

TECHNICAL SPECIFICATION

ACTIVE FIRE PROTECTION SYSTEMS AND EQUIPMENT FOR ONSHORE FACILITIES

DEP 80.47.10.31-Gen.

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DESIGN AND ENGINEERING PRACTICE



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1. INTRODUCTION

1.1 SCOPE

This DEP specifies requirements and gives recommendations for active fire protection systems and equipment for onshore facilities.

For clarity, a distinction is made between the process of determining and selecting the most appropriate fire protection measure (case-by-case justification of fire safety provisions, including tolerability of risk level) and the hardware requirements (how each fire protection system shall be designed and engineered).

This DEP shall be used for the design and engineering of the fire protection systems once the most appropriate fire protection measures for optimising the fire safety of onshore plants have been decided by applying DEP 80.47.10.30-Gen.

Although primarily intended for new construction, this DEP can also be applied for existing plants when fire protection systems need upgrading. When modifications and extensions to existing plants are envisaged, fire protection aspects shall be considered and existing facilities improved where necessary.

In several places throughout this DEP, reference is made to the National Fire Code of the US National Fire Protection Association (NFPA). As documented within, compliance with the referenced standard is either required ("shall") or recommended ("should").

1.2 DISTRIBUTION, APPLICABILITY AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by SIOP and SIEP, the distribution of this document is confined to companies forming part of or managed by the Royal Dutch/Shell Group, and to Contractors nominated by them (i.e., the distribution code is "C", as defined in DEP 00.00.05.05-Gen.).

This DEP is intended for use in oil refineries, chemical plants, gas plants, supply/marketing installations and, where applicable, in onshore exploration and production facilities.

If national and/or local regulations exist in which some of the requirements may be more stringent than in this DEP, the Contractor shall determine by careful scrutiny which combination of requirements will be acceptable as regards safety, economic and legal aspects. In all cases the Contractor shall inform the Principal of any deviation from the requirements of this document which is considered to be necessary in order to comply with national and/or local regulations. The Principal may then negotiate with the Authorities concerned with the object of obtaining agreement to follow this document as closely as possible.

1.3 DEFINITIONS

1.3.1 General definitions

The **Contractor** is the party which carries out all or part of the design, engineering, procurement, construction, commissioning or management of a project or operation of a facility. The Principal may undertake all or part of the duties of the Contractor.

The **Manufacturer/Supplier/Vendor** is the party which manufactures or supplies equipment and services to perform the duties specified by the Contractor.

The **Principal** is the party which initiates the project and ultimately pays for its design and construction. The Principal will generally specify the technical requirements. The Principal may also include an agent or consultant authorised to act for, and on behalf of, the Principal.

The word **shall** indicates a requirement.

The word **should** indicates a recommendation.

1.3.2 Specific definitions

active fire protection	a "dormant" system that needs to be activated in order to perform its function.
fire safety assessment	the process of analysing and evaluating hazards. It involves both causal and consequence analysis and requires determination of likelihood and risk.
combustible materials	materials such as wood, paper, rubber and plastics. For this DEP, all liquid hydrocarbon products handled in plants shall be classed as flammable product.
deluge system	a sprinkler system where the water distribution piping is equipped with open spray nozzles for discharging over an area.
drenching System	a fixed "free-flowing" water discharge device connected by piping to a reliable water source.
high back pressure foam maker	sometimes called a high back pressure foam generator (HBPG), this foam maker is designed to produce air foam under pressure. This device is required for subsurface and semi-subsurface foam injection.
fire area	a plant (surface) area where a sustained and intense fire is considered credible.
fixed foam system	permanent, complete installation including the foam station, distribution piping, and foam application system.
flammable product	for this DEP, all liquid hydrocarbon products handled in plants shall be classed as flammable product. See also combustible product and flammability .
flammability	NFPA 704 defines flammability as the degree of susceptibility of materials to burning. NFPA 325 identifies the flammability rating of a large number of substances.
flammable range	the range of flammable vapour or gas-air mixture between the upper and lower flammable limits. Also, incorrectly, referred to as Explosive Range.
foam maker	device in which air is mixed with the foam solution to produce the required air foam consistency. A foam maker may be fixed and/or integral to the discharge outlet device, or portable.
foam station	permanently located system consisting of a foam concentrate storage vessel, pump(s), proportioner, piping and controls, designed to deliver foam solution to a foam application system.
passive fire protection	a fire protection system that performs its function without relying on the requirement of activation.
prevailing wind	the direction from which the wind is most likely to blow, based on local meteorological observations.
semi-fixed foam system	permanent installation consisting of a foam application system connected to distribution piping which terminates at a safe distance. Mobile or portable foam producing equipment must be transported to the scene and connected to the distribution piping. A foam maker may be part of the portable or permanently installed equipment.
semi-subsurface foam	the discharge of foam at the liquid surface in a tank by means

injection	of a foldable hose, through a rupture disk from an inlet near the bottom of the tank to avoid intimate contact between foam and the liquid.
spray system	a fixed pipe system connected to a reliable fire water source and equipped with spray nozzles for discharge directed at a <u>specific</u> piece of equipment or surface area to be protected.
sprinkler system	a fire protection system consisting of at least one automatic water supply and a distribution piping system equipped with sprinklers for discharge over an area to be protected. Sprinkler system types include wet-pipe, dry-pipe, pre-action, deluge, and combined dry-pipe/pre-action.
subsurface foam injection	the discharge of foam into a tank near the tank bottom (above the water layer) allowing the foam to travel through the product to the surface.

1.3.3 Abbreviations

AFFF	-	Aqueous Film Forming Foam
ANSI	-	American National Standards Institute
BLEVE	-	Boiling Liquid Expanding Vapour Explosion
BS	-	British Standard
CCTV	-	Closed Circuit Television
DEP	-	Design and Engineering Practice
EDP	-	Emergency De-pressuring
ESD	-	Emergency Shut-Down
FAR	-	Field Auxiliary Room
FIT	-	First Intervention Team
FM	-	Factory Mutual
FRED	-	Fire, Release, Explosion, Dispersion
HBPBG	-	High Back Pressure foam Generator
HCM	-	Hazard Consequence Modelling
IPF	-	Instrumented Protective Function
ISGOTT	-	International Safety Guide for Oil Tankers and Terminals
LNG	-	Liquefied Natural Gas
LPG	-	Liquefied Petroleum Gas
MESC	-	Material and Equipment Standards and Code
MIL	-	Military Standard (USA)
NFPA	-	National Fire Protection Association
NGL	-	Natural Gas Liquids
ROV	-	Remotely Operated Valve
TSO	-	Tight Shut Off
UL	-	Underwriter's Laboratories

1.4 CROSS REFERENCES

Where cross-references to other parts of this DEP are made, the referenced section number is shown in brackets. Other documents referenced by this DEP are listed in (8).

2. ENGINEERING, SPECIFICATION, AND INSTALLATION

As fire protection engineering involves a multitude of engineering disciplines, this section is meant to serve as an aid to summarise the design, construction, commissioning, testing, operation and maintenance requirements. NFPA 25 should be consulted for guidance on selected details.

For fire protection systems the scope of work and supply shall include the following as a minimum:

2.1 DESIGN AND ENGINEERING SCOPE

- Preparation of layouts of the system.
- Determination of the total fire fighting agent requirement for each system.
- Hydraulic calculations and dimensioning of all piping sections.
- Preparation of flow diagrams and line designations.
- Preparation of piping general arrangement drawings.
- Preparation of piping isometric drawings.
- Design and requisitioning of all equipment.
- Mechanical calculations.
- Design of pipe length of reduced pipe size (if required for pressure reduction).
- Layout of supports for early co-ordination with Vendors. If equipment to be protected is already at site/installed, special supports shall be designed to avoid welding at site.
- Pipe supports.
- Detailed design of the heat/fire detection and alarm system:
 - lay-outs;
 - single line diagrams;
 - cause and effect diagram (logic diagrams, matrix and write-up);
 - panel lay-out.
- Typical engineered information
 - plot plan(s);
 - piping general arrangement drawings;
 - equipment layout drawing(s);
 - utility engineering flow diagram - fire water system;
 - firewater distribution system general arrangement drawing;
 - equipment list;
 - local codes;
 - single line wiring diagrams.

The above-mentioned engineering documents shall be presented for comments and approval. The design shall be based on the latest revision of equipment and piping arrangement drawings etc.

2.2 MATERIAL SPECIFICATIONS

Starting at the pre-determined interface, all equipment required for the complete system shall be supplied in one specification. All materials and equipment, e.g. pipe sections, shall be shop tested. Special tools, like spray nozzle keys, etc. shall be included.

2.3 INSTALLATION

Unless specified otherwise, the erection refers to the complete system. It shall include flushing and cleaning of the systems, and assistance during acceptance testing.

2.4 ACCEPTANCE TESTING

After the system has been erected the Supplier shall arrange a performance test to confirm that the system performs in accordance with the design requirements.

For integrated fire protection systems - single system consisting of equipment from several proprietary Manufacturers - the general design Contractor shall be responsible for the overall integrity and functionality of the integrated system.

3. DETECTION

Fire protection systems detailed within this DEP are not automatically actuated by a detection system.

If the fire safety assessment dictates that an automated system is required such as that depicted in Appendix 5, the detection system shall be designed and installed in accordance with DEP 32.30.20.11-Gen.

If the fire safety assessment dictates that a fire detection system is required on a floating roof tank (i.e., to detect fires in the rim area) where normal instrument air supply is not available, self-contained modular units shall be installed for a detector tubing system, such as detailed in Appendix 14.

4. WATER-BASED SYSTEMS

4.1 FIRE WATER DISTRIBUTION

The purpose of a fire water distribution system is to guarantee the supply of sufficient water for the prime purpose of fire control and possibly extinguishment, at the desired pressure in the required area.

4.1.1 Storage

(a) General

The fire safety assessment shall determine the storage capacity and sparing philosophy based upon the largest credible fire scenario in the installation.

If an uninterrupted supply of fire water from open water, wells, or a third party fire main cannot be guaranteed at the maximum required water flow rate, pressure and duration, a dedicated fire water storage facility shall be provided. In order to allow inspection and maintenance of water storage facilities, the n+1 principle shall be applied for providing temporary or alternate storage (e.g., cooling water basin, additional tank).

Dedicated fire water storage facilities shall be located off plot in an area, normally within the property fence, at least 50 m away from fire areas.

(b) Design

Fire water storage facilities shall be of the closed or open storage type. The choice is determined by economic and local conditions (e.g. available land area and sub-soil conditions).

(i) Closed storage

Metallic fixed roof tanks are normally more cost-effective than closed non-metallic or concrete tanks. Closed metallic storage facilities shall be in accordance with:

DEP 34.00.01.30-Gen.

DEP 34.11.00.11-Gen.

DEP 34.28.00.31-Gen.

DEP 34.51.01.31-Gen.

(ii) Open storage

Three types of open storage may be used: membrane-lined earthen bundwall basin (refer to Appendix 1), concrete basin, and metallic tank. Adequate fencing/railing and appropriate life saving equipment shall be provided.

Though a membrane-lined earthen bundwall basin is economically attractive, it shall be established whether or not proper construction/material and inspection/maintenance know-how is available in the particular location, as there is an increased potential risk of leaks during construction and inspection.

Basins shall be in accordance with:

DEP 34.00.01.30-Gen.

DEP 34.11.00.11-Gen.

DEP 30.10.02.13-Gen.

Open metallic tanks shall be built in accordance with 4.1.1 (b) (i).

A level instrument, set at 80% of the maximum filling level, shall be installed to give a low level alarm in the main control room. At maximum filling level an overflow shall be provided.

Provisions should be considered for injecting water treatment chemicals to control the growth of algae or bacteria, or to prevent legionellosis.

The design, particularly of open type storage facilities, shall cater for possible evaporation losses.

The discharge connection(s) on the storage facilities (e.g., suction to fire pumps, replenishment system) shall include easy-to-clean strainers.

In climates where freezing may occur, provisions shall be made to prevent the water becoming frozen. Such provisions should include a combination of circulation, heating and increased storage capacity to compensate for an ice layer of specified maximum thickness.

4.1.2 Pumps and Drivers

(a) General

Pumps, drivers, and appurtenances shall be designed and installed in accordance with NFPA 20 and DEP 31.29.02.11-Gen.

The fire safety assessment shall determine the pump sparing (i.e., main pump(s) back-up) philosophy (applying the $n + 1$ principle), the selection of drivers for the pumps, and the maximum flow rate. The avoidance of common mode failures (e.g., fire in the fire water pump house) shall be addressed in the design.

The main purpose of fire water pumps is to pump water from the supply source into the fire water distribution system that the water is delivered at the specific point and time, and at the required quantity and pressure. For this reason, provisions shall be made to ensure supply under abnormal (e.g., power failure) conditions.

Fire water pumps shall be installed in a location which is considered to be safe from the effects of fire and clouds of flammable vapour, and from collision damage by vehicles and shipping. The pumps should be located as close as possible to the fire water storage or alternative water source.

(b) Pump Design

The fire water pumps rated pressure shall be based on a minimum pressure of 10 bar (ga) at the furthest take-off point on the distribution system, with the highest water flow demand. Individual pump design capacity shall not exceed 1000 m³/h unless suitable pump handling and maintenance facilities are available. If the required pump capacity exceeds 1000 m³/h, two or more smaller pumps shall be installed, subject to the $n + 1$ principle.

Fire water pumps shall be of the submerged vertical type if draining from open water, and of the horizontal, between bearings, type if draining from a storage tank.

If a jockey pump is used to keep the distribution system pressurised, it shall be backed up by a spare jockey pump; both pumps shall have a typical capacity of 15 m³/h to compensate for leakage. If the jockey pump(s) is/are also to be used for providing plant service water, then it (they) shall have a capacity of at least 30 m³/h. If there are significant (e.g., excess of 10 m) differences in elevation of sections of the distribution system, the jockey pump and control system shall ensure sections are not left dry or subject to excessive pressures.

(c) Pump Suction and Discharge Piping

Each pump suction should be provided with an easy-to-clean inlet screen with a local differential pressure indication. If individual pump inlet strainers are difficult to maintain, then each pump discharge line shall be equipped with a strainer having a flushing facility. Each pump discharge line shall be fitted with a check valve, pressure gauge and isolation valve. Provisions shall be made to test each pump individually; the test valves shall have a common return line with a flow metering point.

Each pump shall be connected separately to a common manifold (see Appendix 2). The common discharge manifold should be connected to the fire water distribution system by two separate lines, each of the same size as the distribution piping and each equipped with a block valve.

Piping shall comply with DEP 31.38.01.11-Gen.

(d) Driver

The power rating for all the drivers shall be such that it is possible to start each pump against a closed discharge valve with a fire mains pressure ranging between 2 bar (ga) and 16 bar (ga).

Electric power shall be from the essential supply system (refer to DEP 33.64.10.10-Gen.).

Diesel drivers shall be installed and field inspected in accordance with DEP 31.29.00.10-Gen. and DEP 61.10.08.11-Gen. Diesel storage vessels (fuel tank) shall be constructed in accordance with DEP 30.10.02.11-Gen and NFPA 20. A clutch shall not be installed between a diesel driver and a fire water pump.

(e) Housing

Pumps shall be accessible to facilitate maintenance, and be provided with hoisting facilities in accordance with the requirements of DEP 31.25.00.10-Gen. In locations where freezing can occur, the fire water pumps shall be installed in a heated housing for protection; for other locations, only a rain/sun cover may be required.

4.1.3 Pressure Control

For normally manned installations the fire water pumps shall always be started manually. Manual starting of each fire water pump shall be possible at the pump, from the control centre and, if necessary, from the emergency centre. Manual stopping of each pump unit shall only be possible at the pump.

The control scheme shall be designed in accordance with Appendix 2, so that should the main fire water pump(s) fail to start manually or, having started, fail to build up the required pressure in the fire water distribution system within twenty seconds, the fire water pump(s) designated as the spare or back-up shall automatically start.

(a) Normal (Stand-by) Operating Condition

During normal operation, the main fire water pump(s) shall be in the stand-by mode, with either the jockey pump(s) or other pressure source (e.g., static height, cooling water system) maintaining a minimum pressure of 2-3 bar (ga) in the fire water distribution system. In this condition, the pump discharge control valve 100 PCV-101A or 100 PCV-101B (air failure open) is at the minimal stop, while the dump valve 100 PCV-101C (air failure open) is in the closed position.

(b) Fire Operating Condition

When the main fire water pump or the "first main fire water pump" (if more than one main fire water pump is required according to section 4.1.2 (a)) is manually started, 100 PCV-101C shall fully open. To prevent a pressure surge in the main fire water system, the main fire water pump shall only be allowed to start when 100 PCV-101C has reached its fully open position.

If the distribution system pressure does not reach 5.5 bar (ga) within twenty seconds after starting of the first main fire water pump, another pulse shall be sent to start the fire water pump designated as the spare or back-up. Thirty seconds (i.e., the time necessary for the valve to open) after the main fire water pump was manually started, controller 100 PIC-101 shall throttle control valves 100 PCV-101A or 100 PVC-101B, and 100 PCV-101C as required to maintain the fire water distribution system pressure at 6 bar (ga).

In the central control room, a facility (100 HIC-101) shall be provided to adjust the fire water distribution system pressure. While normally set at 6 bar (ga) as noted above, the pressure control system shall be designed allow a manual increase of the fire water distribution system pressure to a maximum of 7 bar (ga).

4.1.4 Pipe and Valves

The fire water distribution system (i.e., pipe, valves, connections) serves to transport water from the fire water pumps to the required area.

(a) Pipe or "Ring Mains"

The distribution system shall consist of "ring mains" as detailed in Appendix 3, installed to reach (surround) all processing units, storage facilities for flammable liquids, loading/unloading facilities for road vehicles and rail cars, gas bottle-filling plants, warehouses, workshops, utilities, training grounds, laboratories and offices. The system shall be installed at close proximity to access facilities where fire-fighting equipment can be hooked up. A single fire-water line is acceptable for a fire-fighting training ground.

The distribution system design shall provide for a maximum allowable velocity in the fire water piping of 3.5 m/s to prevent surging at these conditions. The pipe sizes shall be calculated based on design flow rates at a pressure of 10 bar (ga) at the take-off points of each appropriate section even if one of the supply sides has been blocked or is out of operation. A check calculation shall be made to prove that pressure drop is acceptable with a blocked section of piping in the system. A surge analysis of the fire water distribution system shall be performed and, where required, surge protection devices shall be provided.

A full bore flushing connection shall be provided in the fire water distribution system if the fire-water quality could result in settlement of silt in the piping, if marine growth is likely, or in cases where corrosion (rust flakes) or erosion (cement particles) products may be formed. The full bore valved flushing connections shall be located so that all sections and dead ends can be properly flushed out. The flushing connections shall be sized for a fluid velocity in the relevant piping of not less than 80% of the velocity under normal design conditions, with a minimum of 2 m/s.

The fire water distribution system components shall be installed underground if located within the 0.15 bar over-pressure contour in plant areas where explosions cannot be excluded and in installations where the ambient temperature can drop below 0 °C for prolonged periods. When installed underground, placement shall be in accordance with DEP 31.38.01.11-Gen and materials of construction shall be glass-fibre reinforced plastic (GRP) in accordance with DEP 31.40.10.19-Gen.

When the fire water distribution system is installed above ground, it shall not be laid in pipe tracks at risk from potential spill fires. In addition, protection from potential physical damage shall be provided. The material selection for above-ground piping shall be based on the predominant fire water quality.

(b) Valves

Block valves shall be incorporated in the fire water distribution system so that sections can be isolated for maintenance, etc. These sections shall be selected so that the required quantity of water can still be supplied from other hydrants with fire hoses having a maximum length of 100 m. The valves shall be gate valves of the solid-wedge or type UL-1091 approved butterfly valves. When valves are installed in an underground system, it shall be possible to observe whether the valves are in the open or closed position. This shall be indicated by the rising spindles of the valves, or by valves fitted with position indicators.

At the foot of a jetty, manually operated isolation valves shall be provided between the fire water distribution system and the fire-water piping on the jetty. The objective is to save the integrity of the fire water distribution system in the event of serious damage to the jetty.

4.1.5 Hydrants

In order to be able to take water from the fire water distribution system at the required location, permanent hydrants shall be installed.

(a) Location

Permanent hydrants shall be located in strategic positions. For this purpose, the spacing shall not exceed :

- | | | |
|---|---|------|
| - | around process units and LPG bottle-filling plants | 60 m |
| - | loading/unloading facilities and off-site pump stations | 60 m |
| - | around storage facilities | 80 m |
| - | alongside pipe tracks | 80 m |
| - | around storage and pumping facilities for LPG | 60 m |

- around utility areas, offices, workshops, laboratories, jetty approaches, flares, and other areas. 80 m

Hydrants shall be readily accessible from roads and be located in such a way that possible damage by road traffic will be minimised. They shall be provided with a guard post (see Standard Drawing S 13.008). The location shall not be less than 1.5 m from the curb of the road, and at least 10 m from road crossings, sharp road curves, and buildings or other structures. For processing units/areas, the distance to the nearest hydrant shall not exceed 50 metres. Each hydrant shall be provided with a hard-paved grade.

(b) Selection

Hydrants each with four outlets shall be provided for in:

- processing units/areas;
- loading/unloading facilities;
- LPG bottle filling plants;
- storage facilities for flammable liquids and LPG;
- off-site pump stations;
- jetty heads/berths.

Hydrants with two outlets shall be installed around all other areas, such as:

- jetty approaches;
- warehouses;
- workshops;
- laboratories;
- offices;
- utilities.

All hydrants in and around a process plant shall be of the type suitable to mount stationary monitors (see section 4.1.6). This shall also be considered for other specific locations as directed by the fire safety assessment.

(c) Design

Each outlet branch shall have a DN 80 (3 inch N.P.S.) ANSI 150 class, flat-faced flange, for accommodating a 2½ inch hydrant valve. The valve shall be of the angle type, with an angle of 45° between inlet and discharge, suitable for a working pressure of 16 bar (ga). The valve outlet shall be provided with a 2½ inch or 65 mm coupling in accordance with local standards. The coupling shall point downwards and be fitted with a chained cap. Valves and the valve components shall be as specified in MESC 96.25.10. Recommended coupling types are Storz (which is preferred) and instantaneous - female connection.

For expansion of existing installations, or for new construction projects in the neighbourhood of existing installations, couplings shall be of the same type as already applied in these installations. Couplings should also be compatible with the type used by the local fire brigades.

Where freezing can occur, hydrants shall have an automatic bottom drain valve unless other arrangements are required by local authorities. The drain valves shall have drain holes of minimum size 8 mm and total free area of at least 200 mm². The drains shall be located so that checking for blockage and maintenance is facilitated. The drain openings shall automatically close when the hydrant isolation valve is being opened.

Hydrants shall be in accordance with one of the following Standard Drawings:

GRE underground mains	freezing area	S 88.012
	non-freezing area	S 88.013

Hydrant header construction shall be in accordance with one of the following Standard Drawings:

Four-way hydrants	S 88.014
Four-way hydrants, with monitor connection	S 88.018
Two-way hydrants	S 88.016

(d) Material specification

Hydrants shall be made from carbon steel; for salt/brackish water internally coated carbon steel pipe shall be used in accordance with DEP 31.38.01.12-Gen. Further requirements are specified on Standard Drawings as referred to in (c) above.

4.1.6 Stationary monitors

(a) General

The fire safety assessment shall determine the location, the capacity, the area to be covered, the method of operation (i.e., manual or remote-control powered) and the type (i.e., ground level or elevated) of stationary fire water monitors. For general protection purposes, the preferred arrangement is fixed manually operated monitors with adjustable nozzles installed at strategic points around and inside plant areas where fire hazards have been identified. Generally, self-oscillating monitors are not recommended. The spacing shall be based upon a 50 m, 360 ° water projection with no blockage from adjacent equipment to the fire hazard area.

Where practical, stationary monitors should be installed on fire water hydrants (see 4.1.5).

Elevated stationary fire water monitors shall be installed to protect congested areas and where obstructions (e.g., at table tops and at jetty heads) prevent the effective use of ground level monitors. Locally controlled elevated monitors shall be provided with cable, chain or gear mechanisms to adjust elevation, rotation and nozzle setting. Remotely controlled elevated monitors shall have a rotation and elevation speed of approximately six degrees/second.

In salt/brackish fire water service or in freeze areas, monitors shall be provided with a connection to drain and flush the normally dry parts of the monitor after testing or use.

(b) Design

Upstream of the mounting flange each monitor shall be provided with a butterfly valve accessible from grade (see Standard Drawings S 88.007, S 88.008, S 88.011, S 88.012, S 88.013, S 88.014 and S 88.015). For elevated monitors the valve shall be operable from grade.

The inlet mounting flange connection shall be ANSI/ASME B 16.5, 150 lbs., Raised Face (RF), 4" Nominal Pipe Size (NPS).

The monitor shall have a 2 ½ inch threaded connection and be equipped with a constant flow, adjustable stream (i.e., fog to jet) nozzle.

Unless determined differently from the fire safety assessment, the monitors shall be 2000 l/min capacity at a working pressure of 10 bar (ga). The maximum operating pressure shall be 16 bar (ga). At 7 bar (ga) inlet pressure, the fire water **jet stream** at 30° elevation shall reach 50 m and have a footprint of 4 m x 6 m with 80 % of the total water flow reaching the footprint. At the same inlet pressure (7 bar) water **fog stream** at 30° elevation and 30° nozzle position shall reach 18 m and have a footprint of 7 m x 8 m with 80 % of the total water flow reaching the footprint.

The monitor shall have a horizontal traverse of 360° and a vertical elevation of 15° below to 85° above horizontal. For elevated monitors these figures may be replaced by respectively 75° and 45°. Monitors shall be provided with the ability to lock the traverse and elevation in any chosen position.

All moving parts shall be fully protected/enclosed against ice and dirt.

(c) Material specification

The monitor and nozzle shall have adequate corrosion resistance for the environmental conditions and fire water quality used. Acceptable materials are for:

monitor (stationary part)	c.s. (min. 400 µm epoxy coated internally against seawater)
turret	nodular cast iron, bronze
gears	aluminium bronze - BS 2874 - CA104
lever	stainless steel - ASTM A 312 TP 304
water nozzle	brass
foam nozzle	stainless steel - ASTM A 240 TP 316L

With the exception of stainless steel, all outside surfaces shall be painted with two coats of amine cured epoxy paint of which the top coat shall be red (RAL 3000). (Refer to DEP 30.48.00.31-Gen.).

(d) Remote control

Remote-control power-operated monitors shall be electrically powered from the essential electrical supply (e.g., typical max. power consumption 1 kW). As a minimum, the equipment and operating panel shall be suitably rated to operate in a hazardous zone 2 environment.

The operating panel shall be located upwind of the prevailing wind direction and at least 50 m away from the fire hazard. The operator shall have a good sight of the area. A secondary panel may be installed in the control room if a CCTV is provided.

The panel shall be provided with:

- power on/off switch (incl. status lights), and for foam/water monitors, also activating the foam station;
- joy stick for integrated rotation and elevation, incl. position indicator(s);
- push buttons for "jet"/"fog" or deflector control, incl. position indicator;
- switch for opening water supply valve, incl. "open/closed" position indicator;
- switch for opening the foam solution inlet valve, incl. "open/closed" position indicator;
- reset (stop) button;
- individual failure alarm indication for rotation, elevation and jet/fog control motors;
- maintenance override.

Where electrical and instrumentation cables run through the fire area they shall be protected against the effect of such a fire. This can be achieved by running them underground, by using fire resistant cables, or by enclosing them in fire resistant cable ducting.

4.1.7 Dry Risers

The fire safety assessment shall determine the need and location of dry riser installations. When specified, the riser shall be installed in or adjacent to the stairway (e.g., main, alternate, and emergency access routes). At the ground floor level of the riser(s), a two-way flapper valve ("collecting breeching") shall be permanently installed. On each floor above (and below) the ground floor, two connections shall be provided, each having a hydrant valve and hose connections as detailed in (4.1.7) located 0.7 m above the floor. An automatic vent shall be installed at the riser(s) highest point.

Dry risers shall be made from flanged carbon steel pipe to be hot-dip galvanised after fabrication.

4.2 FIRE WATER SPRAY SYSTEMS

Fire water spray systems shall be used to protect equipment, or portions of equipment, from potential contact with flames or those subject to radiation levels in excess of 12.5 kW/m^2 where similar protection cannot be practically provided by the use of stationary fire water monitors or water drenching systems.

4.2.1 General

The fire safety assessment shall determine which equipment is to be protected, the method of protection, and the amount of protection. All spray system shall be provided with local and remote (e.g., control room) operation.

(a) Hydraulics

The design of a water spray system shall be based on hydraulic calculations to determine the required pressures and corresponding water quantities of the spray nozzles. The calculations shall be submitted to the Principal for approval.

The normal working pressure shall be established at the point of off-take under conditions of maximum water consumption, i.e. for the fire case. The pressure shall be at least 10 bar (ga). Pressure spikes/surges may occur during initial admission of water into a "dry" section of water spray systems. The magnitude of such pressure spikes/surges must be investigated and, if critical, special measures must be taken (e.g. excess flow control, etc.).

The systems shall be designed in such a way that the required pressure for the best operation of the spray nozzles is achieved by adequate dimensioning of the piping without the use of restriction orifices. The on-off control valve, filter etc. shall be factored into the calculation. If there is still a pressure reduction required, a calculated length (max. 2 m) of small bore piping shall be installed downstream of the on-off control valve and the manually operated block valve. The spool material shall be Monel 400, flanged and having a minimum size of DN15.

In all cases a detailed layout shall be made of the equipment and areas to be protected on which the arrangement of the spray nozzles shall be shown. For this purpose the plant's piping model shall be used. Alternatively, in exceptional cases, the relevant piping general arrangement drawing may be used.

(b) Connection to distribution system

A water spray system shall have two separate connections to two different sections of the fire water distribution system. One of the connections shall be equipped with an on-off control valve (see section (e) below); the other connection shall be a standard manually operated valve. Both valves shall, if possible, be installed upwind of the prevailing wind direction. The on-off control valve shall be at least 15 m from the water spray system. The manual valve shall be safely accessible under the prevailing fire scenario, and shall typically be located 30 m away from the spray system. At both connections, a filter (see (d) below) shall be provided (i.e., a shared filter or one per connection).

Piping shall be flanged for all sizes. Where salt/brackish water is used, the flanged cross-over piping from underground to above ground and piping to the on-off control valve and manually operated valve, shall be internally coated; preferably by epoxy paint (minimum 400 μm dry film thickness) or alternatively by cement lining.

In locations susceptible to freezing, electrical trace heating shall be applied in accordance with DEP 33.68.30.32-Gen.

(c) Spray system piping

Horizontal "dry" piping, downstream of the on-off control valve and the manually operated valve, shall be installed with a slope of 1:200 or steeper. At a minimum, low point drains on the piping, weep-holes on the spray headers, and automatic drain valves at selected locations on the system shall be provided. Where the fire water quality necessitates frequent flushing and cleaning of the spray system, a 3 inch branch with valve and 2½ inch hose coupling shall be provided at each fire water supply side (downstream of the on-off control valve and the manually operated valve).

All overhead piping shall be well supported and fixed to prevent deflection and vibrations. When supported from grade, the supports shall be fire-proofed if structural redundancy cannot be incorporated to withstand fire exposure.

Piping shall be flanged for all sizes and hot dip galvanised after pre-fabrication in accordance with DEP 31.38.10.12-Gen. Screwed galvanised piping shall not be used, since damage to the zinc layer at the threads will result in corrosion. In exceptional cases where it is envisaged that the orientation of the water spray nozzles will require adjustment after installation, screwed double elbows shall be provided.

(d) Filter

Filters shall be of a bucket-type design, with a retractable insert. Each filter shall have a minimum capacity of 800% of the nominal inlet piping diameter. The filter openings shall be at least 50% of the size of the smallest spray nozzle orifice opening to be used, with a maximum of 4 mm diameter.

The filter housing shall be carbon steel; for use in salt/brackish water it shall be internally epoxy coated (min. 400 µm). Filter element material to be stainless steel (316L) or Monel 400.

(e) Valves

The on-off control valve or manually operated valve shall be a UL-1091 listed butterfly valve or equivalent approved by Principal. The valve shall be tight shut off (TSO: Class V or VI according to IEC 60534-4) in the forward direction against a maximum pressure of 16 bar (ga). The control valve shall fully open within 10 seconds. Refer to DEP 32.36.01.17-Gen. for control valves and DEP 31.37.00.11-Gen. for instrument air requirements.

(f) Spray nozzles

Medium velocity, full cone, open-type spray nozzles with external deflectors shall be fitted. Internal strainers are not permitted as they can block the nozzle during operation. Recommended operating range is between 2 and 3.5 bar (ga). The orifice diameter of the nozzles shall not be smaller than 8 mm. The nozzles shall be provided with a male threaded connection; min. size ½ inch. Nozzle material to be stainless steel (316) or Monel 400.

The water spray nozzle Manufacturer shall provide full test data on the nozzle, i.e.:

- spray pattern at applicable distance;
- flow rate at applicable pressure;
- distribution rate over the area.

4.2.2 Pump and compressor protection

If the fire safety assessment determines that a pump or compressor shall be protected by a spray system, it shall be designed and installed in accordance with this section and as depicted in Appendices 4 and 6. A maximum of four pumps may be protected by a single spray system.

- NOTES:
1. The 2.5-3 m elevation shown in Appendix 6 is typical; the actual elevation shall be selected so that the spray pattern completely envelopes the pump.
 2. The number of spray nozzles shall be at least two. More nozzles (up to a maximum of four) may be necessary for larger pumps to achieve the water densities shown in Appendix 6.
 3. If a group of pumps (e.g., congested area) is to be protected by a spray system, the spray nozzles shall be spaced in a regular manner; however, the overlapping spray pattern from two adjacent nozzles shall cover the pump body.

4.2.3 Horizontal vessel and heat exchanger protection

If the fire safety assessment determines that a horizontal vessel or heat exchanger shall be protected by a spray system, it shall be designed and installed in accordance with this section and as depicted in Appendix 4.

Spray water nozzles shall be directed radially to the vessel/heat exchanger wall and heads. If spray patterns are obstructed by platforms, stairs, flanges, manholes etc., additional spray nozzles shall be provided to achieve complete coverage. The water spray system shall be arranged so as not to interfere with the future maintenance requirements of the equipment.

The spray nozzles shall be installed at a distance not exceeding 0.6 m from the equipment surface. Only one type and size of spray nozzle shall be fitted. See Appendix 7.

4.2.4 Column and vertical vessel protection

If the fire safety assessment determines that a column or vertical vessel shall be protected by a spray system, it shall be designed and installed in accordance with this section and as depicted in Appendix 4. Fireproofed skirts do not require protection by the water spray system.

The arrangement of water spray nozzles shall be such that complete coverage of shell and heads (including appurtenances) is obtained, with minimum loss due to wind and up-draught. For this purpose spray water nozzles shall be directed radially to the column/vessel wall and heads. The number of spray nozzles on each level and the spray angle (inclination) of the nozzles depend on the column/vessel diameter. If spray patterns are obstructed by platforms, stairs, flanges, manholes etc., additional spray nozzles shall be provided to achieve complete coverage. The water spray system shall be arranged so as not to interfere with the future maintenance requirements of the equipment.

The spray nozzles shall be installed at a distance not exceeding 0.6 m from the equipment/insulation surface. Only one type and size of spray nozzles shall be fitted (see Appendix 8).

4.2.5 Spherical tank protection

If the fire safety assessment determines that a spherical tank shall be protected by a full coverage spray system, it shall be designed and installed in accordance with this section and as depicted in Appendix 4. Other options such as water drenching, partial coverage, and use of stationary fire water monitors shall be addressed in the fire safety assessment.

Spray nozzle arrangements shall be as detailed in Appendix 9 and 10. If the water demand to the sphere spray system is the largest in the facility and more than the "standard" pump rating required for other credible scenarios, the fire safety assessment shall also determine whether further sectionalising of the upper and lower sections of the system may be required. Complete wetting of the entire sphere surface is required independent of rundown. Because of overlap in the spray pattern, spraying of the appurtenances and selection of the next larger spray nozzle, the actual rate is very likely already higher than the required water application rate.

To economise on water consumption, the sphere shall have its spray system split into two entirely separate sections, one for the upper and one for the lower half of the sphere. As well as the sphere surface itself, all appurtenances, non-fire proofed sections of the supporting legs and equipment in the containment area shall be water sprayed. Nozzles shall be installed on a single ring header at the upper part of the sphere. For easy access and maintenance this ring header shall be installed near the top platform. The number of headers plus spray nozzles and the capacity thereof shall be such that the upper half of the sphere is covered with the required application rate as described above. The sphere surface area above the ring header elevation, as well as the appurtenances like safety valves and instrumentation located at the top of the sphere, shall be adequately wetted, possibly by installing additional dedicated spray nozzles located above such equipment.

The lower half of the sphere shall be protected by water spray from nozzles installed at regular intervals to achieve complete coverage (wetting) with overlapping spray patterns. The preferred method is to use a "top" ring header feeding regularly spaced legs in the vertical plane, concentric to the sphere surface.

Spray water nozzles shall be directed radially at the sphere surface. The spray nozzles shall be installed at a distance not exceeding 0.6 m from the equipment surface.

The filling/outlet line shall also be protected by water spray up to the isolating valve, located outside the containment wall.

The sphere's support legs are provided with fire proofing material, which will withstand heat for a limited time period. To cover the extended period of a credible fire, the legs also require spray water protection. Here particular attention shall be paid to the region where the support leg meets the sphere.

Where supports, stairs, platforms, nozzles, manholes etc. interfere with the spray patterns or the rundown water layer, additional spray nozzles shall be provided to guarantee complete coverage. Sufficient allowances shall be made to compensate for water loss due to wind, overshooting etc.

Ring headers shall be constructed from circular or straight pre-fabricated pipe sections. The upper half and lower half "top" ring header shall be firmly supported from the top platform and the sphere's support legs respectively. The vertical legs of the lower part shall be provided with distance pieces (no welding on sphere) and pulled together at their free ends.

4.2.6 Storage Tank protection

If the fire safety assessment determines that a storage tank shall be protected by a water spray system, it shall be designed and installed in accordance with this section and as depicted in Appendix 4.

Spray nozzle arrangements shall be as detailed in Appendices 11, 12 and 13. Typically, the entire roof outer surface (exception: external floating roof) and the wall section facing another tank shall be sprayed. If the water demand to the storage tank spray system is the largest in the facility and more than the "standard" pump rating required for other credible scenarios, the fire safety assessment shall also determine whether the spray system will have to be sectionalised.

If tank spacing is closer than in accordance with the IP Model Code, heat radiation calculations shall be made to determine the maximum heat flux in order to determine the required water spray application rate. In such circumstances the use of splash plates may be considered.

Storage tanks having concrete surfaces, such as LNG/NGL atmospheric refrigerated products tanks, shall generally require water spray system application only to the exposed steel surfaces, including appurtenances. Allowable radiant heat flux for the given concrete thickness shall be calculated to determine the need for water spray on the concrete surfaces.

(a) Tank roof (exception: external floating roof)

For optimum wetting and piping layout, at least one inner ring header, with a radius of 3 metres, shall be installed. This inner ring header shall be equipped with three sub-headers (min. size 2 inch), equally spaced along the inner ring header's circumference and pointing radially inwards. At the end of the sub-header a full pattern nozzle shall be installed. On the circular header(s) full pattern or flat spray nozzles shall be installed. Max. spray distance, for both type of nozzles: "upwards" and "downwards" 2.0 and 2.5 metres respectively. For wetting, a maximum water rundown of 4 metres is permitted. Based upon the foregoing, additional ring headers are required for tanks above 18 m diameter.

(b) Tank wall

The tank wall shall be protected by a circular ring header supported from the tank's top curb angle or wind girder. Max. distance between wall and header centre line is 0.45 m. On this header flat spray nozzles shall be spaced at regular intervals, with an inclination from the vertical axis of 10 to 20 degrees, to achieve complete coverage (wetting) at overlapping spray patterns (see Appendix 13). The number of nozzles depends on the tank diameter. Normally additional ring headers are not required.

Where reinforcing rings, supports, stairs, platforms, nozzles, manholes etc. interfere with the spray patterns or the rundown water layer, additional spray nozzles shall be provided to guarantee complete coverage (including appurtenances).

(c) Tank appurtenances

Radiant heat flux shall be calculated in the fire safety assessment to determine whether water sprays shall be provided for tank appurtenances (e.g., safety valves, piping and instrumentation located at/near the tank's pump/manifold platform, nozzles, structural steel) including the pipe rack/bridge and pumping platform on LNG/NGL tanks.

Fire water stationary monitors fed from a dry header that can be activated by opening an instrumented on-off control valve are the preferred means of protection.

(d) Spray System Piping

Ring headers, serving roof or wall (shell) nozzles, shall be connected to a common supply header. Ring headers shall be constructed from flanged circular pre-fabricated pipe sections. The roof ring headers shall be firmly supported. Pipe supports shall be welded or bonded to the roof.

The supply header shall have a single connection to the fire water distribution system. The connection should be located upwind of the prevailing wind direction. The manually operated valve shall be at least 30 m away from the fire hazard. At the connection a filter shall be installed.

Downstream of the manually operated valve a 3 inch branch, with valve and 2½ inch Storz/instantaneous hose connection, shall be provided for water or smoke testing, flushing with fresh water and drainage.

4.3 WATER DRENCHING

If the fire safety assessment determines that a water drenching system is required as an alternative to stationary fire water monitors or a water spray system, it shall be designed and installed in accordance with the requirements of this section and as detailed in Appendix 19. Additionally, water deflectors as detailed in Appendix 20 shall be provided for proper water flow transition from the roof to wall surfaces.

If applicable, stationary fire water monitors and/or fire water spray systems shall be used in conjunction with water drenching systems to provide protection to areas having obstructions (e.g., platforms, piping, stairways, supports) to the water flow.

A single connections to the distribution piping shall be installed outside the bund wall at a location upwind of the prevailing wind direction. Inside the bund the piping shall be supported on sleepers, installed with a slope of 1:200 or steeper, and equipped with a low point drain. A sign shall be provided at the manually operated valve connection to the distribution piping, stating the equipment being protected.

Piping shall be flanged for all sizes and hot dip galvanised after pre-fabrication.

4.4 SPRINKLER SYSTEMS

Generally, sprinkler systems shall only be utilised to provide protection of areas within buildings.

If the fire safety assessment determines that a sprinkler system is required, it shall be designed and installed in accordance with NFPA 13.

4.5 WATER MIST SYSTEMS

The fire safety assessment shall determine whether water mist systems are to be provided. Water mist system shall be designed and installed in accordance with NFPA 2001 and NFPA 750.

4.6 STEAM SYSTEMS

The fire safety assessment shall determine whether steam systems are to be provided. Such systems are typically installed to smother fires or to dilute gas/air mixtures in enclosed areas, to avoid the escalation of flange fires in hydrogen service, and to protect equipment handling flammable products on or above auto-ignition temperature.

Steam systems for fire protection shall be operable from grade. The manually operated block valve shall be positioned at least 15 m away from the credible fire hazard, and upstream of the prevailing wind direction. A sign board shall be positioned indicating the purpose of the valve. Downstream of the block valve, piping shall be sloped to low points provided with 6 mm diameter drain holes. For further requirements, see DEP 31.38.01.11-Gen.

Consideration shall be given to the installation of test facilities in steam systems for fire protection purposes. Where this is impracticable systems shall be tested during shutdown of the equipment concerned.

Where fixed steam systems are not practical, steam lances (see Standard drawing S 88.005) with 15 m long electrically earthed hoses shall be provided.

Flanged connections (6 inch N.P.S. and larger) in hydrogen service which are not readily accessible from grade shall be provided with steam rings in accordance with Standard drawing S 38.141, S 38. 142, S 38 143, S 38 144.

5. FIRE FIGHTING FOAM SYSTEMS

The purpose of fire fighting foam systems is to deliver a solution of fire fighting foam and water onto a liquid hydrocarbon pool to control vapours or extinguish a fire. NFPA 11 should be consulted for guidance on selected details.

5.1 FOAM CONCENTRATE STORAGE FACILITY

The foam concentrate storage facility shall consist of an elevated foam concentrate storage vessel, foam concentrate circulation pump, and storage vessel filling/discharge facilities. Refer to Appendix 17. The entire facility shall be provided with a concrete slab, which drains, via a normally closed valve, into the AOC drain system. Lighting shall be provided for night-time operations (refer to DEP 33.64.10.10-Gen.).

The foam concentrate storage facility shall be situated in a safe and easily accessible location for road transport operations. Generally this location is in the vicinity of the site's fire station; however, on large sites more foam concentrate storage facilities (fixed or mobile) may be required to facilitate logistics during emergencies.

5.1.1 Storage Vessel

(a) General

The fire safety assessment shall determine the storage capacity and sparing philosophy based upon the largest credible fire scenario in the installation.

The bottom of the foam concentrate storage vessel shall be installed at an elevated level such that mobile foam apparatus - foam tenders, foam trucks - can be filled by gravity. Gravity discharge shall be achieved by a fixed six inch nominal bore pipe. The end of this pipe shall be equipped with a piece of fire water hose to avoid frothing of the concentrate while it is being discharged. Such a hose shall terminate just above the bottom of the foam tender or foam truck. As an alternative, a simple loading arm may be installed and provided with fresh water flushing facilities.

In areas where freezing may occur, the vessel, pump and piping shall be electrically traced in accordance with DEP 33.68.30.32-Gen. A panel mounted low temperature alarm shall be installed.

(b) Design

To avoid foam concentrate deterioration due to contact with air, the vessel shall be equipped with an expansion dome having a volume of at least 2% of the nominal vessel capacity. Such a dome may be combined with a manway having a nominal size of 24 inch. The vessel shall be filled to the intersection of the manway and the vessel shell.

A breathing valve shall be connected to the cylindrical section of the manhole shell. The valve shall be set for typically 5 m bar (ga) overpressure and 5 m bar (ga) vacuum. The capacity of the breathing valve size is governed by the largest filling/discharge rate. The sizing shall also take into account a possible liquid overflow.

As a minimum requirement the vessel shall be engineered according to the design rules of the applicable pressure vessel code, e.g. BS 5500.

Because the foam concentrate will foul sight glasses, a membrane type construction shall be provided. The top of the standpipe shall be provided with a breather. As an alternative, a magnetic type level gauge should be used where the top of the standpipe is connected to the vapour space in the dome.

A heat shield shall be provided against sun radiation, because this may heat the foam concentrate and cause accelerated deterioration. Integrating the heat shield into the insulation shall be considered.

Cage ladder plus access platforms are required for operation, inspection and maintenance of all tank accessories.

The foam concentrate storage vessel shall be constructed from glass-fibre reinforced plastic (GRP). Refer to DEP 31.40.10.19-Gen. Metallic construction may be used as an alternative, depending on the type of foam concentrate to be stored (i.e., fluoro protein - carbon steel internally coated with an amine cured epoxy paint; AFFF or alcohol resistant - AISI 316L). The choice of construction shall be verified with the foam concentrate Supplier/Manufacturer. Any alternative requires the Principal's approval.

5.1.2 Circulation pump and piping

The foam concentrate circulation pump shall be sized to circulate the storage vessel contents in approximately two hours. The preferred method of driving the pump is by means of an electric motor. Refer to DEP 33.64.10.10-Gen. Alternatively the pump may be driven by compressed air. The foam concentrate circulating pump and components shall have adequate corrosion resistance for the environmental conditions and foam quality used, and be provided with water flushing and draining facilities.

All piping components in permanent contact with foam concentrate shall be stainless steel. If the facility is located off plot, glass fibre reinforced plastic may be used as an alternative. Flushing and draining facilities shall be provided.

5.1.3 Filling/discharge facilities

For bulk supply filling, a 2½ inch nominal diameter suction hose connection shall be provided.

For sites which do not have access to foam concentrate in bulk form, a drum unloading facility shall be provided. The drum unloading facility shall comprise of a collecting pit (nominal size 1 m³ fabricated from glass fibre reinforced plastic) and a drum unloading rack. A cover shall be provided to avoid dirt entering the pit. The drum unloading rack shall be sized to accommodate at least three pallets of 200 litre drums, drum handling equipment, and sufficient space to manoeuvre drums.

5.2 FOAM STATION

If the fire safety assessment determines that a foam station is required to provide foam solution to a foam application system (see section 5.3), the information given in this section shall be used in its design and engineering. The fire safety assessment shall also determine the required foam concentrate type, capacity and proportioning.

The foam station shall consist of a foam concentrate storage vessel, pumps, proportioner or mixer, interconnecting piping and a control panel; all skid-mounted (see Appendix 18). The purpose of the foam station is to mix fire water and foam concentrate to produce foam solution which is supplied to foam application systems (see section 5.3)

The foam station shall be installed at a safe distance from the fire area, yet shall be able to supply foam solution to the desired foam application system within two minutes of activation. For this reason radiation heat flux calculations shall be made.

5.2.1 Storage Vessel

The foam concentrate storage vessel for the foam station, shall be designed as detailed in section 5.1.1 (b).

5.2.2 Pumps

The foam concentrate pump should be electrically driven. The 100% spare pump should be diesel driven. The diesel fuel tank shall have a capacity suitable for at least 4 hours running time under full load conditions. For further details of the diesel engine and its fuel tank refer to 4.1.2 (d).

For foam solution demands up to 240 m³/h both foam concentrate pumps may be driven by a water turbine. The water turbine casing should be ASTM A240-TP304; the Pelton wheel should be phosphor bronze.

The foam concentrate pumps and components shall have adequate corrosion resistance for the environmental conditions and foam quality used, and be provided with water flushing and draining facilities.

5.2.3 Piping and proportioner

All piping in permanent contact with the foam concentrate shall be stainless steel unless the facility is located off plot, in which case glass fibre reinforced plastic may be used as an alternative. Flushing and draining facilities shall be provided.

The foam solution piping (i.e., piping between the proportioner and the foam application system) is normally dry. After fabrication the piping shall be hot dip galvanised in accordance with ISO 1461.

Correct dosing of foam concentrate into the fire water is achieved by means of a proportioner. A typical proportioner, suitable for flow rates between 10% and 100% of the design capacity, has a pressure loss of 10% of the inlet pressure. A differential pressure of 1 bar shall be maintained between foam concentrate and fire water supply to the proportioner. Hydraulic calculations shall be made for the entire foam system, including the foam application system. These calculations shall also address pressure pulses resulting from liquid filling of the normally dry foam solution piping.

5.2.4 Controls

A local control panel and logic system shall be provided. The logic system shall control the following functions:

- pump start requires fire water flow;
- pump start requires open suction valve and closed discharge valve;
- discharge valve opening is controlled by fire water flow;
- spare concentrate pump shall start up automatically if the main pump fails to build a minimum pressure of 10 bar within 20 seconds;
- re-circulation valve controlled by fire water flow;
- flushing connections (prevention of water entry into storage vessel);
- foam concentrate circulation (closed discharge valve).

Electrical equipment and instrumentation shall be suitable for the applicable zone of the Hazardous Area Classification (refer to IP Model Code Part 15).

Instrument and electric cabling shall be applied in accordance with DEP 32.37.20.10-Gen. and DEP 33.64.10.10-Gen. respectively (refer to MESC 68.48.5x).

5.3 FOAM APPLICATION SYSTEMS

If the fire safety assessment determines that equipment shall be protected by a foam application system, it shall be designed and installed in accordance with this section. The fire safety assessment shall determine the type of foam concentrate and the required foam solution application rate and pressure.

5.3.1 Subsurface foam injection

The subsurface foam injection system discharges foam solution into a tank near the tank bottom (above the water layer) allowing the foam to travel through the product to the surface. The foam solution shall be delivered by either a foam station (i.e., fixed foam system) or by the first intervention team (FIT) using portable equipment or mobile foam apparatus (i.e., semi-fixed foam system).

Note: This section assumes the design and installation of a semi-fixed, low expansion foam application system. Medium or high expansion foam application systems shall be designed and installed in accordance with NFPA 11A.

Connections to the distribution piping shall be installed outside the bund wall at a location upwind of the prevailing wind direction. Reference is made to standard drawing S 88.022. A

sign shall be provided at the connection point stating the required foam concentration type, foam solution rate (dm^3/min), supply pressure (bar (ga)), and the size and number of portable high back pressure foam makers.

Note: It is assumed that a portable high back pressure foam maker is utilised, however the maker may be permanently installed depending on local preferences.

The section of high back pressure foam maker shall be made based upon hydraulic calculations. NFPA 11 should be consulted for guidance on selected details.

(a) Installation on tank

The distribution piping, including check valve, bursting disc and stop valve, shall be installed to each inlet nozzle on the tank, just above the highest possible water level. The stop valve, bursting disc and check valve shall be installed as close as possible to the tank nozzle. The bursting disc shall be constructed of stainless steel and installed in order to prevent the tank product from entering the check valve. The minimum bursting disc break pressure shall be governed by the thermal relief pressure.

The horizontal piping between the tank and the connections shall be installed with a slope of 1:200 or steeper, and it shall be equipped with adequate free-draining facilities (e.g., typically 6 mm dia. weephole) and flush facilities. Piping shall be hot dip galvanised after fabrication.

(b) Installation on product piping

Subsurface foam injection on product piping upstream of the tank nozzle can only be installed on facilities having all product piping valves (i.e., all valves between the tank and the foam connection) car-sealed open.

The distribution piping, including check valve and stop valve, shall be installed on the product piping upstream of the tank inlet nozzle. The stop valve and check valve shall be installed as close as possible to the product piping connection.

The horizontal piping between the product piping and the connections shall be installed with a slope of 1:200 or steeper, and it shall be equipped with adequate drain facilities (e.g., typically 6 mm dia. weephole) and flush facilities. Piping shall be hot dip galvanised after fabrication.

5.3.2 Semi-subsurface foam injection

The semi-subsurface foam injection system discharges foam solution at the liquid surface in a tank by means of a foldable hose, through a rupture disk from an inlet near the bottom of the tank to avoid intimate contact between foam and the liquid. The foam solution shall be delivered by either a foam station (i.e., fixed foam system) or by the first intervention team (FIT) using portable equipment or mobile foam apparatus (i.e., semi-fixed foam system).

Note: This section assumes the design and installation of a semi-fixed, low expansion foam application system. Medium or high expansion foam application systems shall be designed and installed in accordance with NFPA 11A.

Connections to the distribution piping shall be installed outside the bund wall at a location upwind of the prevailing wind direction. Reference is made to standard drawing S 88.023. A sign shall be provided at the connection point stating the required foam concentration type, foam solution rate (dm^3/min), supply pressure (bar (ga)), and the size and number of portable high back pressure foam makers.

Note: It is assumed that a portable high back pressure foam maker is utilised, however the maker may be permanently installed depending on local preferences.

The distribution piping, including check valve, bursting disc and stop valve, shall be installed to each inlet nozzle on the tank, just above the highest possible water level. The stop valve, bursting disc and check valve shall be installed as close as possible to the tank nozzle. The bursting disc shall be constructed of stainless steel and installed in order to prevent the tank product from entering the hose container. The minimum bursting disc break pressure shall

be governed by the thermal relief pressure. The stop valve shall be designed to allow the hose to be "cut" for replacement and make a proper seal after use.

The system's hose container assembly shall be hot dipped galvanised carbon steel or stainless steel 316L, with the hose made from terylene or as proposed by the Manufacturer.

The horizontal piping between the tank and the connections shall be installed with a slope of 1:200 or steeper, and it shall be equipped with adequate drain facilities (e.g., typically 6 mm dia. weephole) and flush facilities. Piping shall be hot dip galvanised after fabrication.

The section of high back pressure foam maker shall be made based upon hydraulic calculations. NFPA 11 should be consulted for guidance on selected details.

5.3.3 Foam for external floating roof tank

The typical foam application system for a floating roof tank consists of a single foam discharge device (shown in Standard Drawing S 88.009 as a "foam pourer nozzle"), foam maker, foam dam, hose station, and distribution piping. This system discharges foam solution onto the seal area of the floating roof, between the tank wall and the foam dam. The foam solution shall be delivered either by a foam station (i.e., fixed foam system) or by the first intervention team (FIT) using portable equipment or mobile foam apparatus (i.e., semi-fixed foam system).

Note: This section assumes the tank is equipped with a hand-railing around the circumference of the tank on the wind girder. If this is not the case, the fire safety assessment may dictate a system which is designed and installed in accordance with the appendix of NFPA 11.

Connections to the distribution piping shall be installed outside the bund wall at a location upwind of the prevailing wind direction. A sign shall be provided at the connection point stating the required foam concentration type, foam solution rate (dm^3/min), and supply pressure (bar (ga)). Inside the bund the piping shall be supported on sleepers, installed with a slope of 1:200 or steeper, and equipped with a low point drain.

The foam discharge device and hose station shall be provided near the access stairs top platform at wind girder level. A hose box (see DEP 80.47.10.32-Gen.) containing two foam nozzles ($250 \text{ dm}^3/\text{min}$, 7 bar (ga)) and sufficient fire hose sections (20 m long $1\frac{1}{2}$ inch) to reach the opposite wall shall be installed at the top platform. The foam maker shall preferably be located horizontally at the tank wind-girder. Both the foam maker and discharge device shall be provided with screens to prevent "bird-nesting". The discharge device shall be installed below the top of the tank shell unless equipped with a foam splash board.

A foam dam shall be provided, having a height of at least 50 mm above the seal arrangement and a minimum overall height of at least 350 mm. The dam shall be fully seal welded to the roof and provided with water drainage openings (65 x 25 mm) at approx. 3 m pitch as shown on S 88.009.

5.3.4 Foam for internal floating roof tank

The fire safety assessment may dictate a system which is designed and installed in accordance with the appendix of NFPA 11.

5.3.5 Foam-Water Spray System for loading gantries

If the fire safety assessment determines that loading gantries handling flammable liquids shall be equipped with a foam-water spray system, the information given in this section shall be used in its design and engineering. NFPA 11 and NFPA 16 should be consulted for guidance on selected details

The foam-water spray system shall consist of a simple foam induction unit (see Appendix 15), distribution piping, and foam-water spray nozzles. The system shall be provided with local and remote (control room) operation.

The fire safety assessment shall determine the required foam-water application rate and duration. Typically, an application rate of $6.5 \text{ dm}^3/\text{min}/\text{m}^2$ for the floor surface area to be

protected, maintained for a duration of 10 minutes, shall be applied. Once the foam concentrate supply is depleted or switched off, the foam-water spray system shall continue to operate as a fire water spray system.

The foam-water spray nozzle pattern shall cover the road/rail car including its heads, the loading (and vapour return) lines, and the driver's road-car cabin. Spray nozzles shall be directed radially to the road/rail car; to the top, the sides and undercarriage. The number of spray nozzles on each level and the spray angle of the nozzles shall depend on the road/rail car geometry. Generally four horizontal spray nozzle headers shall be required (see Appendices 7 and 13. If spray nozzle patterns are obstructed due to platforms, stairs, flanges, manholes etc., additional spray nozzles shall be provided to achieve complete coverage. Only one type and size of spray nozzles should be used.

5.3.6 Stationary foam monitors

Fire protection can also be provided by fire water monitors equipped with inducting foam nozzles, or foam nozzles installed on stationary foam monitors connected to foam solution distribution piping. See (4.1.6) for monitor details.

6. DRY CHEMICAL SYSTEMS

If the fire safety assessment determines that a dry chemical system is required, the system shall be designed and installed in accordance with NFPA 17.

7. GASEOUS SYSTEMS

If the fire safety assessment determines that gaseous extinguishing systems are required, the information given in this section shall be used in the design and engineering of the system.

7.1 CARBON DIOXIDE EXTINGUISHING SYSTEM

The carbon dioxide extinguishing system shall be designed and installed as a high pressure total flooding system in accordance with NFPA 12.

7.2 CLEAN AGENT EXTINGUISHING SYSTEM

The clean agent extinguishing system shall be designed and installed as a high pressure total flooding system in accordance with NFPA 2001 and its appendices.

Specific care shall be taken with extinguishing concentrations for the fire, validating manufacturers' minimum recommendations, with demonstrations if necessary. Additionally, the system shall be checked for compatibility with the building design, air tightness and venting requirements etc.

7.3 NITROGEN EXTINGUISHING SYSTEM

The nitrogen system designed to extinguish a minor fire on a pressure relief valve (PRV), shall have a nitrogen release rate of twenty times the vapour release rate. The nitrogen may be delivered from supplied cylinders or the fixed plant nitrogen distribution system. The distribution manifold shall be accessible from a safe location according to the fire design scenario.

8. REFERENCES

In this DEP reference is made to the following publications:

NOTE: Unless specifically designated by date the latest issue of each publication shall be used (together with any amendments/supplements/revisions thereto).

SHELL STANDARDS

Index to DEP publications and standard specifications	DEP 00.00.05.05-Gen.
Index to Standard Drawings	DEP 00.00.06.06-Gen
Metallic materials	DEP 30.10.02.11-Gen.
Non-metallic materials: selection and application	DEP 30.10.02.13-Gen.
Painting and coating of new construction projects	DEP 30.48.00.31-Gen.
Guide for the selection of hoisting facilities and weather protection for rotating equipment	DEP 31.25.00.10-Gen.
Installation of rotating equipment	DEP 31.29.00.10-Gen.
Selection, testing and installation of pumps	DEP 31.29.02.11-Gen.
Instrument air supply	DEP 31.37.00.11-Gen.
Piping - general requirements	DEP 31.38.01.11-Gen.
Piping classes - refining and chemicals	DEP 31.38.01.12-Gen.
Fire, gas and smoke detection systems	DEP 32.30.20.11-Gen.
Control valves - selection, sizing and specification	DEP 32.36.01.17-Gen.
Instrument signal lines	DEP 32.37.20.10-Gen.
Electrical engineering guidelines	DEP 33.64.10.10-Gen.
Electrical heat tracing	DEP 33.68.30.32-Gen.
Minimum requirements for structural design and engineering	DEP 34.00.01.30-Gen.
Site preparation and earth works	DEP 34.11.00.11-Gen.
Steel structures	DEP 34.28.00.31-Gen.
Design and fabrication of standard vertical tanks	DEP 34.51.01.31-Gen.
Field inspection prior to commissioning of mechanical equipment	DEP 61.10.08.11-Gen.
Assessment of the fire safety of onshore installations	DEP 80.47.10.30-Gen.
Use of fire fighting agents and movable fire fighting equipment for onshore applications	DEP 80.47.10.32-Gen.

STANDARD DRAWINGS

Traffic barrier for hydrant	S 13.008
Steam ring to horizontal flange DN 150 (6 in) and above in hydrogen service	S 38.141
Two steam rings to horizontal flange DN 150 (6 in) and above in hydrogen service (with spectacle blind, spade, spacer or orifice)	S 38.142
Steam ring to vertical flange DN 150 (6 in) and above in hydrogen service	S 38.143

Two steam rings to vertical flange DN 150 (6 in) and above in hydrogen service (with spectacle blind, spade or spacer)	S 38.144
Steam lance	S 88.005
Two-way or four-way hydrant for steel underground piping in non-freezing areas (hydrant atop main header)	S 88.007
Two-way or four-way hydrant for steel underground piping in non-freezing areas (hydrant aside main header)	S 88.008
Foam pourer nozzles for floating roof tanks	S 88.009
Foam pourers for floating roof tanks	S 88.010
Two-way or four-way hydrant for steel underground piping in freezing areas	S 88.011
Two-way or four-way hydrant for GRE underground piping in freezing areas	S 88.012
Two-way or four-way hydrant for GRE underground piping in non-freezing areas	S 88.013
Two-way or four-way hydrant for steel aboveground piping in non-freezing areas (hydrant atop main header)	S 88.014
Two-way or four-way hydrant for steel aboveground piping in non-freezing areas (hydrant aside main header)	S 88.015
Two-way hydrant header	S 88.016
Four-way hydrant header with monitor connection	S 88.018
Sub-surface foam system for flammable and combustible liquids	S 88.022
Semi-sub-surface foam system for flammable and combustible liquids	S 88.023

AMERICAN STANDARDS

Low expansion foam	NFPA 11
Medium and high expansion foam agents	NFPA 11A
Carbon dioxide extinguishing systems	NFPA 12
Installation of sprinkler systems	NFPA 13
Deluge foam-water sprinkler and foam-water spray systems	NFPA 16
Dry chemical extinguishing systems	NFPA 17
Installation of centrifugal fire pumps	NFPA 20
Inspection, testing and maintenance of water-based fire protection systems	NFPA 25
Guide to fire hazard properties of flammable liquids, gases, and volatile solids	NFPA 325
Standard for the identification of the fire hazards of materials for emergency response	NFPA 704

Water mist fire protection systems

NFPA 750

Clean agent fire extinguishing systems

NFPA 2001

Issued by:
National Fire Protection Association
One Batterymarch Park
PO Box 9101
Quincy, MA 02269-9101
USA

BRITISH STANDARDS

Pressure vessels

BS 5500

Issued by:
British Standards Institution
389 Chiswick High Road
London W4 4AL
UK

Institute of petroleum model code of safe practice in
the petroleum industry:

Part 15: Area classification code for petroleum
installations

IP Model Code Part 15

Issued by:
Institute of Petroleum
61 New Cavendish Street
London W1M 8AR
UK

INTERNATIONAL STANDARDS

Metallic coatings: Requirements for hot dip
galvanised coatings on fabricated products

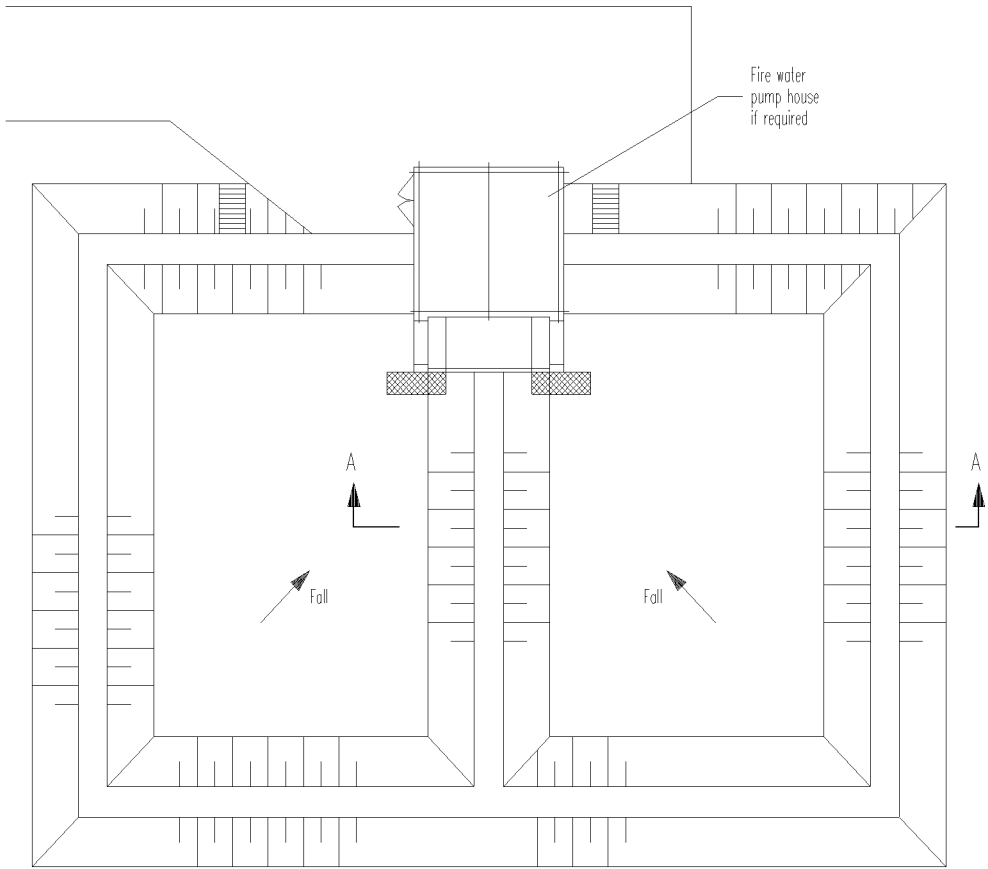
ISO 1461

Issued by:
International Organisation for Standardisation
1, Rue de Varembe
CH-1211 Geneva 20
Switzerland

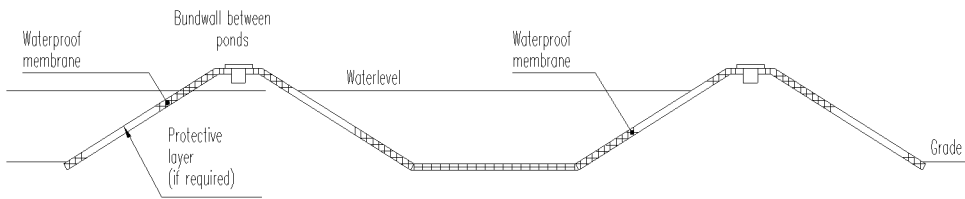
*Copies can also be obtained from national standards
organizations.*

NOTE: Most referenced external standards are available to Shell users on the Shell Wide Web at address
<http://www.shell.com/standards>.

APPENDIX 1 EARTH BUNDWALL BASIN FOR FIRE WATER STORAGE

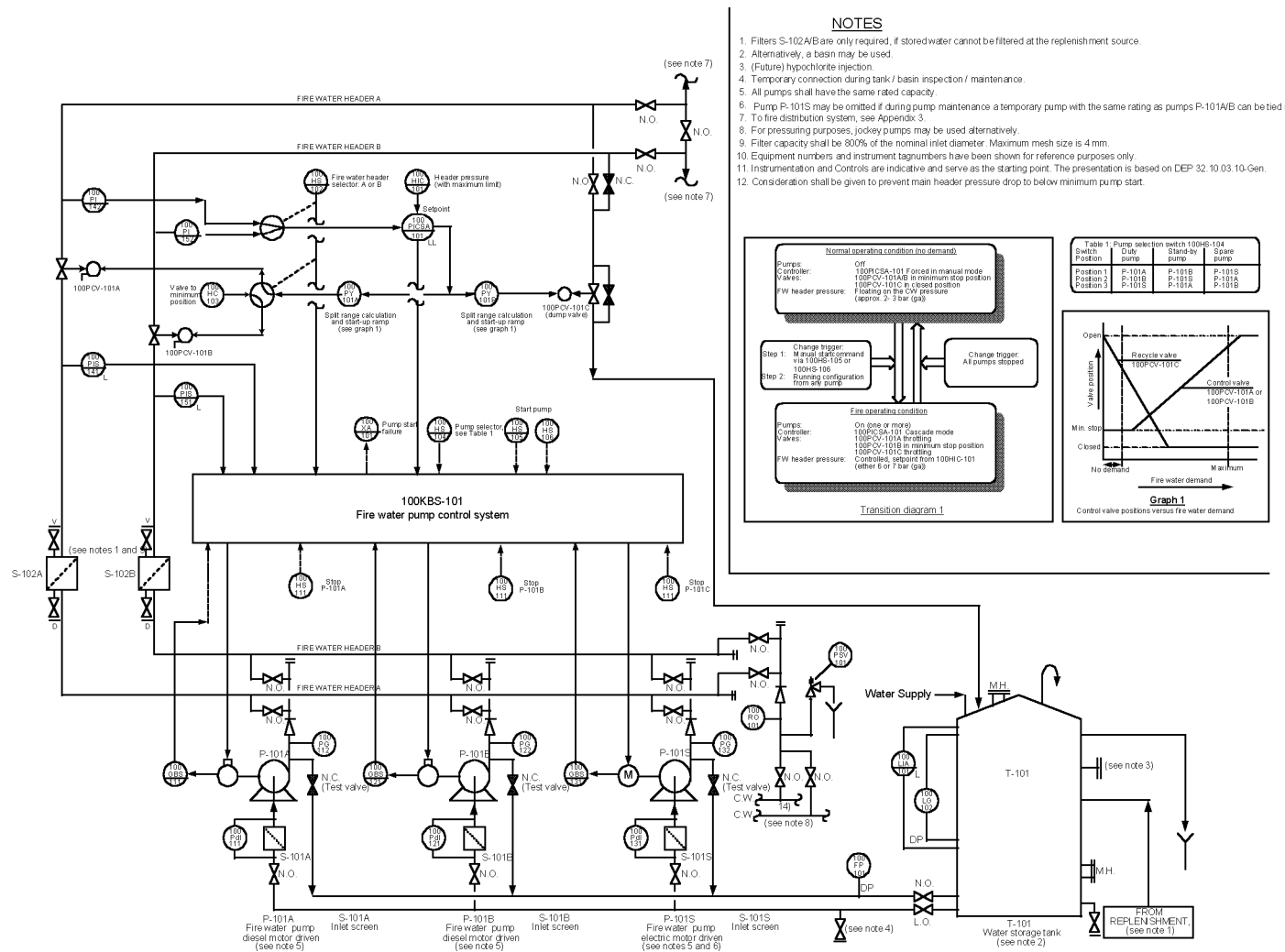


GENERAL ARRANGEMENT

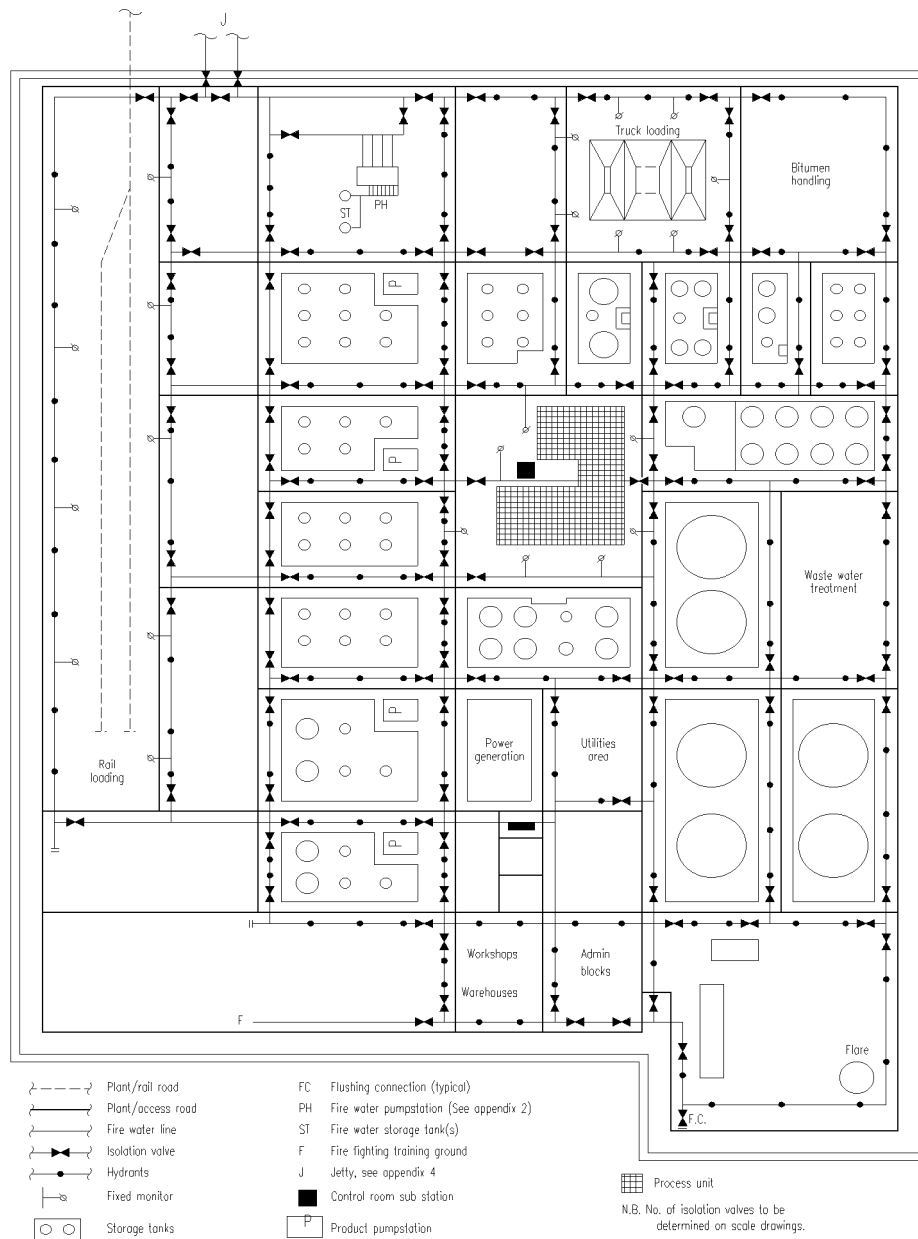


Section A-A

APPENDIX 2 LINE-UP OF FIRE WATER PUMPS AND MAINS - FIRE WATER PRESSURE CONTROL

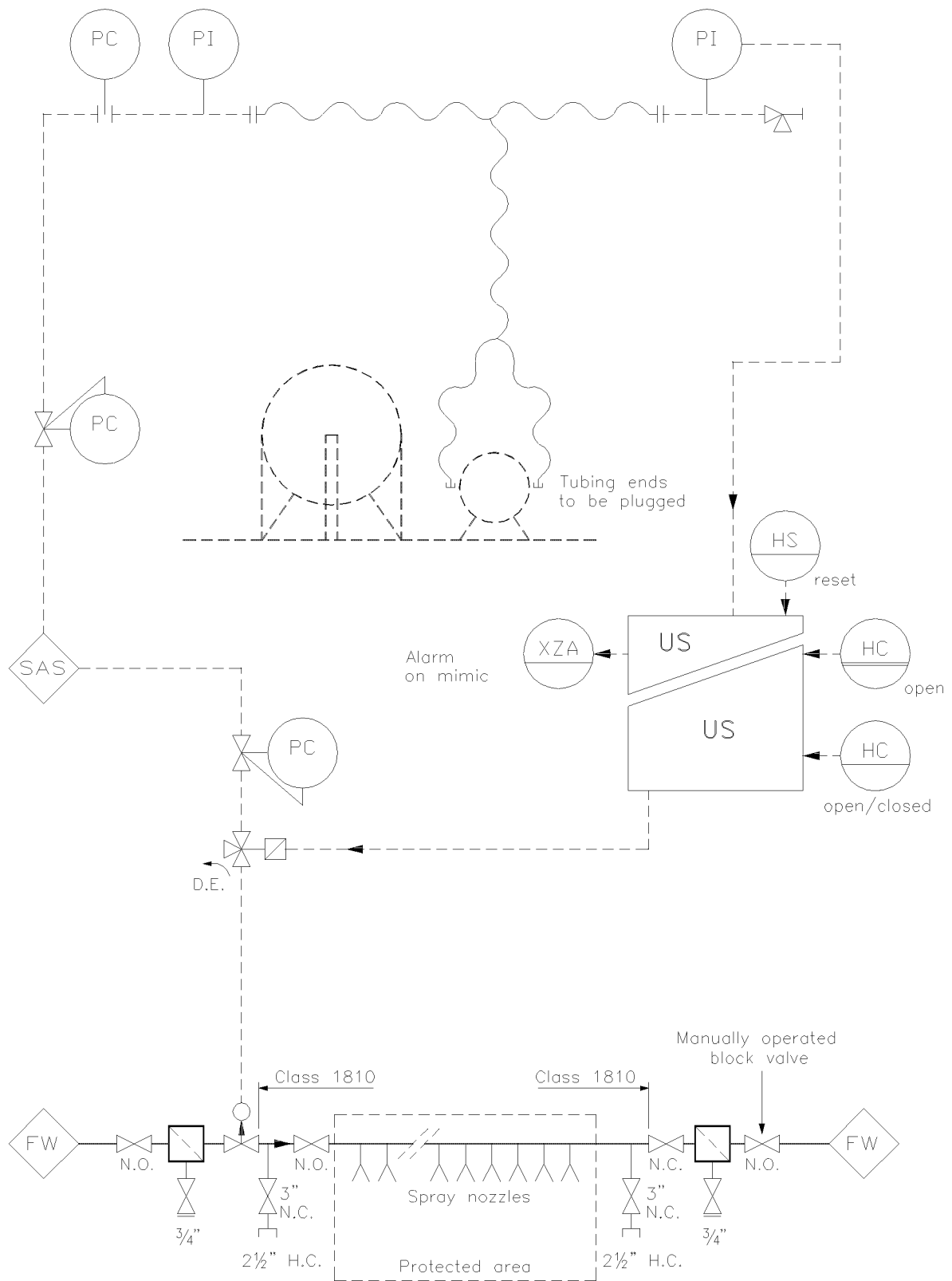


APPENDIX 3 TYPICAL SKETCH OF FIRE WATER DISTRIBUTION SYSTEM

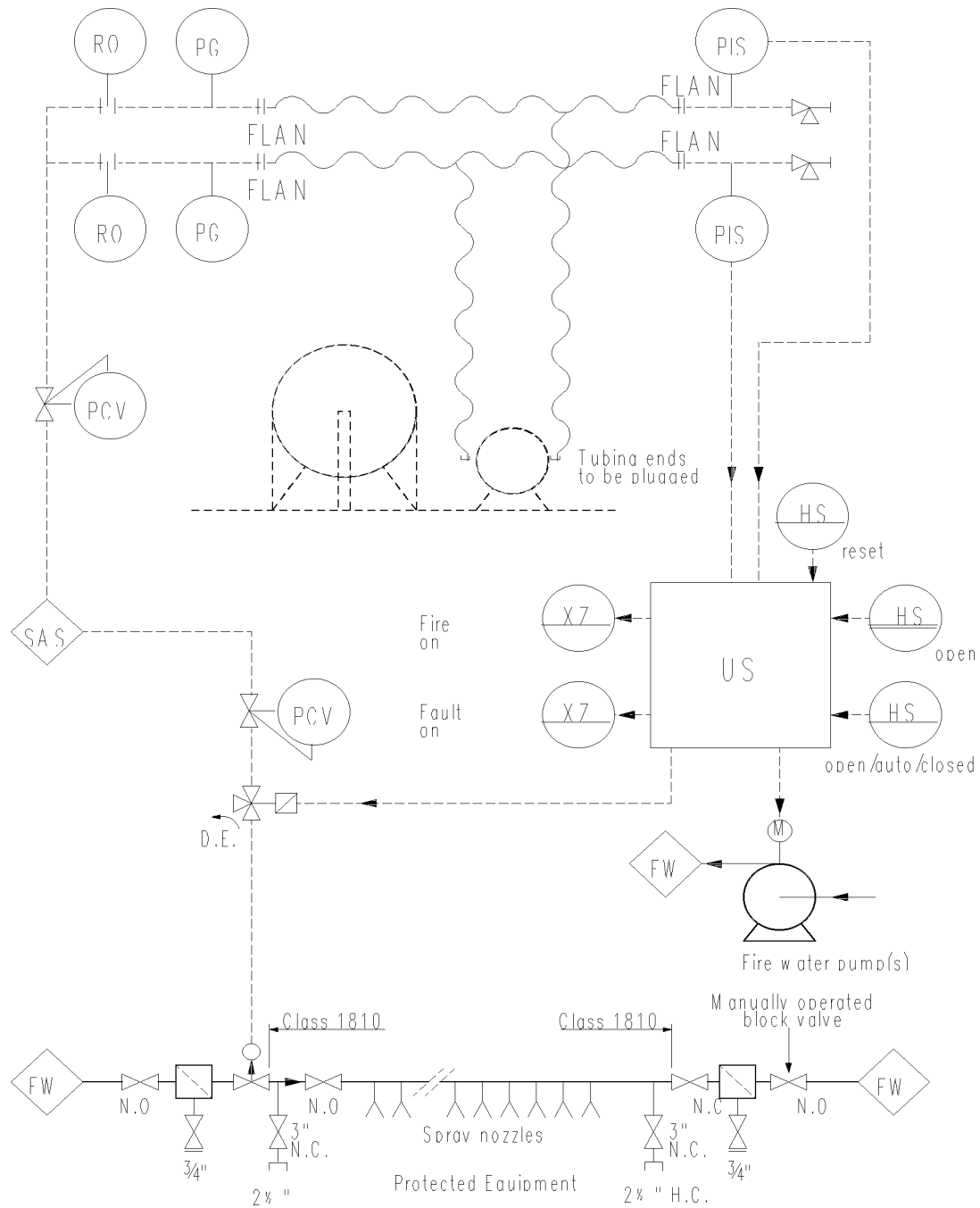


Note: Use hydrant/monitor combination wherever practical.

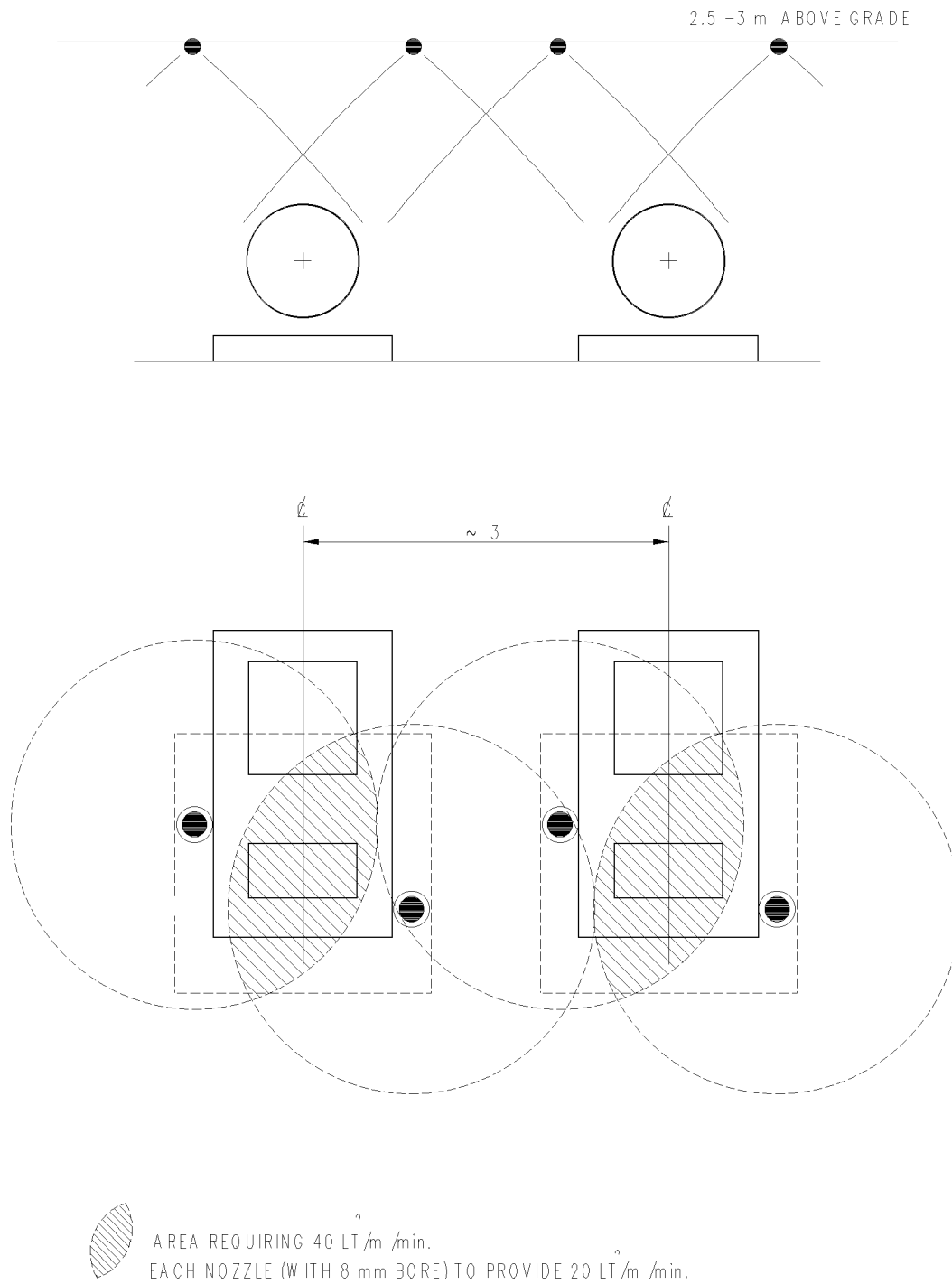
APPENDIX 4 TYPICAL SPRAY SYSTEM FOR FIRE PROTECTION OF EQUIPMENT



APPENDIX 5 AUTOMATED SPRAY SYSTEM FOR FIRE PROTECTION OF EQUIPMENT

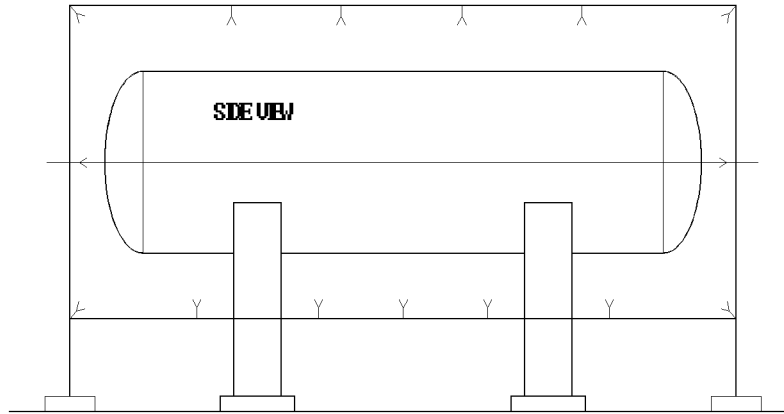


APPENDIX 6 TYPICAL SPRAY NOZZLE ARRANGEMENT FOR PUMPS

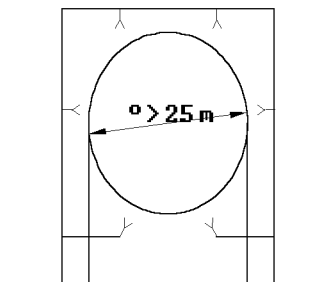
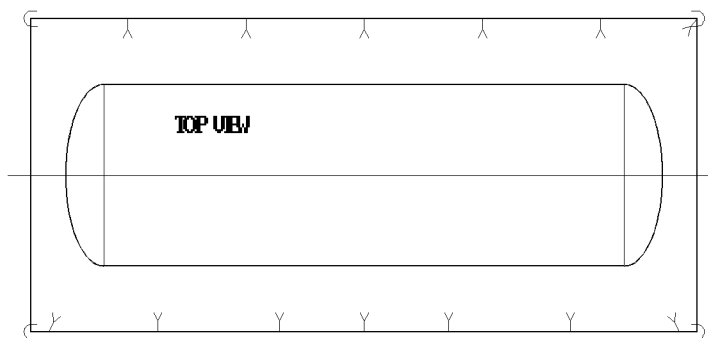
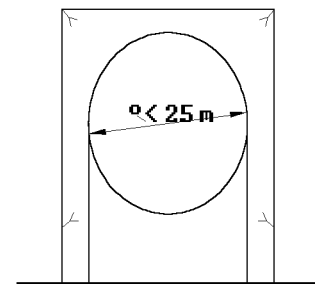
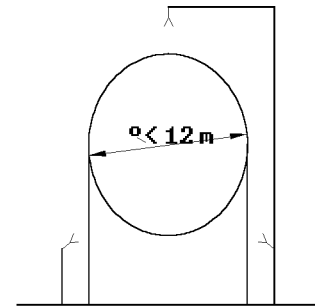


**APPENDIX 7 TYPICAL SPRAY NOZZLE ARRANGEMENT FOR HORIZONTAL VESSELS
AND HEAT EXCHANGERS**

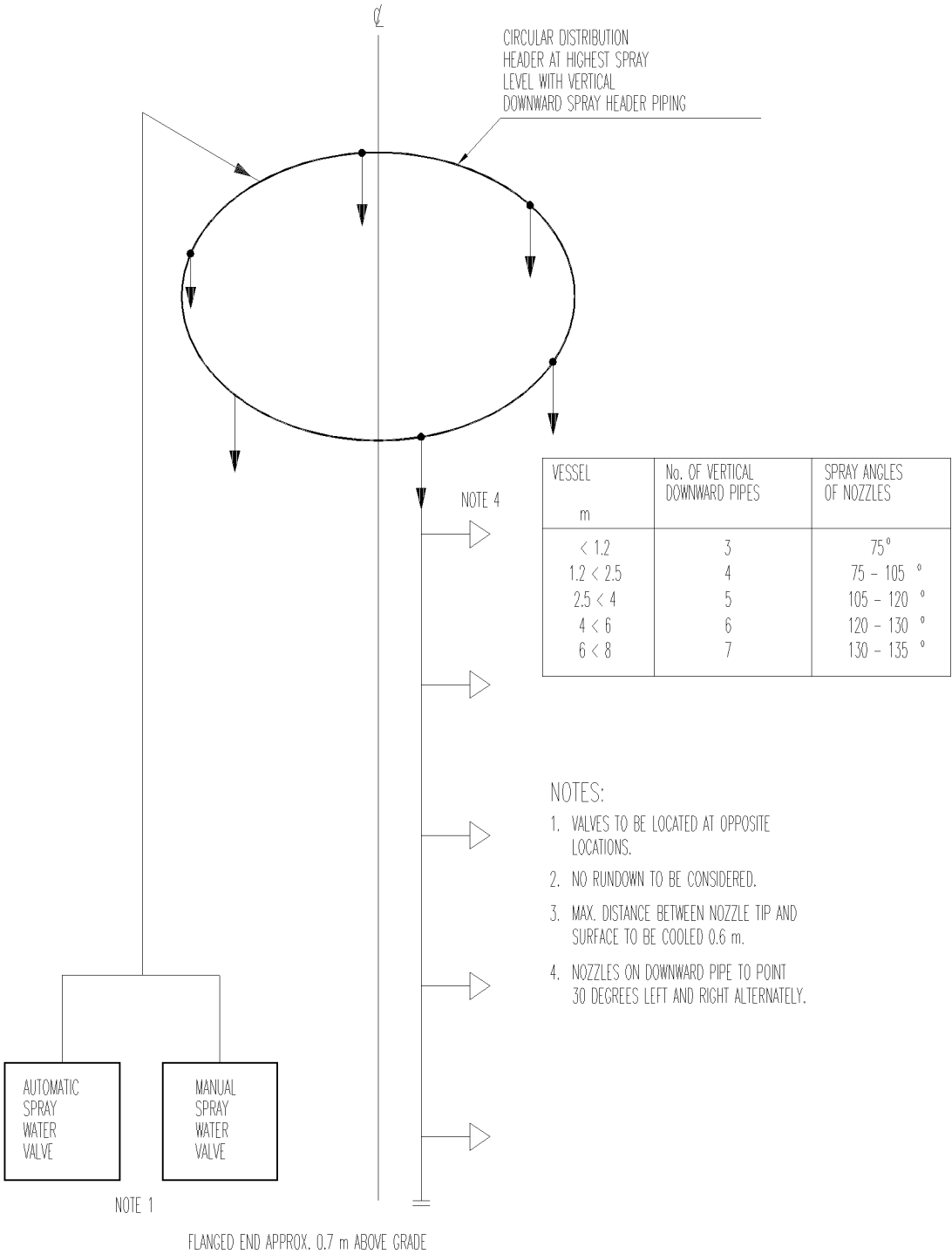
COMPLETE COVERAGE; NO RUNDOWN ALLOWANCE



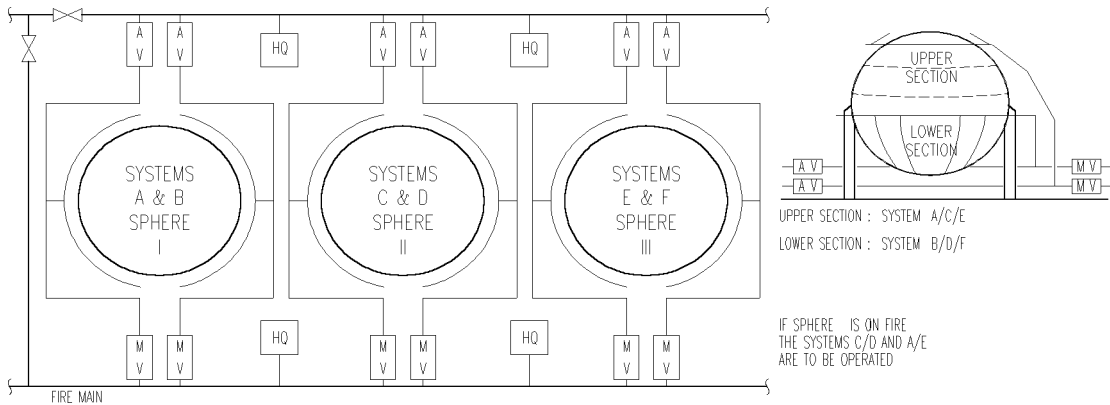
**STAGGERED NOZZLE ARRANGEMENT
4 SPRAY NOZZLE HEADERS FOR
VESSELS UP TO 25 m**



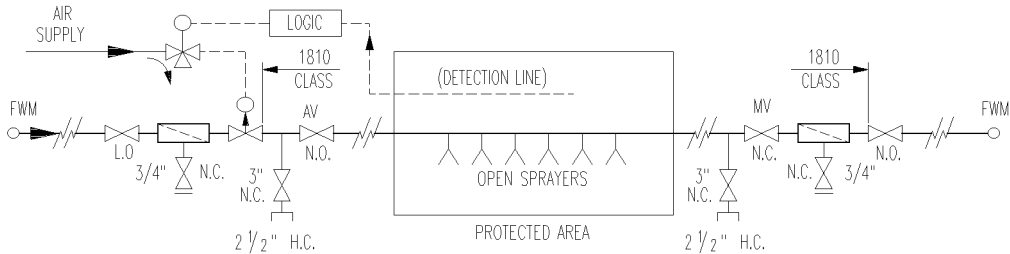
APPENDIX 8 **TYPICAL SPRAY NOZZLE ARRANGEMENT FOR VERTICAL VESSELS AND COLUMNS**



APPENDIX 9 TYPICAL (FULL COVERAGE) SPRAY SYSTEM FOR SPHERICAL TANKS



TYPICAL LPG STORAGE AREA SHOWING EXTENT AND CONNECTIONS OF WATER SPRAY SYSTEMS.
EACH SYSTEM IS TO PROTECT HALF OF A SPHERICAL PRESSURE VESSEL.



TYPICAL SCHEMATIC OF SPRAY SYSTEM (SEE ALSO APPENDICES 5 AND 6)

ABBREVIATIONS :

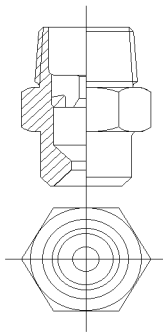
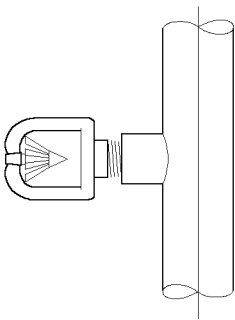
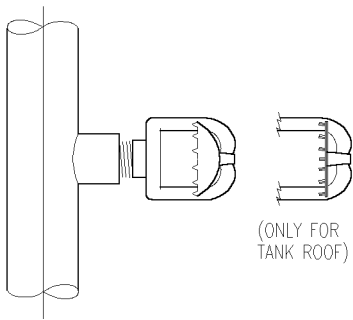
- A.V. : "AUTOMATIC" WATER SPRAY VALVE ASSEMBLY
- M.V. : MANUAL WATER SPRAY VALVE ASSEMBLY
- H.Q. : HYDRANT WITH FOUR VALVED OUTLETS
- H.C. : HOSE COUPLING
- FWM : FIRE WATER MAIN

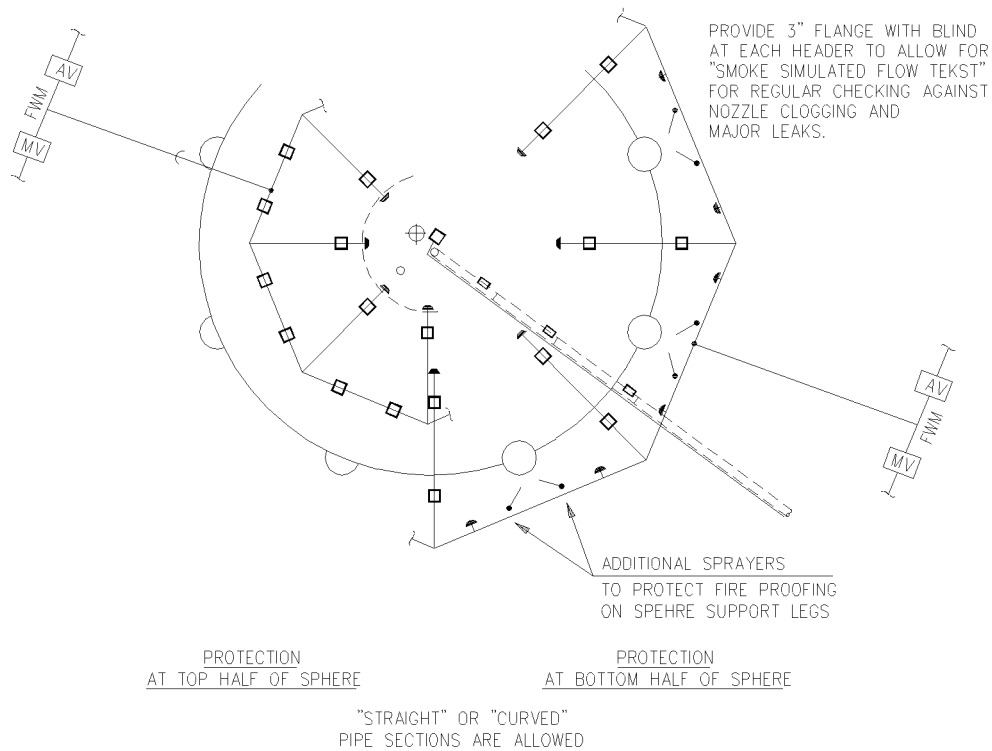
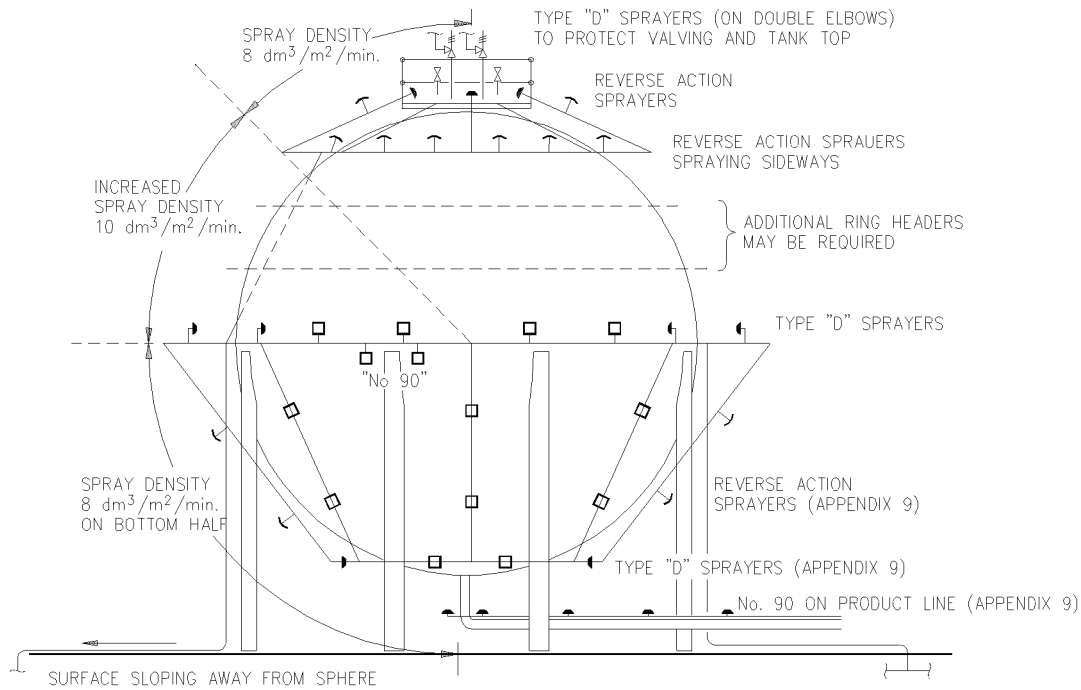
NOZZLE TYPES :

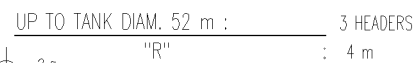
"REVERSE ACTION" WATER SPRAYERS

TYPE "D" WATER SPRAYER

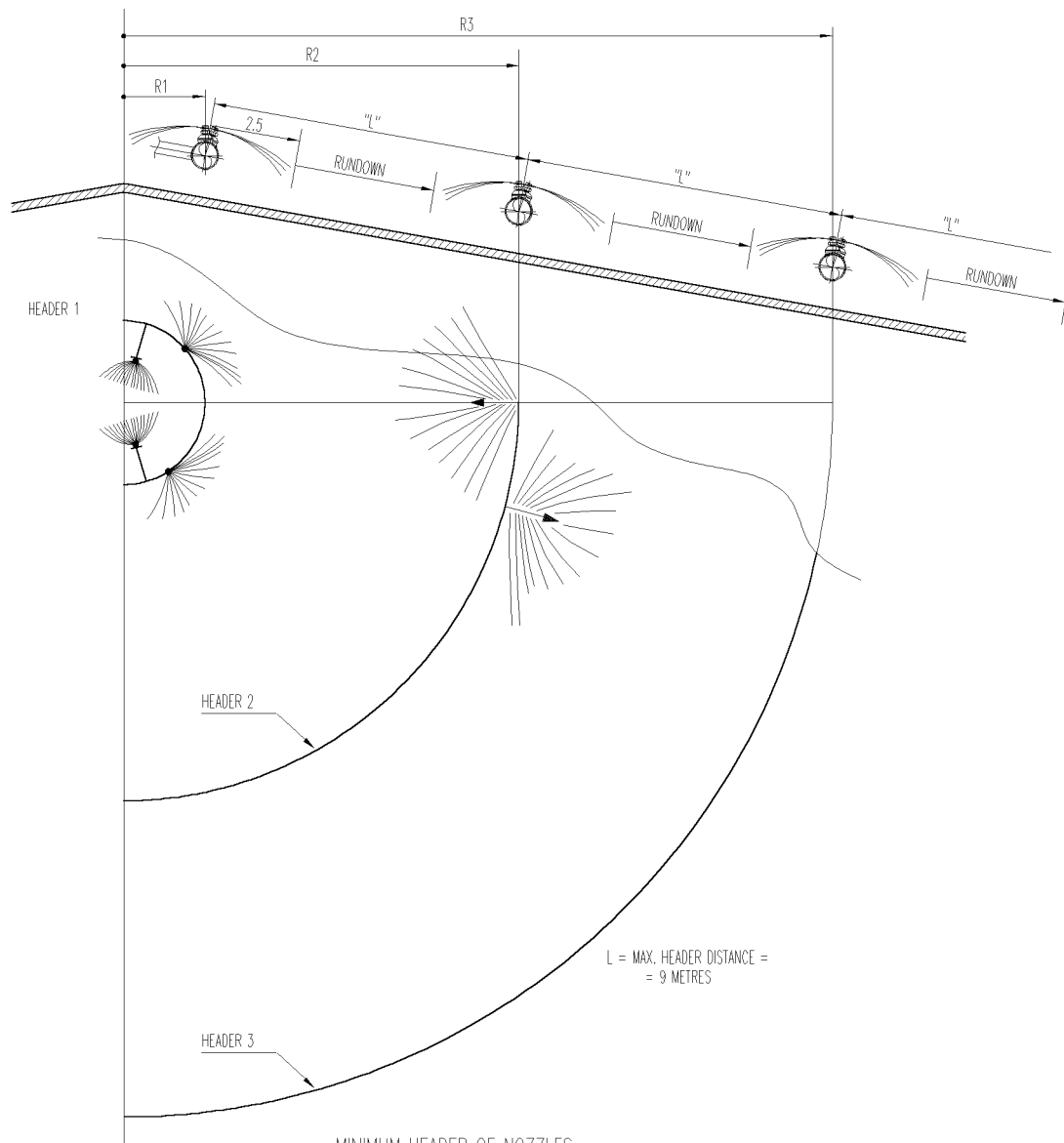
TYPE NO. 90 PROJECTOR



APPENDIX 10 SPHERICAL TANK SPRAY SYSTEM (FULL COVERAGE) DETAILS



APPENDIX 12 TYPICAL SPRAY NOZZLE ARRANGEMENT ON TANK ROOF SUPPLY HEADERS



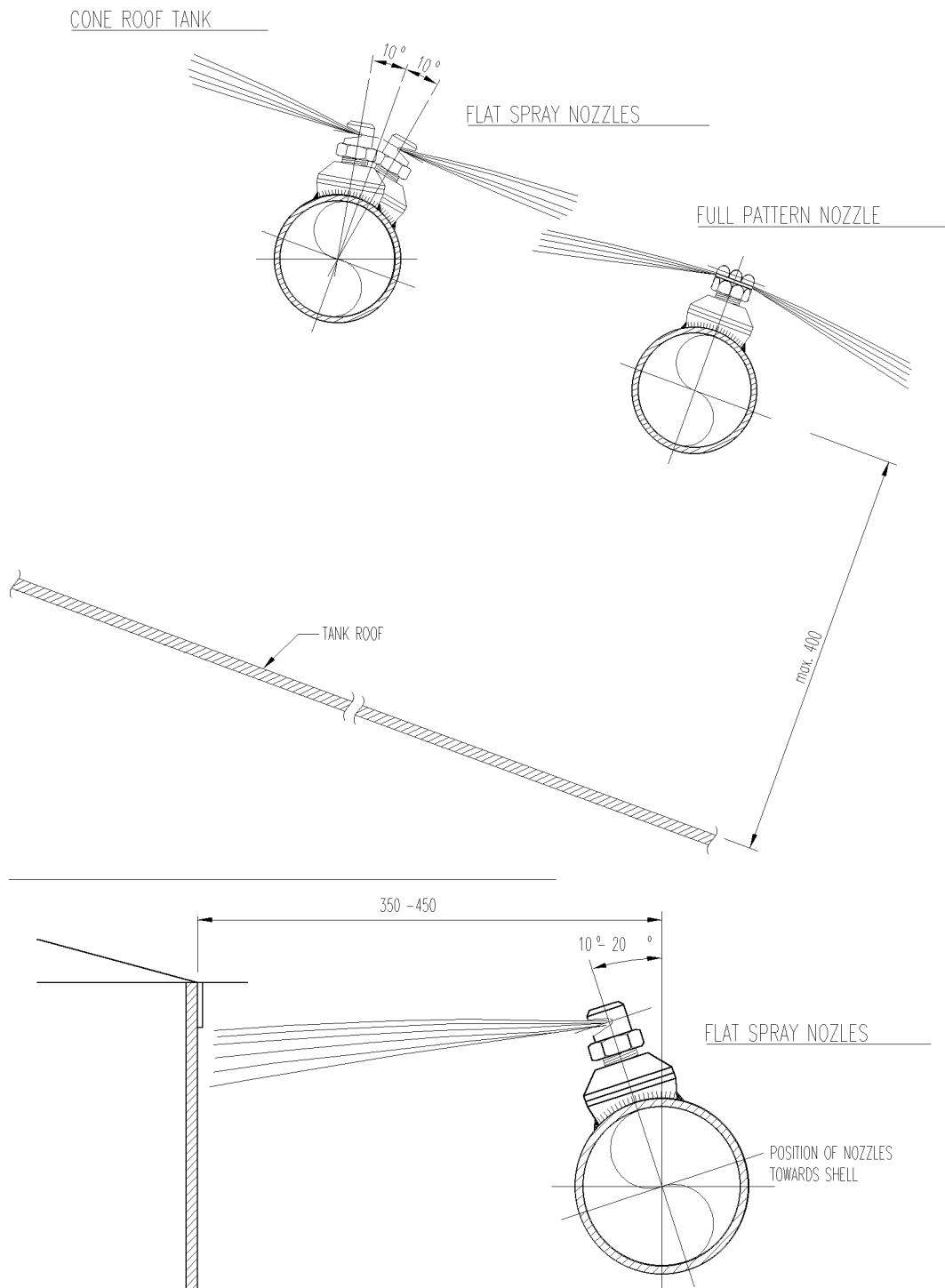
L = MAX. HEADER DISTANCE =
= 9 METRES

MINIMUM HEADER OF NOZZLES:

NOZZLE TYPE \ HEADER TYPE		HEADER 1	HEADER 2*	HEADER 3*
FLAT SPRAY	UPWARDS	3	9 - 12	18 - 24
	DOWNWARDS	6	12 - 16	24 - 30
FULL PATTERN		6	16 - 20	30 - 40

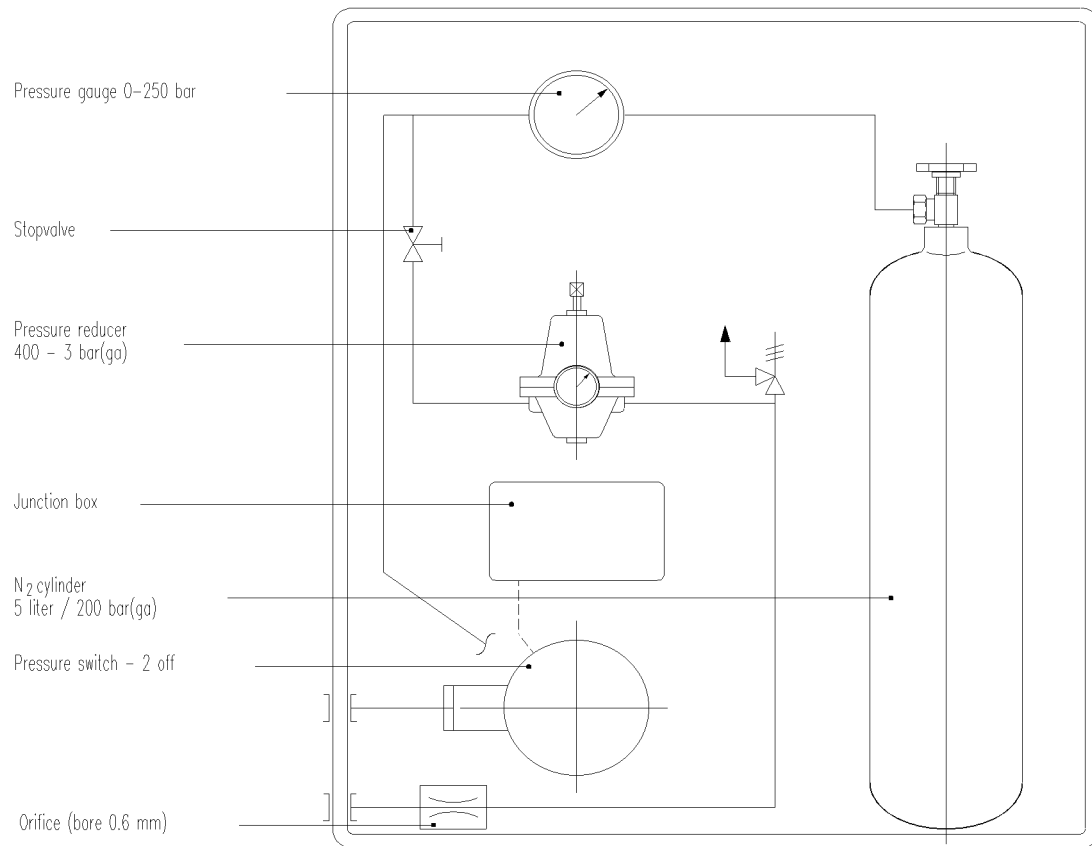
† No. OF NOZZLES DEPENDS ON HEADER DIAM.

APPENDIX 13 TANK SPRAY NOZZLE TYPICAL ARRANGEMENT

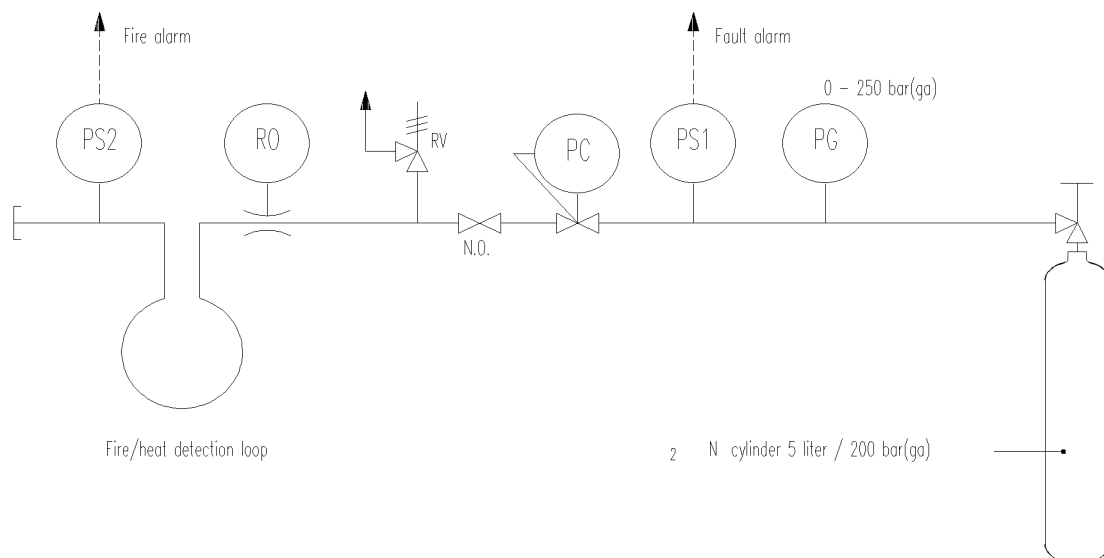


APPENDIX 14 NITROGEN UNIT FOR FIRE/HEAT DETECTION

EQUIPMENT ARRANGEMENT

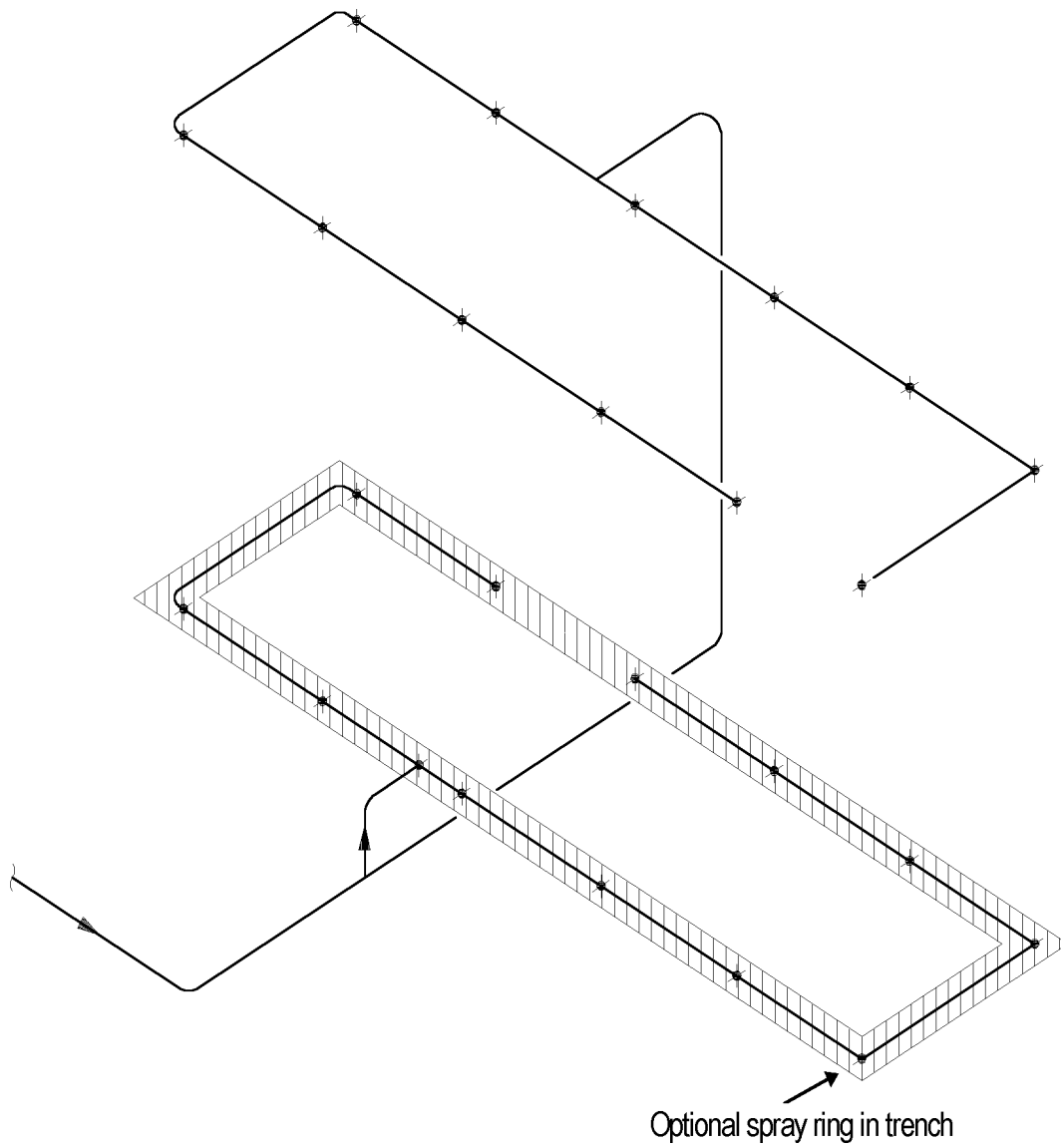


FLOW DIAGRAM

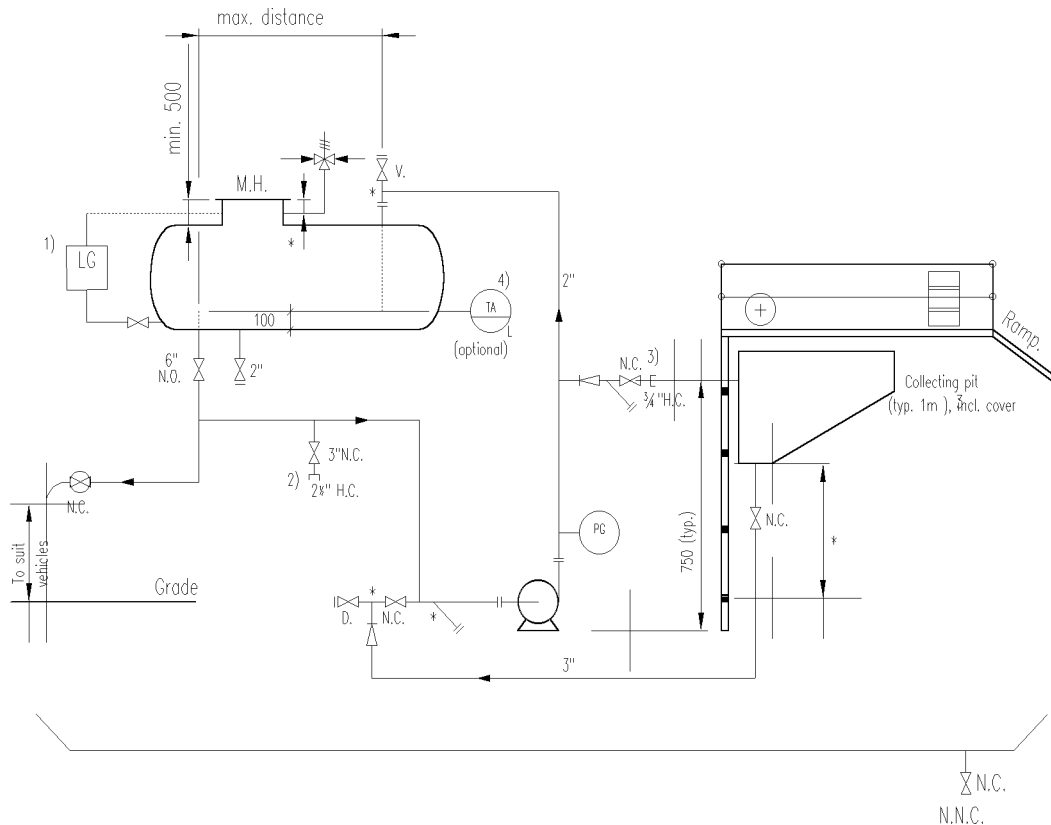


- ## APPENDIX 15 TYPICAL FOAM INDUCTION UNIT

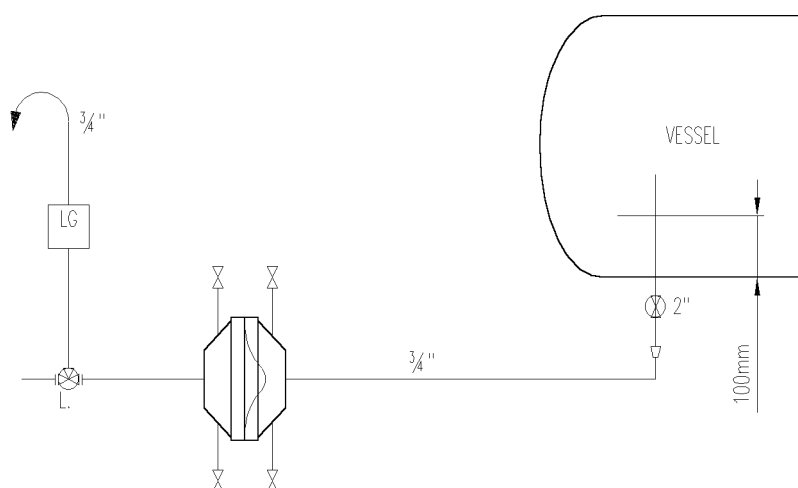
APPENDIX 16 FOAM-WATER SPRAY SYSTEM FOR LOADING GANTRIES



APPENDIX 17 TYPICAL FOAM CONCENTRATE STORAGE FACILITY

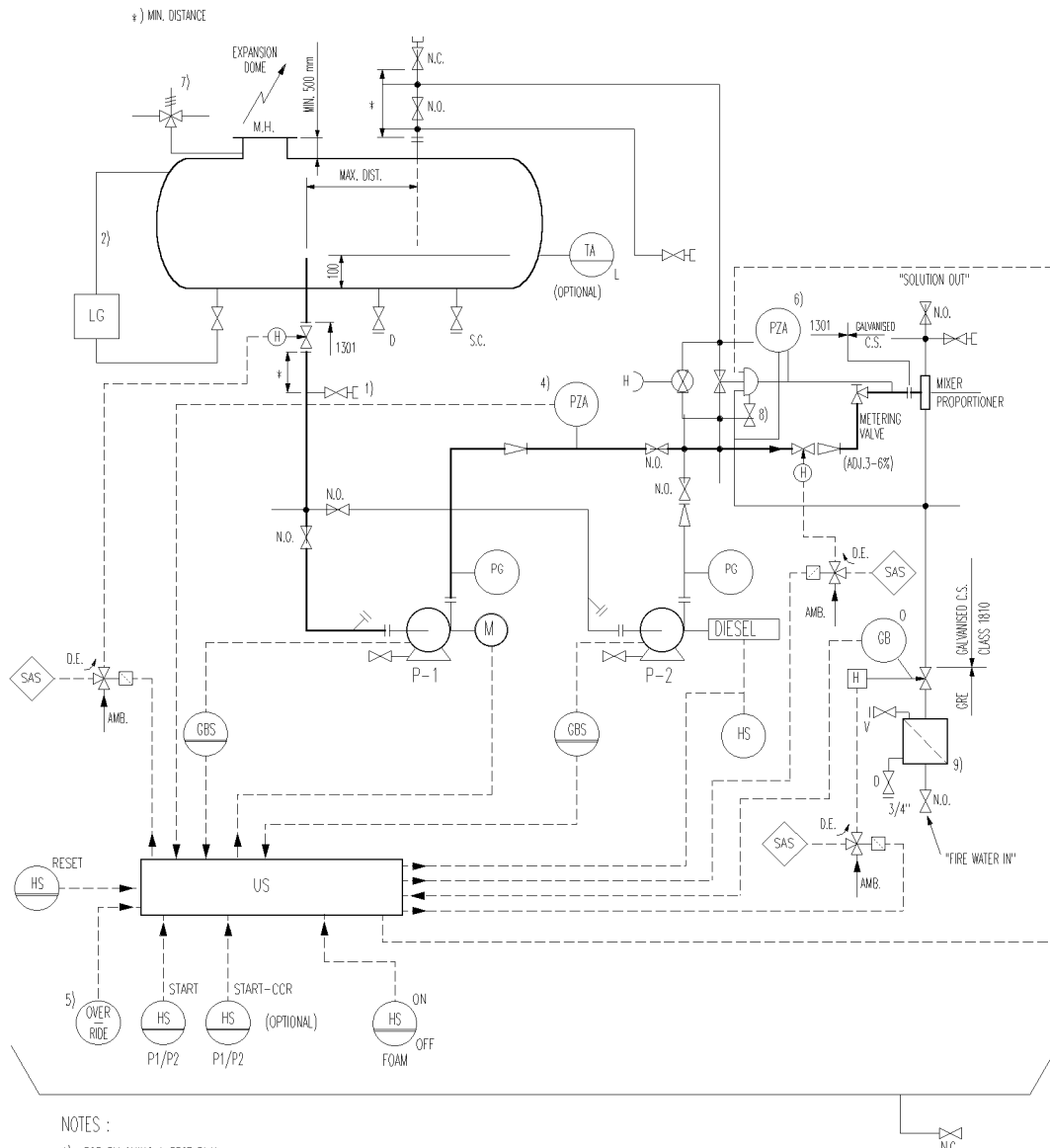


- *) Min. distance
- 1) Membrane type level gauge (see detail); vapour return only required for alternate magnetic type level gauge.
 - 2) Fire hose connection for storage vessel bulk loading & wheeled equipment filling.
 - 3) Topping-up.
 - 4) Only if tracing/heating is required.
 - 5) Level indication visible at pump control panel.

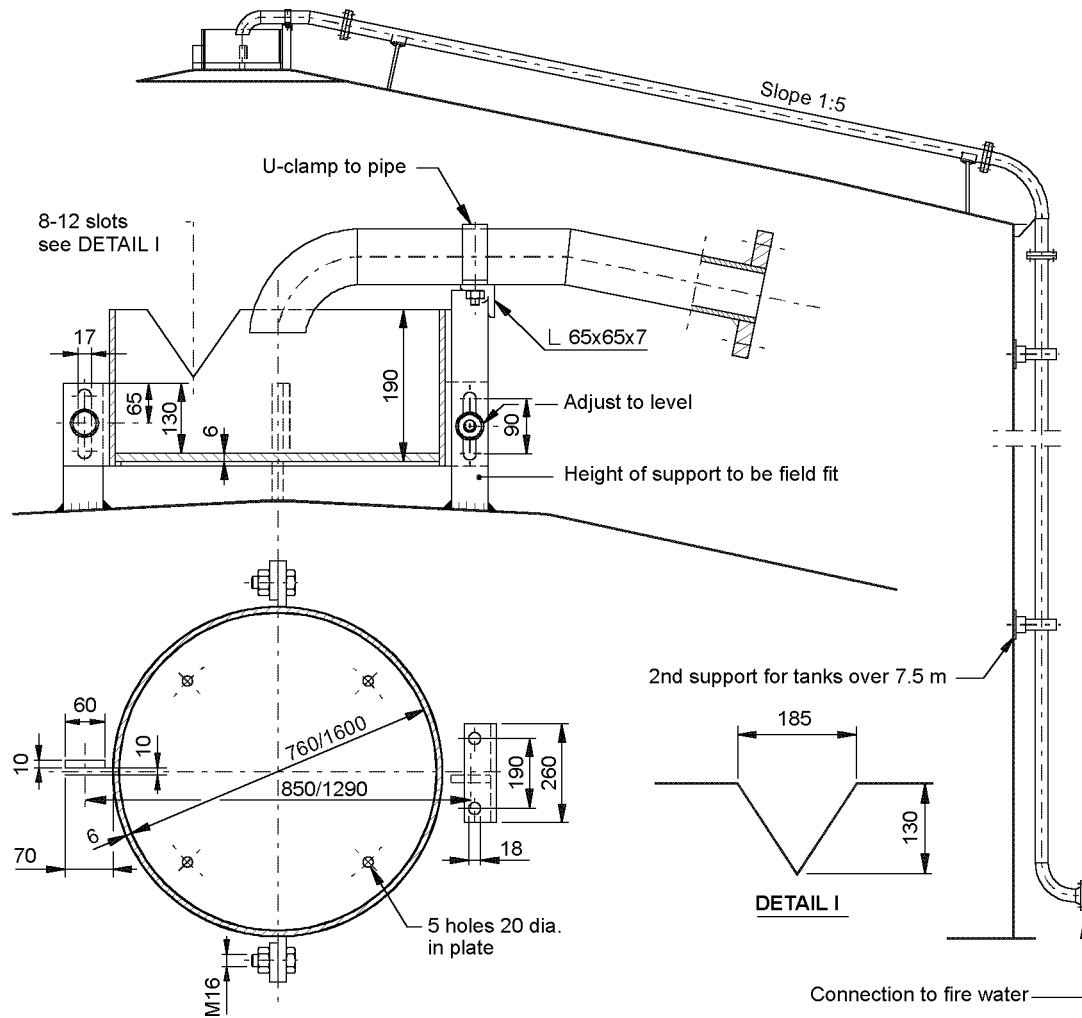


Detail typical membrane type level gauge

APPENDIX 18 TYPICAL FOAM STATION

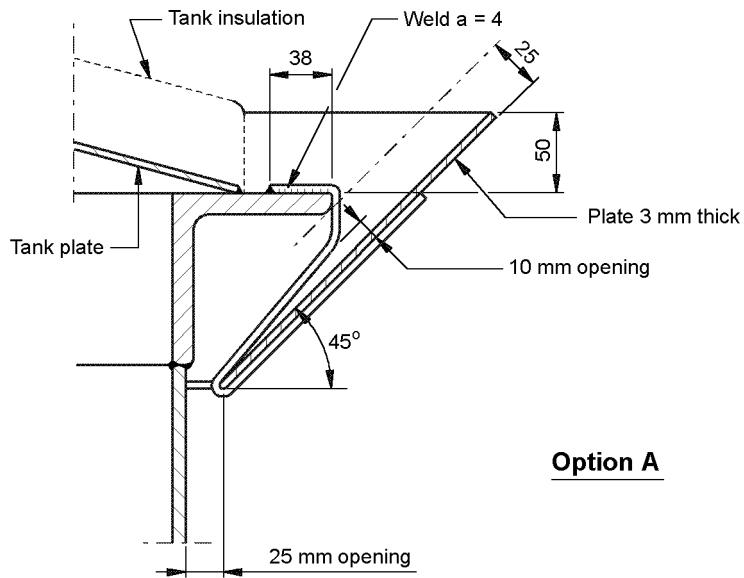


APPENDIX 19 TYPICAL WATER DRENCHING SYSTEM

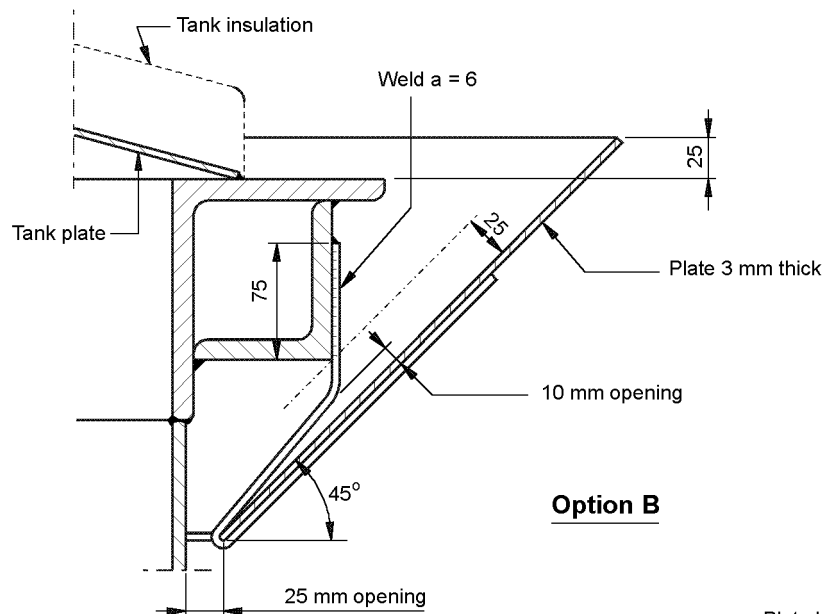


TANK DIAM. in m	Basin dia.	No slots	Q in m ³ /h	Pipe size
4.5	760	8	14.1	DN 50
6	760	8	18.8	DN 80
7.5	760	8	23.5	DN 80
9	760	8	28.2	DN 80
10.5	760	8	32.9	DN 80
12	1200	12	37.7	DN 100
18	1200	12	56.5	DN 100
24	1600	20	75.4	DN 150
36	1600	20	113	DN 150
42	1600	20	131.9	DN 150
48	1600	20	150.8	DN 150

APPENDIX 20 TYPICAL WATER DEFLECTOR FOR WATER DRENCHING SYSTEM



Option A



Option B

