated or made of pipe material suitable for the quality of water. Alternatively, pipes made of composite materials shall be used.

Cast iron pipes shall not be used for fire water services.

ii) Isolation Valves: Cast Steel valves shall be used in all areas including unit areas, offsite and fire water pump stations.

Isolation valves having open/close indication shall be Gate valves more than 16" should be provided with gear mechanism.

iii) Hydrant:

Standpost: Carbon Steel
Outlet valves: Gunmetal / Aluminium
Landing valves: Stainless Steel / Al-Zn Alloy/gunmetal.

iv) Monitors:

Water Monitors: Carbon Steel/ Gun Metal Foam
Monitors: stainless steel/ brass.

v) Fire Hose: Reinforced Rubber Lined Hose as per IS 636 (Type A)/Non-percolating Synthetic Hose (Type B)

vi) In case of underground mains the isolation valves shall be located in RCC/brick masonry chamber.

vii) The above ground fire water mains and the fire hydrant standpost shall be painted with corrosion resistant "Fire Red" paint shade 536 of IS: 5.

viii) Water monitor and hose box shall also be painted in "Fire Red" shade 536 of IS: 5.

ix) Corrosion resistant paint shall be used in corrosion prone areas.

5.9 FIXED WATER SPRAY SYSTEM

5.9.1 General

It is a fixed pipe system connected to a reliable source of water supply and equipped with water spray nozzles for specific water discharge and distribution over the surface of area to be protected. The piping system is connected to the hydrant system water supply through an automatically or manually actuated valve which initiates the flow of water.

i) Fixed water spray system should be provided in high hazard areas where immediate application of water is required (refer 4.2.1,4.2.5,4.2.6, 4.2.8 above).

ii) Water supply patterns and their densities shall be selected according to need. Fire water spray system for exposure protection shall be designed to operate before the possible failures of any containers of flammable liquids or gases due to temperature rise. The system shall, therefore, be
designed to discharge effective water spray within shortest possible time.

5.9.2 Water Spray Application Rates

The following water spray application rates are recommended for general guidance. These rates should be reviewed on case to case basis and increased, if required. While calculating the water rates for spray application for cases other than tanks/vessels, the area should be divided into suitable segments so that maximum water requirement for spray application should generally not exceed 1200 m³/hr.

<table>
<thead>
<tr>
<th>Application Area</th>
<th>Water application rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Atmospheric storage tanks</td>
<td>3 lpm/m² of tank shell area for tank on fire</td>
</tr>
<tr>
<td></td>
<td>3 lpm/m² of tank shell area for exposure protection for tanks located within (R+30) M from centre of tank-on-fire within the same dyke area.</td>
</tr>
<tr>
<td></td>
<td>1 lpm/m² of tank shell area for exposure protection for tanks located outside (R+30) metre from centre of tank-on-fire within the same dyke area.</td>
</tr>
<tr>
<td>Pressure Storage Vessels</td>
<td>10.2 lpm/m² of shell area</td>
</tr>
<tr>
<td>Process Unit Area</td>
<td></td>
</tr>
<tr>
<td>- Pumps (Volatile product service located under Pipe rack)</td>
<td>20.4 lpm/m²</td>
</tr>
<tr>
<td>- Columns, other Extremely hazardous area</td>
<td>10.2 lpm/m²</td>
</tr>
<tr>
<td>LPG pump house</td>
<td>20.4 lpm/m²</td>
</tr>
<tr>
<td>LPG Tank Truck &amp; Tank Wagon loading/ Unloading gantries</td>
<td>10.2 lpm/m²</td>
</tr>
<tr>
<td>LPG Bottling plants:</td>
<td></td>
</tr>
<tr>
<td>- Carousel machine</td>
<td>10.2 lpm/m²</td>
</tr>
<tr>
<td>- Filled cylinder storage</td>
<td>10.2 lpm/m²</td>
</tr>
<tr>
<td>- Empty cylinder storage</td>
<td>10.2 lpm/m²</td>
</tr>
<tr>
<td>- LPG cylinder cold repair.</td>
<td>10.2 lpm/m²</td>
</tr>
<tr>
<td>Shed</td>
<td></td>
</tr>
<tr>
<td>Oil Tank Truck &amp; Tank Wagon loading/ Unloading gantries</td>
<td>10.2 lpm/m²</td>
</tr>
<tr>
<td>Cable Trays</td>
<td>10.2 lpm/m²</td>
</tr>
<tr>
<td>Transformers</td>
<td>10.2 lpm/m²</td>
</tr>
</tbody>
</table>

5.10 FIXED WATER SPRINKLER SYSTEM

i) Fixed water sprinkler system is a fixed pipe tailor made system to which sprinklers with fusible bulbs are attached. Each sprinkler riser/system includes a controlling valve and a device for actuating an alarm for the operation of the system. The system is usually activated by heat from a fire and discharges water over the fire area automatically.

ii) Sprinkler systems are used for fire extinguishment when the hazards located inside buildings. Some of the examples being:

a) Car parking in basement
b) Building/sheds storing combustible and flammable materials.

iii) The water for sprinkler system shall be tapped from plant fire hydrant system, the design of which should include the flow requirement of the largest sprinkler installation.

iv) The design flow for sprinkler installation would depend on the type of hazard and height of piled storage. The water flow rate for automatic sprinkler system for car parking area shall be taken as 5.1 lpm/m² of the area protected by sprinkler installation. The design water flow shall be restricted to a minimum 100 m³/hr and to a maximum 200 m³/hr. The design flow rate for other areas shall be taken as 10.2 lpm/m² of the area protected by sprinkler installation, subject to a minimum of 150 m³/hr and a maximum of 400 m³/hr. Higher water application rates should be used if called for depending on risk involved.

6.0 FOAM SYSTEMS

6.1 TYPES OF FOAM

For detailed description of Fire Fighting Foam Compounds, please
6.2 LOW EXPANSION FOAM

For combating large hydrocarbon fires particularly in a contained area like storage tank, foam has proved useful for its inherent blanketing ability, heat resistance and security against burn-back. Aqueous Film Forming Foam (AFFF) compound is technically superior and compatible with other fire fighting agents. Efficient and effective foam delivery system is a vital tool for its usefulness in controlling the fire. The process of adding or injecting the foam to water is called proportioning. The mixture of water and foam compound (foam solution) is then mixed with air in a foam maker for onward transmission to burning surface.

6.3 FOAM CONVEYING SYSTEMS

The system consists of an adequate water supply, supply of foam concentrate, suitable proportioning equipment, a proper piping system, foam makers and discharge devices designed to adequately distribute the foam over the hazard. Conventional systems are of the open outlet type in which foam discharges from all outlets at the same time, covering the entire hazard within the confines of the system. There are three types of systems:

i) Fixed
ii) Semifixed
iii) Mobile

6.3.1 Fixed Foam System

Fixed foam conveying system comprises of fixed piping for water supply at adequate pressure, foam concentrate tank, eductor, suitable proportioning equipment for drawing foam concentrate and making foam solution, fixed piping system for onward conveying to foam makers for making foam, vapour seal box, and foam pourer.

6.3.2 Semifixed Foam System

Semi-fixed foam system gets supply of foam solution through the mobile foam tender. A fixed piping system connected to foam makers cum vapour seal box in case of cone roof tanks and foam maker and foam pourers in the case of floating roof tanks conveys foam to the surface of tank.

6.3.3 Mobile Foam System

Mobile system includes foam producing unit mounted on wheels which can be self propelled or towed by a vehicle. These units supply foam through monitors/foam towers to the burning surface.

6.3.4 However, certain other systems as follows are also available:

Sub-surface foam injection: This is a system for protection of fixed roof storage tanks. This comprises of high back pressure foam generator and connected through product lines or separate lines near the bottom of the tank.

Under the Seal Foam application:

This is a system for floating roof tank where the foam travels through a flexible pipe inside the tank upto the center of the tank roof and exits at the seal rim of the floating roof precisely where the fire is located thus rapidly flooding the rim seal area and quickly extinguishing the fire.

Automatic Actuated Foam Flooding system:

In this system all the components and ingredients including premix solution are contained within the system. Such systems usually have a premix solution supply tank pressurised by air or inert gas. The automatic sensing of fire releases this pressure and places the system into operation. The minimum requirement in design for the automatic actuated foam flooding system is given in Annexure VII.

6.4 FLOATING ROOF TANK PROTECTION USING FOAM

6.4.1 Protection using Semi-Fixed Foam System:

For floating roof tank, foam shall be...
poured at the foam dam to blanket the roof’s rim seal. Features of foam system for floating roof tank protection shall be as follows:

i) System shall be designed to create foam blanket on the burning surface in a reasonably short period.

ii) Foam shall be applied to the burning hazard continuously at a rate high enough to overcome the destructive effects of radiant heat.

iii) Foam makers/foam pourers shall be located not more than 24 M apart on the shell perimeter based on 600 mm foam dam height. The height of foam dam shall be at least 51 mm above the top of metallic secondary seal.

iv) A minimum of two foam pourers shall be provided.

6.4.2 Protection using Automatic Actuated Foam Flooding system:
Provision of an automatic rim-seal protection system of foam flooding type shall be in line with the details mentioned at 4.2.3 and at Annexure-VII.

6.5 FIXED ROOF TANK PROTECTION USING FOAM

Foam conveying system shall have same features as of floating roof tank excepting that a vapour seal chamber is required before the foam discharge outlet.

Features of the foam system for fixed roof protection shall be as follows:

i) The vapour seal chamber shall be provided with an effective and durable seal, fragile under low pressure, to prevent entrance of vapour into the foam conveying piping system.

ii) Where two or more vapour seal chambers are required these shall be equally spaced at the periphery of the tank and each discharge outlet shall be sized to deliver foam at approximately the same rate.

iii) Tanks should be provided with foam discharge outlets/ vapour seal chambers as indicated below:

<table>
<thead>
<tr>
<th>Tank Diameter in M.</th>
<th>Minimum number of foam discharge outlet</th>
</tr>
</thead>
<tbody>
<tr>
<td>upto 20</td>
<td>2</td>
</tr>
<tr>
<td>&gt;20 upto 25</td>
<td>3</td>
</tr>
<tr>
<td>&gt;25 upto 30</td>
<td>4</td>
</tr>
<tr>
<td>&gt;30 upto 35</td>
<td>5</td>
</tr>
<tr>
<td>&gt;35 upto 40</td>
<td>6</td>
</tr>
<tr>
<td>&gt;40 upto 45</td>
<td>8</td>
</tr>
<tr>
<td>&gt;45 upto 50</td>
<td>10</td>
</tr>
</tbody>
</table>

The estimation of number of foam discharge outlet is based on pourer capacity of 1000 lpm at a pressure of 7 kg/cm² upstream of eductor. This can be suitably adjusted for different vapour seal chamber capacity in accordance with para 6.4 (iii).

6.6 FLOATING CUM FIXED ROOF TANK PROTECTION USING FOAM

Protection facilities shall be provided as required for fixed roof tank.

6.7 DYKE AREA/ SPILLS/ OIL SEPARATOR PROTECTION USING FOAM
Portable monitors/ Medium Expansion foam generator/ foam hose streams shall be considered for fighting fires in dyke area, spills and oil separator.

6.8 FOAM APPLICATION RATE

The minimum delivery rate for primary protection based on the assumption that all the foam reaches the area being protected shall be as indicated below. In determining total solution flow requirements, potential foam losses from wind and other factors shall be considered. For cone roof tanks containing liquid hydrocarbons, the foam solution delivery rate shall be at least 5 lpm/m² of liquid surface area of the tank to be protected. For floating roof tanks containing liquid hydrocarbons foam solution delivery rate shall be at least 12 lpm/m² of seal area with foam dam height of 600 mm of the tank to be protected. In case of floating roof sinking, the rate considered should be 8.1 lpm/m² of liquid surface areas.

"OISD hereby expressly disclaims any liability or responsibility for loss or damage resulting from use of the OISD Standards/ Guidelines/ Recommended Practices."
6.9 DURATION OF FOAM DISCHARGE
The equipment shall be capable of providing primary protection at the specified delivery rates for the following minimum period of time.

i) Tanks containing liquid hydrocarbons - Class 'C' Petroleum ....30 minutes.

ii) Tanks containing Class 'A' & 'B' Petroleum or liquids heated above their flash points --- 65 minutes

iii) Where the system's primary purpose is for spill fire protection. --- 30 minutes

6.10 FOAM QUANTITY REQUIREMENT
Calculation of foam compound storage should be based on the design criteria as per item 4.2.

The aggregate quantity of foam solution for a single largest tank fire should be calculated as sum total indicated below under items (i), (ii) and (iii) for a minimum period of 65 minutes. The quantity of foam compound required should be calculated based on 3% or 6% concentrate.

i) Foam solution application at the rate of 5 lpm/m² for the liquid surface of the single largest cone roof tank or at the rate of 12 lpm/m² of rim seal area of the single largest floating roof tank whichever is higher.

However, a foam solution application rate of 8.1 lpm/m² of the liquid surface of the largest floating roof tank for 65 minutes shall be considered for a roof sinking case. (Refer Annexure-VI for sample calculation)

ii) One portable foam monitor of 4500 lpm foam solution capacity.

iii) Two hose streams of foam each with a capacity of 1140 lpm of foam solution. A typical example showing calculation of foam compound requirement is given at Annexure - II.

6.11 FOAM COMPOUND STORAGE
- Foam compound should be stored in containers of 20-30 litre capacity or 200 / 210 litre capacity barrels in case of protein, fluoroprotein or AFFF. Foam compound can also be stored in overhead storage tank of suitable capacity for quick filling of foam tender / nurser during emergency.

- Type of foam compound used can be protein or fluoro-protein or AFFF. Alcohol Resistant Foam can be used for specific application. Minimum of 90% of storage of foam compound shall be of AFFF type. Minimum life of foam compound shall be taken as per manufacturer's data.

- Foam compound should be tested periodically for ensuring its quality and the deteriorated quantity replaced. The deteriorated foam compound can be used for fire training purposes.

- Quantity of foam compound equal to 100% of requirement as calculated in 6.11 should be stored in the installation, subjected to a minimum of 60,000 litres. However, for installations having tankages larger than 60 M diameter, minimum of 77000 liters foam should be stored (refer Annexure VI) or foam sufficient to fight two major fires whichever is more.

7.0 CLEAN AGENT BASED PROTECTION SYSTEM FOR CONTROL ROOM, SRR AND COMPUTER ROOM PROTECTION

QUANTITY AND STORAGE OF CLEAN AGENT
Each hazard area to be protected by the protection system shall have an independent system.

The time needed to obtain the gas for...
replacement to restore the systems shall be considered as a governing factor in determining the reserve supply needed. 100% standby charge of clean agent containers shall be considered for each protected hazard.

Storage containers shall be located as near as possible to hazard area but shall not be exposed to fire.

Storage containers shall be carefully located so that they are not subjected to mechanical, chemical or other damage.

All the components of the system shall be capable of withstanding heat of fire and severe weather conditions.

8.0 CARBON DIOXIDE SYSTEMS

Fixed CO₂ systems shall be provided in Turbo generator enclosure, Gas turbine enclosure etc as per OISD STD 173. Fixed CO₂ system should be designed and installed in accordance with NFPA-12.

Before the CO₂ flooding system is operated; persons in the confined area should be evacuated.

Carbon dioxide is an odourless and colourless inert gas having a proven fire extinguishing property. When applied in a proper manner and in proper quantities on a fire hazard, it extinguishes fire by cutting off the oxygen and creating an inert atmosphere around the hazard. If the inert atmosphere is maintained for a reasonable time the possibility of flash back also is reduced.

Carbon dioxide is best applied to a fire hazard through a fixed system consisting of CO₂ storage, distribution piping and discharge nozzles.

9.0 DRY CHEMICAL EXTINGUISHING SYSTEM

The extinguishing system comprises of supplying the Dry Chemical agent, manually or automatically, through a distribution system onto or into the protected hazard.

9.1 RECOMMENDED USE:

Dry chemical powder extinguishing system can effectively be used on following hazards.

- Electrical hazard such as transformers or oil circuit breakers.
- Combustible solids having burning characteristic like naphthalene or pit which melts while on fire.
- Class 'A', 'B', 'C' & 'D' fire using multipurpose dry chemical. Requirement for each item should be finalised while deciding design basis.

9.2 SYSTEM DESIGN:

Basic requirement of designing the dry chemical extinguishing system is to provide for sufficient quantity and rate of discharge depending upon the hazard.

System consists of dry chemical powder and expellant gas container assemblies of capacity sufficient for given hazard with distribution piping and discharge nozzles. System can be actuated manually or automatically on visual or automatic means of detection. Alarm and indication shall be provided to show that the system has operated and personnel response is needed.

Personnel safety shall include training, warning signs, discharge alarm, respiratory protection and prompt evacuation of personnel.

Following types of systems can be provided to protect a hazard:

a. Total flooding system
b. Local application system
c. Hand hose line system, and
d. Pre-engineered system

(Refer NFPA-17 for limitations & precautions for use of dry chemical and for system design)
10.0 Modernization plan for fire fighting equipments:

Rapid intervention, Water Mist cum Compressed air Foam Technology

The technology of water mist cum compressed air foam system involves creation of water mist or a mist combination of water and foam using specialized nozzles. The mist droplets create an enlarged surface area resulting in rapid cooling due to absorption of heat. Mist droplets turn to steam on contact with fire resulting in blanketing effect, thereby cutting off oxygen & extinguishing the fire very fast. This is achieved by propelling mixture of water & foam using compressed air.

Water mist cum Compressed air foam system is for low as well as high pressure rating. The suitability of the system shall be decided for the particular application based on minimum recoil jerk, safety of the user and refillability criteria. The system shall be approved as per highest international safety standard DIN EN3 or equivalent for maximum fire rating.

The water mist cum compressed air foam system has advantage over conventional fire fighting systems (DCP, CO₂) as it provides combined effect of cooling & blanketing which results in efficient fire fighting thereby helping control fire in the initial stages. Mist also helps in blocking radiant heat making it easier for the fire fighter to approach the fire.

In addition to the conventional fire extinguishing systems such as foam, carbon-dioxide and DCP, the Back pack/Portable/Trolley mounted (mobile) water mist cum compressed air foam technology should be used to fight fires at critical locations such as hot pumps handling fluids above auto ignition temperature, like column bottom pumps at CDU, VDU, Coker, FCCU & HCU units, any other high temperature column, exchangers etc. Criteria to determine the quantity is given in the following table.

11.0 FIRST AID FIRE FIGHTING & Other EQUIPMENT

11.1 Criteria to determine the quantity needed:

Portable fire fighting equipment shall be provided in Refinery/Process plant as indicated in the following table:
<table>
<thead>
<tr>
<th>Description</th>
<th>Norms/criteria to determine the quantity needed</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Conventional fire fighting equipments</strong></td>
<td></td>
</tr>
<tr>
<td>i) Dry chemical powder fire extinguishers</td>
<td>While selecting the Extinguisher, due consideration should be given on the factors like flow rate, discharge time and throw in line with IS: 2190 / UL711. Extinguisher to be located in process units, pump houses, pump area, LPG storage area, LPG bottling plant, Oil separator, tank truck/ tank wagon loading areas, substations, Work shops, laboratory, power station buildings etc. The number should be determined based on the max. Traveling distance of 15 M in above areas. At least one fire extinguisher shall be provided for every 250 m² of hazardous operating area. There shall be not less than two extinguishers at one designated location e.g. pump house.</td>
</tr>
<tr>
<td>DCP* -10 kg capacity: IS:15683/ UL299</td>
<td></td>
</tr>
<tr>
<td>ii) Dry chemical powder fire extinguishers 25/50/75 kg capacity: IS:10658/ UL299 (in addition to 10kg DCP requirement)</td>
<td>The extinguishers with the selection criteria viz. flow rate, discharge time and throw mentioned as above, to be located in critical operating areas. At least one fire extinguisher should be provided for every 750 m² of hazardous operating area.</td>
</tr>
<tr>
<td>iii) CO2 extinguishers 4.5/6.5/9.0/22.5 kg capacity (IS:2878/UL154)</td>
<td>To be located in substations, power stations, office building and control room. The number should be determined based on the maximum traveling distance of 15 metre. At least one fire extinguisher shall be provided for every 250 m² of hazardous operating area. There shall not be less than 2nos. extinguishers at one designated location e.g. control room.</td>
</tr>
<tr>
<td>iv) Portable clean agent extinguishers</td>
<td>This should be as an alternate to CO2 extinguisher. To be located in control rooms, computer rooms, laboratories and office buildings.</td>
</tr>
<tr>
<td>v) Portable water-cum-foam monitor.</td>
<td>Minimum 2 no. for Petroleum refinery and 1 no. for Gas Processing Plant</td>
</tr>
<tr>
<td>vi) Steam lancers(as a part of utility station)</td>
<td>For fighting incipient fires at flange leakages &amp; hot pumps.</td>
</tr>
<tr>
<td>vii) Rubber hose reel (25mm)</td>
<td>To be located in Process unit battery limits and other process areas for quenching of incipient fires.</td>
</tr>
<tr>
<td><strong>Modernization plan for fire fighting equipments</strong></td>
<td></td>
</tr>
<tr>
<td>vii) Rapid intervention, Water Mist cum Compressed air Foam Technology: Filling capacity 35 to 50 litres for trolley mounted &amp; 9 litres for backpack system. The system shall be approved as per highest international safety standard DIN EN3 or equivalent for maximum fire rating.</td>
<td>In addition to the conventional fire extinguishing systems such as foam, carbon-dioxide and DCP, Minimum of one trolley type should be provided as an alternate to existing DCP system at each critical locations such as hot pumps handling fluids above auto ignition temperature, like column bottom pumps at CDU, VDU, Coker, FCCU &amp; HCU units and minimum one back pack at critical high temperature column &amp; exchangers in these units.</td>
</tr>
<tr>
<td>Note : 1) In place of 10 kg, 5 Kg DCP Extinguisher shall be provided at elevated locations. 2) For substations, power station; the number and area for placement of extinguishers should be decided as per OISD STD-173 requirements.</td>
<td>&quot;OISD hereby expressly disclaims any liability or responsibility for loss or damage resulting from use of the OISD Standards/ Guidelines/ Recommended Practices.&quot;</td>
</tr>
</tbody>
</table>
11.2 Other fire fighting Equipment:

Additionally, following items should also be provided. The number of units required for these shall be decided by local management, on case-to-case basis.

i) Thermal imaging Camera: As an aid to the fireman during fire fighting operation to locate the seat of the fire and to facilitate search and rescue operation in smoky area e.g. during cable gallery.

ii) Personal Protective Equipment required during Fire Fighting like Water gel based blanket, Fire Proximity Suit, Self contained breathing apparatus, Air line breathing apparatus, Safety Helmets, Fire Helmets, Stretcher, First Aid box, Rubber hand gloves, canister mask etc.

iii) Other Equipments like Portable Gas detectors, Explosive meter, Oxygen meter, Hand operated siren, Red/Green Flag for fire drill, Safe walk roof top ladder, emergency lighting, portable mega phone, various leak plugging gadgets, oil dispersants and oil adsorbents, lifting jacks (for rescue of trapped workers), etc.

Note: The number of unit required for these should be decided by local management, on case to case basis.

12.0 MOBILE FIRE FIGHTING EQUIPMENT

12.1 Fire Tenders:

The exact number of fire tenders shall be higher of the items (a) or (b):

(a) The quantities firm up in each case based on two simultaneous major fires taking into consideration the size, location of the plant and statutory requirements.

(b) The quantities indicated below.

i) 3 nos. of foam tenders out of which two are for fire fighting one for spill/ standby. The foam tender should have foam tank capacity of 3000/3600 litre and the pump capacity of minimum 4000 lpm at 8.5 kg/cm².

ii) One DCP tender having 2 vessels of 2000 kg capacity each with Nitrogen as expellant gas. These are required for fighting LPG/Gas fires.

A monitor should have a variable throw of 15/25/40 kg/sec. The throw of the monitor shall be 40 to 50 M for the DCP charge.

12.2 Other Mobile Equipment

In addition to fixed monitors provided in the tank farm, following additional mobile equipments shall be provided:

i) Minimum 2 nos. of foam tank trailers with field adjustable variable flow water cum foam monitors having foam tank capacity of 500-1000 liters and monitors capacity of minimum 1000 GPM and UL/FM listed / approved.

ii) Minimum 2 nos. of Trolley mounted water cum foam monitors of capacity of minimum 2000 GPM with field adjustable variable flow and UL/FM listed / approved. Foam induction to the monitor shall be possible from minimum 60M distance from the monitor.

iii) 1 to 2 numbers of Foam Nurser (i.e. Trailer mounted foam compound supply tank) with foam compound tank of 7000 – 16000 litre capacity with suitable pump for foam transfer.

iv) 1 to 2 nos. of portable/ trailer fire pumps of capacity ranging from 1800 to 2250 lpm at discharge pressure of 7 kg/cm² g.

12.3 Other Fire Fighting Equipment

Following other fire fighting equipments shall be provided:

i) Emergency rescue equipment like cutters, expanders, inflatable lifting bags, leak pads, protective clothing, breathing apparatus, trolley mounted
BA set

ii) Fire Hoses: IS 636: Type A or Synthetic hose of Type B.

The hose length shall be calculated as follows:

i) For installation with hydrants upto 100 Nos: - One 15 mtrs hose length/hydrant.

ii) For installation with more than 100 hydrants:
- One 15 metre hose length/hydrant, for the first 100 hydrants; and,
- One 15 M hose length for every 10 hydrants above 100.

The hose length so calculated shall be suitably divided into hose lengths of 15 M, 22.5 M or 30 M. Of the total requirement of the hoses, minimum 50% of hoses shall be of type B.

iii) Fire jeep (s) with two way radio communication facility and towing facility.

iv) One ambulance fitted with medical aid and suitable arrangements.

v) Other accessories, foam making branch pipes, nozzles, etc. as per requirements.

vi) 4” Hoses of suitable length for feeding to large capacity monitors wherever installed.

In addition to above, provision of following equipment should also be considered:

i) Suitable equipment for fighting high level fires.

ii) Multipurpose fire fighting skid should be used as a single self sufficient unit of having capacity of discharging foam, water/ water mist & DCP and thus performing multiple functions effectively, individually or together, saving power and time in combating a fire. Such a Multipurpose fire fighting skid should be used in lieu of one foam tender/ DCP tender as described in 10.1(b)-(i).

Broad specifications of the fire fighting equipment listed above are given in Annexure-lll.

"OISD hereby expressly disclaims any liability or responsibility for loss or damage resulting from use of the OISD Standards/ Guidelines/ Recommended Practices."
<table>
<thead>
<tr>
<th>S. No</th>
<th>Description</th>
<th>Quantity to be stored</th>
</tr>
</thead>
<tbody>
<tr>
<td>i)</td>
<td>Dry chemical powder: Reaction product of urea and Potassium bicarbonate i.e. Potassium Carbamate or Potassium Allophonate base - as spare charge for the DCP tender/Trolleys. The DCP product should be UL listed. While selecting the dry chemical powder, due consideration should be given to the typical properties viz. Apparent Density (0.65 +/- 0.05), Fire Rating (144B), Thermal Gravimetric Analysis (with decomposition at around 250°C) and foam compatibility.</td>
<td>4000 kg for the DCP tender plus 500 kg for additional requirement. This is in addition to the charge loaded on tender.</td>
</tr>
<tr>
<td>ii)</td>
<td>Siliconised Potassium bicarbonate DCP powder (IS 4308:2003/UL listed) / Mono-ammonium phosphate based DCP powder (IS: 14609/UL listed) for recharging of fire extinguishers.</td>
<td>As required based on shelf life. However, minimum 10% of the total charge in the extinguishers should be maintained.</td>
</tr>
</tbody>
</table>
| iii) | Foam compound: (IS: 4989 (Part-III) / UL listed (UL-162)                     | Higher of the quantities in :
  1. 60,000 litre (excluding that in foam tender) for installation having largest tank of diameter as 60 M.  
  2. 77,000 litre (excluding that in foam tender) for installation having largest tank of diameter as 79 M. Or, (as calculated in 6.11).  
  3. In the installation where the largest tank diameter is less than 60 M, foam quantity requirement (excluding that in foam tender) shall be calculated as per 4.4.11 of OISD-STD-117. (Refer Annexure- II and Annexure-VI for typical calculation for foam requirement)
14.0 DETECTION SYSTEM AND ALARM

Human beings are excellent fire detectors since they possess sense of smell, sight, and touch. But since human senses are also unreliable due to the need for frequent rest and relaxation, a number of mechanical, electrical and electronic devices have been developed to mimic human senses in the detection of gases / smoke / heat and flame.

A flammable gas detector is designed to give a warning of the presence of flammable gases or vapours in air, well before they reach explosive concentrations. Normally, the detector provides visible and audible alarm signals, but frequently it performs a further function by initiating control action such as increasing ventilation or shutting off the source of gas. A flammable gas detector can also be used for tracing leaks and checking that vessels or tunnels are gas free before entering.

14.1 AREAS TO BE COVERED WITH DETECTORS

14.1.1 The following areas shall be provided with hydrocarbon gas detectors:
- Light hydrocarbon pumps in process units.
- Process cooling tower top platform in the units having pressurised cooling water return.
- Fuel gas knock out drum
- Suction side of forced draft air blowers if located where hydrocarbon vapours can be present.
- Light hydrocarbon pump stations if located below grade level.
- LPG Horton spheres
- LPG pump house
- LPG bulk truck loading area
- LPG bulk wagon loading area
- LPG bottling, storage, repair sheds.
- Gas compressor
- Air-intake point for control room, in line with OISD-STD-163.

The exact location and number of points should be decided on need basis.

14.1.2 Following areas shall be provided with Smoke/ Flame / Heat detectors with alarm and/or system to actuate relevant fire suppression system:
- LPG spheres
- LPG filling sheds
- LPG pumps/compressors
- LPG loading/unloading, both in tank truck and tank wagon gantry

14.1.3 Hydrocarbon detectors shall be installed near all potential leak source of class-A e.g. tank dykes, tank manifolds, pump house manifold etc.

(Refer Explanatory Note for implementation vide Annexure IX)

Hydrocarbon detector of proper type shall be selected and also shall be proof tested and shall be maintained in good condition.

14.1.4 Additionally, following areas should also be provided with suitable detectors:
- Extremely hazardous area in process units
- Computer room, Server room, Process control rooms, Record room
- Unmanned electric substations / MCC rooms
- Cable galleries
- Chemical Storage

"OISD hereby expressly disclaims any liability or responsibility for loss or damage resulting from use of the OISD Standards/ Guidelines/ Recommended Practices."
15.0 COMMUNICATION SYSTEM

Effective communication is an essential element in the fire protection system of any plant. The following communication systems should be provided in the Refinery/Process plants.

i) TELEPHONE

Fire Station Control Room shall be provided with 2 nos. of internal telephones which are exclusively meant for receiving fire/emergency calls only. These phones should have facilities for incoming calls only. For general communication a separate telephone should be provided.

Fire Station should also have a direct P&T telephone. Hot line, telephone for contacting mutual aid parties shall be provided wherever possible.

ii) PUBLIC ADDRESS SYSTEM

Public address system should be connected to all control rooms, administration building (all floors), all departmental heads, security etc. Telephone exchange should control and take care of this system.

iii) A.R.P. (AIR RAID PROTECTION) SYSTEM / PAGING

Air raid communication system (with civil defence) should be provided in the control room of fire station. The details of such a system should be worked out in association with civil defence authorities of the area.

Alternatively, group communication system (all call system)/ alpha numerical pager system should be considered for group emergency communication.

iv) FIRE SIRENS

The Fire siren/s should be located suitably to cover the whole area with the operational control in the Fire station control room. These should be tested at least once in a week to keep them in working condition.

Fire siren code should be as follows:

1. SMALL FIRE: No siren

2. MAJOR FIRE: A wailing siren for two minutes.

3. DISASTER: Same type of siren as in case of Major Fire but the same will be sounded for three times at the interval of one minutes i.e.( wailing siren 2min + gap 1 min + wailing siren 2min + gap 1min + wailing siren 2min) total duration of Disaster siren to be eight minutes.

4. ALL CLEAR (For fire): Straight run siren for two minutes.

5. TEST: Straight run siren for two minutes at frequency atleast once a week.

v) WALKIE-TALKIE / WIRELESS

All the Fire Tenders shall be provided with a walkie-talkie/ wireless system which will help in communicating with the people in case the other system fails. Besides, key personnel co-ordinating emergency operations should also be provided with walkie-talkie.

vi) FIRE ALARM SYSTEM

The fire alarm systems includes manual call points (break glass), automatic gas/smoke/heat detectors, release & inhibit switches for fire suppressing clean agent and conventional or micro-processor based data gathering panels viz. central fire alarm panel, mimic panels & associated equipments.

Manual Call Points shall be provided at suitable locations like access point, approach roads, walkways etc. to cover the critical areas. These manual call points activate the audio-visual alarm in the Central fire alarm panel installed in fire station and in the repeater panel installed in the respective area control room(s). The location of these points

"OISD hereby expressly disclaims any liability or responsibility for loss or damage resulting from use of the OISD Standards/ Guidelines/ Recommended Practices."
shall be conspicuously marked on the annunciation panel for proper identification. These manual call points should also have suitably wired telephone handset to facilitate communication with respective area control room and fire station.

16.0 INSPECTION & TESTING OF FIRE PROTECTION SYSTEM:
The fire protection equipment shall be kept in good operating condition all the time and the fire fighting system shall be periodically tested for proper functioning and logged for record and corrective actions. In addition to routine daily checks/maintenance, the following periodic inspection/testing shall be ensured.

16.1 FIRE WATER TANK/RESERVOIR/Foam Tanks
i) Above ground fire water tanks should be inspected externally & internally as per OISD-STD-129.
ii) The water reservoir shall be emptied out & cleaned once in 3 years. However, floating leaves, material or algae, if any shall be removed once in 6 months or as & when required.
iii) The foam tanks shall be inspected every 3 years externally and shall undergo internal inspection every 10 years.

16.2 FIRE WATER PUMPS
i) Every pump should be tested by running it minimum two times a week.
ii) Once a month each pump should be checked for the shut off pressure and auto start operation. Observations should be logged.
iii) Once in six months each pump shall be checked for performance. This can be done by opening required number of hydrants/monitors depending on the capacity of the pump and by verifying that the discharge pressure, flow and the motor load are in conformance with the design parameters. For flow measurement suitable devices like ultrasonic instrument can be considered.

16.3 FIRE WATER RING MAIN
The ring main should be checked once a year for leaks etc. by operating one or more pumps with the hydrant points kept closed as required to get the maximum operating pressure.

The ring main, hydrants, monitors, valves should be visually inspected every month for any pilferage, defects and damage.

All fire main valves should be checked for operation and lubricated once in six months for fresh water and once in three months for saline/ETP water.

Thickness survey & inspection of Firewater header should be done once in three years.

Segment - wise flushing of main header should be done once a year.

16.4 FIRE WATER SPRAY SYSTEM
Fixed water cooling spray systems on storage tanks should be tested at least once in six months.
Deluge systems on LPG spheres and bullets should be tested at least once in every three months, for proper performance.

Spray system in LPG bottling plant and should be tested at least once in every quarter. Operation of ROVs should be checked once in three months.

16.5 FIXED / SEMI-FIXED FOAM SYSTEM
Foam system on storage tanks should be tested once in 12 months. This shall include the testing of foam maker/chamber.

The foam chamber should be designed suitably to facilitate testing of foam discharge outside the cone roof tank.
Piping should be flushed with water after testing foam system.

Thickness survey & inspection of Foam system piping should be done as per

“OISD hereby expressly disclaims any liability or responsibility for loss or damage resulting from use of the OISD Standards/ Guidelines/ Recommended Practices.”
OISD STD 142.

16.6 CLEAN AGENT (HALON SUBSTITUTE) BASED EXTINGUISHING SYSTEM

The systems should be checked as given below:

a) Agent quantity and pressure of refillable containers should be checked, six monthly.

b) The complete System should be inspected for proper operation once every year (Refer latest NFPA 2001(2008 Edition & latest) for details of inspection of various systems).

16.7 MOBILE FIRE FIGHTING EQUIPMENT AND ACCESSORIES

Foam tenders should be tested at least once a week. This should include running of pump and foam generation equipment.

All other mobile equipment should be checked, serviced and periodically tested under operating conditions, at least once a month.

Trailer mounted pumps should be test run at least once a week.

All the fire hoses should be hydraulically tested at least once in six months.

DCP tender should be visually inspected every week. This should include checking of expelled gas.

Records shall be maintained of all maintenance, testing and remedial/ corrective actions taken wherever necessary.

16.8 DCP / CO₂/ FOAM TYPE FIRE EXTINGUISHERS:

Inspection and testing frequency and procedure should be in line with OISD-STD-142.

16.9 COMMUNICATION SYSTEM

Fire sirens should be tested at least once a week. Testing of Manual call points once in a month, walkie-talkies every week and other communication systems covered under item 13.0 should be done as per manufacturer's guidelines.

16.10 DETECTORS

The operability of all types of detectors should be tested once in every three months. Calibration of gas detectors using test gas should be done once in every six months or as per manufacturer's specification whichever is earlier.

17.0 FIRE FIGHTING ORGANISATION

A full-fledged fire fighting organisation shall be provided. A typical organisation for the fire and safety department for a large size, Refinery/Gas Process Plant is given below:

```
DGM/CHIEF MANAGER
FIRE & SAFETY

SR MGR/MANAGER
(FIRE PROTECTION)

MG R/DY.MGR./
SR. FIRE OFFICER
(FIRE MAINT.)

EACH SHIFT SR. FIRE OFFICER & FIRE OPERATORS

SR MANAGER /MANAGER (SAFETY)

MG R/DY.MGR./
SR. OFFICER
(OPERATIONS)

SAFETY OFFICER
```

“OISD hereby expressly disclaims any liability or responsibility for loss or damage resulting from use of the OISD Standards/ Guidelines/ Recommended Practices.”
The Fire Protection / Fighting organisation shall be manned by personnel having suitable professional qualification & training. For ease of identification of the fire fighters, the crew members should be provided separate uniform.

18.0 FIRE PROTECTION TRAINING

All the plant personnel shall be trained on fire prevention and fire fighting aspects. Fire fighting skill upgradation / refresher training shall be given periodically. The fire crew belonging to the fire fighting department shall be given intensive training for the use of all equipment and in various fire fighting methods for handling different types of fires.

Regular contractors and security personnel shall be given safety, fire Fighting and rescue operation Training through oil industry approved reputed institute and record maintained.

A fire training ground with the following minimum training facilities should be set up:

a) Trench fire simulation facilities
b) A small open top tank fire simulation facility
c) Pan fire simulation facility.
d) Pipeline flange leak fire simulation facility
e) Fire suits and breathing apparatus.

A mock fire drill should be conducted once in a month to rehearse the fire emergency procedure and to keep the fire fighting team trained and alert and facilities in top order.

A layout of typical fire training ground and a brief write up on the facilities in the training ground are given in Annexure-IV.

For refineries & Gas Processing Plants not equipped with adequate fire training facilities; skill up gradation/ refresher training shall be periodically conducted at reputed institutes having live module fire fighting training facilities.

19.0 MUTUAL AID

Refineries/process plants should have written mutual aid agreements with similar neighbouring industries fully detailing the responsibilities of the members of the scheme, the procedures to be adopted, the minimum number of equipment and manpower and minimum quantity of consumables to be exchanged/loaned. A model agreement of mutual aid is given in Annexure - V.

A chart showing mutual aid arrangement shall be exhibited prominently at least in fire station and Disaster Control Room.

20.0 FIRE EMERGENCY PROCEDURES

Each installation shall prepare a detailed "Fire emergency procedures" manual outlining the actions to be taken by each personnel during a major incident for use by the organization and this manual shall be available to all personnel in the installation.

The fire emergency procedures including fire fighting plan should be prepared for fighting fires in the process units, in and around tanks, in the LPG storage and bottling plants, product loading gantries, separators, electrical fire, warehouse and building fires etc.

21.0 FIRE STATION / CONTROL ROOM

Fire Station Control Room is of critical importance as it is main coordinating centre between the emergency site and response crew. Important activities of control room are communication, mobilisation, up-keeping and maintenance. The location and construction of control room should therefore be suitable for these activities.

21.1 LOCATION

Fire station should be located at minimum risk area. It should be spaced at a safe distance from any process plant and other hazardous areas. For details refer OISD-STD-118.

When planning for new fire station,

"OISD hereby expressly disclaims any liability or responsibility for loss or damage resulting from use of the OISD Standards/ Guidelines/ Recommended Practices."
adequate land should be provided for parking and maneuvering of fire appliances. Also, access and exits of the building should not be obstructed by other vehicles. Fire station control room should be close to parking bay for fire appliances and should have good view of vehicles parked. Additional Fire-post should be considered during the expansion for improving the response time.

21.2 COMMUNICATION:

Reliable communication system is must for supporting effective fire service dept. operations. Following equipment must be available in the Control Room, (i) Telephones (2) Wireless sets/ walkie-talkie (with a dedicated frequency) (3) Hotlines to neighbouring industries/civil Fire Brigade (4) Fire Alarm system with central control in fire station.

21.3 GENERAL:

a) Fire Station should have 2 overhead storage tanks for foam compound storage, so that during emergency refilling is not delayed.

b) Control room should have portable emergency lights.

c) Fire Station should have prominently located pressure gauge showing fire water network pressure.

d) Emergency power supply shall be ensured for Fire Station & Fire water Pump House.

22.0 PASSIVE FIRE PROTECTION MEASURES / OTHER SAFETY MEASURES

Although adequate fire protection is provided in an installation, Passive fire protection measures as indicated below should be adopted wherever required.

a) Fire Proofing of structural members b) Spark Arresters and Flame Arresters c) Fire Separation Walls in concealed space/Electrical Substation/ transformer yard/ bays/ cable galleries.

d) Fire Seals in underground sewer system / Flare Knock out Drums e) Impounding Basins/Dyke Walls f) Lightning Arresters g) Pressurisation of Enclosure h) Venting Facilities of process equipment i) Electrical Relays and Fuses, earth leakage circuit breakers, neutral current circuit breaker j) Fire retardant coatings and tapes for cables k) Fire resistant low smoke insulation cable.

l) Flame proof and flame resistant electrical enclosure.

m) Insulation of hot surfaces.

23.0 FIRE PROTECTION SYSTEM AUDIT

In view of continuous expansion and additions in refineries, the system should be internally audited once in 3 years for compliance of OISD standards and statutory requirements.

24.0 REFERENCES

1) NFPA-11 Standard For Low Expansion Foam Systems

2) NFPA 11-A Standard For Medium & High Expansion Foam Systems

3) NFPA 13 Standard For The Installation Of Sprinkler Systems

4) NFPA 15 Standard For Installation Of Water Spray Systems

5) NFPA 17 DCP System

6) NFPA 20 Standard For Installation Of Centrifugal Fire Pumps


"OISD hereby expressly disclaims any liability or responsibility for loss or damage resulting from use of the OISD Standards/ Guidelines/ Recommended Practices."
8) API - 2001 Fire Protection In Refineries
9) Petroleum Rules -2002
10) Fire Protection Manual (Part-II) Of TAC
11) TAC Building Regulations
12) TAC Regulations For Electrical Equipment Of Buildings
14) International Safe Practices Of Oil Industry
15) IS:3844- Code Of Practice For Installation Of Internal Fire Hydrants In Multistorey Building
16) OISD-STD-142 Inspection Of Fire Fighting Equipment & Systems
17) OISD-STD-154 Safety Aspects In Functional Training
19) IS-15683: Portable Fire Extinguishers - Performance and Construction - Specification
20) IS-14609 : Dry Chemical Powder for fighting A,B,C Class Fires - Specification
21) UL154: Carbon-Dioxide Fire Extinguishers
22) UL299: Dry Chemical Fire Extinguishers
23) UL711: Rating & Fire Testing of Fire Extinguishers

“OISD hereby expressly disclaims any liability or responsibility for loss or damage resulting from use of the OISD Standards/ Guidelines/ Recommended Practices.”
ANNEXURE-1

EXAMPLE FOR CALCULATION OF FIRE WATER FLOW RATE

1. DESIGN BASIS
The fire water system in an installation shall be designed to meet the fire water flow requirement to fight two major fires simultaneously.

2. FIRE WATER DEMAND
Various areas which can be under fire shall be considered and fire water demand for each area shall be calculated based on design basis, as indicated below:

2.1 FLOATING ROOF TANKS PROTECTION

a) Data:
- Total storage capacity in one dyke area = 120,000 m³
- No. of tanks = 2
- Capacity of each tank = 60,000 m³
- Diameter of each tank = 79 M
- Height of each tank = 14.4 M

b) Cooling water requirement:
- Cooling water rate @ 3 lpm/ m² of tank shell area for tank on fire,
  - Cooling water required = \( \pi \times 79 \times 14.4 \times 3 \)
  - = 10721 lpm
  - = 643 m³/hr

Assuming that second tank is located within the tank dyke at a distance more than 30 meters from the tank shell.
Therefore, in such case cooling water required at the rate of 1 lpm/ m² of tank shell area shall be 215 m³/hr.
Total cooling water = 858 m³/hr

c) Foam water requirement for rim seal area:
- Water flow required for applying foam on a largest tank burning surface area.
  - Diameter of the tank (D1) = 79M
  - Distance of foam dam from shell = 0.8M
  - Diameter of roof up to foam dam (D2) = 79 - (2 x 0.8) = 77.4
  - the rim seal area = \( \frac{\pi}{4} \times (79^2 - 77.4^2) \)
  - = \( \pi / 4 \times 250.2 \)
  - = 196.4 m²

- Foam solution rate @ 12 lpm/ m²
  - (For 3% foam concentrate)
  - = 0.97 x 2356.8 lpm
  - = 2286 lpm.
  - = 2286 x 60 m³/hr
  - = 137.16 m³/hr.
  - Say 137 m³/hr

d) Fire water for supplementary hose stream based on 4 hydrant streams + 2 High Volume Long Range water monitor.
- 4x36 m³/hr + 2x228 m³/hr = 600 m³/hr

"OISD hereby expressly disclaims any liability or responsibility for loss or damage resulting from use of the OISD Standards/ Guidelines/ Recommended Practices."
e) **Total water required:**
- Tank cooling: 858 m³/hr
- Foam application: 137 m³/hr
- Supplementary stream: 600 m³/hr
- Total: **1595 m³/hr**

## 2.2 CONE ROOF TANKS PROTECTION

### a) Data:
- Total storage capacity = 50,000 m³
- No. of tanks = 4 with 12500 m³ capacity each.
- Diameter of each tank = 37.5 M
- Height of each tank = 12 M

### b) **Cooling water requirement:**
- Cooling water rate = 3 lpm/ m² of tank shell area for tank-on-fire
- Cooling water required = \( \pi \times 37.5 \times 12 \times 3 \)
  = 4241 lpm
  = 254 m³/hr
- Cooling water required for other tanks at the rate of 3 lpm/ m² of shell area for tanks falling within (R+30) metre from centre of tank on fire,
  = 3 x 254 m³/hr
  = 762 m³/hr
- Total cooling water rate
  = 254 + 762
  = 1016 m³/hr

d) **Foam water requirement** (for 1 tank only) @ 5 lpm/ m²,
- Foam solution rate = \( \pi \times (37.5)^2 \times 5 \)
  = 5522 lpm
  = 331 m³/hr

e) **Total water required**:
- Tank cooling: 1016 m³/hr
- Foam application: 331 m³/hr
- Supplementary stream (including 2 HVLR): 600 m³/hr
- Total: **1947 m³/hr**

## 2.3 LPG SPHERES AREA PROTECTION

### a) Data:
- No. of sphere in one area = 3
- Diameter of each sphere = 17 mtrs

### b) **Cooling water requirement**:
- Water rate for cooling = \( \pi \times 172 \times 10 \) lpm
  = 9079 lpm
  = 545 m³/hr
- Considering other 2 spheres located within (R+30) M from centre of sphere and fire cooling water rate for 3 spheres
  = 3 x 545 m³/hr

*OISD hereby expressly disclaims any liability or responsibility for loss or damage resulting from use of the OISD Standards/ Guidelines/ Recommended Practices.*
c) Hose stream requirement (including 2 HVLR) = 600 m³/hr  
d) Total water requirement = 2255 m³/hr

2.4 LPG RAIL WAGON LOADING GANTRY PROTECTION

a) Data:
   - Total No. of loading points = 40
   - Consider 20 loading points on each side = 7 M
   - Centre to centre rail spacing
   - Length of Rail gantry = 160 M
   - Width of cooling = 12 M

b) Cooling water requirement:
   - Divide the whole areas into 4 segments and consider 2 segments operating at any time:
     - Water rate = 2x40x12x10 = 9600 lpm
     - = 576 m³/hr
   - c) Supplementary hose requirement (including 1 HVLR) = 372 m³/hr
   - d) Total water requirement = 948 m³/hr

2.5 PROCESS UNIT PROTECTION

For process unit protection in case of fire, water is to be applied using fixed water monitors and hose lines. Unit blocks separation is by 30 metre. Three following alternatives are considered for fire water rate.

Alternate - I
   - Total unit area = 120 x 80 m²
   - Consider water rate @ 1 lpm / m² on area basis,
     - Water rate = 9600 x 1 lpm = 576 m³/hr
   - Water for supplementary hose stream (including 2 HVLR) = 600 m³/hr
   - Total water rate = 1176 m³/hr

Alternate - II
   - Consider a 10 M x 10 M portion of process unit area on fire. Provide water cover over an area of 30mts x 30mts at the rate of 10 lpm / m²,
     - Water rate = 900 x 10 lpm
     - = 540 m³/hr
     - Water for supplementary hose steam (including 2 HVLR) = 600 m³/hr
     - Total water rate = 1140 m³/hr

Alternate - III
   - Water required for portion of unit area provided with fixed spray system (Extreme Hazardous Area)
     - Area assumed = 1000 m²
     - Water rate = 10 lpm / m²
     - Cooling water required = 600 m³/hr
     - Water for supplementary hose stream (including 2 HVLR) = 600 m³/hr
     - Total cooling water required = 1200 m³/hr
     - Considering the maximum water under alternative I, II & III
     - Design flow rate = 1200 m³/hr
Fire water calculation for full surface fire on largest floating roof tank (roof sinking case) – Treated as a single contingency

a) **Data:**
- Total storage capacity in one dyke area = 120,000 m³
- No. of tanks = 2
- Capacity of each tank = 60,000 m³
- Diameter of each tank = 79 M
- Height of each tank = 14.4 M

b) **Cooling water requirement:**
- Cooling water rate @ 3 lpm/ m² of tank shell area for tank-on-fire
- Cooling water required = \( \pi \times 79 \times 14.4 \times 3 \)
  = 10721 lpm
  = 643 m³/hr

Assuming that second tank is located within the tank dyke at a distance more than 30M from the tank shell.
Then, cooling water requirement @ 1 lpm/ m² of tank shell area shall be 215 m³/hr.

**Total cooling water = 858 m³/hr**

c) **Water requirement in foam application**
- Foam Application Rate = 8.1 lpm (as per NFPA-11)
  Foam Solution Requirement = \( \frac{\pi \times 79 \times 79}{4} \times 8.1 \)
  = 39704 lpm
  = 2382 m³/hr
  Say, = 2400 m³/hr
  Water required for the foam solution = 97% x 2400 m³/hr
  = 2328 m³/hr
  Say = 2330 m³/hr

d) **Fire water for supplementary hose stream based on 4 hydrant streams + 2 High Volume Long Range water monitor.**
  4x36 m³/hr + 2X228 m³/hr = 600 m³/hr

e) **Total water required:**
- Tank cooling = 858 m³/hr
- Foam application = 2330 m³/hr
- Supplementary stream = 600 m³/hr
- **Total** = 3788 m³/hr

**Say Total water requirement = 3800 m³/hr**
3.0 TOTAL DESIGN FIRE WATER RATE

For two major fire fought simultaneously
Fire water rates for 5 cases are given below:

i) Floating roof tank protection = 1595 m³/hr
ii) Cone roof tank protection = 1947 m³/hr
iii) LPG sphere protection = 2255 m³/hr
iv) LPG rail wagon loading gantry = 948 m³/hr
v) Process unit protection = 1200 m³/hr

For fighting the above two major fires simultaneously, the design firewater rate is the sum of the two highest water rates i.e.

Design fire water rate = 2255 m³/hr + 1947 m³/hr
= 4202 m³/hr
Say = 4200 m³/hr

For full surface fire of largest floating roof tank (Roof sinking case):
Total firewater flow rate required as per typical calculations shown at 2.6 is 3800 m³/hr.
The design Firewater rate shall be highest of above 3.1 or 3.2.

Note:
Full surface fire of a floating roof tank roof sinking case being a remote possibility, it is considered as a single largest contingency for the purpose of arriving at design fire water requirement.
EXAMPLE FOR CALCULATION OF FOAM COMPOUND REQUIREMENT

1. CONE ROOF TANK PROTECTION:

i) Data:

| Total Storage capacity in one dyke area | =50,000 m³ |
| Number of tanks | = 4 |
| Diameter of each tank | = 37.5 M |
| Height of each tank | = 12 M |

ii) The quantity of foam compound shall be calculated as follows:

Consider foam solution application @ 5 lpm/ m² for the liquid surface of the single largest cone roof tank in the dyke area.

\[
\text{Foam solution rate} = \pi \times (37.5)^2 \times 5 / 4 = 5522 \text{ lpm}
\]

\[
\text{Foam compound required} = \frac{5522 \times 3}{100} = 166 \text{ lpm}
\]

\[
\text{Foam compound quantity for 65 minutes} = 166 \times 65 = 10790 \text{ litre}
\]

iii) Consider one portable foam monitor of 4500 lpm foam solution capacity:

\[
\text{3% Foam compound required} = 135 \text{ lpm}
\]

\[
\text{Foam compound required for 65 minutes} = 8775 \text{ litre}
\]

iv) Consider 2 hose streams of foam with a capacity of 1140 lpm of foam solution capacity

\[
\text{3% Foam compound required} = 68.4 \text{ lpm}
\]

\[
\text{Foam compound required for 65 minutes} = 4446 \text{ litre}
\]

v) Total foam compound required for cone roof tank area Protection:

\[
\text{Foam compound required for Cone Roof Tank} = 10790 \text{ litre}
\]

\[
\text{Foam Compound required for 1 Foam Monitor} = 8775 \text{ litre}
\]

\[
\text{Foam Compound required for 2 hose streams} = 4406 \text{ litre}
\]

\[
\text{Total} = 23971 \text{ litre}
\]

\[
\text{Say} = 24000 \text{ litres}
\]
2. FLOATING ROOF TANK PROTECTION

i) Data:

- Total Storage Capacity in one dyke = 120,000 m³
- No. of Tanks = 2
- Capacity of Each Tank = 60,000 m³
- Diameter of each tank = 79 M
- Height of each tank = 14.4 M

iii) Consider foam solution application rate of 12 lpm/ m² of seal area of the single largest floating roof tank in the dyke area:

For floating roof tank of 79 M diameter,
- Diameter of the tank (D1) = 79M
- Distance of foam dam from shell = 0.8M
- Diameter of roof up to foam dam (D2) = 79 - (2X0.8) = 77.4
- Rim seal area = \(\frac{\pi}{4} \times (79^2 - 77.4^2)\) = \(\frac{\pi}{4} \times 250.2\) = 196.4 m²
- Foam solution rate @ 12 lpm/ m² = 2356.8 lpm
- 3% Foam Compound required = 70.7 lpm
- Foam Compound required for 65 mins. = 4596 liter

iii) Foam Compound required for 1 foam monitor and 2 hose streams as calculated for cone roof protection

- 1 Foam monitor = 8775 liter
- 2 Hose streams = 4446 litre

iv) Total foam compound required for floating roof tank area Protection:

- Foam Compound required for Floating Roof Tank = 4596 liter
- Foam compound required for 1 foam monitor = 8775 liter
- Foam compound required for 2 hose streams = 4446 litre
- Total required = 17817 liter
- Say, = 18000 liter

3. On the lines of the above example foam compound requirement should be calculated for various dyke areas. Requirements to fight major fires in two dyke areas (with maximum foam compound rates requirements) should be added, to arrive at the total requirement of the installation.

For example, for 2 cone roof tank dyke areas with largest tank diameter of 37.5 metres in each area, foam compound required works out as 2x24000 liters i.e. 48000 liters.

"OISD hereby expressly disclaims any liability or responsibility for loss or damage resulting from use of the OISD Standards/ Guidelines/ Recommended Practices."
Similarly for 2 floating roof tank dyke areas with largest tank diameter of 79 M. in each area, foam compound required works out as 2 X 18000 liters i.e. 36000 liters.

4. Foam Requirement for Full surface fire of the largest floating roof tank (roof sinking Case): considered as a single largest contingency & detailed at Annexure-VI
### ANNEXURE - III

**BROAD SPECIFICATIONS FOR FIRE FIGHTING EQUIPMENT**

*(Refer OISD| STD -115 for details)*

<table>
<thead>
<tr>
<th>No.</th>
<th>Equipment</th>
<th>Broad Specification Capacity And Size</th>
<th>Suitability</th>
</tr>
</thead>
</table>
| I.  | Foam Tender | - Diesel Engine Chassis with compatible PTO Unit payload  
- Foam compound Tank - 3000 lts.  
- Water tank - 2600 lts.  
- Pump capacity - 4000 lpm@ 8.5 kg/sq.cm g & 2500 lts/min @ 10 kg/sq.cm g  
Foam/water monitor of capacity 2500 to 2800 lts/min – 1 No. | - To supply Foam Solution to Fixed foam System.  
- To supply form to spill fires |
| II. | Hydraulic Platform with articulated or telescopic arm | - Diesel Engine Chassis with compatible PTO Unit - MIN.HP280  
- Foam generating equipment  
- Cage area – 1.4 sq. mt.  
- Extinguishing Articulated boom Of 30 M height  
- Throwing distance Horizontal :100-120M Height: 65-75mt.  
- Boom movement – 360 degrees  
- Foam/water monitor capacity 5000 to 6000 plum  
- Pump capacity – 5000 to 6000 Lts/min. at 10 kg/sq. cm.g  
- Remote operation from rear of truck  
- Operation to suit water Connection from hydrants | - For foam application on oil fires  
- For fire fighting Of tall columns And inaccessible area  
- For rescue |
| III. | DCP Tender | - Diesel engine chassis –payload :13  
- 2 spheres of 2000 kg DCP each  
- Expellent gas system (Nitrogen gas cylinders 28x50 lts at 140 kg/cm² g  
- Automatic regulator for output and range  
- DCP monitor with range 15, 25 and 40 kg/second at operating pressure of 14 kg/cm² g  
- Monitor throw - 40 to 50 mtrs | - For gas Fires and Spill fires |

"OISD hereby expressly disclaims any liability or responsibility for loss or damage resulting from use of the OISD Standards/ Guidelines/ Recommended Practices."
| IV. Emergency Rescue Tender | Rescue equipment | Breathing equipment | Protective clothing | First Aid Equipment | For rescue Operations |
| V. Foam Tank Trailers with Water-cum-Foam monitors | Foam compound storage capacity 1000 litres | Filed adjustable variable flow Water cum foam monitor of capacity 1000 GPM with UL/FM listed / approved | For spill fires |
| VI. Trolley mounted Water-foam-Monitors | Filed adjustable variable flow Water cum foam monitor of capacity 2000 GPM with UL/FM listed / approved. Foam induction to the monitor shall be possible from minimum 60M distance from the monitor. | For oil fire - For hot work |
| VII. Foam Nurser (Trailer mounted foam supply tank) | Foam Compound storage - 4500 litres. | Pump capacity : 160 lts/min | To supply Foam compound During fire fighting |
| VIII. Mobile fire Trailer pump | Pump capacity 1800 to 2250 Lts/min at 7 kg/sq.cm. g | As a booster Pump - Fire water use from additional source |
| IX. Fire hoses -2 ½” | Reinforced rubber lined hoses type “A” or “B” as per IS 636 | General fire Fighting |
| X. Fire jeep | Standard design with two-way radio Communication facility | Towing trailer Type equipment - General vigilance |
| XI. Ambulance | Medical first aid equipment | Medical aid |
| XII. Other accessories Foam making branch pipes, nozzle etc. | As per standard specifications Lts/min at 7 kg/sq.cm. g | For fire Fighting |

NOTE: The capacities of equipment given above are minimum required. However, higher capacities can be provided on need basis.

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

FIRE TRAINING GROUND - FACILITIES

1.0 LAYOUT OF TYPICAL FIRE TRAINING GROUND

A typical layout of a fire training ground is shown in fig.1

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

46
2.0 DETAILS OF FACILITIES IN TRAINING GROUND

Details of different facilities in the fire training ground are described below.

2.1. Facility for storage tank fire

Storage tanks are provided with fixed foam line connection and fixed cooling water system to fight tank fires. The foam is to extinguish the fire and cooling water is to prevent spreading of fire in the neighbouring tanks. Training ground should have a tank with fixed foam installation with isolation valves on product lines.

2.2 Facility for pit fire:

During operation of the refinery, sometimes hydrocarbon liquids get released from the process equipment and accumulate in the open areas/pit. To fight such fires, the facility should be provided on the ground.

2.3 Facility for pipeline fires:

In the refinery equipment are connected by pipelines and to rundown the products from the process units to storage tanks. These pipes can leak at flange joints and result in a fire. Facilities should be provided to simulate such fires.

2.4. Facilities for wagon gantry fire:

Gantry fires are difficult to control due to rapid spreading of fires all around the gantry. Such fires can be controlled with the following arrangements
a) Isolate the oil supply
b) Cooling the area as well as surroundings with water spray & facilities should be provided for such simulations.

2.5 Facilities for LPG fire

LPG is produced in the refinery and stored in containers from where it is despatched to the market. Chances of fires due to leakage of LPG in the process unit are less as it is processed in closed system. Probability of LPG fires during bottling; loading/unloading of cylinders is more.

The most dangerous aspect in LPG fires is explosion of bullet/cylinders. To tackle such fires, training facility should be installed.

2.6 Facility for high elevation column fire

In the refinery, there are tall structures such as columns/vessels. To tackle fires on such equipment the most important activities are isolation and cooling the equipment as well as surrounding area. Generally, isolation of inlet side of the equipment is not much difficult, most difficult isolation is on the outlet side. To approach to the isolation valve, personal protective equipment with water screen is necessary. Facilities should be provided to simulate all such actions.
ANNEXURE-V

ARRANGEMENT OF MUTUAL AID

A typical arrangement through mutual aid agreement is given below:

Chembur Trombay Industrial belt spread over about 10 sq.KM is situated in north-east Greater Bombay. Industries operating in the zone include oil refineries, chemical and petrochemical complexes, fertilizer, power generation and a nuclear complex. The area at present is inhabited by large population living in residential buildings, chawls and hutments. The Eastern Express Highway and Bombay-Pune Road pass on one side of the area, while on other side; it is bounded by sea and creek. The roads in the area are loaded with passenger and goods traffic including hazardous chemicals. A railway line for goods traffic also runs from Kurla to the end of Corridor road, to meet the rolling stock requirement of the industries.

The industries in the area have fire fighting and emergency handling equipment and services depending upon the nature and size of their operations. Industries have also drawn up their On-Site Emergency Plans which are periodically revised and updated. However, the resources available with a single factory being limited can not be sufficient to control a major emergency. To overcome such constraints, the factories have come forward to form the Mutual Aid Scheme of Chembur-Trombay Region.

The main objective of Mutual Aid Scheme is to provide necessary help in case of emergencies when requisitioned by any of the members, in the minimum possible time to save life, property and minimise damage.

The members of Mutual Aid Response Group are

- Aegis Chemicals
- Apar Industries
- BARC
- BPCL
- Bombay Paint
- CTTL
- HPCL
- HP BDU
- IOBL
- IOCL
- MBPT
- ONGC
- RCF
- TATA Power

The members have agreed to extend help by

- a) Rushing fire fighting appliances and equipment
- b) Deployment of trained / technical personnel
- c) Passenger transport and ambulance
- d) Mobile equipment
- e) Tools, tackles and service equipment
- f) Personal Protective / Special equipment
- g) Medical and Health Services

Mutual Aid members meet and discuss items of common interest like preparedness and compliance status of Emergency Plans along following lines in scheduled meetings.

- a) Location of factory, accessibility, escape routes
- b) Information about hazardous chemicals
- c) Likely on-site / off-site emergencies
- d) Method of communication
- e) Strengths and weaknesses.

All members carryout on-site mock drills in their respective factories as well as combined mock drill for on site emergencies. All the real emergencies in this area have been so far effectively tackled by Mutual Aid

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

Assistance from Mutual Aid Response Group (MARG)

1. An effort has to be made to dovetail On-site emergency plan to Off-site plan.

2. Training sessions and mock drills in First Aid, Fire Fighting, Evacuation, First Responders, should be conducted to appraise and train different levels of responders in emergency control.

3. During an emergency assistance should be sought from the immediate neighboring MARG members enlisted having appropriate expertise as per the guidelines and equipments, gadgets for controlling situation and statutory authorities simultaneously.

4. All the personnel in the factory who are responders for emergencies must be made aware of the availability of such MARG assistance and methods of getting it.

5. Assisting organization must be properly briefed by the unit seeking the assistance about the nature of emergency, materials involved and metrological conditions (wind direction), precise nature of help required to ensure proper response.

6. Assisting can be requested in the form of either equipment or expertise or both with expert operating personnel.

7. In case of equipment received from assisting organization:
   a. It must be properly used.
   b. Returned promptly.
   c. In case of damage it should be repaired from approved agency and returned in good working condition.
   d. Consumables should be replaced / reimbursed.

8. It is understood that in case of any accident to any personnel while assisting organization that is receiving the help should extend its co-operation in bearing a reasonable part of expenses, beyond that covered by an insurance policy.

General:

MARG also has its limitations

Each organization is primarily responsible for keeping its plants in safe condition, identifying, assessing, minimizing and eliminating hazards and risk, maintaining necessary equipment for special kinds of risks that the organization might be facing and training its personnel for emergency control.

It can seek help from others in the MARG in terms of equipment, expertise and special materials. However, it is only complimentary to its own arrangements and commitment to safety and emergency control.

Mutual Aid and Response is sought only when in-house efforts seem to be inadequate to meet the demand of the situation and that of the civic group is not adequately resourced to meet the sudden requirement without loss of time.

"OISD hereby expressly disclaims any liability or responsibility for loss or damage resulting from use of the OISD Standards/ Guidelines/ Recommended Practices."
Example of Fire Case in a large Floating Roof Tank after sinking of floating roof

Example for calculation of Foam Requirement for Floating Roof tank with Portable Monitors:

DATA

1. Diameter of Tank : 79 m
2. Type of Roof : Floating Roof
3. Foam Application Rate : 8.1 lpm (as per NFPA-11)

Foam Solution Requirement = \( \pi \times 79 \times 79 \) \( \frac{8.1}{4} \)

= 39704 lpm

= 2382 m³/hr

Say, = 2400 m³/hr

This much quantities has to be thrown over to sunken roof area with the help of external long range high volume monitors from the road side periphery of the tank farm. The same can be achieved by 5 nos. of 2000 gpm such monitors. In design firewater rate calculation in Ann-I, sinking of floating roof of the largest tank has been considered as a single largest contingency to sizing the fire water network around tank farms to take up such firewater load so that long range monitors can be fed from this network by diverting water available in other areas of the installation to tank farms in such emergency.

Foam Compound Requirement = 39704 \times \frac{3}{100}

= 1191.12 lpm,

Say, = 1191 lpm

Foam Compound Requirement = 1191 \times 65

= 77415 litres
The automatic actuated flooding system is designed to automatically detect and extinguish the floating roof tank rim seal fire at its incipient stage. The system is mounted on the roof of the tank. The minimum requirement for the design of the system is given below:

1.0 Foam Flooding system:

Selection and design of foam based rim seal fire protection system shall be as defined in the latest NFPA - 11 & 11A Standard for Low and Medium Expansion Foam. Film Forming Fluoroprotein Foam (FFFP) / Aqueous Film Forming Foam (AFFF) type concentrate is used in the system.

1.1 Foam Application system:

A large storage tank requires one or more than one modular units for foam application in the entire rim seal. Each such unit consists of a foam distribution pipe, laid along the tank perimeter over the rim seal area. The spray nozzles for foam application are mounted on the distribution pipe at suitable intervals. Distribution pipe is permanently connected to a storage vessel containing pre-mix foam and both are placed on the roof. The foam is kept pressurised with nitrogen. The premix foam solution is contained in a vessel which is kept charged with nitrogen. The system is designed for minimum foam application rate of @ 18 lpm/ m² of rim seal area. For effective control, foam is discharged in approximately 40 seconds.

1.2 Alarm & Auto-actuation system:

In case of fire on the rim seal, it is automatically detected by a device capable to sense the same. The device then actuates the spray system for application of foam in the complete area of rim seal to quickly extinguish the fire in its incipient stage. An audio-visual alarm is also coupled with the detection & extinguishing system for necessary fire alert.

The system includes a fire detector network which senses fire and actuates the automatic release of the extinguishing medium on the rim seal area. Each tank shall have independent detection & extinguishing system.

The validity of the approach must be demonstrated by the designer for an effective total flooding extinguishing system which quickly detects and extinguishes fire in its incipient stage without re-flash. Also, the design considerations should include the impact of the weight of the modules placed on the floating roof.

The detection system needs to be highly reliable and shall work at varied site ambient temperatures for protection of rim seal fire.

Only those Rim seal protection systems, which use the linear heat hollow metallic tube type detectors with foam based extinguishing media, either for existing/ new or for replacements of existing detection system when due, shall be used. These detection systems shall be certified by any of the international certifying agencies like UL, FM, VdS or LPC to ensure that those systems are used which meet with highest international standards of safety certification.

“OISD hereby expressly disclaims any liability or responsibility for loss or damage resulting from use of the OISD Standards/ Guidelines/ Recommended Practices.”
1.3 Calculations for modular Foam application system for 79 mtr dia tank:

- Rim seal area of Tank: \( \pi \times 79 \times 0.3 = 74.5 \text{ m}^2 \) (Considering a flexible seal area of typically 300 mm)
- Rate of Foam application @ 18 LPM/m\(^2\) = 1341 LPM
- Total Foam solution required in 40 sec = 894 litre
- Total nos. of Modular unit required for the tank = 7 *
  * (considering a vessel of 150 litre capacity containing 135 litre of Foam)
BRIEF DESCRIPTION OF FIRE FIGHTING FOAM

1.0 FIRE FIGHTING FOAM:
Fire fighting foam is a homogeneous mass of tiny air or gas filled bubble of low specific gravity, which when applied in correct manner and in sufficient quantity, forms a compact fluid and stable blanket which is capable of floating on the surface of flammable liquids and preventing atmospheric air from reaching the liquid.

2.0 TYPES OF FOAM COMPOUND
Two Types of foams are used for fighting liquid fires:

2.1 CHEMICAL FOAM: When two or more chemicals are added the foam generates due to chemical reaction. The most common ingredients used for chemical foam are sodium bicarbonate and aluminium sulphate with stabilizer. The chemical foam is generally used in Fire extinguishers.

2.2 MECHANICAL FOAM: It is produced by mechanically mixing a gas or air to a solution of foam compound (concentrate) in water. Various types of foam concentrates are used for generating foam, depending on the requirement and suitability. Each concentrate has its own advantage and limitations. The brief description of foam concentrates is given below.

3.0 MECHANICAL FOAM COMPOUND:
Mechanical foam compound is classified in to 3 categories based on its expansion ratio.

LOW EXPANSION FOAM: Foam expansion ratio can be up to 50 to 1, but usually between 5:1 to 15:1 as produced by self aspirating foam branch pipes.

The low expansion foam contains more water and has better resistant to fire. It is suitable for hydrocarbon liquid fires and is widely used in oil refinery, oil platforms, petrochemical and other chemical industries.

MEDIUM EXPANSION FOAM: Foam expansion ratio vary from 51:1 to 500:1 as produced by self aspirating foam branch pipes with nets. This foam has limited use in controlling hydrocarbon liquid fire because of its limitations w.r.t. poor cooling, poor resistant to hot surface/radiant heat etc.

3.3 HIGH EXPANSION FOAM: Foam expansion ratio vary from 501:1 to 1500:1, usually between 750:1 to 1000:1 as typically produced by foam generators with air fans. This foam has also very limited use in controlling hydrocarbon liquid fire because of its limitations w.r.t. poor cooling, poor resistant to hot surface/radiant heat etc. It is used for protection of hydrocarbon gases stored under cryogenic conditions and for warehouse protection.

4.0 TYPES OF LOW EXPANSION FOAM:
Foam concentrates to be used shall conform to IS 4989 & UL-162

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

53
4.1 PROTEIN BASE FOAM:

The foam concentrate is prepared from hydrolyzed protein either from animals or vegetable source. The suitable stabilizer and preservatives are also added.

The concentrate forms a thick foam blanket and is suitable for hydrocarbon liquid fires, but not on water miscible liquids. The effectiveness of foam is not very good on deep pools or low flash point fuels which have had lengthy pre-burn time unless applied very gently to the surface.

The concentrate is available for induction rate of 3 to 6%. The shelf life of concentrate is 2 years.

4.2 FLUORO PROTEIN FOAM:

This is similar to protein base foam with fluro-chemical which makes it more effective than protein base foam.

The concentrate forms a thick foam blanket and is suitable for hydrocarbon liquid fires, but not on water miscible liquids. The foam is very effective on deep pools of low flash point fuels which have had lengthy pre burn time.

The concentrate is available for induction rate of 3 to 6% and the shelf life is similar to that of protein base foam.

4.3 AQUEOUS FILM FORMING FOAM (AFFF):

The foam concentrate mainly consists of fluoro carbon surfactants, foaming agent and stabilizer. This can be used with fresh water as well as with sea water.

It produces very fluid foam, which flows freely on liquid surface. The aqueous film produced suppresses the liquid vapour quickly. The foam has quick fire knock down property and is suitable for liquid hydrocarbon fires. As the foam has poor drainage rate, the effectiveness is limited on deep pool fires of low flash point fuels which have lengthy pre burn time.

The concentrate is available for induction rate of 3 to 6% and the shelf life is more than 15 years. This can also be used with non aspirating type nozzles.

4.4 MULTIPURPOSE AFFF:

Multipurpose AFFF concentrate is synthetic, foaming liquid designed specially for fire protection of water soluble solvents and water insoluble hydrocarbon liquids. This can be used either with fresh water of sea water.

When applied it forms foam with a cohesive polymeric layer on liquid surface, which suppresses the vapour and extinguishes the fire. The foam is also suitable for deep pool fires because of superior drainage rate and more resistive to hot fuels/radiant heat.

The 3% induction rate is suitable for liquid hydrocarbon fires and 5% for water miscible solvents. The shelf life of concentrate is not less than 10 years. This can also be used with non aspirating type nozzles.

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

54
4.5 FILM FORMING FLOURO PROTEIN (FFFP);

FFFP combines the rapid fire knock down quality of conventional film forming AFFF with the high level of post fire security and burn back resistance of floouro protein foam. The concentrate can either be used with fresh water or sea water.

The foam is suitable for hydrocarbon liquid fires including deep pool fires of low flash point fuels which have had lengthy pre burn time.

The concentrate is available for induction rate of 3 to 6% and the shelf life is not less than 5 years. This can also be used with non aspirating type nozzles.

5.0 TYPES OF MEDIUM AND HIGH EXPANSION FOAM:

Synthetic foam concentrate is used with suitable devices to produce medium and high expansion foams. This can be used on hydrocarbon fuels with low boiling point. The foam is very light in weight and gives poor cooling effect in comparison to low expansion foams. The foam is susceptible to easy break down by hot fuel layers and radiant heat.

The induction rate in water can vary from 1.5 to 3%.

Many of the low expansion foam concentrate can also be used with suitable devices to produce medium / high expansion foam.
Annexure-IX

Explanatory Note indicating Implementation schedule

Clause 4.2.3 Automatic actuated rim seal fire detection and extinguishing system shall be provided on all external floating roof tanks storing Class A petroleum.

i) The rim seal protection system shall be implemented in all existing installations progressively within 24 months for class A floating roof tanks above 5000 KL capacity & balance class A floating roof tanks progressively in 36 months from the date of issuance of the standard.

ii) Installation of rim seal system shall be done for all new/upcoming external floating roof tanks storing Class A petroleum storage tanks with immediate effect.

iii) The automatic actuated rim seal fire detection & extinguishing system already provided in existing tanks shall be replaced with linear heat hollow metallic tube type detectors with foam based extinguishing media whenever the existing system is due for replacement or shall be replaced within a period of 4 years from the day of installation whichever is earlier.

Clause 5.7.4 Remote operated High Volume Water cum Foam Monitors

i) Shall be provided progressively within 24 months from the issuance of the Standard for existing tank farms.

ii) Installation of monitors for all new/upcoming tanks shall be done along-with commissioning of the tanks.

Clause 14.1.3 DETECTION AND ALARM SYSTEM

i) Hydrocarbon Detectors shall be provided progressively within 24 months from the issuance of the Standard for existing locations.

ii) For new/upcoming locations it shall be implemented with immediate effect.