DESIGN OF TOTAL FLOODING SYSTEM FOR MARINE TERMINAL CONTROL ROOM AT VOTL

Dissertation work

Submitted in the Partial Fulfillment of the Requirement
For the Award of the Degree of

Master of Technology
in
(Health, Safety and Environment)

Under the Guidance of

Mr. Deep Saxena
(Dy GM, HSE&F)
Vadinar Oil Terminal Ltd
Jamnagar

Dr. Nihal Siddiqui
Assistant Professor
UPES, Dehradun

Submitted by

VENUGOPAL. R
R070205014

College of Engineering Studies
University of Petroleum and Energy Studies
Dehradun (May 2007)

Refinery Site, 39 km Stone,
Jamnagar-Okha Highway, (SH-25)
Taluka - Khambhalia
Dist. Jamnagar.- 361 305.
Phone : (+91-2833) 241444
Fax : (+91-2833) 241414 / 241818

CERTIFICATE

*This is to certify that the work embodied in this project entitled "**Design of Total Flooding System for Marine Control Room at VOTL** " being submitted by **Mr. Venugopal. R** to the University of Petroleum & Energy Studies, Dehradun, in partial fulfillment of the requirement for the award of Degree of **Master of Technology** in **Health, Safety & Environment**, is a bona fide work carried out by him from 20th March, 2007 to 29th April, 2007 under my supervision and guidance. He has been registered for M.Tech Degree in **Health, Safety & Environment** vide University Registration No. R070205014. It is also certified that this project is a result of his own investigations and the work has not been submitted to any other University for any other degree.*

(Mr. Deep Saxena)
Dy General Manager, HSE&F
Vadinar Oil Terminal Ltd
Jamangar

CERTIFICATE

This is to certify that the project work entitled **" Design of Total Flooding System for Marine Control Room at VOTL"** submitted by **"Venugopal R"** in partial fulfillment of the requirements for the award of the degree of Master of Technology (Health ,Safety & Environment), at College of Engineering Studies, University of Petroleum & Energy Studies, is a bona fide record of the work carried out by him at Vadinar Oil Terminal Ltd(VOTL), Jamnagar under the guidance of "Mr. Deep Saxena (Deputy GM, HSE&F)" and "Dr Nihal Anwar Siddiqui, Assistant Professor, University of Petroleum & Energy Studies, Dehradun".

To the best of my knowledge, the contents of this project work did not form a basis of the award of any previous degree or published material by any one else.

The work is comprehensive of sufficient standard and here by recommended for the award of the degree of M.Tech in Health, Safety & Environment.

Dr. Nihal Anwar Siddiqui
Assistant Professor, CES
UPES
Dehradun

Dr.B.P.Pandey
Dean, CES
UPES
Dehradun

Acknowledgements

This is to acknowledge with thanks, the help, guidance and support that I have received during my tenure in ***Vadinar Oil Terminal Limited(VOTL).***

I am very much obliged in showing my gracious attitude to the management of VOTL-Jamnagar for giving me an opportunity to pursue my project, in particularly ***Mr. Deep Saxena, Deputy General Manager, HSE&F*** *for his valuable support.*

I am grateful to ***Mr. K. Balasubramanian, Head of Marine Facilities,*** *for the encouragement, guidance and the assistance he has provided throughout the project period.*

I extend my profound gratitude to ***Capt. Deepak Sachidev (Head of Marine Operations)*** *and also to* ***Mr. Saurav Dharshan (Deputy Manager)*** *for their inspiration, interest, guidance and suggestions throughout the project work*

I also Thank ***Dr. N.A Siddique (Course Co-ordinator HSE, UPES)*** *for his valuable support.*

Thanks are due to ***Dr. B.P Pandey (Dean, COE, UPES)*** *for all the encouragement provided by them.*

CONTENTS

EXECTIVE SUMMARY

Essar Oil Limited is one among the leading refineries in India. Its refinery at Jamnagar is having a refining capacity of 10.5 MMTPA. By 2010, refining capacity of the refinery will be 30MMTPA. Thus Essar Oil Ltd plays an important role in the oil and gas sector of India.

This final dissertation work covers the design of FM-200 based total flooding system for the marine control room at Vadinar Oil Terminal Ltd. This report also covers the fire protection facilities required for a port terminal as per OISD-156 and OCIMF(Oil Companies International Marine Forum). This report also covers the detailed study of fire protection system available at the jetty area.

Design of total flooding system includes the selection of extinguishing agent, estimation of the area to be protected, estimation of the quantity of agent required, selection of pipeline and line sizing.

This project work has helped in bridging the gap between, the theoretical concepts and the practical orientation involved for the design and installation of the fire protection facilities required for a marine control room. The information and knowledge provided by the company have proven to be very helpful for the fulfilment of the project work.

2. ABOUT THE COMPANY

ESSAR OIL LIMITED

Essar Oil Ltd. (EOL) has emerged as a leading integrated oil and gas company spanning the entire value chain, from deep within the earth all the way to the end-consumer. Essar has exploration and production (E&P) rights in some of India's most valuable oil and gas blocks. EOL is building a state-of-the-art refinery and a countrywide network of modern retail fuel outlets.

Essar is one of the first private companies to bid for exploration blocks in 1993. We won two onshore blocks in Rajasthan and one in the Mumbai offshore region, where we have completed the first phase and are moving into test drilling. We were then awarded a block each in the Cambay basin (Gujarat) and Cachar (Assam). We believe that we have lowered the risks and increased the rewards of exploration by carefully selecting the blocks with maximum potential.

Essar is among the first to enter the refining sector when it was opened to private participation. Our US$ 2.14 bn (Rs.99billion) refinery at Vadinar, Gujarat, which has achieved full financial closure, is two-thirds complete . With a capacity of 10.5 MTPA (that can rise to 12 MTPA after de-bottlenecking), this world-class refinery complex is focused on producing middle distillates like aviation turbine fuel, kerosene oil and high-speed diesel, which form over 60% of India's demand. We will also produce LPG and transport fuels including petrol conforming to Euro III and Euro IV product quality standards for the domestic and export markets.

VADINAR OIL TERMINAL LIMITED

Terminal Facilities and Operations

Tanker Berth

There is a tanker terminal with one tanker berth for the export of refined products. Typically the products handled are Gasoline, High speed diesel (HSD), Super Kerosene Oil (SKO), Aviation Turbine Fuel (ATF), FO/VGO and Naphtha.

Safety measures provided at berths include provision gas sensors, fire monitors, a foam system and a deluge curtain and water barrier. Loading arms are equipped with PERC (Power Emergency release couplings) which will disconnect the loading arms if the tanker along side drifts in longitudinal or transverse direction and exceeds the set limits of loading arms.

The berth is comprised of a piled jetty with provision for 04 breasting dolphins and 04 mooring dolphins with quick release mooring hooks at each mooring point. Berthing and un berthing is carried out during daylight hours only. Mooring dolphins are fitted with quick release hooks capable of withstanding a load of 45 Tons/per hook. Mooring Dolphins are capable of withstanding 100 tonnes load.

The usual mooring configuration will be 03 head/stern lines, 03 breast lines and 02 springs (3+3+2). During Monsoon final mooring configuration could be 4+3+3 (As advised by KPT).

Berth Length : 309.5 Mtrs.

Draft at the Berth

Vessels arriving or departing from the Berth in ballast conditions comply with MARPOL Annex I regulations.

Charted depth at berth is 20 meters.

Max loaded draft allowed at the Berth is 15 Mtrs.

Berth Facilities

Max Beam acceptable: No restrictions.

Maximum Length acceptable: 245 Mtrs.

Maximum Depth Alongside: 20 Mtrs.

Maximum Permissible Draft Alongside: 15 Mtrs.

Maximum Deadweight acceptable: 100000 M.Ts.

Maximum trim: 2.5 Mtrs and IMO requirement

Cargo Operational facilities

Arms connections:

The SPM has following available hose sizes for receiving the cargo.

2 x 16": Crude oil.

The berth has following Loading arms available for loading the product grades.

1) 1 x 16": ATF / SKO

2) 1 x 12 ": Naphtha / Gasoline/ HSD

3) 1 x 12": FO/VGO.

Loading Rates

Maximum loading rate for all the products at the Jetty is 2000 m^3/hr/arm except for FO and VGO for which Maximum loading rate is1400 m3/hr/arm.

Maximum Discharge Rate

Maximum receiving rate at the SPM is 10,000 m^3/hr (Total for 2 x 16" hoses).

Manifold Pressure

Ship maintains 10.0 kgf/cm^2 at the manifold during discharging operations.

Pipeline sizing

Cross country lines -24"

Terminal transfer lines : 32 "

Header lines : 20

Weather

Max wind criteria for berthing – 25 kts, Wave height – 1.5 Mtrs.

Cargo suspension – 25 kts.

Hose disconnection – 30 kts.

Unmooring – 35 kts, Wave height – 3.0 Mtrs.

OPERATION, CONTROL AND SAFEGUARDING

Essar Oil Limited receives product from Essar refinery tank farm through 3 * 24" -18 km long pipelines for loading in 25000 -100000 DWT ships berthed at the jetty .The entire operation of receipt and loading is carried out as per the philosophy as described below.

Product Selector Pig Launcher /Reciever Control (PSPC)

This DCS based software control and monitors the receipt and loading operation .It will receive signals from operator (manual inputs ,Pig arrival signals .Flow meter Computer systems (FMCS) ,loading arm control systems (LACS) and refinery tank

farm dispatch control systems (RTDCS) .Its output goes to various MOVS on product transfer lines and to Pig Controllers (PC).

Pig Controllers

Spheres are used for liquid batch separation in lines carrying two or more fluids with minimal mixture of products and sphere wear is negligible

Arrival of spheres at check point is registered by detectors and signals from detectors and signals from detectors are used to automate the operation of manifold valves.

Following are the integral parts of pig launcher /receiver station

- Pressure gauge /Pressure transmitter
- Mainline trap valve
- Trap Kicker /by pass trap valve
- Vent and drain valves
- Pig arrival sensors (PAS) with potential free contacts for use in interlocks/synchronization

Remote/Motor Operated Valves on Pig Launcher

There are three MOVs for each Pig Reciever /Launcher which will regulate the flow through the pig barrel or bypass it .These valves will be called into operation automatically to trap/ launch the pig by respective pig controller.

MOVs on product transfer lines

All motorized valves are fire safe type with a control unit supplied as part of MOVs actuators. All mov's operate on 3 phase 415 v AC with following features

- Integral local operating station
- Local digital display of

  Valve Position

  Set Torque Level

a) Alarms Control Configurations

- Top/side hand wheeled with auto/manual selection
- valve jamming protection
- instant reverse protection (ball plug valve)

Monitoring systems on transfer lines

Pressure transmitter

Pressure transmitter tappings to maintain a 10 kg/cm2 are provided to ensure working at safe pressure limits.

Pressure transmitter is provided a 4 - 20 mA signal from the pipeline.

Temperature transmitters

Temperature transmitters are field mounted with flame proof sensor heads

It is a 2 wire type which gives a 2-20 mA dc.

Density Transmitter

Density transmitter are installed in the line also give a 4-20 mA.dc

All transmitters are provided with 24 V DC available in the control room through UPS.

3. FIRE PROTECTION FACILITIES REQUIRED IN PORT TERMINAL AS PER OISD 156 AND OCIMF

GENERAL

Layout of a Port Terminal should be done in accordance with Standard Engineering Practices/Requirements. A good layout provides adequate fire fighting access, means of escape in case of fire and segregation of facilities so that adjacent facilities are not endangered during a fire.

The following fire protection facilities shall be provided depending upon size, nature/risk of installation:

- Fire Water System
- Foam System
- Halon Protection System
- DCP Protection System
- First Aid Fire Fighting Equipments.
- Mobile land and water borne Fire Fighting Equipments.
- Fire Alarm/Communication System.

DESIGN CRITERIA FOR FIRE PROTECTION

i) It is assumed that in case of fire on ship tanker, ship will be towed to open sea and that fire protection for ship tanker will be treated as first aid till towing is done.

ii) Fire water system shall be designed for facilities on the basis that city fire water is not available close to the installation.

iii) One single largest risk shall be considered for providing fire protection facilities.

iv) All facilities shall be covered with Hydrant System as detailed in 4.3.7

v) Tower mounted water /Foam monitors shall be provided for protection to loading arms/first aid to tankers.

vi) Water curtains shall be provided for segregation of loading arms/piping manifold and ship tanker in the event of fire on either of these facilities.

vii) Manual/automatic below deck fixed water spray system or pile fire-proofing to protect berth structure and installations shall be provided.

viii) For Port Terminal handling ships of less than 50,000 tonnes capacity one set of Fire water Pumps shall be provided which will cater to both tower mounted monitors as well as hydrant service and water curtains, and for Port terminal handling ships of 50,000 tonnes or larger two sets of Fire water Pumps shall be provided for:

I) Tower mounted water/foam monitors.

ii) Hydrant Service and water curtains.

ix) Halon Fire Protection shall be provided for control room/computer room.

x) Dry Chemical Powder (DCP) protection shall be provided for LPG/Gas loading / unloading terminals.

3.1 FIRE WATER SYSTEM

Water is an essential and the most important medium to mankind for fire protection. Water is available is ample quantities at terminals and on ships. Water spray and water fog may be used effectively against oil fires and for making a screen between the fire fighter and the fire. water is used for fire extiguishhment, fire control, cooling of equipment water fog may be used effectively against oil fires and for making a screen between the fire fighter protection of personnel from heat radiation owing to danger of electrical shock, water should not be directed towards any live electrical equipment.

3.1.a) COMPONENTS OF WATER SYSTEM

The main components of the system are:

- Fire water storage.

- Fire water pumps.

- Distribution piping network.

3.1.b) DESIGN FLOW RATE

I) The fire water system at port Terminal shall be designed to meet the fire water flow requirements of a single largest risk at a time

ii) Fire water flow rate for Port terminal protection shall be aggregate of the following:

- Water flow for Tower mounted water/foam monitors for protection of loading arms./ piping manifold and ship tanker.

- Water flow for area segregation by providing water curtains between ship tanker and loading arms and Hydrant service.

iii) Design Flow rate shall vary with type of product and size of ships handled. Refer Table-1 (for POL products) & Table –II (for Liquefied Petroleum Gas) for water flow design requirements.

FIRE WATER DESIGN REQUIREMENT FOR PORT TERMINALS HANDLING OIL AND PETROLEUM PRODUCTS (EXCLUDING LIQUEFIED HYDROCARBON GASES)

SL.NO	INSTALLATION	FIRE WATER RATE
1	Barge berth at a wharf or Jetty	Fire mains/monitors with a fire water supply of 288M3/hr (One monitor + Four hydrants)
2	Tanker berth at a wharf or jetty handling ships of less that 20,000 tonnes deadweight capacity	Fire mains/monitors with a fire water supply of 410 M3/hr (2 monitors X 3000lpm+ 50m3)
3	Tanker berth at a wharf or Jetty Handling ships of 20,000 tonnes and above but less than + 50,000 tonnes dead weight	Fire mains/monitors with a fire water supply of 820M3/hr 2 monitors X 3000 lpm + 2 jumbo Nozzles X 3000 lpm +100 m3
4	Tanker berth at a wharf of Jetty handling ships of 50,000 tonnes and above but less than 100,000 tonnes deadweight	i) 600 M3/Hrs for water/ foam monitors) 2 tower monitors X 5000 lpm) ii) 600 M3/Hrs for hydrant & water curtain service. (2 Jumbo Nozzles X 5000 lpm)
5	Tanker berth at wharf or Jetty handling ships of 100000 tonnes deadweight or more	i) 720 M3/Hrs for water/ Foam monitors (2 Foam monitors (2 monitors X 6000 lpm) ii) 720 M3/Hrs for water curtain service. (2 Jumbo Nozzles X 6000lpm)

3.1.c) DESIGN FIRE WATER PRESSURE

The fire water pressure system shall be designed for a minimum residual pressure of 7.0 Kg/cm.Sq. g at the hydraulically remotest point of application in the terminal.

3.1.d) FIRE WATER SOURCE

Sea water which is available in plenty near Port terminal can be conveniently used for fire fighting. However consideration shall be given to location of fire water source so that it is away from major oil leakage source so that sea water free from oil is available during fire incidence.

FIRE WATER DESIGN GUIDE FOR PORT TERMINAL HANDLING LIQUEFIED HYDROCARBON GASES

Sl.No	INSTALLATION	FIRE WATER RATE
1	Tanker berth at Jetty handling ships of size less than 10,000 tonnes deadweight	Fire main incorporating isolating valves, fire hydrants and fixed water monitors with a fire water supply of 2 x 140 M3/hr (2 X 3000 lpm monitors + 2 X 300 lpm Jumbo Nozzles)
2	Tanker berth at a Jetty handling ships of size from 10000 tonnes to 20000 deadweight	Fire main incorporating isolating valves, fire hydrants and fixed water monitors with a fire water supply of 2 x 720 M3/hr (2 Tower monitors x 6000 lpm + 2 Jumbo Nozzles x 6000 lpm)

3.2) FIRE WATER PUMPS

i) Centrifugal type fire water pumps shall be installed to meet the design fire water flow rate and head. These should have flooded suction.

ii) The pumps shall be capable of discharging 150% of its rated discharge at a minimum of 65% of the rated head. The Shut-off head shall not exceed 120% of rated head for horizontal centrifugal pumps and 140% for vertical turbine pump.

iii) A minimum of 50% standby pump(s) (minimum one no.) of the same type as the main pumps shall be provided. Standby pump provision shall be as follows:

- If one pump is the requirement then a standby of the same capacity shall be provided.

- If 2 pumps are required then one additional pump of similar capacity shall be provided as spare.

iv) The fire water pump(s) including the standby pump(s) shall be of diesel engine driven type. Where electric supply is reliable 50% of the pumps may be electric driven. The diesel engines shall be quick starting type with the help of push buttons located on or near the pumps or located at a remote location. Each engine shall have an independent fuel tank adequately sized for 6 hours continuous running of the pump.

v) Fire water pump shall be located in a covered shed 100 M(Minimum) away from equipment or where hydrocarbons are handled or stored.

vi) Fire water pumps shall be exclusively used for fire fighting purpose only.

vii) Jockey Pumps shall be provided having a minimum capacity at 3% of the total system capacity at all jetties handling hydrocarbons. The fire water system shall be kept at a minimum pressure of 7kg/sq.cm at jetties where a tanker is berthed and/or the hydrocarbon lines are kept charged after

loading/unloading. At jetties where flushing of hydrocarbon lines are done after each loading/unloading the fire water network need not be kept charged.

3.3) FIRE WATER DISTRIBUTION NETWORK

i) The fire water network shall be laid to ensure multi-directional flow in the system where possible. Isolation valves shall be provided in the network to enable isolation of any section of the network. The isolation valves shall be located normally near the loop junctions. Additional valves shall be provided in the segments where the length of the segment exceeds 300 meters.

ii) The fire water network piping should normally be laid above ground at a height of 300 mm to 400 mm above finished grade. However, the fire water network piping shall be laid below ground level at the following places:

a. Road crossings.

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

iii) Where the pipes are laid underground the following protections shall be observed:

- The main shall have at least one metre earth cushion in open ground and 1.2 metre cushion under the roads.
- The mains shall be provided with protection against soil corrosion by suitable coating/wrapping.
- In case of poor soil conditions it may be necessary to provide concrete / masonary /supports under the pipe.

iv) Where the pipes are laid above ground, the following protection shall be provided:

- The mains shall be supported at regular intervals not exceeding 6 meters.

- The system for above ground portion shall be analysed for flexibility against thermal expansion and necessary expansion loops where called for shall be provided.

v) 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.

The system shall be designed so that a minimum 7 kg/cm2g residual pressure is available at the hydraulically remotest section of the terminal for the designed flow rate at that point.

vi) As per International maritime Requirements all marine terminals and berths with a Fire water system should have at least one International shore Fire connection (ISC) through which water could be supplied to a tanker fire main if required for shipboard fire fighting.

3.3.a) HYDRANTS

i) Hydrants shall be located bearing in mind 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 metres length on the Jetty for high hazard area. Hydrants protecting utilities and miscellaneous buildings in high hazard areas may be spaced at 45 metres intervals. The horizontal range & coverage of hydrants with hose connections shall not exceeds 45 M.

ii) Hydrants shall be located at a minimum distance of 15 metres from the periphery of tanker or equipment under protection. In case of buildings this distance shall not be less than 5 meters from the face of building. Provision of

hydrants within the building shall be provided in accordance with IS standard No.3844.

Hydrant/Monitors shall be located along side berms for easy accessibility.

iii) Double headed hydrants with two separate landing valves on 4" standpost shall be used. All hydrant outlets shall be situated 1.4 metre above ground level.

3.3.b) FOAM/WATER MONITOR

a) Tower Monitors

For protection of ship tank and loading arms long range/high head foam/water monitor shall be used. This can be effectively achieved by mounting monitor on a steel tower of suitable height. Tower Monitors shall be minimum two for each jetty handling ships of 20000 tonnes and more. These shall be auto operated from control room which should be located minimum 100 Mts. from the manifold.

The height of the monitor shall be such that it will cover the deck of the largest tanker in the lightest condition at spring tides at the jetty. Tower monitors shall be located minimum 15 Mts. away from the hazardous area it is to protect. However, if existing monitors cannot be relocated then a concrete cover shall be provided over the steel structure so that it is protected against fire.

b) Ground Monitors

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

Connection for fixed water monitors shall be provided on the fire water network. Each of these connections shall be provided with independent isolation valves.

The layout of monitor shall be established based on hazard involved and layout considerations.

3.3.c) JUMBO CURTAIN NOZZLES

A water curtain shall be provided between loading arms and ship tanker for segregation of the tow hazardous equipments. 2 Nos. jumbo curtain Nozzles shall be provided at jetties handling ships of 20000 tonnes deadweight and above for segregation purposes.

MATERIAL SPECIFICATIONS

The piping material specification shall be as given below: In case of sea water service the fire water main pipes shall be cement mortar lined internally.

I) Pipes		CS as per IS:3589/IS:1239
ii) Isolation Valves		Cast steel rising stem type.
iii)	Hydrant	Carbon Steel
	Standpost	Carbon Steel
	Outlet)	
	)	Gunmetal
	Valves)	
iv)	Monitors	Carbon Steel/Aluminum alloy
v)	Fire Hose	Reinforced rubber lined
vi)	Foam Piping	Carbon steel.

vii) In case of underground mains the isolating valves shall be located in RCC/brick masonary chamber.

viii) The above fire water mains and the hydrant standpost shall be painted with corrosion resistant "Fire Red" paint.

ix) Water monitor and hose box shall be painted "Yellow".

3.3.d) FIXED WATER SPRAY SYSTEM

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

ii) Fixed water spray system shall be provided at all jetties handling ships of more than 20000 tonnes deadweight for segregation of loading arms and ship.

iii) 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.

3.4) FOAM SYSTEM

Type of Foam.

Generally, two types of foams are ins use. These are low expansion foam and high expansion foam. Low expansion foam has an expansion ration 1 : 6 to 1 : 10 and is used for hydrocarbon oil fire. High expansion foam has an expansion ration of 1 " 200 to 1 : 1000 is used for protection of Hydrocarbon gases stored under cryogenic conditions and for warehouse protection.

High expansion foam systems have special applications and are not commonly used in oil industry. Their requirement may be examined for specific needs. The details of such systems are not covered in this standard.

Low Expansion System

For combating large hydrocarbon fires particularly, in contained area like a tanker, foam has proved useful for its inherent blanketing ability, heat resistance and security against burn back.

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 is called proportioning. The mixture of water and foam liquid (foam solution) is mixed with air in a foam maker for onward transmission to burning surface.

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.

These 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.

Self-contained systems are those in which all components and ingredients, including water, are contained within the system. Such systems usually have a water supply of premix solution supply tank pressurised by air or inert gas. The release of this pressure places the system into operation.

There are three basic types of systems:

i) Fixed;
ii) Semi-Fixed;
iii) Mobile

i) Fixed Foam System

Fixed foam conveying system comprises 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 for further application.

ii) Semi-fixed Foam System

This system gets supply of foam solution through the mobile foam tender/foam trolley. A fixed piping system connected to foam makers, conveys foam to the surface of application.

iii) Mobile System.

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

Foam Application Rates.

Foam solution delivery rate shall be at least 51 pm/M2 of liquid surface area to be protected. For tower monitor the foam solution rate shall match monitor discharge capacity.

Duration of Foam Discharge

The foam equipments shall be capable of operation to provide primary protection at the delivery rates specified for a minimum period of 60 minutes.

Water for Foam Making

Sea water shall be considered for selection of foam compound.

Foam Compound Requirement

i) The foam compound requirement shall be calculated based on tow tower mounted monitors operating simultaneously for 60 minutes.

ii) The quantity required for two portable foam monitors of 2400 1 pm foam solution capacity shall be provided.

The aggregate quantity of foam solution shall be sum of (I) and (ii) for a minimum period of 60 minutes for each jetty. From this calculate the quantity of foam concentrate required based on 3 or 6% concentrate.

iii) Foam compound requirement for oil Port terminal having more than one oil jetty shall be as below:

a) Foam compound requirement equal to 50% of calculated Foam compound as per para 4.4.7 shall be stored at each jetty.

b) Balance quantity on foam compound requirement shall be so located that it is available to fight fire at any of the jetties.

c) Total quantity Foam compound shall not be less than the requirement for the largest jetty or the sum total of 50% of requirement for each of the jetties, whichever, is higher.

Foam Compound Storage

Foam compound shall be stored in an elevated storage tank of capacity as per shown in the below table.

Additional Foam compound should be stored in containers of 20/25 liters capacity or 200/210 liters capacity barrels.

Type of foam compound used can be protein or flurolprotein FFFP or AFFF. Minimum life of FFFP/AFFF should be 10 years. The quality of the protein based foam compound having shelf life of only 2 years shall be regularly checked and the deteriorated foam shall be replaced.

FOAM COMPOUND REQUIREMENT

INSTALLATION SIZE	BASIS OF FOAM REQUIREMENT	3% FOAM COMPOUND
Barge Berth at warf of jetty	2 X 2400 lpm Foam Monitors	8640 lit
Tanker Berth at warf of jetty handling ships of less than 20000 tonnes deadweight capacity.	2 X 300 lpm Foam Monitors	10800 lit
Tanker Berth at a warf or jetty handling ships of 20,000 tonnes & above but less than 50,000 tonnes dead weight	2 X 3000 lpm tower Foam Monitors + 1 base Monitor 1 X 1500 lpm	10800 lit 2700 lit Total = 13,500 lit
Tanker Berth at a warf jetty handling ships of 50,000 tonnes & above but less than1,00,000 tonnes dead wt	2 X 5000 lpm Tower Foam Monitor + 2 X 2400 lpm base Foam Monitor	26640 lit
Tanker Berth at warf or jetty handling ships of 1,00,000 tonnes dead wt. and larger	2 X 6000 lpm Tower Foam Monitors + 2 X 2400 lpm base Foam Monitors	30240 lit

3.5) HALON PROTECTION SYSTEM

General

Halon is a liquefied gas extraordinarily effective as fire extinguishing agent.
The system broadly consists of Halon container, feed lines, Halon ring mains/laterals as required spray nozzles, signaling equipment and cables, heat detection and activation devices. This system can detect, control and extinguish the fire and also simultaneously give audio visual indication to the control panel.

Recommended Use

This system is recommended for protection of:

- Control Rooms

- Computer Rooms

Halon Quantity and Storage

Each hazard area to be protected by halon system shall have independent halon protection system. The time needed to obtain Halon for replacement to restore the systems shall be considered as a governing factor in determining the reserve supply needed. 100% 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.

Control Room and Computer Room Protection

Halon 1301 is recommended for protection of control rooms and computer room. Capacity of Halon 1301 shall be based on minimum concentration of 5% halon of enclosed volume. 10% extra concentration should be used for leakage. It is advisable that persons should be evacuated from the area after the halon system comes into operation.

3.5.a) DCP PROTECTION SYSTEM

Dry Chemical Power (DCP) is discharged from a fixed system or a portable extinguisher as a free flowing cloud. (It is most effective in dealing initially with a fire resulting from an oil spill on a jetty or on the deck of a tanker but can also be used in confined spaces. It is especially useful for burning liquids escaping from leaking pipelines and joints. It is a non-conductor and suitable agent for dealing with electrical fires).

DCP has negligible cooling effect and gives no protection against re-ignition. DCP of foam compatible type should be used in conjunction with foam.

DCP application rates for fixed systems shall be decided based on risk involved. These are usually based on 1 to 2 minutes discharge & used in short spells of 10, 20 or 40 seconds with DCP release of 25 kg to 50 kg/second.

Requirements for portable and wheeled Fire extinguishers for marine terminals is given in table-3 and Table 4.

3.6) FIRST AID FIRE FIGHTING EQUIPMENT

Portable Fire extinguishers

Portable extinguishers shall be located at convenient locations and shall at all times be readily accessible and clearly visible. The maximum running distance to locate an extinguisher shall not exceed 15 meters. Following types of portable fire fighting equipment should be made available at the jetty area.

- DCP
- Carbon dioxide
- Foam Based

3.7) MOBILE FIRE FIGHTING EQUIPMENT.

Land Based

Mobile fire fighting equipments include foam 'tenders', water tender, DCP tenders etc. The requirement of such equipments may be reviewed keeping in view the size, nature and location of OIL Jetty. The equipments available at nearby installations and their availability in case of need shall be taken into consideration for deciding the type & no. of mobile fire fighting equipment.

Water Borne

Water borne fire fighting equipment in the form of fire floats or fire tugs can be highly effective for fire fighting at a terminal. Such a capability is normally best provided by working tugs or fire floats fitted with fire fighting equipment.

A minimum of two fire floats per prot and a minimum of one at each geographical jetty area shall be provided and placed in such a way that it should be able to reach the scene of the fire in ten minutes.

REQUIREMENT FOR PORTABLE AND WHEELED FIRE EXTINGUISHER FOR TERMINALS HANDLING CRUDE OIL & PETROLEUM PRODUCTS

SL.NO	INSTALLATION	REQUIREMENT OF FIRE EXTINGUISHER
1	Barge berth at a wharf or Jetty.	2 X 10 Kg. DCP
2	Barge berth at a wharf or Jetty handling ships or less than 20,000 tonnes capacity	2 X 50 kg wheeled DCP 2 X 10 kg DCP
3	Tanker berth at a wharf or Jetty handling ships of 20,000 tonnes and above but less than 50,000 tonnes capacity.	4 X 10 kg DCP 2 X 75 kg wheeled DCP
4	Tanker berth at a wharf or Jetty handling ships of 50,000 tonnes upto less than 100000 Tonnes capacity.	6 X 10 kg. DCP 4 X 75 wheeled DCP
5	Tanker berth at a wharf or jetty handling ships of 100000 Tonnes and larger	6 X 10 kg. DCP 4 X 75 wheeled DCP

REQUIREMENT FOR PORTABLE AND WHEELED FIRE EXTINGUISHER FOR PORT TERMINALS HANDLING LIQUEFIED PETROLEUM GAS

Sl.NO	INSTALLATION	REQUIREMENT
01	Tanker berth at a wharf or Jetty handling ships less than 10,000 tonnes deadweight.	4 X10 kg DCP 4 X 75 kg wheeled DCP
02	Tanker berth at a wharf or Jetty handling ships of 10,000 tonnes to 20000 Tonnes capacity	6 X 10 kg DCP Extinguishers 8 X 75 kg wheeled DCP Extinguishers.

FIRE PROTECTION AT PORT TERMINAL.

A typical example illustrating requirements of :

- Fire Water system.
- Foam feed system
- Safety equipments.
- First aid equipments
- Mobile equipments.

On large size Port Terminal is given at Annexure-III

SAFETY EQUIPMENTS IN FIRE STATION

The following Safety equipments shall be provided in Fire Station:

- Fire Safety Suits - 2 Nos.
- Fire Proximity Suits - 10 Nos.
- Breathing Apparatus - 4 Nos.

FIRE ALARM SYSTEM/COMMUNICATION

FIRE ALARM SYSTEM

Electrical/hand operated fire siren shall be installed at suitable location in all ports. The operating switch buttons shall be located near the Risk Area at a safe identifiable and accessible locations.

COMMUNICATION SYSTEM

Adequate and intrinsically safe communication system like telephone/PA/Paging/Walkie-talkie system should be provided.

GAS DETECTION SYSTEM

Gas detectors shall be provided along LPG jetty at locations where there is change of gas leakage. These areas are mainly loading arms/Manifold area etc.

FIRE PROTECTION SYSTEM, INSPECTION AND TESTING

The fire protection equipment should be kept in good operating conditions all the time and the fire fighting system should be periodically tested for proper functioning and logged for record and corrective actions. Inspection of fire fighting equipments should be done in accordance with OISD-Standard-142 on Inspection of Fire Fighting Equipment. In addition to routine daily checks/ maintenance, the following period inspection/testing shall be ensured:

FIRE WATER PUMPS

i) Every pump should be in test run for at least half an hour minimum two times a week.

ii) Once a month each pump should be checked and tested and the shut off pressure observed and logged.

iii) Once in six months each pump should be checked for performance. This may be done by opening required number of hydrants/monitors depending on the capacity of the pump and by verifying that the discharge pressure and the motor load are in conformance with the design parameters.

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, 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 a month.

FIRE WATER SPRAY SYSTEM

Fixed Water cooling spray systems or nozzles should be tested at least once a month.

TOWER MONITOR FOAM SYSTEM

Tower Monitor foam system should be tested once in 3 months. This shall include the testing of all foam making equipment.

After testing foam system, piping should be flushed with water.

HALON SYSTEM

Halon system should be visually checked once a week. Smoke detectors should be cleaned once in three months.

HOSES

Fire hoses shall be tested once in 6 months to a minimum water pressure of 7 kg/cm2g.

FIRST AID FIRE FIGHTING EQUIPMENT

The first aid Fire Fighting Equipments shall be provided at Port terminal as per scale given below:

Sl.NO.	Description	Norms/criteria to determine the quantity needed
01	Dry Chemical powder fire extinguishers10 kg capacity	Locate in Hydrocarbon pump area, LPG/OIL manifold area, loading areas, substations, workshops, laboratory, power station buildings etc. The number to be determined based on the travelling distance of 15m in above areas (at least one fire extinguisher for every 250 m2 area)
02	Dry Chemical Powder fire extinguishers. 50/75 kg capacity	Loading arms areas. The number to be determined/based on the max. travelling distance of 50m in above areas (at least one fire extinguisher for every 750 m2 area).
03	CO2 extinguishers of 4.5 kg capacity or 6.8 kg on wheels.	Sub stations and power stations. The number to be determined based the max. travelling distance of 15M (at least one fire extinguisher for every 250 m2 area).
04	Portable Halon extinguisher of 5 kg	For use in control room, computer room, laboratories and office buildings.(At least one extinguisher for every 250 sq.mt area).

4. Existing Fire Protection \ Fighting Equipments Available At VOTL

FIRE HYDRANTS

HYDRANTS	LOCATION
D.H. – 01	Near Sea Intake Pump
D.H. – 02	Near Diesel Storage Tank
D.H. – 03	Near Diesel Storage Tank
D.H. – 04	East side MTCB
D.H. – 05	East side MTCB
D.H. – 06	Pig Area South
D.H. – 07	Pig Area South
D.H. – 08	Foam Tank
D.H. – 09	Foam Tank
D.H. – 10	Pig Area Slope Tank
D.H. – 11	Pig Area Slope Tank
D.H. – 12	North Pig Area
D.H. – 13	Cross Country Line
D.H. – 14	Cross Country Line
D.H. – 15	Cross Country Line
D.H. – 16	Cross Country Line
D.H. – 17	North Pig Area
D.H. – 18	Pressure Surge Valve 32" line
D.H. – 19	P.S.V 32" line
D.H. – 20	Jetty- Sampling Area-
D.H. – 21	North Breast Dolphin
D.H. – 22	Loading Arm Area
D.H. – 23	South Breast Dolphin

MONITORS

TYPE OF MONITORS	LOCATION	Operation Auto / Manually
Tower Monitor -01	Jetty- North	Auto & Man.
Tower Monitor -02	Jetty – South	Auto & Man.
Fixed Water Monitor-01	Loading Arm	Manually
Fixed Water Monitor-02	North Pig Area	Manually
Portable Monitor	Loading arm	Manually

FIRE EXTINGUISHERS

TYPE OF EXTINGUISHER	LOCATION
DCP 75KG - 01	Loading Arm
DCP 75 KG – 02	Loading Arm
DCP 25 KG-01	Sea Water Intake Pump
DCP 25 KG -02	Near Diesel Storage Tank
DCP 25 KG -03	Jetty - Loading Arm
DCP 25 KG - 04	Jetty – Loading Arm
DCP 10 KG -01	Inside Sea Water intake
DCP 10 KG -02	Inside Sea Water Intake
DCP 10 KG -03	---
DCP 10 KG -04	---
DCP 10 KG -05	Near SIP Store House
DCP 10 KG -06	Near Transformer SB-71

DCP 10 KG -07	Inside SB-71
DCP 10 KG -08	Instrumentation room MTCB
DCP 10 KG -09	MTCB Ground Floor
DCP 10 KG -10	Near Density. Mtr. Cross C. L.
DCP 10 KG -11	MTCB Top Floor
DCP 10 KG -12	Near Big Slope Tank
DCP 10 KG -13	--
DCP 10 KG -14	Near Pig Receiver Line -2
DCP 10 KG -15	Near Pig Receiver Line -2
DCP 10 KG -16	Near Pig Receiver Line -1
DCP 10 KG -17	Near Pig Receiver Line -1
DCP 10 KG -18	Pig Area Plat Farm
DCP 10 KG -19	Pig Area Plat Farm
DCP 10 KG -20	Pig Area Plat Farm
DCP 10 KG -21	Sampling Area Jetty
DCP 10 KG -22	Sampling Area Jetty
DCP 10 KG -23	Near Pig Receiver Line -2
CO2 6.8KG -01	Inside SB- 71
CO2 6.8KG -02	Inside SB- 71
CO2 6.8KG -03	-----
CO2 6.8KG -04	Control Room MTCB

FIRE WATER PUMP AT SEA WATER INTAKE WELL -

TYPE OF PUMP	Discharge Capacity	Operation Auto/ Man.
Jockey -01 – T. M.	33 M^3 /Hr.	Auto & Man.
Jockey -02 – T. M.	33 M^3 /Hr.	Auto & Man.
Jockey -03 – Hyd.	33 M^3 /Hr.	Auto & Man.
Jockey -04 – Hyd .	33 M^3 /Hr.	Auto & Man.
Electric -01 –T. M.	792 M^3 /Hr.	Auto & Man.
Electric- 02 – Hyd	792 M^3 /Hr	Auto & Man.
Diesel -01 – T. M.	822 M^3 /Hr	Auto & Man.
Diesel -02 – Hyd .	822 M^3 /Hr	Auto & Man.

M.C.P. (Manual Call Point)

Sr. No. Of MCP	LOCATION
MCP-01	Near North Tower monitor
MCP-02	Near Slope Tank Jetty
MCP-03	----
MCP-04	Near Loading arm -02
MCP-05	Near Loading arm -04
MCP-06	Near Loading arm- 06
MCP-07	----
MCP-08	Near Control Panel
MCP-09	---
MCP-10	Near Tower mon. South
MCP-11	Near Slope tank – jetty
MCP-12	----
MCP-13	Near Surge Tank

MCP-14	Sampling area – jetty
MCP-15	Near Tower mon. south
MCP-16	---
MCP-17	--
MCP-18	Near electric room jetty
MCP-19	On way road to jetty
MCP-20	On way road to jetty
MCP-21	On way road to jetty
MCP-22	On way road to jetty
MCP-23	On way road to jetty
MCP-24	Cross Country Line
MCP-25	Cross Country Line
MCP-26	Cross Country Line
MCP-27	Entrance G- floor MTCB
MCP-28	Entrance 1st -floor MTCB
MCP-29	Entrance 2nd Floor MTCB
MCP-30	East MTCB G-floor
MCP-31	East MTCB G-floor
MCP-32	North MTCB G-floor
MCP-33	North Pig area
MCP-34	North Pig area plat farm
MCP-35	Pig Receiver Area L-2
MCP-36	Big Slope Tank
MCP-37	Near Foam Tank Tank
MCP-38	South pig area plat farm
MCP-39	South pig area
MCP-40	---
MCP-41	---
MCP-42	---

MCP-43	----
MCP-44	Near Security Gate
MCP-45	On the way road to jetty
MCP-46	On the way road to jetty
MCP-47	On the way road to MTCB
MCP-48	On the way road to MTCB
MCP-49	On the way road to MTCB
MCP-50	On the way road to MTCB
MCP-51	On the way road to MTCB
MCP-52	On the way road to MTCB
MCP-53	On the way road to MTCB
MCP-54	East Side SB-71
MCP-55	West Side SB-71
MCP-56	Near Diesel Storage Tank
MCP-57	Near SB-71 Transformer
MCP-58	Near Sub Station-71 South
MCP-59	On Way to sea intake pump
MCP-60	On Way to sea intake pump
MCP-61	On Way to sea intake pump
MCP-62	On Way to sea intake pump
MCP-63	----
MCP-64	West Store House
MCP-65	East side of Store House
MCP-66	-----
MCP-67	Entrance Sea Water Pump
MCP-68	East Sea Intake pump
MCP-69	Behind Sea Intake Pump
MCP-70	Inside Sea intake pump

LIFE BOUYA RING

TYPE OF LIFE SAVING EQPT.	LOCATION
Life Buoy Ring -01	South Mooring Dolphin
Life Buoy Ring -02	South Breast Dolphin
Life Buoy Ring -03	Near North Tower Monitor
Life Buoy Ring -04	Near North High Mast
Life Buoy Ring -05	North Mooring Dolphin
Life Buoy Ring -06	Gangway –North B.D.

5. Total Flooding System

For over 25 years, Halon 1301 has been the most commonly chosen gaseous agent for use in 'Total flooding' fire protection system, notably for the protection of electronic data processing equipment such as computer rooms, telephone switch rooms etc. Halon 1301 has been considered particularly suitable where it has been necessary to protect area occupied by the people.

The main reason for the wide use of Halon 1301in fire protection can be summarized as follows:

- High efficiency fire extinguishing capability.
- It disperse to achieve a uniform concentration in an enclosure.
- Low levels of residue generation resulting in little or no damage to electronic equipment.
- Electrically non conducive

In the late 1980's it became evident that Halon 1301 was one of the key chemicals contributing to the breakdown of the earth's ozone layer.

Halon 1301 was being released into the atmosphere as a result of:

- Activations due to fire.
- Discharge test during commissioning.
- Spurious system discharges.
- General leakage during manufacture and container filling.

Although Halon 1301 is produced in much smaller quantities than the chloroform carbon's (CFC'S) which are right to be the major contributors to ozone depletion the ozone depleting potential of Halon 1301 is 12-16 times greater for a given volume.

It therefore becomes desirable to find gaseous extinguishing agent with similar fire protection capabilities top that of Halon 1301 without the disadvantage of ozone depletion.

The cessation of production of Halon 1301 from Jan 1st 1994 was result of an agreement between the participants of the Montreal protocol signed by the government of India. But the use of Halon 1301 has not been banned till the existing stocks are used up. The alternative agents for Halon 1301 fall into 2 categories 'the inert gas' and the halocarbon agents.

Inert gas agent:

An agent that contains as primary component are or more of the gases helium, neon, agon or nitrogen. Inert gas agents that are blends of gases can also contain carbon dioxide as secondary component.

Halocarbon agent:

An agent that contains as primary component one or more organic compounds containing one or more of the elements fluorine, chlorine, bromine or iodine.

Halocarbon clean agents extinguish fires by a combination of chemical and physical mechanism depending upon the compound. The halocarbon species scavenge the flame radicals , thereby interrupting the chemical chain reaction.

About 15 gaseous alternatives to Halon have been proposed in the last 3 years. These are Fm 200, FE –13, CE4 – etc … FM 200 has been installed at served places in the world including India these have the characteristics as below:

- Zero ozone depletion potential
- Electrically non conductive.
- Liquefied gases.
- Clear agents readily vaporize, leaving no residence
- Protection system hardware is similar to Halon 1301.
- More expensive than Halon 1301 in comparison.

FM –200 is the trade name. The chemical name is Heptafluropropane (3 F7H). And the designation given is HFC –227ea.

Another agent by the brand name NAF S 111 is also used in place of Halon 1301 which is a HCFC blend A and this has small ozone depletion potential. NAF SIII is now widely used and preferred over FM 200 as a total flooding Agent.

Agents Addressed in NFPA 2001

FC-2-1-8	Perfluoropropane	C3F8
FC-3-1-10	Perfluorobutane	C4F10
HCFC Blend A	Dichlorotrifluoroethane HCFC-123 (4.75%) Chlorodifluoromethane HCFC-22 (82%) Chlorotetrafluoroethane HCFC-124 (9.5%) Isopropenyl-1- methylcyclohexene (3.75%)	CHCl2CF3 CHClF2 CHClFCF3
HCFC-124	Chlorotetrafluoroethane	CHClFCF3
HFC-125	Pentafluoroethane	CHF2CF3
HFC-227ea	Heptafluoropropane	CF3CHFCF3
HFC-23	Trifluoromethane	CHF3
HFC-236fa	Hexafluoropropane	CF3CH2CF3
FIC-13I1	Trifluoroiodide	CF3I
IG-01	Argon	Ar
IG-541	Nitrogen (52%) Argon (40%) Carbon dioxide (8%)	N2 Ar CO2
IG-55	Nitrogen (50%) Argon (50%)	N2 Ar

5.1) FM-200

1,1,1,2,3,3,3-Heptafluoropropane, also called heptafluoropropane, HFC-227 or HFC-227ea (ISO name), is a colourless odourless gaseous halocarbon. It is commonly used as a gaseous fire suppression agent

Its chemical formula is CF_3-CHF-CF_3, or C_3HF_7. With a boiling point of -16.4 °C, it is a gas at room temperature. It is slightly soluble in water (260 mg/L).

HFC-227ea finds use in fire suppression systems in data processing and telecommunication facilities, and in protection of many flammable liquids and gases. Effective fire suppression requires introducing 7% concentration of the HFC-227ea agent. Its NOAEL level for cardiac sensitization is 9%. EPA allows concentration of 9 volume % in occupied spaces without mandated egress time, or up to 10.5% for a limited time. Most fire suppression systems are designed to provide concentration of 7-11%.

The HFC-227 fire suppression agent was the first environmentally acceptable replacement for Halon 1301. In addition, HFC-227 leaves no residue on valuable equipment after discharge.

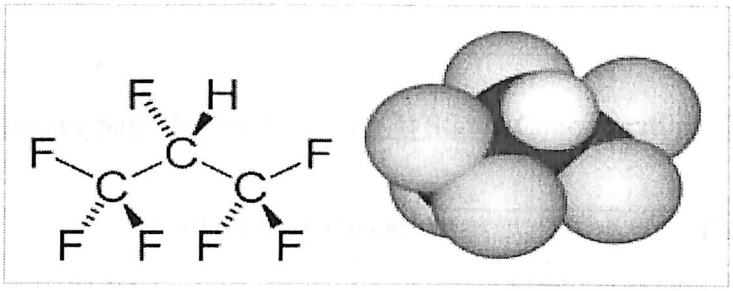
HFC-227ea contains no chlorine or bromine atoms, presenting no ozone depletion effect. It is therefore an environment-friendly replacement for Halon 1301 and Halon 1211 based systems. Its atmospheric lifetime is approximated between 31 and 42 years. It leaves no residue or oily deposits and can be removed by ventilation.

As an aerosol propellant, HFC-227ea is used in pharmaceutical metered dose inhalers such as those used for dispensing asthma medication.

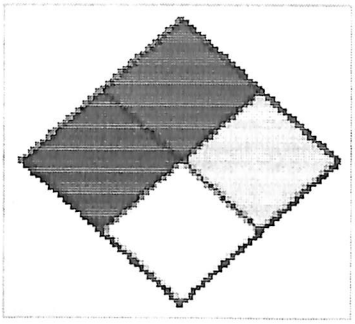
FM-200 (HFC-227) can be used in occupied and unoccupied areas and has the lowest global warming potential and zero ozone depleting potential. FM 200 is the most commercially available agent. The cylinders must be located in, or adjacent to a protected area and the design concentration in occupied areas must be limited to 7% to

9%. This alternative cannot be piped over long distances, and its low boiling point means the agent must be stored in a controlled environment.

,3,3-Heptafluoropropane



Chemical name	1,1,1,2,3,3,3-Heptafluoropropane
Other names	Heptafluoropropane Apaflurane HFC-227ea R-227ea HFC-227
Chemical formula	C_3HF_7
Molecular mass	170.03 g/mol
CAS number	[431-89-0]
Density	1.46 g/cm^3 at -16 °C
Melting point	-131 °C
Boiling point	-16.4 °C
SMILES	FC(C(F)(F)F)C(F)(F)F

NFPA 704	

Time for Safe Human Exposure at Stated Concentrations for HFC-227ea

H-FC227ea Concentration		Human Exposure Time
% v/v	ppm	(minutes)
9.0	90,000	5.00
9.5	95,000	5.00
10.0	100,000	5.00
10.5	105,000	5.00
11.5	110,000	1.13
11.5	115,000	0.60
12.0	120,000	0.49

5.2) INERGEN

Inergen is a blend of inert atmospheric gasses that contains 52% nitrogen, 40% argon, and 8% carbon dioxide. It is considered a clean agent for use in gaseous fire suppression applications. Inergen does not contain halocarbons, and has no ozone depletion potential. It is non-toxic. Inergen is used at design concentrations of 40-50% to lower the concentration of oxygen to a point that cannot support combustion.

The most significant component of Inergen is carbon dioxide, which allows the human body to adapt to the environment of reduced oxygen that is present after discharge of the agent. Discharge of Inergen results in an approximate 3% concentration of carbon dioxide within the space. This is similar to the buildup of carbon dioxide that occurs

within the lungs during prolonged exercise. This directs the human body to take deeper breaths and to make more efficient use of the available oxygen.

Unnecessary exposure to inert gas agent systems resulting in low oxygen atmospheres shall be avoided. The requirement for pre-discharge alarms and time delays is intended to prevent human exposure to agents. The following additional provisions shall apply in order to account for failure of these safeguards:

(a) Inert gas systems designed to concentrations below 43 percent (corresponding to an oxygen concentration of 12 percent, sea level equivalent of oxygen) shall be permitted, given the following:

(1) The space is normally occupied.

(2) Means are provided to limit exposure to no longer than 5 minutes.

(b) Inert gas systems designed to concentrations between 43 and 52 percent (corresponding to between 12 and 10 percent oxygen, sea level equivalent of oxygen) shall be permitted, given the following:

(1) The space is normally occupied.

(2) Means are provided to limit exposure to no longer than 3 minutes.

(c) Inert gas systems designed to concentrations between 52 and 62 (corresponding to between 10 and 8 percent oxygen, sea level equivalent of oxygen) shall be permitted given the following:

(1) The space is normally unoccupied.

(2) Where personnel could possibly be exposed, means are provided to limit the exposure to less than 30 seconds.

(d) Inert gas systems designed to concentrations above 62 percent (corresponding to 8 percent oxygen or below, sea level equivalent of oxygen), shall only be used in unoccupied areas where personnel are not exposed to such oxygen depletion.

The nitrogen and argon components are used to offset the weight of the carbon dioxide, which allows the Inergen blend to have the same density as normal atmosphere. This is done in order to prevent special considerations from needing to be taken in order to prevent agent leakage.

Advantages:

Inergen does not contain halocarbons. It has no ozone depletion potential and unlike halocarbon agents, does not chemically react with the fire to create acid byproducts.
Inergen is safer to use than carbon dioxide in applications where evacuation may not be possible prior to discharge of the agent. Inergen is designed to be breathable after discharge. Pure carbon dioxide is not.
Inergen is non-toxic, and does not create the same health risks as the use of halocarbon agents. In certain concentrations, halocarbon agents can cause heart palpitations.
Inergen has the same density as normal atmosphere. No special considerations are needed in order to prevent agent leakage.

Disadvantages:

Inergen requires more space for storage tanks. Unlike carbon dioxide or halocarbon agents, Inergen agent does not liquify under pressure.
Inergen requires that 40-50% of the room atmosphere be replaced with Inergen in a short amount of time. This creates a large amount of pressure, which must be relieved in order to prevent damage to the enclosure.

5.3) NAFS 111

NAFS 111 is a blend of hydro chlorofluro-carbons (HCFC's) and a detoxifying agent named NAFXX.

The composition of NAFS111 is

- HCFC 123 Dichlorotrifluro ethane 4.75%.
- HCFC 22 Chlorodifluromethane 82.00%.
- HCFC 124 Chlorotetrafluro ethane 9.50%
- Iso propenyl -1- methyl cyclohenane 3.75%.

Physical properties of HCFC Blend

Ozone Depletion Potential	-	0.036
Global Warming Potential	-	1444
Atmospheric life time	-	12 years
Molecular weight	-	92.90
Boiling point at 760 mm Hg	-	(-38.3^{0}C)
Critical temperature	-	124.4^{0}C
Critical density	-	577 kg/m^3
Viscosity, liquid at 25^{0}C	-	0.21 centi poise
Solubility of water in agent At 21^0 C	-	0.12% by weight
Specific heat, liquid at 25^{0}C	-	1.256
Heat of Vaporization at boiling point	-	225.6

Halogenated Agent Quality Requirements

Property	Specification
Agent purity, mole %, minimum	99
Acidity, ppm (by weight HCl equivalent), maximum	3
Water content, % by weight, maximum	0.001
Nonvolatile residues, grams/ 100 mL maximum	0.05

TOXICITY INFORMATION FOR HALOCARBON CLEAN AGENT

AGENT	LC 50 or ALc	NOAEL	LOAEL
FC-3-1-10	> 80%	40%	>40%
HCFC Blend A	645	1005	>100%
HCFC – 124	23-295	1.0%	2.5%
HFC-227 ea	>80%	9%	10.5%
HFC –23	> 65%	50%	>50%
HCFC –236 fa	>18.9%	10%	15%
Halon 1301	>80%	5%	7.5%

LC 50 : Lethal Concentration 50 (LC-50) is the concentration lethal to 50% of a rat population during a 4-hour exposure. The ALC is the approximate lethal concentration.

NOAEL –No observed adverse effects level:

The highest concentration if which no as adverse toxicological or physiological effect has been observed.

LOAEL: Lowest observation Adverse Effect Level:

The lowest concentration at which an adverse physiological or toxicological effect has been observed.

Critical Parameters

AGENT	NAFS III	FM 200	Halon 1301
Ozone Depleting Potential (ODP)	0.036	0	16-20
Global Warming Potential	1444	3300	5600
Atmospheric life time (ALT)	12 years	42 years	65 years

Protection Per 1000 m^3

AGENT	HALON 1301	Inergen	FM 200	NAFS III
No.of Cylinders	5	51	9	5
Quantity of extinguishments (Kg)	331	501	681	363

NAF SIII has a very negligible ODP of 0.036 the maximum allowed by US EPA is 2, comparatively law GWP (1444) and a very low atmospheric lifetime 12 years. But FM-200 is having zero ozone depleting potential and having a Global warming Potential (GWP) of 3300, which is very low when compared with halon.

FM-200 acts as a fire –extinguishing agent by breaking the free radical chain reaction which occurs in the flame during combustion and pyrolysis. Due to its low toxicity level FM-200 is suitable for protection if normally occupied areas.

FM-200 is listed as an acceptable alternative to Halon 1301 in the U.S Environmental Protection agencies (EPA) Significant New Alternative Policy (SNAP) list. Moreover FM-200 based total flooding system is cheaper than other halon alternative.

6. Design of Total Flooding System using FM-200

- Study of the site and architectural drawings
- To get correct data before designing.
- Determine design concentration
- Based on type of risk fuel and ambient temperature within the hazard.
- Calculation of precise volume of hazard
- To establish correct quantity of agent required.
- Provide for leakage factor.-To make provision for possible leakage from the hazard after discharge.
- Arrive at total quantity of FM-200 required in kg.
- Weight equivalent for design concentration and leakage factor.
- Prepare piping isometry drawing as per the design requirements and site conditions.
- Determine fill density.
- Determine diameter for each pipe section .
- Determine nozzle orifice diameter. .
- Select container size based on full density
- Integrate with fire detection system for automatic actuation and manual controls.
- Ensure installation of piping as per approved design.
- Pressure testing and purging of the pipe network can be done with dry nitrogen or compressed air.
- Ensure proper mechanical support for the system.
- Design concentrations as determined by tests-Extinguishing concentrations 7.2% for both class A and B fires 8.6% is required at 20^0C

The design concentration for any hazard is based on the fuel/type of risk being protected.

Class A risks

The design concentration for such risks shall be extinguishing concentration determined by test conducted during listing programme plus a 20 % safety factory. The extinguishing concentration is 7.2% determined from test. Adding 20% safety factor we get a design concentration of 8.6%.

Class B risks

The design concentration for such risks shall be the extinguishing concentration for the respective class B fuel as determined by the cup burner test plus a 20% safety factor. Here also the extinguishing concentration determined from the test is 72%. Adding a 20% safety factor we get the design concentration as 8.6%.

Class C risk:

There is no separate design concentration criteria for class C fires as all class C fires are either class A or class B in the presence of energized electrical equipment. All clean agents listed in the NFPA 2001 are electrically non-conducting agents and therefore suitable for class C application.

Total Flooding Quantity

The amount of halocarbon agent required to achieve the design concentration shall be calculated for the following formula:

$$W = \frac{V}{S}\left[\frac{C}{100-C}\right]$$

Where

W = weight of clean agent (kg)

V= Net volume of hazard, calculated as the gross volume minus the volume of fixed structures impervious to clean agent vapour (m^3).

S = Specific volume of separated agent vapour at 1 atmosphere and the temperature, t. (m^3/kg)

C = Agent design concentration (Volume%)

t = minimum anticipated temperature of the protected volume (^{0}C).

This calculation includes an allowance for the normal leakage from a "tight" enclosure due to agent expansion.

Design Factor

In addition to the concentration requirements, additional quantities are required through the use of design factors to compensate for any special conditions that would affect the extinguishing efficiency.

Tee Design Factor:

Where a single agent is used to protect multiple hazards, a design factor from the following table can be used: The design factors based on the number of tee's in pipeline.

The hazard with the greatest design factor tee count shall be used to determine the design factor.

Exeption: For system that pass a discharge test, this design factor does not need to apply.

Design Factor Tee count	Halocarbon design factor
0-4	0.00
5	0.01
6	0.02
7	0.03
8	0.04
9	0.05
10	0.06
11	0.07
12	0.07
13	0.08
14	0.09
15	0.09

16	0.10
17	0.11
18	0.11
19	0.12

Duration of Protection:

It is important that the agent design concentration not only shall be achieved, but also be maintained for the specified of time to allow effective emergency action by trained personal.

For halocarbon agents, the discharge time required to achieve 95% of the minimum design concentration for flame extinguishments based on a 20 percent safety factor shall not exceed 10 seconds,

The discharge time period is defined as the time required to discharge, 95% of the agent mass at 21^0 C, necessary to achieve the minimum design concentration based on a 20 percent safety factor for flame extinguishments.

The detail on the system shall include information and calculations on the amount of agent; container storage pressure; internal volume of the container; the location, type, and flow rate of each nozzle including equivalent orifice area; the location, size, and equivalent lengths of pipe, fittings, and hose; and the location and size of the storage facility. Pipe size reduction and orientation of tees shall be clearly indicated. Information shall be submitted pertaining to the location and function of the detection devices, operating devices, auxiliary equipment, and electrical circuitry, if used. Apparatus and devices used shall be identified.

Any special features shall be adequately explained. n the design of a total flooding system, the characteristics of the protected enclosure shall be considered.

The area of unclosable openings in the protected enclosure shall be kept to a minimum. To prevent loss of agent through openings to adjacent hazards or work areas, openings shall be permanently sealed or equipped with automatic closures. Where reasonable

confinement of agent is not practicable, protection shall be expanded to include the adjacent connected hazards or work areas or additional agent shall be introduced into the protected enclosure using an extended discharge configuration.

Forced-air ventilating systems shall be shut down or closed automatically where their continued operation would adversely affect the performance of the fire extinguishing system or result in propagation of the fire. Completely self-contained recirculating ventilation systems shall not be required to be shut down. The volume of the ventilation system and associated ductwork shall be considered as part of the total hazard volume when determining the quantity of agent. The protected enclosure shall have the structural strength and integrity necessary to contain the agent discharge. If the developed pressures present a threat to the structural strength of the enclosure, venting shall be provided to prevent excessive pressures.

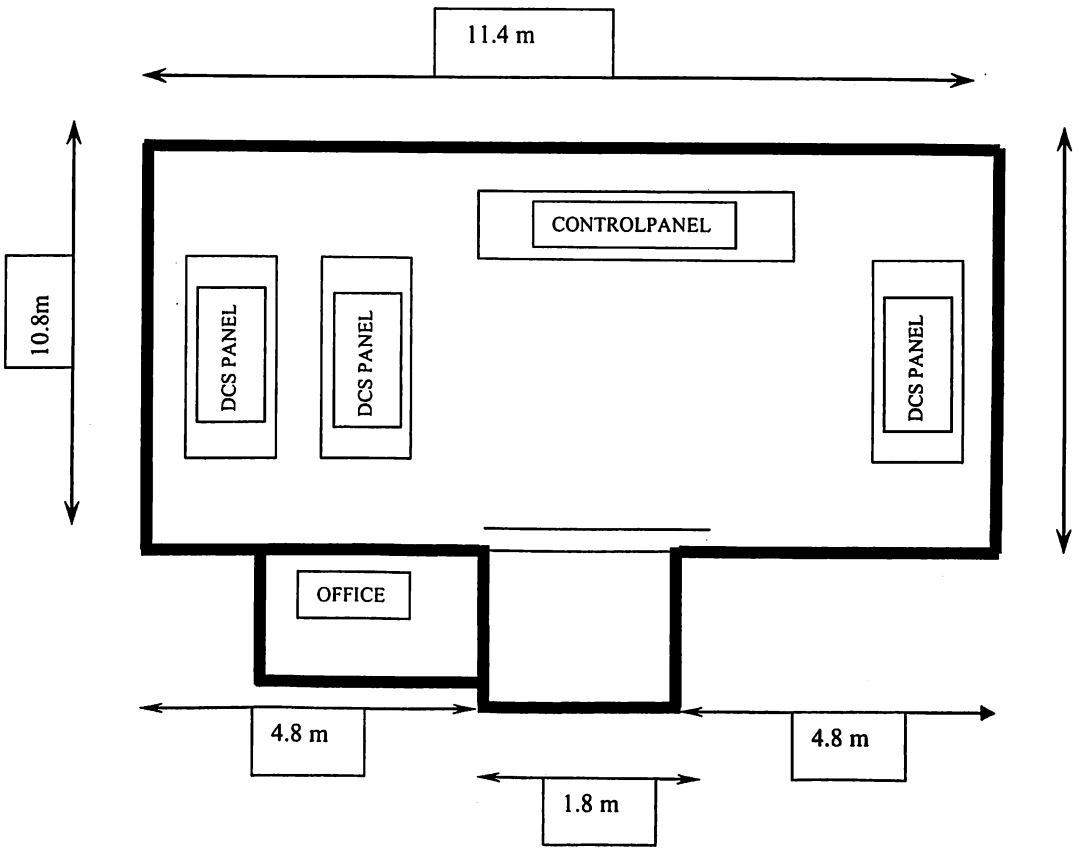
The flame extinguishing or inerting concentrations shall be used in determining the agent design concentration for a particular fuel. For combinations of fuels, the flame extinguishment or inerting value for the fuel requiring the greatest concentration shall be used unless tests are made on the actual mixture.

DESIGN OF TOTAL FLOODING SYSTEM FOR CONTROL ROOM AT VOTL USING FM-200

STEP 1

Study of the site and architectural drawings

The DCS panel and control panel room is located at the ground floor of marine terminal control building. As per OISD-156 the DCS panel room and control panel rooms shall be protected by total flooding system. DCS panel/control room is fully air conditioned and not having natural ventilation. Height of the control room is 6m but it is having false ceiling at an elevation of 4 m from the false floor. False floor is 1 m above the concrete floor.



STEP 2

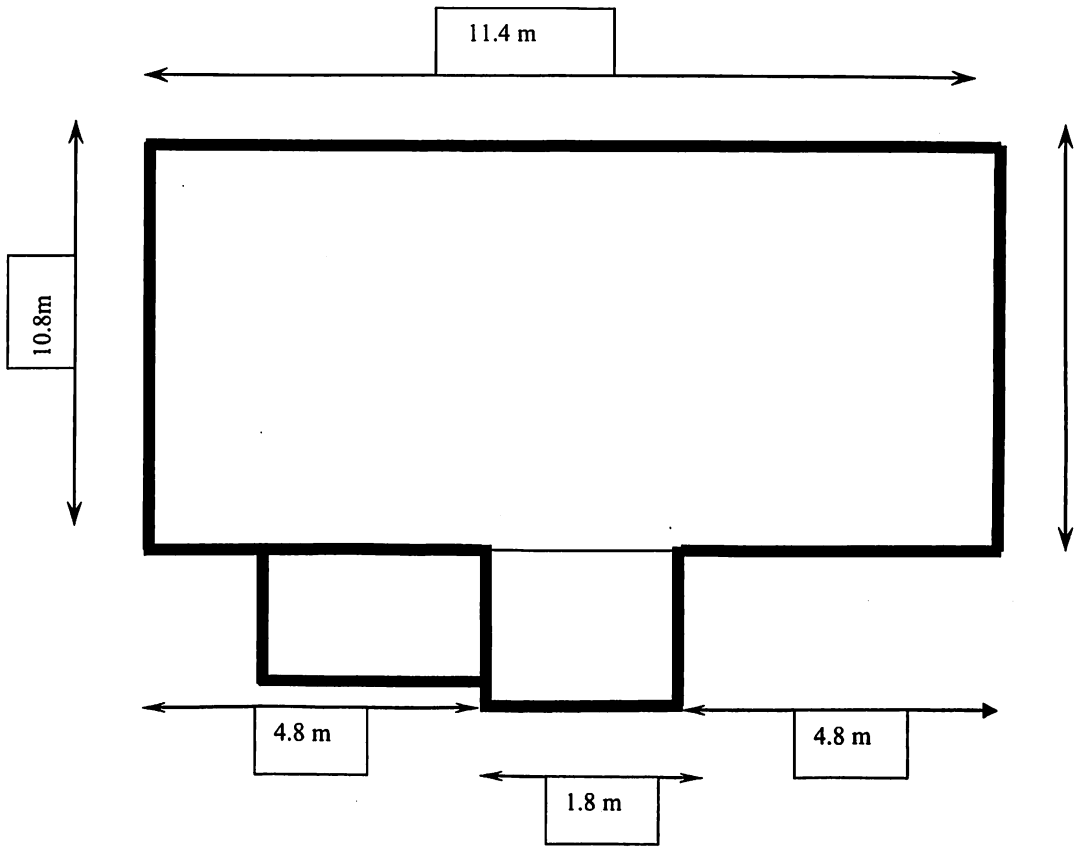
Determine design concentration

Design concentration of FM-200 in occupied areas must be limited to 7% to 9%. Since the control\panel room always have the operator and radio office inside, we can limit the design concentration to 8%

STEP 3

Calculation of precise volume of hazard

The dimensions of room is 11.4 X 10.8 X 6



STEP 4

To establish correct quantity of agent required

Total volume to be protected = 11.4m X 10.8m X 6m

= 738.72 m3

Design concentration of FM-200 = 8%

The amount of halocarbon agent required to achieve the design concentration shall be calculated for the following formula:

$$W = \frac{V}{S}\left[\frac{C}{100-C}\right]$$

Where

W = weight of clean agent (kg)

V= Net volume of hazard, calculated as the gross volume minus the volume of fixed structures impervious to clean agent vapour (m^3).

S = Specific volume of separated agent vapour at 1 atmosphere and the temperature, t. (m^3/kg)

C = Agent design concentration (Volume%)

t = minimum anticipated temperature of the protected volume (^{0}C).

$$\text{Amount of FM-200 required W (kg)} = \frac{738.72}{0.1378} X \left[\frac{8.00}{100-8}\right]$$

Specific volume of FM-200 at 21 C is 0.1378

$$W = 5360.8 \text{ X } \frac{8.00}{92} \text{ kg}$$

= 466 Kg of FM-200 is required for the protection of control room having a hazard volume of 738 meter cube.

W = 466 Kg (Quantity without considering leakage factor)

Step 5

Weight equivalent for design concentration and leakage factor.

Giving a 10% leakage factor, weight becomes

$$W = 466kg + 10\% \text{ of } 466kg$$
$$= 466\ kg + 46\ kg$$
$$W = 512\ kg$$

Step 6

Determine diameter for each pipe section

95% of 512 kg is to be discharged in 10 sec.

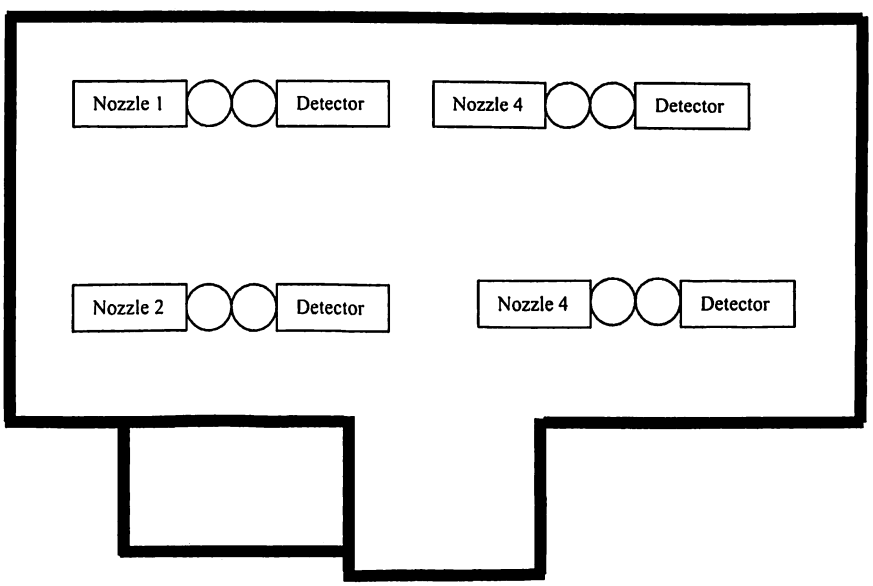
95% of 512 kg = 486.4 Kg.

Discharge rate of FM – 200 = 48 kg\ sec

Critical density of FM – 200 = 621 kg/m^3.

486.4 kg in 10 sec ie,486.4/621 = 0.7832m^3 in 10 sec.

Discharge of FM-200 per second Q = 0.07832 m^3 / sec



Pipe diameter at main manifold is taken as 2.5 inch

Diameter of main manifold pipeline = 62.5 mm

Area of pipe, A = (Π X 62.5 X 62.5)/ 4 mm^2

= 3066.4 mm^2

Area of cross section of manifold pipeline = 0.003066 m^2

Velocity of gas through main manifold pipeline = Q / A

Velocity of gas through pipe = 0.07832 / .003066

= 25.5 m/s.

Diameter of branch line are taken as 1.5 inch

Cross sectional area of 37.5mm pipe = $0.001115^6 m^2$

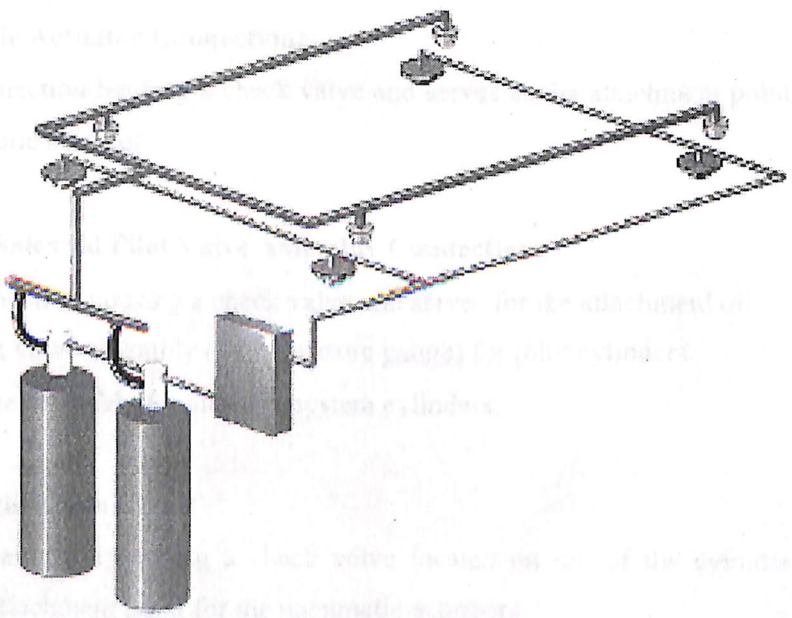
Quantity of FM-200 flowing through each branch line will be

= 0.01958 m^3 / s

Velocity of agent through the branch pipeline = 0.01958/ $0.0011115 m^2$

= 17.56 m / sec

Graphical representation of the pipe network



Components of the Total Flooding System

Cylinder:

The welded seam steel cylinders are manufactured to the requirements of the Department of Transportation (DOT) for compressed gas and have internal neck threads for cylinder valve connection.

Dip Tube:

A threaded dip tube extends from the cylinder valve down to within approximately 1½in. (38 mm) of the bottom of the cylinder.

Cylinder Valve:

A pressure differential type cylinder valve having a forged brass body is attached to the cylinder neck and serves to control the flow of FM-200 from the cylinder. The valve is secured to the cylinder by means of 4.5-12UN-2A screw threads and is sealed by a cylinder O-ring. A synthetic rubber seat is attached to a steel seat retainer, which is screwed into the bottom of the valve. The seat retainer also supports the dip tube.

The cylinder valve has five connections, as follows:

1. **Manual-Pneumatic Actuator Connection:**

This is a threaded connection housing a check valve and serves as the attachment point for the manual-pneumatic actuator.

2. **Pressure Gauge/ Solenoid Pilot Valve Assembly Connection:**

This is a threaded connection housing a check valve and serves for the attachment of:

- Solenoid pilot valve assembly (with pressure gauge) for pilot cylinders.
- Pressure gauge assembly for all other system cylinders.

3. **Pneumatic Actuator Connection:**

This is a threaded connection housing a check valve located on top of the cylinder valve. It serves as an attachment point for the pneumatic actuators.

4. Safety Disc Connection:

Two frangible safety discs are located on opposite sides and serve to protect the cylinder against excessive internal pressure. The discs are designed to burst in a range of 850 psi to 1000 psi (5860 kPa to 6895 Kpa).

5. Discharge Connection:

This connection (2 in. nominal pipe size) (50 mm) is in the form of an outlet fitting which threads into the valve body and is sealed with an O-ring. The exposed end is grooved for attachment of grooved fittings. The outlet fitting can be removed for replacement if necessary.

CONCLUSION

Essar Oil Limited is one among the leading refineries in India. Its refinery at Jamnagar is having a refining capacity of 10.5 MMTPA. By 2010, refining capacity of the refinery will be 30MMTPA. Thus Essar Oil Ltd plays an important role in the oil and gas sector of India.

This project has helped us to familiarize with the working culture existing in the organization and in the understanding the interaction between the organization critical processes.

In the given project period, a total flooding system was designed for the marine control room of Vadinar Oil Terminal Ltd. The design was carried out in several steps in a systematic manner in association with the personal from various departments of the organization. Also I got the opportunity to get familiarised with the existing fire fighting system at Vadinar Oil terminal Ltd.

I would once again like o thank Vadinar oil Terminar Ltd for its full-hearted support it has given me during my project period and I am truly grateful for the opportunity provide.

REFERENCES

1. Lees, Frank P. (1996).Loss Prevention in the Process Industries(2nd Ed.). Oxford: Butterworth- Heinemann.

2. Oil Industry Safety Directorate (OISD) Standard No: 156.Standard for the fire protection of jetty, terminal and port facilities.

3. Oil Industry Safety Directorate (OISD) Standard No: 116. Fire Protection facilities for Petroleum Refineries and Oil/Gas Processing Plants

4. NFPA: 2001. Standard for the use of Clean Agents