MANUAL

ACTIVE FIRE PROTECTION SYSTEMS AND EQUIPMENT FOR ONSHORE FACILITIES

DEP 80.47.10.31-Gen.

June 1992
(DEP Circulars 64/97 and 41/99 have been incorporated)

DESIGN AND ENGINEERING PRACTICE

USED BY

COMPANIES OF THE ROYAL DUTCH/SHELL GROUP

PREFACE

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They are based on the experience acquired during their involvement with the design, construction, operation and maintenance of processing units and facilities, and they are supplemented with the experience of Group Operating companies. Where appropriate they are based on, or reference is made to, national and international standards and codes of practice.

The objective is to set the recommended standard for good design and engineering practice applied by Group companies operating an oil refinery, gas handling installation, chemical plant, oil and gas production facility, or any other such facility, and thereby to achieve maximum technical and economic benefit from standardization.

The information set forth in these publications is provided to users for their consideration and decision to implement. This is of particular importance where DEPs may not cover every requirement or diversity of condition at each locality. The system of DEPs is expected to be sufficiently flexible to allow individual operating companies to adapt the information set forth in DEPs to their own environment and requirements.

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NOTE: In addition to DEP publications there are Standard Specifications and Draft DEPs for Development (DDDs). DDDs generally introduce new procedures or techniques that will probably need updating as further experience develops during their use. The above requirements for distribution and use of DEPs are also applicable to Standard Specifications and DDDs. Standard Specifications and DDDs will gradually be replaced by DEPs.

TABLE OF CONTENTS

APPENDICES

1. INTRODUCTION

1.1 SCOPE

This DEP gives guidelines and minimum requirements for active fire protection systems and equipment, which should be used for the design and engineering of fire protection and fire-control/extinguishing facilities for application in onshore oil and gas processing, petrochemical installations, storage facilities, jetties, terminals, loading and unloading facilities.

The contents of this publication have been structured into stand-alone sections for each application to provide complete packages of information for the intended user.

For clarity, a distinction is made between policy matters (case by case justification of fire safety provisions, including tolerability of risk level) and hardware requirements (how each application shall be engineered and operated). This DEP covers the hardware requirements. With this issue of DEP 80.47.10.31-Gen., the hardware requirements stated in DEP 80.47.10.30-Gen. (issue April 1985) shall be considered obsolete. In future it is expected that DEP 80.47.10.30.-Gen. will specifically cover the policy aspects of fire safety for MF facilities EP55000-23 will cover the policy aspects for EP facilities.

Although primarily intended for new construction, the requirements of this manual can also be applied for existing plants when the need is expressed for improvements to fire protection systems. When modifications and extensions to existing plants are envisaged, fire protection aspects shall always be considered and existing facilities improved where necessary. In addition, the updating of fire-fighting training grounds is strongly recommended when they no longer provide the facilities for the required level of training.

For matters not included, the National Fire Code of the US National Fire Protection Association (NFPA) shall be consulted.

1.2 DISTRIBUTION, APPLICABILITY AND REGULATORY CONSIDERATIONS

Unless otherwise authorised by SIPM, 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.

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

For the purposes of this DEP, the following definitions apply:

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** 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 and abbreviations

Active fire protection: a "dormant" system that requires to be activated in order to perform its function.

Combustible product: a medium having a flash point of ≥ 37.8°C.

Deluge system: a fire protection system where the supply valve is activated by a separate detection system installed in the same area. The water distribution piping system is normally equipped with sprayers and/or open sprinklers.

Fire area: a plant (surface) area where a sustained and intense fire is considered credible.

Flammable product: a medium having a flash point below 37.8°C and a maximum vapour pressure of 276 kPa (abs) at 37.8°C.

Masterplan fire-fighting systems: a drawing covering the entire installation (location) on which all fire-detection and fire-protection systems (fixed, mobile and portable) are indicated.

Passive fire protection: a system that performs its function without relying on the requirement of activation.

Prevailing wind: the direction from which the wind is originating, having the highest percentage of occurrence based on local meteorological observations.

Sprayer: a discharge device directing most of the discharged water in a pattern peculiar to the particular discharge device.

Sprinkler: a discharge device directing most of the discharged water in a downwards direction.

Sprinkler system: a fire protection system consisting of at least one water supply and a distribution piping system normally equipped with closed sprinklers. A closed sprinkler is activated by the heat from a fire melting an integrated frangible element.

Water spray system: a fire protection system where the water supply valve is manually or automatically activated. The water distribution piping is normally equipped with sprayers (= water spray nozzles).

The following abbreviations are used throughout this DEP:

ANSI	-	American National Standards Institute
BLEVE	-	Boiling Liquid Expanding Vapour Explosion
BS	-	British Standard
DEP	-	Design and Engineering Practice
FM	-	Factory Mutual

HBPG	-	High Back Pressure foam Generator
LNG	-	Liquefied Natural Gas
LPG	-	Liquefied Petroleum Gas
MESC	-	Material and Equipment Standards and Code
MIL	-	Military Standard (USA)
NFPA	-	National Fire Protection Association
TSO	-	Tight Shut Off
UL	-	Underwriter's Laboratories

1.4 CROSS REFERENCES

Where cross references are made, the number of the section or sub-section referred to is shown in brackets.

All publications referred to in this document are listed in (4).

2. EXTINGUISHING SYSTEMS

2.1 FIRE WATER SYSTEM

(a) Purpose

The purpose of a fire water 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, when necessary. In some cases water may mitigate a gas release.

(b) Design

Generally, a fire water system comprises the following :

- fire water storage or fire water sourced from open water or wells
- fire water pumps
- fire water mains
- fire water hydrants.

For material selection no distinction is made between brackish and salt water systems.

2.1.1 Fire water storage

(a) Purpose

If uninterrupted supply of fire water from open water, wells or a third party fire main cannot be guaranteed at the required rate, pressure and duration, a dedicated fire water storage facility shall be provided.

(b) Location

Dedicated fire water storage facilities (and fire water pumps) shall be located off plot in an area, normally within the property fence, at least 50 to 100 metres away from credible fire areas.

Pump heads and/or pipe sizes shall be selected to ensure correct quantity and pressures at the furthest take off point.

(c) Operation

Fire water storage facilities shall contain sufficient water for at least six hours uninterrupted water supply at the required maximum water demand of the fire water pump(s). The replenishment rate should not be less than 60% of the maximum fire water pump capacity to provide minimum 10 hours water supply.

If a secure alternative water supply is available (e.g. well water tank) the fire water storage requirement may be reduced accordingly.

In order to allow inspection and maintenance of water storage facilities, back-up shall be provided. A single (minimum 100%) storage facility may be used only if a minimum 100% secure alternative water source is available (e.g. from the cooling water system) If this is not available then two storage facilities shall be provided as follows:

either	2 * 100%	if there is not a temporarily available supply;
or	2 * Y%	if there is a temporarily available supply of at least (100 - Y)%. In any case, Y shall not be less than 60.

(d) Design

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

(i) Closed type storage

Metallic fixed roof tanks are preferred. Generally, closed non-metallic or concrete structures are not cost effective. Closed type 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 type storage

Three types of open storage are distinguished:
- membrane-lined earthen bundwall basin (Refer to Appendix 1),
- concrete basin,
- metallic tanks.

To avoid personnel from drowning, 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.

Tanks shall be in accordance with 2.1.1.d (i)

(iii) Additional requirements
The suction facilities for the fire water pumps and the replenishment system shall include easy-to-clean strainer facilities.

A panel mounted low level alarm, set at 80% of the maximum filling level, shall be incorporated.

The maximum filling level shall be provided with an overflow.

The water quality may require that provisions are made for hypochlorite injection to control the growth of algae.

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

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

A tie-in facility shall be provided to allow hypochlorite injection for prevention of algae growth.

2.1.2 Fire water pumps

(a) Purpose

The main purpose of fire water pumps is to serve as a means to transport water through a fire mains system such that the water is delivered at the specific point and time at the required quantity and pressure. For this purpose a back-up facility is required to ensure supply under abnormal (power failure) conditions.

(b) Location

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

The avoidance of common mode failures (e.g. fire in the fire water pump house) shall be addressed in the design.

(c) Design

The maximum (rated) pump pressure shall be based on a minimum pressure of 10 bar(ga) at the furthest take-off point under full flow conditions. As pumps are an essential part of the installation's vital fire-fighting system, spare pumps are required. Apart from the main (normally electric driven) pump, two diesel-driven pumps shall be installed to provide a totally reliable and secure fire water supply under all circumstances.

The three pumps should be identical and their individual rated capacity shall be at least 60% of the largest fire water demand. If tie-in facilities are available for the hook-up of a 100% temporary (diesel-driven) pump, two 100% (largest required fire water capacity) pumps may be installed of which at least one is equipped with a diesel drive.

Individual pump capacity shall not exceed 1000 m^3/h unless suitable handling and maintenance facilities are available. If the required pump capacity would exceed 1000 m^3/h, two or more smaller pumps shall be installed, together with an adequate number of spare pumps.

Fire water pumps shall be of the submerged vertical type when taking suction from open water, and of the horizontal, between bearings, type when suction is taken from a storage tank.

The power for all the drivers shall be rated such that it is possible to start each pump against a closed discharge valve with a fire mains pressure ranging between 2 and 16 bar(ga). Electric power shall be from the essential supply system (refer to DEP 33.64.10.10-Gen.). For additional requirements of diesel drives, refer to 2.1.2(f).

Pumps and drives shall comply with the requirements of DEP 31.29.02.11-Gen. and NFPA-20 (which includes that the driver cope with 150% pump capacity at 0.65 times the maximum head).

Pump suctions should be provided with an easy-to-clean inlet screen. If individual pump inlet strainers are difficult to maintain, 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 ring main system by two separate lines, each of the same size as the ring main and each equipped with a block valve.

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.

(d) Operation

The main (stand-by) fire water pump shall be provided with automatic starting facilities which will function immediately the fire alarm system activates for any of the following causes :

- when a fire call point is activated;
- when an automatic fire detection system is activated;
- when the pressure in the fire water ring main system falls below the minimum required static pressure which is normally 2 to 3 bar(ga).

The back-up fire water pumps shall be provided with automatic starting facilities which will function if the main fire water pump does not start or, having started, fails to build up the required pressure in the fire water ring main system within 20 seconds.

Manual starting of each pump unit (without the fire alarms coming into operation) 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.

Upon start-up of the fire water pump, over-pressurization of the common manifold and fire mains is avoided by applying the asymmetric split range principle on the pressure indicator controller (see Appendix 2).

For safe handling of hand-held fire hoses, the pressure indicating controller shall keep the fire water pressure within acceptable limits (typically max. 7 bar(ga) for a 1½ inch hose). In the "stand-by situation" the controller is set at 6 bar(ga); if necessary the pressure can be increased at the request of the fire-fighter commander. Adjustment of the pressure indicator controller's set point shall be done from the control panel in the control centre.

Stopping the pump (e.g. after testing or operational use), shall return the logic system to the automatic starting position. This "auto start" position shall be indicated as "Auto-start stand-by" on the control room panel.

(e) Material selection

Piping components and materials shall comply with DEP 31.38.01.10-Gen.

Diesel storage vessels shall be made from carbon steel (refer to DEP 30.10.02.11-Gen.).

(f) Diesel drive and diesel storage

A clutch shall not be installed between a diesel drive and a fire water pump.

Diesel drives shall be installed and field inspected in accordance with DEP 31.29.00.10-Gen., DEP 61.10.08.11-Gen. and NFPA-20.

For diesel engines, the following additional requirements shall also apply :

- the capacity of each fuel tank shall be such that the engine can operate on full power for at least 24 hours;
- the tank shall be installed at a safe distance from the engine, with the bottom at least 0.2 m above the suction valve of the fuel injection pump;
- the tank shall be provided with a sump, an expansion dome, a level gauge and a low-level alarm set at the level: "2-hour fuel remaining";
- the tank shall be provided with facilities and hose connections for refilling directly from drums.

In areas where freezing may occur, the entire diesel storage and supply system shall be heat-traced to avoid wax formation.

2.1.3 Fire water mains

(a) Purpose

Fire-water mains serve to transport water from the fire-water pumps to the required area.

(b) Location

Fire-water mains shall be 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 should be installed at close proximity to access facilities where fire-fighting equipment can be hooked-up.

Fire-water mains should be laid underground in order to provide a safe and secure system; installation under heavy duty paving or heavy goods vehicle's access roads shall be avoided. In areas where the ambient temperature can drop below 0°C, installation underground will protect against freezing. The required depth of the ring main system depends on local conditions. Where applicable, the water level in the mains (and in the hydrant branch connection) shall be at least below the local frost level. In areas accessible to traffic with dead weight over 3.5 tons and at road crossings, water mains shall not be less than 1 m below ground level. Refer to DEP 31.38.01.11-Gen.

When, in exceptional circumstances, fire-water mains are installed above ground they shall not be laid in pipe tracks where they could be at risk from spill fires. Aboveground fire mains should be installed in such a manner that the possibility of physical damage is minimised.

(c) Design

In order to ensure that the required capacity and pressure can be maintained at all times, a ring main system shall be provided (see Appendix 3).

Fire-water ring main systems shall be equipped with hydrants, see (2.1.4).

A surge analysis of the fire water system shall be performed and, where required, surge protection devices shall be provided.

Large areas shall be subdivided into smaller sections, each enclosed by fire-water mains equipped with hydrants and block valves. Such interconnections shall also be laid along plant roads.

A single fire-water line is acceptable for a fire-fighting training ground.

The fire-water lines from the fire pumps to a jetty shall be provided with isolating valves for closing in the event of serious damage to the jetty. These valves shall close without causing excessive surge pressures.

Block valves shall be incorporated in the ring main system so that sections can be isolated for maintenance, etc. These sections shall be selected so that the required quantity of water for the isolated area 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 may be indicated by the rising spindles of the valves, or the valves may be fitted with position indicators.

The fire-water ring main pressure shall be such that under fire conditions, a pressure of 10 bar(ga) exists at the most remote location under the required design flow conditions; the maximum allowable velocity in the system is 3.5 m/s to prevent surging at these conditions. The fire-water mains network 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 when 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 network.

The ring main shall be kept pressurised at typically 2 to 3 bar (ga).

If a jockey pump is used to keep the ring mains pressurized, it shall be backed up by a spare jockey pump; both pumps shall have a capacity of 15 m^3/h to compensate for leakages. If the jockey pumps are also to be used for providing plant service water, then each pump shall have a capacity of at least 30 m^3/h. In all cases the pressurizing facilities shall be designed for the discharge pressure of the fire water pumps.

(d) Material selection

The pipeline material for installation underground shall be glass-fibre reinforced epoxy with rubber seal lock joints or flanged connections in accordance with DEP 31.38.70.37-Gen. and DEP 31.38.01.12-Gen. (class 1712 for salt/brackish water, class 1710 for fresh water). The installation of GRE piping shall be supervised by the supplier of the piping.

For aboveground piping material selection advice shall be obtained from the Principal.

(e) Operation

Under non-fire conditions the system shall be kept full of water and at a pressure of 2 to 3 bar(ga) by means of either a jockey pump, a connection to the cooling water supply system, or by static head from a water storage tank. The fire mains pressure controller(s), fitted with a minimum stop for control purposes, shall be in the "closed" position (see Appendix 2)

Upon manual or automatic activation, a pulse signal will be generated to start the stand-by fire pump. If the ring main pressure has not reached 5.5 bar (ga) within 20 seconds after the pulse has been generated, another pulse shall be sent to start the back-up fire-water pump.

The ring main pressure will tend to rise to the set pressure of the pumps' minimum flow controller. This rise in pressure may occur rapidly in case of zero or relatively small flows for hand-held equipment, usually during training sessions. To ensure safety of personnel

under all conditions, a split-range spill-back pressure controller shall be installed.
Thirty seconds after the first starting signal has been generated, the fire-mains pressure controller will be set to 6 bar (ga) automatically. In the central control room a panel-mounted facility shall be provided to adjust the fire-mains set pressure at the request of the leading fire fighter.

The fire-water mains shall be provided with full bore valved flushing connections 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.

2.1.4 Hydrants

(a) Purpose

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

(b) Location

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

-	around process units, LPG bottle-filling plants and loading/unloading facilities	60m
-	around storage facilities	80 m
-	alongside pipe tracks	80 m
-	around storage and pumping facilities for LPG and LNG	60 m
-	around utility areas, offices, workshops, laboratories, jetty approaches, etc.	80m

Hydrants shall be readily accessible from roads and be located in such a way that possible damage by road traffic will be minimized. 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 kerb of the road, and at least 10 m from road crossings, sharp road curves, and buildings or other structures.

(c) Design

Hydrants with four (4) outlets shall be provided for:
- around processing units/areas,
- loading/unloading facilities,
- LPG bottle filling plants,
- storage facilities for flammable liquids, LPG and LNG
- jetty heads/berths.

Hydrants with two (2) outlets shall be installed around all other areas, e.g.:
- jetty approaches,
- warehouses
- workshops,
- laboratories,
- offices,
- utilities
- training grounds.

All hydrants around process plant shall be of the type suitable to mount stationary monitors (see 3.2.4). This shall also be considered for other specific locations.

Each hydrant shall be provided with a hard-paved grade.

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:
- Storz (which is preferred);
- 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 for 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. This shall be indicated in the project specification. The drain valves shall have drain holes of minimum size 8 mm and total free area of at least 200 mm^2. Location of the drains shall be such 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 Drawing(s) for:

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 Drawing(s) for:

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

(d) Material selection

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. (class 1803). Further requirements are specified on Standard Drawings as referred to in (c) above.

2.1.5 Dry Risers

(a) Purpose and Location

Dry risers are required to facilitate the supply of water (or foam solution) to portable fire-fighting equipment at all levels of multi-story structures and buildings. For dry risers on floating roof tanks, see 2.4.1.1.

(b) Operation

Dry risers shall only be used after careful consideration has been given to the safety aspects involved in sending personnel to a particular level under emergency conditions.

Dry risers provide a quick means to supply water, foam solution and foam to an elevated area. This requires that hose boxes, containing hand-held equipment plus fire hoses, shall be installed at all floor levels (refer to DEP 80.47.10.32-Gen.).

(c) Design

Dry risers shall be installed near stairways (both the main access route as well as the alternative/emergency access route).

At ground floor level a two-way flapper valve ("collecting breeching") shall be permanently installed while near each landing two hydrant valves (for type and size, see 2.1.4) are required 0.7 m above floor level. Single-valve arrangements will normally suffice for office buildings.

Dry riser inlets and outlets shall be equipped with standard hose connections for fire hoses (see 2.1.4). An automatic vent is required at the highest point.

(d) Material selection

Dry risers shall be made from flanged carbon steel pipe to be hot-dip galvanized after fabrication (DEP 31.38.01.12-Gen. class 1810).

For hydrant valves, refer to (2.1.4).

2.2 WATER SPRAY SYSTEM

2.2.1 Water spray protection for cooling purposes: Pump protection.

(a) Purpose

Pumps handling LNG, LPG and products near their auto-ignition temperature shall be protected by water spray, not only to suppress and possibly extinguish fires but also to cool down equipment (to avoid flash fires).

(b) Location

The pumps, including a radius of at least 1.2 m around the periphery, shall be protected by water spray.

For protection of more than one pump by the same water spray system, refer to DEP 80.47.10.30-Gen.

(c) Operation

The system shall be activated automatically by a fire/heat detection system. In addition, manual activation shall be provided from the control room. For a typical scheme, see Appendix 4. Apart from the fire/heat detection system, if a gas detection system is installed around LNG or LPG product pumps, this shall also activate the water spray system.

In salt/brackish water service the normally "dry" piping shall be flushed clean with fresh water after testing or use.

(d) Design

(i) General

For water application rates refer to DEP 80.47.10.30-Gen. The following shall be added to the afore-mentioned application rates: 20% due to water not reaching the equipment (because of wind or other factors), and in addition 10% as a flow balancing factor for discharge nozzle pressure variations.

Spray nozzles shall be installed as shown in Appendix 5.

NOTES :

1. The 2.5-3 m elevation shown in Appendix 5 is typical; the actual elevation shall be selected such 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 5.

For new projects the spray nozzle layout shall be indicated on the model to demonstrate that no interference with piping or structures, etc. will occur.

If a group of pumps (e.g. in a congested area) is to be protected by water spray, the spray nozzles shall be spaced in a regular manner; however the overlapping water spray, from two adjacent nozzles, shall cover the pump body.

(ii) Heat/fire detection

Each water spray system shall be equipped with a heat/fire detection system.

Air pressurised, double loop, detection tubing shall be installed at the equipment to be protected. Sections of plastic detection tubing shall only be installed in those areas where credible fires (excessive heat) may occur, i.e. typically at a mechanical seal and at the inlet/outlet piping flanges. The tubing shall be flame-retardant, black polyethylene, of a brand to be approved by Principal. The sections of plastic tubing shall be interconnected by PVC-covered copper tubing using connectors with metal tubing inserts. All plastic and copper tubing shall be well supported. For typical line-up schematic see drawings S-88020 or S-88021. Construction drawings shall be submitted for approval by the Principal.

Alternatively glass bulb detectors (nominal melting point 80 degrees Centigrade) or fusible fittings (nominal melting point 70 degrees Centigrade) may be applied as point detectors. The nickel plated brass detector or stainless steel (AISI 316) fitting shall be connected to the copper nickel alloy tubing by means of a tee-fitting. The tubing supports shall be metallic.

The loss of pressure in a single loop shall result in a fault alarm, while loss of pressure in both loops will result in a fire alarm (two out of two voting system). Both alarms shall be visually and audibly annunciated on the fire and gas detection panel. The fire alarm shall start the fire water pump(s) and it shall de-energise the solenoid valve in the instrument impulse line to the automatic on-off valves of the corresponding water spray system. Each automatic on-off valve shall be provided with a three position switch (open/automatic/closed) to be installed on the smoke, fire and gas detection panel in the control room. For a typical scheme see Appendix 4.

(iii) 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 (see DEP 80.47.10.30-Gen.). 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 application of restriction orifices. The on-off valve, filter etc. shall be part of 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 valve and downstream of the manually operated block valve. The spool shall be flanged and it shall have a minimum size of ½ inch (material to be Monel 400; DEP 31.38.01.12-Gen., piping class 1602).

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.

(iv) Piping line-up

A spray water pipe system shall have two connections to the fire water ring main. The connections should be in opposite locations in relation to the equipment/area to be protected.

The automatic on-off control valve shall be installed downwind of the prevailing wind direction. The automatic valve manifold shall be at least 15 m from the spray system. Upwind the manual valve shall be at least 30 m away from the spray system. At both connections a filter shall be provided; for size see - Filter (below).

In the exceptional case that the distance from the fire water mains to the manually operated block valve is more than 100 m, the fire water supply to this valve may be taken from the same side as the on-off control valve. In such a case an isolation valve shall be provided in the fire water main between both branch connections.
To save on filter capacity, adjacent spray water systems that may operate simultaneously may be served by a common filter in both fire water supplies (the on-off control valve side and the manually operated block valve side).
Horizontal "dry" piping, downstream of the block valve and of the automatic on-off valve shall be installed with a slope of 1:200 or steeper and it shall be fitted with adequate drain facilities; weepholes in spray headers and automatic drain valves shall be provided at selected locations.

At each fire water supply side (downstream of the on-off control valve and the block 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.

All overhead piping shall be well supported and fixed to prevent deflection and vibrations. When supported from grade the supports shall be fire-proofed (refer to 2.10).

- Filter:

  The in-line filters shall be of a bucket-type design, with a retractable filter 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.

- On-off control valve:

  The automatic on-off control valve shall be a UL-1091 listed butterfly valve or equivalent approved by Principal. The valve shall be tight shut off (TSO) against a maximum pressure of 16 bar(ga). When instrument air pressure drops to 3 bar(ga) the valve shall be activated to fully open within 10 seconds. The actuator shall be sized such that the valve can be fully opened and closed under the maximum occurring pressure differential or maximum flow conditions.

- Water spray nozzles:

  Medium velocity, full cone, open-type spray nozzles with external deflectors shall be applied. 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.

  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.

- Climatic conditions:

  In locations susceptible to freezing, electrical trace heating (refer to DDD 33.68.30.32-Gen.) shall be applied to fire water manifolds and piping installed in access pits.

- Corrosion protection:

  Where salt/brackish water is used, the flanged cross-over piping from underground to above ground and piping to the automatic on-off valve or block valve shall be internally coated; preferably by epoxy paint (minimum 400 microns dry film thickness) or alternatively by cement lining (DEP 31.38.01.12-Gen., class 1803).

(v) Instrumentation

The solenoid valve shall be electrically operated and be suitable for the applicable zone of the Hazardous Area Classification (refer to IP-15).

Instrument air supply pressure: min. 3 bar(ga), max. 7 bar(ga).

(e) Material selection

(i) Piping

The piping/fitting material shall be selected in accordance with DEP 31.38.01.10-Gen. Maximum pressure upstream the on-off control valve is 16 bar(ga). The "dry" pipe sections shall be flanged for all sizes and shall be hot dip galvanised after pre-fabrication in accordance with (DEP 31.38.01.12-Gen., class 1810).

(ii) In-line filter

The filter housing shall be carbon steel; for use in salt/brackish water it shall be internally epoxy coated (min. 400 microns).

Filter element material to be stainless steel (316L) or Monel 400.

(iii) On-off control valve

Valve to have corrosion resistant internals and rubber lined carbon steel body. Refer to relevant MESC description as indicated in the piping class.

(iv) Water spray nozzles

Nozzle material to be stainless steel (316) or Monel 400.

(v) Solenoid valve

Body material: brass.

(f) Scope

For scope of work and supply see section 3.

2.2.2 Water spray protection for cooling purposes: Horizontal vessels and horizontal heat exchangers.

(a) Purpose

Each horizontal vessel or heat exchanger, normally holding butane or lighter products (e.g. LPG and LNG) and holding a liquid volume of more than 5 m^3, shall be protected by a dedicated water spray system to cool down the product and the vessel/ exchanger, to avoid flange failures and a BLEVE.

(b) Location

For protection of more than one horizontal vessel or heat exchanger by the same water spray system refer to DEP 80.47.10.30-Gen.

(c) Operation

The spray system shall be activated automatically by a fire/heat detection system. In addition manual activation shall be provided from the central control room. For a typical scheme see Appendix 4.

In salt/brackish water service the normally "dry" piping system shall be flushed clean with fresh water after testing or use.

(d) Design

(i) General

For water application rates refer to DEP 80.47.10.30-Gen.

The following shall be added: 20% due to water not reaching the equipment (because of wind or other factors), and in addition 10% as a flow balancing factor for discharge nozzle pressure variations.

For LPG/LNG vessels with depressurising facilities and heat resistant (1200°C) insulation conforming to UL-1709, spray water requirements shall be subject to approval by the Principal.

Equipment, insulated for process purposes, shall also be protected by water spray.

Spray water nozzles shall be directed radially to the vessel/heat exchanger wall and heads. 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 applied. (See Appendix 6).

For new projects the spray nozzle layout shall be shown on the plant's piping model to demonstrate that no interference with piping or structures, etc. will occur. In exceptional cases the relevant piping general arrangement drawing(s) may be used.

(ii) Heat/fire detection

Each water spray system shall be equipped with a heat/fire detection system.

Air pressurised, double loop, detection tubing shall be installed near the credible fire sources on the equipment. Sections of plastic detection tubing shall only be installed in those areas where credible fires (excessive heat) may occur. The tubing shall be flame-retardant, black polyethylene, of a brand to be approved by Principal. The sections of plastic tubing shall be interconnected by PVC-covered copper tubing using connectors with metal tubing inserts. All plastic and copper tubing shall be well supported. For typical line-up schematic see drawings S-88020 or S-88021. Construction drawings shall be submitted to the Principal.

Alternatively glass bulb detectors (nominal melting point 80 degrees Centigrade) or fusible fittings (nominal melting point 70 degrees Centigrade) may be applied as point detectors. The nickel plated brass detector or stainless steel (AISI 316) fitting shall be connected to the copper nickel alloy tubing by means of a tee-fitting. The tubing supports shall be metallic.

The loss of pressure in a single loop shall result in a fault alarm, while loss of pressure in both loops shall result in a fire alarm (two out of two voting system). Both alarms shall be visually and audibly annunciated on the fire and gas detection panel. The fire alarm shall start the fire water pump(s) and it shall de-energise the solenoid valve in the instrument impulse line to the automatic on-off valves of the corresponding water spray system. Each automatic on-off valve shall be provided with a three position switch (open/automatic/closed) to be installed on the smoke, fire and gas detection panel in the central control room. For a typical scheme, see Appendix 4.

(iii) 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 (see DEP 80.47.10.30-Gen). 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 application of restriction orifices. The on-off valve, filter etc. shall be part of the calculation. If pressure reduction is still required, a calculated length (max. 2 m.) of small bore piping shall be installed downstream of the on-off valve and downstream of the manually operated block valve. The spool shall be flanged and it shall have a minimum size of ½ inch; material Monel 400, (DEP 31.38.01.12-Gen., class 1602).

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 employed.

(iv) Piping line-up

A spray water pipe system shall have two connections to the fire water ring main. The connections to be in opposite locations in relation to the equipment/area to be protected. The connection downwind the prevailing wind direction shall be equipped with the automatic on-off control valve. This valve manifold shall be at least 15 from the periphery of the spray system, while the upwind manifold for the manually operated block valve shall be at least 30 m away from the spray system. At both connections a filter shall be installed; for size see - Filter (below).

In the exceptional case that the distance from the fire water mains to the manually operated block valve is more than 100 m, the fire water supply to this valve may be taken from the same side as the on-off control valve. In such a case an isolation valve shall be provided in the fire water main between the two branch connections.
To save on filter capacity adjacent spray water systems, that may operate simultaneously, can be served by a common filter in both fire water supplies (the on-off control valve side and the manually operated block valve side).
Horizontal "dry" piping, downstream of the block valve and of the automatic on-off valve, shall be installed with a slope of 1:200 or steeper and it shall be fitted with adequate drain facilities; weepholes in spray headers and automatic drain valves shall be provided at selected locations.

At each fire water supply side (downstream of the on-off control valve and the block 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.

All overhead piping shall be adequately supported and fixed to prevent deflection and vibrations. When supported from grade the supports shall be fire-proofed (Refer to 2.10).

In exceptional cases where it is envisaged that the orientation of the water spray nozzles requires adjustment after installation, a screwed double elbow shall be provided.

- Filters:

  The in-line filters shall be of a bucket-type design, with a bucket-type filter insert. Each filter shall have a minimum capacity of 800% of the nominal inlet pipe size.

  The filter openings shall be at least 50% of the size of the smallest spray nozzle orifice opening to be used; maximum diameter 4mm.

- On-off control valve:

  The automatic on-off control valve shall be a UL-1091 listed butterfly valve or equivalent approved by Principal. The valve shall be tight shut off (TSO) against a maximum pressure of 16 bar(ga). When instrument air pressure drops to 3 bar(ga) the valve shall be activated to fully open within 10 seconds. The actuator shall be sized such that the valve can be fully opened and closed under the maximum occurring pressure differential or maximum flow conditions.

- Water spray nozzles:

  Medium velocity, full cone, open-type spray nozzles with external deflectors shall be applied. Internal strainers are not allowed to avoid individual nozzles becoming blocked 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 to have a male threaded connection, min. size ½ inch.

  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,
  - all areas of 100 x 100 mm^2 to receive at least 20% of the average application ($dm^3/min/m^2$).

- Climatic conditions:

  In locations susceptible to freezing, electrical trace heating (refer to DDD 33.68.30.32-Gen.) shall be applied to fire water manifolds and piping installed in access pits.

- Corrosion protection:

  Where salt/brackish water is used, the flanged cross-over piping from underground to above ground and piping to the automatic on-off valve or block valve shall be internally coated; preferably by epoxy paint (minimum. 400 microns dry film thickness) or alternatively by cement lining (DEP 31.38.01.12-Gen., class 1803).

(v) Instrumentation

The solenoid valve shall be electrically operated and be suitable to operate in accordance with the Hazardous Area Classification (refer to IP Model Code of Safe Practice - Part 15). Instrument air supply pressure: min. 3 bar(ga), max. 7 bar(ga).

(e) Material selection

(i) Piping

The piping/fitting material shall be selected from the applicable piping classes (DEP 31.38.01.10-Gen.). The maximum pressure upstream the on-off control valve is 16 bar(ga). The "dry" pipe sections shall be flanged for all sizes and shall be hot dipped galvanised after pre-fabrication in accordance with DEP 31.38.01.12-Gen., class 1810.

(ii) In-line filter

The filter housing shall be carbon steel; for use in salt/brackish water it shall be internally epoxy coated (min. 400 microns).

Filter element material to be stainless steel (316L) or Monel 400.

(iii) On-off control valve

Valve to have corrosion resistant internals and carbon steel body with inside rubber lining. Refer to relevant MESC description as indicated in the piping class.

(iv) Water spray nozzles

Nozzle material to be stainless steel (316) or Monel 400.

(v) Solenoid valve

Body material: brass.

(f) Scope

For scope of work and supply see section 3.

2.2.3 Water spray protection for cooling purposes: Columns and vertical vessels.

(a) Purpose

Each column or vertical vessel, normally holding butane or lighter products (e.g. LPG and LNG) and holding a liquid volume of more than 5 m^3, shall be protected by a dedicated water spray system to cool down the product and the vessel/columns to avoid flange failures and a BLEVE.

Insulated equipment shall also be protected by water spray. Fireproofed skirts do not require protection by a water spray system.

(b) Location

The vertical extent of the water spray application shall be based on release scenarios, surface areas that can sustain a pool fire and fire hazard calculations to be approved by Principal.

(c) Operation

The spray system shall be activated automatically by a fire/heat detection system. In addition manual activation shall be provided from the central control room. For a typical scheme see Appendix 4.

In salt/brackish water service the normally "dry" piping system shall be flushed clean with fresh water after testing or use.

(d) Design

(i) General

For water application rates refer to DEP 80.47.10.30-Gen.

Generally the following shall be added: 20% due to water not reaching the equipment (because of wind or other factors), and in addition 10% as a flow balancing factor for discharge nozzle pressure variations.

For LPG/LNG equipment with depressurising facilities and heat resistant (1200°C) insulation conforming to UL-1709, spray water requirements shall be discussed with the Principal.

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.

In case 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 applied (see Appendix 7).

For new projects the spray nozzle layout shall be shown on the plant's piping model to demonstrate that no interference with piping or structures, etc. will occur. In exceptional cases the latest revision of the relevant piping general arrangement drawing(s) may be used.

(ii) Heat/fire detection

Each water spray system shall be equipped with a heat/fire detection system.

Air pressurised, double loop, detection tubing shall be installed. Sections of plastic detection tubing shall only be installed in those areas where credible fires (excessive heat) may occur, i.e. typically at the inlet/outlet piping flanges. The tubing shall be flame-retardant, black polyethylene, of a brand to be approved by Principal. The sections of plastic tubing shall be interconnected by PVC-covered copper tubing using connectors with metal tubing inserts. All plastic and copper tubing shall be well supported. For typical line-up schematic see drawings S-88.020 or S-88.021. Construction drawings shall be submitted for approval by purchaser.

Alternatively glass bulb detectors (nominal melting point 80 degrees Centigrade) or fusible fittings (nominal melting point 70 degrees Centigrade) may be applied as point detectors. The nickel plated brass detector or stainless steel (AISI 316) fitting shall be connected to the copper nickel alloy tubing by means of a tee-fitting. The tubing supports shall be metallic.

The loss of pressure in a single loop shall result in a fault alarm, while loss of pressure in both loops shall result in a fire alarm (two out of two voting system). Both alarms shall be visually and audibly annunciated on the fire and gas detection panel. The fire alarm shall start the fire water pump(s) and it shall de-energise the solenoid valve in the instrument impulse line to the automatic on-off valves of the corresponding water spray system. Each automatic on-off valve shall be provided with a three position switch (open/automatic/closed) to be installed on the smoke, fire and gas detection panel in the central control room. For a typical scheme see Appendix 4.

(iii) Hydraulics

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

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 (see DEP 80.47.10.30-Gen.). 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 application of restriction orifices. The on-off valve, filter etc. shall be part of the calculation. If there is still a pressure reduction required, a piece of small bore piping (max. length: 2 m) shall be installed downstream of the on-off valve and downstream of the manually operated block valve. The spool shall be flanged and it shall have a minimum size of ½ inch (material: Monel 400; DEP 31.38.01.12-Gen., piping class 1602).

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 employed.

(iv) Piping line-up

A spray water pipe system shall have two connections to the fire water ring main. The connections should be in opposite locations in relation to the equipment/area to be protected. The automatic on-off control valve shall be installed downwind of the prevailing wind direction. This valve manifold shall be at least 15 m from the periphery of the spray system, while the upwind manually controlled block valve manifold shall at least be 30 m away from the spray system. At both connections a filter shall be installed.

In the exceptional case that the distance from the fire water mains to the manually operated block valve is more than 100 m, the fire water supply to this valve may be taken from the same side as the on-off control valve. In such a case an isolation valve shall be provided in the fire water main between both branch connections.

To save on filter capacity adjacent spray water systems, that may operate simultaneously, can be served by a common filter in both fire water supplies (the on-off control valve side and the manually operated block valve). In such a case an additional on-off control valve is required.

Horizontal "dry" piping, downstream of the block valve and of the automatic on-off valve, shall be installed with a slope of 1:200 or steeper and it shall be fitted with adequate drain facilities; weepholes in spray headers and automatic drain valves shall be provided at selected locations.

At each fire water supply side (downstream of the on-off control valve and the block 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.

All overhead piping shall be adequately supported and fixed to prevent deflection and vibration. This may be executed by means of clamps on the vessel proper (or its platforms) or from supports in pipe bridges. In the exceptional case that the spray water piping is supported from grade, these supports require protection against pool fires, e.g. fire proofing (see 2.10) or internal water flow.

In exceptional cases that it is envisaged that the orientation of the water spray nozzles requires adjustment after installation, a screwed double elbow shall be provided.

- Filter:

  The in-line filters shall be of a bucket-type design, with a bucket-type filter insert. Each filter shall have a minimum capacity of 800% of the nominal inlet pipe size.

  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.

- On-off control valve:

  The automatic on-off control valve shall be a UL-1091 listed butterfly valve or equivalent approved by Principal. The valve shall be tight shut off (TSO) against a maximum pressure of 16 bar(ga). When instrument air pressure drops to 3 bar(ga) the valve shall be activated to fully open within 10 seconds. The actuator shall be sized such that the valve can be fully opened and closed under the maximum occurring pressure differential or maximum flow conditions.

- Water spray nozzles:

  Medium velocity, full cone, open-type spray nozzles with external deflectors shall be applied. Internal strainers are not allowed to avoid individual nozzles becoming blocked 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 threaded male connection (min. size: ½ inch).

  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,
  - each area of 100 x 100 mm^2 to receive at least 20% of the average application rate ($dm^3/min/m^2$).

- Climatic conditions:

  In locations susceptible to freezing, electrical trace heating (refer to DDD 33.68.30.32-Gen.) shall be applied to fire water manifolds and piping installed in access pits.

- Corrosion protection:

  Where salt/brackish water is used, the flanged cross-over piping from underground to above ground and piping to the automatic on-off valve or block valve shall be internally coated; preferably by epoxy paint (minimum. 400 microns dry film thickness) or alternatively by cement lining (DEP 31.38.01.12-Gen., class 1803).

(v) Instrumentation

The solenoid valve shall be electrically operated. It shall be suitable to operate in the zone determined by the Hazardous Area Classification (refer to IP Model Code of Safe Practice - Part 15). Instrument air supply pressure: min. 3 bar(ga), max. 7 bar(ga).

(e) Material selection

(i) Piping

The piping/fitting material shall be selected from the applicable piping classes (see DEP 31.38.01.10-Gen.). The maximum pressure upstream the on-off control valve is: 16 bar(ga). The "dry" pipe sections shall be flanged for all sizes and shall be hot dip galvanised after pre-fabrication in accordance with (DEP 31.38.01.12-Gen., class 1810).

(ii) In-line filter

The filter housing shall be carbon steel; for use in salt/brackish water it shall be internally epoxy coated (min. 400 microns).

Filter element material to be stainless steel (316L) or Monel 400.

(iii) On-off control valve

Valve to have: carbon steel body (plus internal rubber lining) and corrosion resistant internals. Refer to relevant MESC description as indicated in the piping class.

(iv) Water spray nozzles

Nozzle material to be stainless steel (316) or Monel 400.

(v) Solenoid valve

Body material: brass.

(f) Scope

For scope of work and supply see section 3.

2.2.4 Water spray protection for cooling purposes: Spherical tanks

(a) Purpose

Pressurised storage spheres and vessels, normally holding butane and lighter hydrocarbon products (e.g. LPG) and having a liquid volume of more than 5 m^3, shall be provided with a water spray system as a protection against a credible engulfed fire and radiated heat from a fire at the top of the sphere proper or an adjacent object on fire. Heat, originating from these various options, on pressurized metallic parts in the vapour phase may lead to local hot/weak spots, which may cause a BLEVE.

The engulfed fire pool case determines the spray water application rate. Refer to (d)-(i).

(b) Location

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 (see Appendix 8). 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.

(c) Operation

The spray system shall be activated automatically by a fire/heat detection system. A sphere on fire shall have both sections activated automatically. If adjacent sphere(s) are present, they shall have only the upper section activated automatically. In addition manual activation shall be provided from the central control room. For a typical scheme see Appendix 4.

In salt/brackish water service the normally "dry" piping system shall be flushed clean with fresh water after testing or use.

(d) Design

(i) General

For water application rates refer to DEP 80.47.10.30-Gen. Complete wetting of the entire sphere surface is required independent of rundown. Because of overlap in the spray pattern, spraying of the appurtenances and the selection of the nearest larger spray nozzle, the actual rate is at least 10 $dm^3/min/m^2$.

For any equipment in the vicinity (e.g. pipe racks, pumps etc.) heat calculations shall be made to determine the necessity of cooling by means of water spray.

Generally the following shall be added: 20% due to water not reaching the equipment (because of wind or other factors), and in addition 10% as a flow balancing factor for discharge nozzle pressure variations.

Nozzles should be installed on a single ring header at the upper part of the sphere. For easy access and maintenance this ring header is usually 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.

In order to apply a minimum of different spray nozzle sizes and types, it should be aimed to select the same spray nozzles for the upper and lower half of the sphere.

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.

The water spray system shall be arranged so as not to interfere with the future maintenance requirements of the equipment.

For new projects the spray nozzle layout shall be checked with the model to make certain that no interference with piping or structures, etc. will occur.

(ii) Heat/fire detection

Each water spray syem shall be equipped with a heat/fire detection system. (melting temperature: 90°C).

Air pressurised, double loop, detection tubing shall be installed near the credible fire sources, i.e. the top of the sphere and the inlet/outlet piping flanges. The sections of detection tubing shall be flame-retardant, black polyethylene, of a brand to be approved by Principal. The plastic tubing shall be interconnected by PVC covered copper tubing using connectors with metal tubing inserts. For typical line-up schematic see drawings S-88.020 or S-88.021. Construction drawings shall be submitted for approval by purchaser.

Alternatively glass bulb detectors (nominal melting point 80 degrees Centigrade) or fusible fittings (nominal melting point 70 degrees Centigrade) may be applied as point detectors. The nickel plated brass detector or stainless steel (AISI 316) fitting shall be connected to the copper nickel alloy tubing by means of a tee-fitting. The tubing supports shall be metallic.

The loss of pressure in a single loop shall result in a fault alarm, while loss of pressure in both loops will result in a fire alarm (two out of two voting system). Both alarms shall be visibly and audibly annunciated on the gas, fire and smoke detection panel. The fire alarm shall start the fire water pump(s) and it shall de-energize the solenoid valve in the instrument impulse line to the automatic on-off valves of the corresponding water spray system.

Each automatic on-off valve shall be provided with a three position switch (open/automatic/closed) to be installed on the gas, fire and smoke detection panel. For a typical scheme see Appendix 8.

(iii) 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 approved by Principal.

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 (see DEP 80.47.10.30-Gen. The minimum pressure shall be at least 10 bar(ga); by exception 7 bar(ga). Refer to 2.1.2-(c) for large fire water demands at reduced supply pressures.

Pressure spikes/surges may occur during initial admission of water into "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 application of restriction orifices. The on-off valve, filter etc. shall be part of 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 valve and downstream of the manually operated block valve. The spool shall be flanged and it shall have a minimum size of ½ inch (material to be Monel 400; DEP 31.38.01.12-Gen., class 1602)

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.

(iv)Piping line-up

Each spray water pipe section/system shall have two connections to the fire water ring main. The connections should be in opposite locations in relation to the equipment/area to be protected. The automatic on-off control valve shall be located downwind of the prevailing wind direction. This valve manifold shall be at least 15 m from the periphery of the spray system. For the upwind manual operated valve this distance shall be at least 30 m from the periphery of the spray system. At both connections a filter shall be installed; for size see - Filter (below).

In the exceptional case that the distance from the fire water mains to the manually operated block valve is be more than 100 m, the fire water supply to this valve may be taken from the same side as the on-off control valve. In such a case an isolation valve shall be provided in the fire water main between both branch connections.
To save on filter capacity adjacent spray water systems, that may operate simultaneously, can be served by a common filter in both fire water supplies (the on-off control valve side and the manually operated block valve side).

Horizontal "dry" piping, downstream of the block valve and of the automatic on-off valve, shall be installed with a slope of 1:200 or steeper and it shall be equipped with adequate drain facilities (typical 6 mm dia. weephole). Vertical legs, flowing downwards, shall be provided with blind flange plus weephole.

At each fire water supply side (downstream of the on-off control valve and the block 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.

All overhead piping shall be adequately supported and fixed to prevent deflection and vibrations. When supported from grade in the containment area, the supports shall be fire-proofed (Refer to 2.10).

In exceptional cases where it is envisaged that the orientation of the water spray nozzles requires adjustment after installation, a screwed double elbow shall be provided.

- Filter:

  The in-line filters shall be of a bucket-type design, with a bucket-type filter insert. Each filter shall have a minimum capacity of 800% of the nominal pipe size.

  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.

- On-off control valve:

  The automatic on-off control valve shall be a UL-1091 listed butterfly valve or equivalent approved by Principal. The valve shall be tight shut off (TSO) against a maximum pressure of 16 bar(ga). When instrument air pressure drops to 3 bar(ga) the valve shall be activated to fully open within 10 seconds. The actuator shall be sized such that the valve can be fully opened and closed under the maximum occurring pressure differential or maximum flow conditions.

- Water spray nozzles:

  Medium velocity, full cone, open-type spray nozzles with external deflectors shall be applied. Internal strainers are not allowed to avoid individual nozzles becoming blocked during operation. Recommended operating range 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 threaded male connection (min. size: ½ inch).

  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,
  - each area of 100 x 100 mm^2 to receive at least 20% of the average application rate ($dm^3/min/m^2$).

- Climatic conditions:

  In locations susceptible to freezing, electrical trace heating (refer to DDD 33.68.30.32-Gen.) shall be applied to fire water manifolds and piping installed in access pits.

- Corrosion protection:

  Where salt/brackish water is used, the flanged cross-over piping from underground to above ground and piping to the automatic on-off valve or block valve shall be internally coated; preferably by epoxy paint (minimum 400 microns dry film thickness) or alternatively by cement lining DEP 31.38.01.12-Gen., class 1803.

(v) Instrumentation

The solenoid valve shall be electrically operated and be suitable to operate in the applicable Hazardous Area Classification zone (refer to IP Model Code of Safe Practice - Part 15).
Instrument air supply pressure: min. 3 bar(ga), max. 7 bar(ga).

(e) Material selection

(i) Piping

The piping/fitting material shall be selected from the applicable piping classes (see DEP 31.38.01.10-Gen.). The maximum pressure upstream the on-off control valve is: 16 bar(ga). The "dry" pipe sections (min. size 2 inch) shall be flanged for all sizes and they shall be hot dip galvanised after pre-fabrication in accordance with DEP 31.38.01.12-Gen. (class 1810).

(ii) In-line filter

The filter housing shall be carbon steel; for use in salt/brackish water it shall be internally epoxy coated (min. 400 microns).

Filter element material to be stainless steel (316L) or Monel 400.

(iii) On-off control valve

Valve to have carbon steel body with internal rubber liner and corrosion resistant internals. Refer to relevant MESC description as indicated in the piping class.

(iv) Water spray nozzles

Nozzle material to be stainless steel (316) or Monel 400.

(v) Solenoid valve

Body material: brass.

(f) Scope

For scope of work and supply see section 3.

2.2.5 Water spray protection for cooling purposes: Fixed roof tanks.

(a) Purpose

Fixed roof storage tanks up to 10 m height can be protected by mobile equipment if the First Intervention Team (FIT) is available, with sufficient manpower, within typically seven minutes. In case more than seven minutes are required, or in case insufficient manpower is available and for larger tanks, fixed water spray systems shall be installed to protect against anticipated radiated heat from adjacent equipment on fire.

(b) Location

Normally the entire roof outer surface and the wall section exposed to heat radiation as determined in the pre-fire plans (scenarios), shall be sprayed. In the case that the water demand to fixed roof tank(s) is the largest in the complex and more than the "standard" pump rating required for other credible scenarios, the tank roof spray system may be divided into sections.

(c) Operation

The spray system shall be activated by a manually operated valve. The valve's location shall be marked with a sign board stating the purpose of the valve.

In salt/brackish water service the normally "dry" piping system shall be flushed clean with fresh water after testing or use.

(d) Design

(i) General

For water application rates refer to DEP 80.47.10.30-Gen.

To the application rates shall be added: 20% due to water not reaching the equipment, because of wind or other factors, plus 10% as a flow balancing factor for discharge nozzle pressure variations.

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

(ii) Tank roof

For optimum wetting and piping lay out 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" respectively 2.0 and 2.5 metres. 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 (see Appendices 9, 10 and 11).

(iii) 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 11). The number of nozzles depends on the tank diameter. Normally additional ring headers are not required.

In order to apply a minimum of different spray nozzle sizes and types, one size and type of nozzle should be chosen for the roof, and one size and type for the tank wall.

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 appurtenance).

Ring headers shall be constructed from flanged circular pre-fabricated pipe sections.

The roof ring headers shall be firmly supported. Pipe supports to be welded or bonded to the roof.

The water spray system shall be arranged so as not to interfere with the maintenance requirements of the tank and appurtenances.
If tanks are included on the piping model for new projects, the spray nozzle layout shall be indicated on the model to check that no interference with piping or structures, etc. will occur.

(iv) 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. Calculation method shall be approved by Principal.

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 (see DEP 80.47.10.30-Gen. The minimum pressure shall be at least 10 bar(ga); by exception 7 bar(ga). Refer to 2.1.2-(c) for large fire water demands at reduced supply pressures.

Pressure spikes/surges may occur during initial admission of water into "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 application of restriction orifices. The manually operated valve, filter etc. shall be part of the calculation. If pressure reduction is still required, a calculated length (max. 2 m.) of small bore piping shall be installed downstream of the manually operated block valve. The spool shall be flanged and it shall have a minimum size of ½ inch, material: Monel 400; DEP 31.38.01.12-Gen., piping class 1602.

In all cases a detailed layout shall be made of the equipment and areas to be protected and on which the arrangement of the spray nozzles shall be shown. For this purpose the latest revision of the relevant piping general arrangement drawing may be employed.

(v) Piping line-up

Ring headers, serving roof or wall (shell) sprayers, shall be connected to a common supply header. This supply header shall have a single connection to the fire water ring main. 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; for size see: - Filter (below).

Horizontal "dry" piping, downstream of the manual operated valve, shall be installed with a slope of 1:200 or steeper, and it shall be equipped with adequate drain facilities (typically 6 mm dia. weephole). It shall be installed in the pipe track, it shall pass over the bund wall and it shall be supported on sleepers within the bund.

Vertical legs to be provided with a bottom blind flange for cleaning purposes (min. size 2 inch).

Downstream the manual 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.

All overhead piping shall be adequately supported and fixed to prevent deflection and vibrations.

- Filter:

  The in-line filter shall be of a bucket-type design, with a bucket-type filter insert. Each filter shall have a minimum capacity of 800% of the nominal inlet pipe size.

  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.

- Manually operated valve:

  The manually operated valve shall be a UL-1091 listed type butterfly valve or equivalent approved by Principal.

- Water spray nozzles:

  Medium velocity, flat spray or full tank top pattern, open-type spray nozzles with external deflectors shall be applied. Internal strainers are not allowed to avoid individual nozzles becoming blocked 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 have male threaded connections; min. size: ½ inch.

  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.

- Climatic conditions:

  In locations susceptible to freezing, electrical trace heating (refer to DDD 33.68.30.32-Gen.) shall be applied to fire water manifolds and piping installed in access pits.

- Corrosion protection:

  Where salt/brackish water is used, the flanged cross-over piping from underground to above ground and piping to the automatic on-off valve or block valve shall be internally coated; preferably by epoxy paint (minimum 400 microns dry film thickness) or alternatively by cement lining (DEP 31.38.01.12-Gen., class 1803).

(e) Material selection

(i) Piping

The piping/fitting material shall be selected from the applicable piping classes (see DEP 31.38.01.10-Gen.). The maximum pressure upstream the manual operated valves is 16 bar(ga).
The "dry" pipe sections (typical min. size 2 inch) shall be flanged for all sizes and they shall be hot dip galvanised after pre-fabrication in accordance with DEP 31.38.01.12-Gen. (class 1810).

(ii) In-line filter

The filter housing shall be carbon steel; for use in salt/brackish water it shall be internally epoxy coated (min. 400 microns).

Filter element material to be stainless steel (316L) or Monel 400.

(iii) Manually operated valve

Butterfly valve to have carbon steel body (internally rubber lined) and corrosion resistant internals. Refer to relevant MESC description as indicated in the piping class.

(iv) Water spray nozzles

Nozzle material to be stainless steel (316) or Monel 400.

(f) Scope

For scope of work and supply see section 3

2.2.6 Water spray protection for cooling purposes: Floating roof tanks.

(a) Purpose

Floating roof storage tanks up to 10 m height can be protected by mobile equipment if the First Intervention Team (FIT) is available, with sufficient manpower, within typically seven minutes. In case more than seven minutes are required, or in case insufficient manpower is available and for larger tanks, fixed water spray systems shall be installed against (credible) radiated heat from adjacent equipment on fire.

(b) Location

The floating roof itself does not require cooling by a fixed water spray system; the boxed sections/pontoons will serve as an insulation layer, while single sheeting is able to absorb heat as it floats on the product (heat sink). Therefore only those parts of the floating roof tank shell that are exposed to heat radiation as determined in the pre-fire plans (scenarios) shall be sprayed.

(c) Operation

The spray system shall be activated by a manually operated valve. The valve's location shall be marked with sign board stating the purpose of the valve.

In salt/brackish water service the normally "dry" piping system shall be flushed clean with fresh water after testing or use.

(d) Design

(i) General

For water application rates refer to DEP 80.47.10.30-Gen.

To the application rates shall be added: 20% due to water not reaching the equipment, because of wind or other factors, plus 10% as a flow balancing factor for discharge nozzle pressure variations. Heat radiation calculations shall be made, to determine the max. heat flux in order to arrive at the required water spray application rate.

(ii) Tank shell

The tank shell 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: 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 11). The number of nozzles is depending on the tank diameter. Normally additional ring headers are only required if additional wind girders are applied. One size and type of spray nozzles should be selected.

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. Ring headers shall be constructed from curved pre-fabricated pipe sections. Headers shall be firmly supported.

The water spray system shall be arranged so as not to interfere with the maintenance requirements of the tank and appurtenances.

(iii) Activation

The floating roof tank spray systems shall be activated manually.

(iv) Hydraulics

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

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 (see DEP 80.47.10.30-Gen.). The pressure shall be at least 10 bar(ga).

Refer to 2.1.2-(c) for large fire water demands at reduced supply pressures.

Pressure spikes/surges may occur during initial admission of water into "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 application of restriction orifices. The manually operated valve, filter etc. shall be part of the calculation. If there is still a pressure reduction required, a calculated length (max. 2 m.) of small bore piping shall be installed downstream the manually operated block valve. The spool shall be flanged and it shall have a minimum size of ½ inch (material: Monel 400; DEP 31.18.01.12-Gen., piping class 1602).

In all cases a detailed layout shall be made of the equipment and areas to be protected and on which the arrangement of the spray nozzles shall be shown.
For this purpose of the relevant tank drawing and piping general arrangement drawing may be employed.

(iii) Piping line-up

The supply line to the header shall have one connection to the fire water ring main. The manual operated valve shall be located upwind from the prevailing wind direction, and at least 30 m away from the spray system in an easily accessible place outside the bund. Upstream the manual operated block valve a filter shall be installed; for size see - Filter (below).

Horizontal "dry" piping, downstream of the manual operated valve, shall be installed with a slope of 1:200 or steeper, and it shall be equipped with adequate drain facilities (typically 6 mm dia. weephole). Piping shall be installed in the pipe track, it shall pass over the bund and it shall be supported on sleepers within the bund.

Vertical legs to be equipped with a bottom blind flange (min. size 2 inch).

Downstream the manual 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.

All overhead piping shall be adequately supported and fixed to prevent deflection and vibration.

- Filter:

  The in-line filter shall be of a bucket-type design, with a bucket-type filter insert. Each filter shall have a minimum capacity of 800% of the nominal inlet pipe size.

  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.

- Manual operated valve:

  The manual operated valve shall be an UL-1091 listed type butterfly valve or equivalent approved by Principal.

- Water spray nozzles:

  Medium velocity, full cone, open-type, flat spray nozzles with external deflectors shall be applied. Internal strainers are not allowed to avoid individual nozzles becoming blocked during operation.

  Recommended operating range is between 2 and 3 bar(ga). The orifice diameter of the nozzles shall not be smaller than 8 mm. The nozzles shall have a male threaded connection; min. size: ½ inch.

  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

- Climatic conditions:

  In locations susceptible to freezing, electrical trace heating (refer to DDD 33.68.30.32-Gen.) shall be applied to fire water manifolds and piping installed in access pits.

- Corrosion protection:

  Where salt/brackish water is used, the flanged cross-over piping from underground to above ground and piping to the automatic on-off valve or block valve shall be internally coated; preferably by epoxy paint (minimum. 400 microns dry film thickness) or alternatively by cement lining (DEP 31.38.01.12-Gen., class 1803).

(e) Material selection

(i) Piping

The piping/fitting material shall be selected from the applicable piping classes (see DEP 31.38.01.10-Gen.). The maximum pressure upstream the manual operated valves is: 16 bar(ga). The "dry" pipe sections (typical min. size 2 inch) shall be flanged for all sizes and they shall be hot dip galvanised after pre-fabrication in accordance with DEP 31.38.01.12-Gen., class 1810.

(ii) In-line filter

The filter housing shall be carbon steel; for use in salt/brackish water it shall be internally epoxy coated (min. 400 microns).

Filter element material to be stainless steel (316L) or Monel 400.

(iii) Manual operated valves

Valve to have carbon steel body (internally rubber lined) and corrosion resistant internals. Refer to relevant MESC description as indicated in the piping class.

(iv) Water spray nozzles

Nozzle material to be stainless steel (316) or Monel 400.

(f) Scope

For scope of work and supply see section 3.

2.2.7 Water spray protection for cooling purposes: Atmospheric refrigerated product tanks

(a) Purpose

Atmospheric refrigerated product tanks, i.e. for LNG or NGL, shall be equipped with fixed water spray systems against credible (radiated) heat sources to maintain integrity from fires either on the equipment itself or on adjacent equipment.

In addition a spray water system may help to dilute vapours escaping from a gas leak.

(b) Location

The water spray system shall only be installed in areas where heat flux levels, due to credible fire scenarios, exceed the max. allowable levels for the particular construction material (steel or concrete). For typical allowable levels refer to DEP 80.47.10.30-Gen.

(c) Operation

In order to activate the spray system, use shall be made of a fire/heat detection system. In addition use shall be made of the installed gas detection system. Both detection systems shall be based on the two out of two voting principle.

For *steel* tanks, triggering of a detection system shall result in raising an alarm only. Activation of the spray water system shall only be done *manually* from the central control room and locally near the tanks, by means of a two way switch (open/closed) mounted in the gas, fire and smoke detection panel (see Appendix 12).

NOTE: Automatic activation shall not be provided since an indiscriminate supply of relatively warm water will increase:

- in case of a gas leak, vaporization with increased risk of ignition, due to the vapour cloud spreading over a larger area,
- the flame size of an already existing fire.

For *concrete* tanks, triggering of a detection system shall initiate automatic activation of the water spray system. In addition, in the control room and locally near the tanks, manual activation shall be provided by means of a three way switch (open/automatic/closed), mounted in the gas, fire and smoke detection panel (see Appendix 13).

NOTE: Partial rupture of a concrete tank, due to a foreign object, is not considered a credible risk.

In salt/brackish water service the normally "dry" piping system shall be flushed clean with fresh water after testing or use.

(d) Design

(i) General

Heat radiation calculations shall be made, to determine local heat fluxes for the various scenarios as described in DEP 80.47.10.30-Gen.
On *concrete* tanks full tank fires are considered a "non-credible" event. Therefore, on concrete tanks, only heat fluxes of fires, (e.g. from relief valves or leaking flange connections) onto appurtenances shall be considered.
For (mounded) *steel* tanks a full tank fire is a credible event; the resulting heat flux shall be taken into account for adjacent equipment. On the tank itself heat fluxes of fires, from e.g. relief valves or leaking flange connections, onto appurtenances shall also be considered.

The pipe rack/bridge, including its structural steel, shall also be protected by water spray. The extent is determined by heat radiation calculations. For the required water application rate the Principal shall be consulted.

To maintain structural integrity of (mounded) steel tanks, their entire exposed surface, including all appurtenances (e.g. nozzles, relief valves, piping, structural steel etc.), shall be completely wetted by droplets; no dry spots are permitted (rundown shall not be taken into account). For mounded tanks this means that only the protruding exposed steel surface requires complete wetting.

Generally concrete tanks require water spray systems only on exposed steel surfaces, including appurtenances, and those concrete surfaces where, over time (10 min. up to 48 hours), the max. actual down wind heat flux is above the max. allowable heat flux for the specific concrete thickness (see DEP 80.47.10.30-Gen.). Water spray systems protecting against radiated heat require application rates ranging between 2 and 10 $dm^3/min/m^2$ exposed surface, for which advice from the Principal shall be sought.

In general, equipment subject to an engulfing fire, shall be sprayed at a minimum water application rate of 8.5 $dm^3/min/m^2$ *exposed* equipment surface or 20 $dm^3/min/m^2$ *projected* equipment surface area, whichever is greater.

The following shall be added to the above application rates: 20% due to water not reaching the equipment (because of wind or other factors), and in addition 10% as a flow balancing factor for discharge nozzle pressure variations.

In case that the water demand to tank(s) is the largest in the complex *and* above the rated pump capacity, it is advisable to use the 150% rated capacity at the lower discharge head (65%) for the design of the water spray system (see 2.1.2(c)).

(ii) Tank roof

Nozzles shall be equally spaced on ring headers. The number of ring headers is depending on the roof dimensions and the type of nozzle used.

For maintenance the top ring header is usually installed near the pump/manifold platform. The number of spray nozzles and the capacity thereof shall be such that the roof is covered with the required application rate as described above.The exposed steel roof surface area above the top ring header elevation, as well as the appurtenances (like safety valves, piping and instrumentation located at/near the tank's pump/manifold platform), must also be wetted; possibly by installing additional dedicated spray nozzles, located above such equipment.

In order to apply a minimum of different spray nozzle sizes and types, it should be aimed to select one particular size and type of nozzle for the roof.

(iii) Tank wall

The tank wall shall be protected by circular ring headers supported from the tank wall. Max. distance between wall and header centre line: 0.6 m. Spray nozzles shall be spaced at regular intervals on the headers. The nozzles shall be directed radially towards the wall surface, to achieve complete coverage (wetting) with overlapping spray patterns (see Appendix 7). The number of nozzles depends on the tank diameter.

A minimum of different spray nozzle sizes and types shall be applied.

Where reinforcing rings, supports, stairs, platforms, nozzles, manholes etc. interfere with the spray patterns, additional spray nozzles shall be provided to assure complete coverage.

Ring headers shall be constructed from flanged curved pre-fabricated pipe sections. The headers shall be firmly supported. Pipe supports shall be welded to the roof and wall.

The water spray system shall be arranged so as not to interfere with the maintenance requirements of the equipment.

If tanks are included on the piping model for new projects, the water spray piping layout shall be indicated on the model to check that no interference with piping or structures, etc. will occur.

(iv) Heat/fire detection

Each tank shall be equipped with a heat/fire detection system. Air pressurised tubing systems will activate the fault and/or fire alarms in case the tubing is subjected to heat (typically at 90°C).

Sections of plastic detection tubing shall only be installed in those areas where credible fires (excessive heat) may occur, i.e. typically at the inlet/outlet piping flanges. The tubing shall be flame-retardant, black polyethylene, of a brand to be approved by Principal. The sections of plastic tubing shall be interconnected by PVC covered copper tubing using connectors with metal tubing inserts. All plastic and copper tubing shall be well supported. For typical line-up schematic see drawings S-88020 or S-88021. Construction drawings shall be submitted for approval to the Principal.

Alternatively, glass bulb detectors (nominal melting point 80°C) or fusible fittings (nominal melting point 70°C) may be applied as point detectors. The nickel plated brass detector or stainless steel (AISI 316) fitting shall be connected to the copper nickel alloy tubing by means of a tee-fitting. The tubing supports shall be metallic.

For *steel* tanks, where *manual* activation of the water spray system is required, a *single* loop system shall be installed. For *concrete* tanks, where *automatic* activation of the water spray system is required, a *double* loop system (two out of two voting principle) shall be installed.

Loss of pressure in *a* loop will result in a *fire* alarm for *steel* tanks (having manual spray water system activation); for *concrete* tanks (having automatic spray water system activation) it shall result in a *fault* alarm only.
Loss of pressure in *both* loops, as used on *concrete* tanks, shall result in a *fire* alarm.

Fault and fire alarms shall be annunciated visually and audibly on the fire and gas detection panel. The *fire* alarm shall start the fire water pump(s). For (*mounded*) *steel* tanks the solenoid valve in the instrument impulse line to the on-off control valve shall be de-energised *manually*; while for *concrete* tanks the solenoid valve in the instrument impulse line to the on-off control valve shall be de-energised *automatically* upon a *fire* alarm.

De-energising the solenoid valve shall cause the downstream instrument line to be vented to atmosphere. As a result the on-off control valve in the water spray system shall open. For typical schemes see Appendices 12 and 13.

(v) 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 approved by Principal.

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 (see DEP 80.47.10.30-Gen. The pressure shall be at least 10 bar(ga).
Refer to 2.1.2-(c) for large fire water demands at reduced supply pressures.

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 application of restriction orifices. The on-off valve, filter etc. shall be part of the calculation. If pressure reduction is still required, a calculated length of small bore piping shall be installed downstream of the on-off valve and downstream of the manually operated block valve. The spool shall be flanged with a max. length of 1 m; it shall have a minimum size of ½ inch (material to be Monel 400; DEP 31.38.01.12-Gen., piping class 1602).

In all cases a detailed layout shall be made of the equipment and areas to be protected and on which the arrangement of the spray nozzles shall be shown. For this purpose the relevant piping general arrangement drawing may be employed.

(vi) Piping line-up

Each spray water system shall have two connections to the fire water ring main. Connections shall be in opposite locations in relation to the equipment/area to be protected. The connection to be equipped with the automatic on-off control valve shall preferably be (as close as possible) located downwind of the prevailing wind direction. At both connections a filter shall be installed; for size see - Filter (below).

In the exceptional case where the distance from the fire water mains to upwind the manually operated block valve will be more than 100 m, the fire water supply to this valve may be taken from the same side as the on-off control valve. (Both valves to be located upwind). In such a case an isolation valve shall be provided in the fire water main between both branch connections.
To save on filter capacity adjacent spray water systems, that may operate simultaneously, can be served by a common filter in both fire water supplies (the on-off control valve side and the manually operated block valve side).

Both the on-off control valve, as well as the manual operated block valve, shall be at least 50 m away from the credible fire hazard.

Horizontal "dry" piping, downstream of the manual operated block valve and of the automatic on-off valve, shall be installed with a slope of 1:200 or steeper, and it shall be equipped with adequate drain facilities (typically 6 mm dia. weephole). Vertical legs flowing downwards shall be provided with blind flange plus weephole.

At each fire water supply side (downstream of the on-off control valve and the block valve) a 3 inch branch with valve and 2½ inch Storz/instantaneous hose connection shall be provided for full draining, water or smoke testing, flushing with fresh water and drainage.

All overhead piping shall be adequately supported and fixed to prevent deflection and vibrations.

In exceptional cases where it is envisaged that the orientation of the water spray nozzles requires adjustment after installation, screwed double elbows shall be provided.

- Filter:

  The in-line filters shall be of a bucket-type design, with a bucket-type filter insert. Each filter shall have a minimum capacity of 800% of the nominal inlet pipe size.

  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.

- On-off control valve:

  The on-off control valve shall be a UL-1091 listed butterfly fire water valve or equivalent approved by Principal. The valve shall be tight shut off (TSO) against a maximum pressure of 16 bar(ga). When the instrument air pressure drops to 3 bar(ga) the valve shall be activated to fully open within 10 seconds. The actuator shall be sized such that the valve can be fully opened and closed under the maximum occurring pressure differential or maximum flow conditions.

- Water spray nozzles:

  Medium velocity, full cone, projector or full tank top pattern (with external deflector), open-type spray nozzles shall be applied. Internal strainers are not allowed to avoid individual nozzles becoming blocked 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 have a male threaded connection; min. size ½ inch.

  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,
  - each area of 100 x 100 mm^2 to receive at least 20% of the average application rate ($dm^3/min/m^2$)

- Water nozzles for the pump/manifold area:

Mini-jet/semi-fog type nozzles shall be used, with a typical capacity of 1000 dm^3/min, at an operating pressure of 2 to 3.5 bar(ga).

- Climatic conditions:

  In locations susceptible to freezing, electrical trace heating (refer to DDD 33.68.30.32-Gen.) shall be applied to fire water manifolds and piping installed in access pits.

- Corrosion protection:

  Where salt/brackish water is used, the flanged cross-over piping from underground to above ground and piping to the automatic on-off valve or block valve shall be internally coated; preferably by epoxy paint (minimum 400 microns dry film thickness) or alternatively by cement lining (DEP 31.38.01.12-Gen., class 1803).

(iv) Instrumentation

The solenoid valve shall be electrically operated and be suitable for the applicable zone of the Hazardous Area Classification (refer to IP Model Code of Safe Practice - Part 15).
Instrument air supply pressure: min. 3 bar(ga), max. 7 bar(ga).

(e) Material selection

(i) Piping

The piping/fitting material shall be selected from the applicable piping classes (see DEP 31.38.01.10-Gen.). The maximum pressure upstream the on-off control valve and manual operated (N.C.) block valve is 16 bar(ga).

The "dry" pipe sections (min. size 2 inch) shall be flanged for all sizes and they shall be hot dip galvanised after pre-fabrication (DEP 31.38.01.12-Gen., class 1810).

(ii) In-line filter

The filter housing shall be carbon steel; for use in salt/brackish water it shall be internally epoxy coated (min. 400 microns).

Filter element material to be stainless steel (316L) or Monel 400.

(iii) On-off control valve

Butterfly valve to have a rubber lined carbon steel body with corrosion resistant internals.

Refer to relevant MESC description as indicated in the piping class.

(iv) Water (spray) nozzles

Nozzle material to be stainless steel (316) or Monel 400; with male screwed thread (min. size: ½ inch).

(v) Solenoid valve

Body material: brass.

(f) Scope

For scope of work and supply see section 3.

2.2.8 Stationary monitors

(a) Purpose

Where no fixed water spray systems are provided but , cooling of equipment surfaces is required, in view of credible fires stationary monitors shall be used to provide rapid application of fire water with minimum manpower involvement.

(b) Location

For location of stationary elevated monitors see DEP 80.47.10.30-Gen.

Stationary monitors should be installed on fire water hydrants (see 2.1.4); however, free standing (direct tie-in) may also be considered.
Elevated monitors are used for congested areas and where obstructions (e.g. at table tops and at jetty heads) prevent the effective use of ground level (hydrant mounted) stationary monitors.

(c) Operation

Information provided in the following sections is applicable to water as well as foam/water monitors. It shall be noted that a water monitor is not suitable for foam application. A foam monitor can be used for water application, although the water trajectory and footprint are impaired (less efficient) compared to a water monitor operating under the same conditions.

Stationary monitors can be either installed at ground level or elevated. Elevated monitors can be either locally operated from ground level, remotely operated from a particular vantage point at a safe distance or operated from the central control room.

For ground level monitors rotation, elevation and nozzle adjustment are done manually without gears.

Locally controlled elevated monitors shall be provided with cable, chain or gear mechanisms to adjust elevation, rotation and nozzle setting. The means of adjustment require approval by the Principal.

Remotely controlled elevated monitors shall have a rotation and elevation speed of approx. 6 degrees/s.

When monitors are in use it shall be possible to leave the monitor unattended while operating safely.

In salt/brackish water service the normally "dry" piping system shall be flushed clean with fresh water after testing or use.

(d) Design

(i) General

Upstream of the mounting flange each monitor shall be provided with a butterfly valve accessible from grade (See Std. Drgs. S88.007/008/011/012/013/014/015). For elevated monitors the valve shall be operable from grade.

The inlet mounting flange connection shall be to ANSI/ASME B 16.5, 150 lbs., R(aised) F(ace), 4" N(ominal) P(ipe) S(ize).

The monitor shall have a capacity of at least 120 m^3/h at 10 bar (ga) normal operating pressure.
Min./max. operating pressure to be respectively 6/16 bar (ga).

The water monitor shall have a 2 ½inch threaded end allowing easy connection of an adjustable nozzle. The nozzle shall be of the constant flow, fog to jet stream type and shall have a capacity of 120 m^3/h at 10 bar(ga), unless otherwise specified.

The monitor, in combination with its specific nozzle, shall meet at least the following:
Typical min. required trajectory (in still air, with 10 bar(ga) inlet pressure, 30 degrees elevation and footprint assumed at mounting flange face level):
- jet : 53 m to the centre of a 6 x 6 m (width x depth) foot print,
- 30 degrees fog : 20 m to the centre of a 7 x 4 m (width x depth) foot print.

Stationary water monitors shall be of such design that the hydraulic forces, taking account of pressure surges when opening the upstream block (butterfly) valve, are balanced.

The monitor shall be able to rotate 360 degrees by means of a turret that is lockable in any position. Elevation setting should be from 15 degrees below to 85 degrees above the horizontal; however, for elevated monitors these figures may be replaced by respectively 75° and 45°. Rotation and elevation movement shall be by means of a lever; setting and locking shall be easy. The moving parts shall be fully protected/enclosed against ice and dirt.

Elevated monitors shall have their mounting flange installed approx. 3 m above the level where the credible fire may occur.

(ii) Piping

Full drainage facilities shall be provided. This is particular important in areas where freezing may occur.

Flushing facilities are required for salt/brackish water and foam solution service.

Elevated monitors require properly supported water supply piping. The required pipe supports may form an integral part of the supporting structure (including an access ladder). A platform shall be provided for inspection and maintenance.
Heat flux calculations, with a Principal approved computer program, shall be made to determine the requirement for a water spray system on the support structure proper.

(iii) Foam solution

Foam monitors require compatible proportioning equipment that shall be installed at ground level (see 2.4.4.1). Foam monitors shall have an expansion ratio of between 8:1 and 10:1.

(e) Material selection

Monitor and nozzle shall be of materials and coatings suitable for intended use in seawater and outdoor weather conditions. Acceptable materials are for:

monitor (stationary part)	:	carbon steel (min. 400 microns epoxy coated internally for 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

Grades are indicative only; nearest equivalent may be proposed for approval by Principal.

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.).

Where salt/brackish water is used above ground, "wet" fire water supply lines shall be carbon steel, with an internal epoxy coating (min. 400 microns) or alternatively cement lined (DEP 31.38.01.12-Gen., class 1803).
"Dry" lines shall be flanged carbon steel and hot dip galvanised after fabrication (DEP 31.38.01.12-Gen., class 1810).

(f) Testing

Monitors shall be tested and certified by an independent authority to be approved by Principal. The manufacturer shall provide a copy of the certified test report.

As a minimum the test report shall include the following data:
- foot print (width x depth), i.e. area where 80% of the total water flow hits the horizontal plane through the raised face of the mounting flange, for jet and 30 degrees fog (both at 30 degrees elevation),
- throwing distance (trajectory), measured from nozzle exit to centre of foot print,
- pressure at monitor inlet flange,
- flow rate,
- diameter of used hose connection,
- wind speed and direction,
- angle between wind direction and water trajectory.

(g) Remote control

For location of remote controlled stationary monitors see DEP 80.47.10.30-Gen. Generally these monitors are of the elevated type.

Remotely controlled monitors shall be electrically powered from the essential electrical supply (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 credible hazard. The operator shall have a good sight of the area. A secondary panel may be installed in a control room.

The panel shall be weather proofed and equipped with a pair of binoculars. At least the following facilities shall be provided:
- 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.

Electrical and instrumentation cables shall be installed underground. Where this is not possible fire resistant cables shall be installed, either sprayed with water or enclosed in fire resistant cable ducting. (Refer to DEP 32.37.20.10-Gen. and MESC 68.48.5x).

(h) Self oscillation

Self oscillation is used where automatic rotation, over a preset angle, is required for stationary elevated water monitors. It is only applied in combination with remote controlled monitors.

A stroke adjustment facility shall be provided to set rotation sectors between min. 45 degrees and max. 315 degrees (Rate of stroke: approx. 360 degrees/min.).

The electric powered oscillating motor and associated instrumentation shall be in accordance with the applicable hazardous area classification code for the hazard under emergency conditions.

With reference to (g) the operating panel shall be extended with the following:
- on/off switch, incl. status light, for oscillating mode,
- push buttons, incl. position indicators, to increase/decrease stroke,
- failure (alarm) indication for oscillating motor.

2.3 WATER SPRINKLER OR DELUGE SYSTEMS

For application see DEP 80.47.10.30-Gen. Design requirements shall be in accordance with NFPA-13.

2.4 FOAM SYSTEMS

Foam systems can be divided in aspirating and non-aspirating systems.

2.4.1 Aspirating foam systems

Aspirating foam systems are primarily intended for fire extinguishment.
In exceptional cases, e.g. refrigerated liquefied gas products, such systems are used to reduce heat input from the environment.

2.4.1.1 Low expansion foam systems - **subsurface** foam injection

(a) Purpose

Fixed roof storage tanks higher than 10 metres, containing non water miscible combustible or flammable products (both having a viscosity up to 100 mm^2 (cSt) and a max. operating temperature of 95°C), shall be equipped with subsurface foam injection systems to effectively extinguish a full surface tank fire.

(b) Operation

Upon detection of a fire in the tank the foam injection system should be operated with minimum manpower. If a First Intervention Team can supply foam within 10 minutes after raising the alarm, the foam solution shall be supplied by means of a foam concentrate carrying fire truck equipped with a proportioning system.

For this purpose the truck shall carry portable high back-pressure foam generators (HBPGs). At the foam solution supply connection location for a particular tank, a sign shall be provided stating the following information:

- number and size of HBPG to be hooked-up (in case portable HBPGs are used)
- foam solution rate (dm^3/min)
- required solution supply pressure (bar(ga)) at the HBPG's inlet (min. to be 7 bar (ga))

The correct procedure of starting-up a foam solution supply system, by first introducing water into the piping system, will also assist circulating the top hot fuel layer circulating over the tank contents.

If a FIT is not available a foam station (see section 2.4.4.1) shall be required.

In order to be able to check the foam supply during application a foam sampling connection shall be provided outside the bund wall.

The normally "dry" piping system shall be flushed clean with fresh water after testing or use.

(c) Design

Reference is made to standard drawing S 88.022.

(i) Foam application

For details on foam application rate and time, see DEP 80.47.10.30-Gen.The foam solution rate (dm^3/min) for a particular tank is the product of its fixed inside liquid surface area (m^2) multiplied by the foam solution application rate (dm^3/m^2/min). Thus the foam solution rate is constant for a typical tank.
As the expanded foam operates against the tank static head and piping friction losses, a High Back Pressure foam Generator (HBPG) having an expansion ratio of between 3:1 and 4:1 shall be used.
As foam has only a limited travel distance the amount of foam inlet nozzles varies according to the tank diameter.

The foam solution supply connection and HBPG shall be installed outside the bund wall at a location upwind of the prevailing wind direction. From this point separate piping systems, containing their own HBPG, check-valve, bursting disc and stop-valve, run to each inlet nozzle. In order to supply foam evenly to each tank foam inlet nozzle, the design of the system shall be hydraulically balanced (approx. equal flow to each nozzle).

(ii) Piping system

Normally foam solution from the fire truck is supplied to the *portable* HBPG. If a foam station is used, a permanently installed HBPG shall be applied.

Depending on the manufacturer and type of HBPG the pressure loss across the HBPG is 60 or 75% of the inlet pressure. The HBPG's minimum operating inlet pressure is 7 bar(ga), resulting in a minimum HBPG outlet pressure of either 2.4 or 1.8 bar to overcome friction losses and static liquid tank head. For expanded foam friction losses refer to NPFA-11. In case higher downstream pressures (for the outlet piping head) are required, the HBPG inlet pressure shall be increased.

To ease subsurface foam injection operations, particularly with *portable* HBPG, it shall be aimed to standardize on HBPG size (typically 900 dm^3/min) and use multiples if required. An HBPG's turndown ratio is maximum 90%.

In the HBPG, located outside the bund wall, air is mixed with the foam solution to form foam.
The foam piping is connected to a dedicated tank nozzle just above the highest possible water level. Upstream, as close as possible to the tank nozzle, a stop valve, bursting disc and check valve are installed.

The bursting disc shall prevent tank product entering the check valve. The check valve is required to prevent product back flow in case of a possible fire hose burst.

If an *existing* tank has to be equipped with sub-surface foam injection and the tank cannot be made available for the installation of the system described above, product lines may be used for injecting foam. The minimum bursting disc break-pressure is governed by the thermal relief pressure.

(iii) Material selection

The bursting disc assembly should be made from stainless steel.
All dry piping components shall be hot dip galvanized after (pre-)fabrication (DEP 31.38.01.12-Gen., class 1810).

2.4.1.2 Low expansion foam systems - **semi subsurface** foam injection

(a) Purpose

Dehydration tanks (which have highly fluctuating water levels) and fixed roof storage tanks containing slops, deballasting water, combustible or flammable products that are water miscible (e.g.: polar solvents, alcohols, gasohols with more than 15% alcohols by volume) shall be equipped with semi subsurface foam injection systems to extinguish a possible full surface tank fire effectively.

Ensuring that such a system functions effectively, the above products shall have a maximum viscosity of 100 m^2/s (cSt) and a max. operating temperature of 95°C.

(b) Operation

Upon detection of a fire the foam injection system shall be operated with minimum manpower. If a First Intervention Team can supply foam within 10 minutes after raising the alarm, the foam solution shall be supplied by means of a foam concentrate carrying fire truck equipped with a proportioning system. For this purpose the truck shall carry portable high back pressure foam generators (HBPG).

At the foam solution supply connection location for a particular tank, a sign shall be provided stating the following information:

- number and size of HBPG to be hooked-up (in case portable HBPG are used)
- foam solution rate (dm^3/min)
- required solution supply pressure (bar(ga)) at the HBPG inlet (min. to be 7 bar (ga))

In addition to the portable HBPG a container holding a hose is permanently installed externally as close as possible to the tank's foam inlet nozzle(s). The hose is forced out of the container by the foam pressure and it will float through the stored liquid to the surface, avoiding direct contact of foam and product.

The normal procedure of starting-up a foam solution supply system, (i.e. by first introducing water into the piping system) will also assist forcing the hose out of the container and mixing the top hot fuel layer with colder product.

In case operation of a foam carrying fire fighting truck is not viable, the use of a foam station (see section 4.2.4.1) shall be required.

In order to be able to check the foam supply during application, a foam sampling connection shall be provided outside the bund wall.

The normally "dry" piping system shall be flushed clean with fresh water after testing or use.

(c) Design

Reference is made to standard drawing S 88.023.

(i) Foam application

For foam selection and details on foam application rate and time, see respectively DEP 80.47.10.10-Gen. and DEP 80.47.10.30-Gen. Application rate and time for a typical product shall be confirmed by the foam concentrate supplier.
The foam solution rate (dm^3/min) for a particular tank is the product of its fixed inside liquid surface area (m^2) multiplied by the foam solution application rate (dm^3/m^2/min). Thus the foam solution rate is constant for a typical tank.
As the expanded foam operates against the tank static head and piping/hose friction losses, a High Back Pressure foam Generator (HBPG) having an expansion ratio of between 3 and 4 to 1 shall be used.

As foam has only a limited travel distance the amount of foam inlet nozzles varies according to the tank diameter (refer to S 88.023).

The foam solution supply connection and HBPG shall be installed outside the bund wall at a location upwind of the prevailing wind direction. From this point separate piping systems, containing their own check-valve, isolation valve, hose container, bursting disc and stop-valve, run to each inlet nozzle. In order to supply foam evenly to each tank foam inlet nozzle, the design of the system shall be hydraulically balanced (approx. equal flow to each nozzle).

(ii) Piping system

Normally foam solution from the fire truck is supplied to the *portable* HBPG. In case a foam station is used a permanently installed HBPG shall be applied.

Depending on the manufacturer and type of HBPG the pressure loss across the HBPG is 60 or 75% of the inlet pressure. The HBPG's minimum operating inlet pressure is 7 bar(ga), resulting in a minimum HBPG outlet pressure of either 2.4 or 1.8 bar to overcome friction losses and static liquid tank head. For expanded foam friction losses reference is made to NFPA-11. In case higher downstream pressures (for the outlet piping head) are required, the HBPG inlet pressure shall be increased.

To ease semi subsurface foam injection operations, particularly with *portable* HBPG, it shall be aimed to standardize on HBPG size (typically 900 dm^3/min) and use multiples if required. An HBPG's turndown ratio is maximum 90%. In the HBPG air is mixed with the foam solution to form (expanded) foam. The foam piping is connected to a dedicated tank nozzle just below the minimum product level. Upstream, as close as possible to the tank's foam inlet nozzle, tank isolation valve, bursting disc, hose container and check valve are installed.

The stop valve, being a gate valve, shall be able to "cut" the hose for replacement after use. The bursting disc shall prevent tank product entering the hose container. The check valve is required to prevent product back flow in case of a possible fire hose burst.

(iii) Material selection

The material selection of the tank isolation valve is determined by the tank product (see DEP 31.38.01.10-Gen.: Piping classes, Part 1-Basis of Design) and the "hose cutting" requirement.

The bursting membrane assembly shall be made as per manufacturers recommendation.

Hose container assembly to be galvanised carbon steel or stainless steel 316L; hose to be made from terylene or as per manufacturer's proposal.

For the expanded foam all dry piping components shall be hot dip galvanized after (pre-)fabrication (see DEP 31.38.01.12-Gen., class 1810).

2.4.1.3 Low expansion foam systems - floating roof tank

(a) Purpose

Floating roof storage tanks containing combustible or flammable products shall be equipped with foam pourers to address rim fires only. Proper tank engineering including an independent "high-high" level alarm, and proper tank maintenance, including the seal system, will result in a full surface tank fire to be considered a non-credible event.

(b) Operation

Upon detection of a fire by means of a heat/fire detection system, the foam system should be operated with minimum manpower.
If a First Intervention Team can supply foam within 10 minutes after raising the alarm, the foam solution shall be supplied by means of a foam concentrate-carrying fire truck equipped with a proportioning system. In all other cases the use of a foam station (see section 4.2.4.1) shall be required.

If a fire truck is used, a sign board shall be provided at the foam solution supply connection location. This sign shall state:
- the required foam solution rate (dm^3/min);
- the required solution supply pressure (bar (ga)).

(The procedure of starting-up a foam solution supply system, by first introducing water into the piping system, has negligible detrimental effect on fighting floating roof rim fires).

Foam solution is supplied through risers to a High Back Pressure foam Generator (HBPG), which feeds foam pourer nozzles with expanded foam.
The foam solution riser installed near the access stair's top platform at wind girder level shall be equipped with two hose connections upstream of the HBPG. These connections can be used as back-up for manual foam application through hand held foam branch pipes provided safety of personnel is not jeopardized. A hose box (see DEP 80.47.10.32-Gen.) containing sufficient 20 m long 1½ inch fire hoses and two hand held foam branch pipes (typically: 250 dm^3/min foam solution at 7 bar(ga)), shall be installed at the top platform.

After use/testing the system shall be flushed with fresh water. In addition it shall be checked that the system is drained.

(c) Design

Reference is made to standard drawing S 88.009.

(i) Foam application

For details on foam application rate and time, see DEP 80.47.10.30-Gen. Generally, the minimum foam solution application rate is 12 $dm^3/min/m^2$ at the target area between tank shell and foam dam; the foam solution application rate shall be 20 $dm^3/min/m^2$ at the foam pourer nozzle outlet, to be maintained for at least 30 minutes.

The foam application rate (dm^3/min) is the product of:
- fixed surface area (m^2), between tank shell and foam dam,

- solution application rate ($dm^3/m^2/min$).

Thus the foam solution application rate is constant for a typical tank.

An HBPG shall be used suitable to operate against an expanded foam pourer back pressure of 0.6 bar(ga). To improve fluidity the generator shall have a foam expansion ratio of between 3 and 4 to 1.

The foam dam drainage holes shown on S 88.009 are larger than normal in order to avoid blockage and possible subsequent sinking of the floating roof. To compensate for undue foam escape through these holes, the HBPG solution capacity shall be at least 900 dm^3/min.

(ii) Heat/fire detection

The tank shall be equipped with a heat/fire detection system. A pressurised single loop tubing system will activate the alarm system in case the tubing detects heat (approx. 90°C).

Plastic detection tubing shall be installed in the rim area where credible fires (excessive heat) may occur, i.e. the rim seal area. The tubing shall be flame-retardant, black polyethylene, of a brand to be approved by Principal. All plastic tubing shall be well supported. Construction drawings shall be submitted for approval by purchaser.

The loss of pressure in the single loop shall result in a fire alarm. The alarm shall be visually and audibly annunciated on the fire and gas detection panel located in the control room. The fire alarm shall start the fire water pump(s).

The loop is kept pressurised by a self contained modular unit to be installed on the floating roof. For a typical example see Appendix 14. The pressure switches, junction box and energised instrumentation shall be suitable for a zone 1 hazardous area.

Alternatively at nominal two metres interval, a glass bulb detector (nominal melting point 80°C) or fusible fitting (nominal melting point 70°C) may be applied. The nickel plated brass detector or stainless steel (AISI 316) fitting shall be connected to the copper nickel alloy tubing by means of a tee-fitting. The tubing shall be supported from the foam dam by metallic supports.

(iii) Piping system

Foam has a limited travel distance, therefore "cow horn" type foam pourer nozzles shall be installed at a max. pitch of 30 m around the tank circumference at wind girder level (See Std Drg S 88.009.). Each foam pourer and its HBPG shall be fed from a dedicated riser (supply line). Inside the bund the foam solution supply piping shall be supported on sleepers. From the foam solution supply connection piping shall run over the bund wall.

The foam solution supply connection (to be provided with blinded Storz or instantaneous male/female fire hose connection) shall be installed outside the bund wall, preferably at a location upwind from the prevailing wind direction or alternatively in a safe place. In the vicinity of such a location fire water hydrants shall be provided. In order to supply foam evenly to foam pourer nozzles, the design of the piping system shall be hydraulically balanced (approx. equal flow to each nozzle).

In the absence of a windgirder the HBPG shall be installed at tank base level.

Depending on the manufacturer and type the pressure loss across the HBPG is 60 or 75% of the inlet pressure. The HBPG's minimum operating inlet pressure is 7 bar(ga), resulting in a minimum HBPG outlet pressure of either 2.4 or 1.8 bar to overcome friction losses. (HBPG's turndown ratio is maximum 90%)

The HBPG shall be installed horizontally for easy access, and to avoid fouling of the air inlet and venturi assembly.

Inside the bund horizontal "dry" piping shall be installed with a slope of 1:200 or steeper and it shall be equipped with a low point drain. Foam solution risers to be provided with bottom blind flange plus weephole.

The foam dam shall have a height at least 50 mm above the seal arrangement;

however, the minimum height shall be 350 mm. The dam shall be fully seal welded to the roof and it shall be provided with water drainage openings (65 x 25 mm) at approx. 3 m pitch.

If an existing floating roof tank has to be equipped with foam pourer nozzles and the tank cannot be made available for installation of the system described above, the use of a single foam solution supply line feeding a ring header, at tank base or wind girder level, may be considered.

(c) Material selection

The HBPG shall preferably be made from stainless steel (316L).

All dry piping components shall be flanged hot dip galvanized after pre-fabrication (see DEP 31.38.01.12-Gen., class 1810).

2.4.1.4 Medium/high expansion foam systems

For application see DEP 80.47.10.30-Gen. Design requirements shall be in accordance with NFPA-11A.

2.4.2 Non-aspirating foam systems

Non-aspirating foam systems are intended for rapid fire *control* (not primarily extinguishment), as required on e.g. manned loading facilities (see also DEP 80.47.10.10-Gen.). Rapid fire control is achieved through excellent flowing capability due to the low expansion ratio. The throw capability (trajectory) is compatible with water spray droplets.

2.4.2.1 Non-aspirating foam systems for loading gantries

(a) Purpose

Loading gantries are areas where personnel are continuously present during loading operations and where they are exposed to increased risk from road or rail tankers being temporarily hooked up to loading systems.

Loading gantries handling flammable and combustible hydrocarbons/chemicals shall be equipped with non-aspirating foam systems to provide:

1. Quick fire knockdown for the control/extinguishment of pool fires, to allow personnel to be rescued in the event of a fire,
2. Heat exposure protection against engulfing fires, for adjacent equipment in the loading area.

LPG loading facilities shall only be provided with water spray systems. With the exception of the foam concentrate related hardware, the system requirements remain the same.

(b) Location

The non-aspirating foam systems shall at least cover the road/rail car, including its heads, plus the loading (and vapour return) lines. In addition the driver's road-car cabin shall be included.

(c) Operation

The spray system shall be activated automatically by a fire/heat detection system. In addition, manual activation shall be provided in the vicinity of the loading area and in the local loading supervisor's office or central control room. For typical scheme see Appendix 4.

In salt/brackish water service the normally "dry" piping system shall be flushed clean with fresh water after testing or use.

(d) Design

(i) General

The use of foam and water spray appears conflicting, thus after system initiation, use

of foam shall only be maintained sufficiently long to provide time for personnel rescue operations by means of AFFF foam application. As a non-aspirating foam system is used, with an expansion ratio of between 1 and 2 to 1, cooling of equipment is also achieved in the initial stage after system initiation.
For the duration of foam application and foam/water application rates refer to DEP 80.47.10.30-Gen. However, foam application should be maintained for 10 minutes; the nett minimum foam/water rate shall be 6.5 $dm^3/min/m^2$ area to be protected. The following should be added to the aforementioned application rates: 20% due to water not reaching the equipment (because of wind or other factors), and in addition 10% as a flow balancing factor for discharge nozzle pressure variations. On the tanks themselves rundown shall not be incorporated in the design. In order to minimise the grade surface area to be protected, drain gullies with fire traps shall be provided around the vehicle/rail cars.

Due consideration shall be given to the split-up of the area and/or equipment to be protected with a view to economise on foam and water.

Foam/spray water nozzles shall be directed radially to the vehicle/rail car; to the top, the sides and undercarriage of the road/ rail tank cars. The number of spray nozzles on each level and the spray angle of the nozzles depend on the road/rail car geometry. Generally four horizontal spray nozzle headers are required (see Appendices 6 and 15-2 and 3).

In case spray 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 shall be applied.

The foam/water spray system shall be arranged so as not to interfere with the maintenance requirements of the installation.

For new projects the spray nozzle layout shall be shown on the plant's piping model to make certain that no interference with piping or structures, etc. will occur. For existing plant the relevant piping general arrangement drawing(s) may be used.

(ii) Foam system

For introduction of foam concentrate into fire water, two systems can be distinguished:

- the balanced pressure proportioning system;
- the induction system.

In both systems foam concentrate is mixed with water (either fresh or salt/ brackish). The volume of foam concentrate is either automatically determined by proportioning equipment or by venturi action and orifices.

Balanced pressure proportioning system

This system consists basically of a foam concentrate storage tank, a foam pump, an automatically monitored pressure control unit and a venturi type proportioning controller in the fire water line. This system offers a reliable and accurate operation and is able to function over a *wide range of flows* and *varying inlet pressures*.

Induction system (see Appendix 15-1)

This system consists of an in-line inductor which introduces foam concentrate from a vessel by means of venturi action. The correct operation is very sensitive to water flow and pressure level changes. These changes will result in incorrect proportioning. The maximum lift of the foam concentrate to the inductor shall be 1.8 m (refer to NFPA-11).

This system is only recommended for systems where fixed capacities are required and the permanent pressure loss (30% of inlet pressure) can be accommodated.

NOTE: The application of storage tanks with flexible diaphragms or bladders can only be recommended when the tank has such a design that it is possible to easily replenish the foam supply during operation.

AFFF concentrate storage tank

For the requirements of the foam concentrate storage tank, reference is made to 2.4.4 (d)(i).

Foam concentrate pump

The foam pump shall be of the electrically driven centrifugal type. The electric driver shall be suitable for the applicable zone of the Hazardous Area classification (refer to IP Model Code of Safe Practice - Part 15), however as a minimum the driver shall conform to the requirements of hazardous area zone 2.

For foam solution demands up to 240 m^3/h a water turbine may be considered (typical water consumption at 10 bar(ga) fire water mains pressure: 25% of the fire water demand).

Proportioning controller

The proportioning controller/in-line inductor shall be designed for proportioning ratios of 3 and 6% (externally adjustable).

The minimum and maximum capacity shall be based on the section with the smallest and largest foam/water spray demand respectively.

For further requirements refer to 2.4.4 (d)(ii).

(iii) Heat/fire detection

Each foam/water spray system shall be equipped with a heat/fire detection system.

Sections of plastic detection tubing shall only be installed in those areas where credible fires (excessive heat) may occur, i.e. typically at the inlet/outlet piping flanges. The tubing shall be flame-retardant, black polyethylene, of a brand to be approved by Principal. The sections of plastic tubing shall be interconnected by PVC covered copper tubing using connectors with metal tubing inserts. All plastic and copper tubing shall be well supported. For typical line-up schematic see drawings S-88.020 or S-88.021. Construction drawings shall be submitted for approval by purchaser.

Alternatively glass bulb detectors (nominal melting point 80 degrees Centigrade) or fusible fittings (nominal melting point 70 degrees Centigrade) may be applied as point detectors. The nickel plated brass detector or stainless steel (AISI 316) fitting shall be connected to the copper nickel alloy tubing by means of a tee-fitting. The tubing supports shall be metallic.

The loss of pressure in a single loop shall result in a fault alarm, while loss of pressure in both loops will result in a fire alarm (two out of two voting system). Both alarms shall be visually and audibly annunciated on the fire and gas detection panel. The fire alarm shall start the fire water pump(s) and it shall de-energise the solenoid valve in the instrument impulse line to the automatic on-off valves of the corresponding foam/water spray system. Each automatic on-off valve shall be provided with a three position switch (open/automatic/closed) to be installed on the smoke, fire and gas detection panel in the central control room. For a typical scheme see Appendix 4.

(iv) Hydraulics

The design of a foam/water spray system shall be based on hydraulic calculations to determine the required pressures and corresponding foam/water quantities of the foam/water spray nozzles. The calculations shall be approved by Principal. Refer also to NFPA-16.

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 (see DEP 80.47.10.30-Gen.). 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 application of restriction orifices. The on-off valve, filter etc. shall be part of the calculation. If pressure reduction is still required, a piece of small bore piping (max. length: 2 m) shall be installed downstream of the on-off valve and downstream of the manually operated block valve. The spool shall be flanged and it shall have a minimum size of ½ inch (material to be stainless steel, DEP 31.38.01.12-Gen., class 1303).

In all cases a detailed lay-out shall be made of the equipment and areas to be protected and on which the arrangement of the spray nozzles shall be shown.

(v) Piping line-up

A foam/water spray water pipe system shall have two connections to the fire water ring main. Connections to be in opposite locations in relation to the loading area to be protected. The connection to be equipped with the automatic on-off control valve shall be located downwind of the prevailing wind direction. This valve manifold shall be at least 15 m from the periphery of the spray system, while the upwind manually controlled block valve manifold shall at least be 30 m away from the spray system. At both connections a filter shall be installed; for size see - Filter (below).

In the exceptional case that the distance from the fire water mains to the manually operated block valve will be more than 100 m, the fire water supply to this valve may be taken from the same side as the on-off control valve. In such a case an isolation valve shall be provided in the fire water main between both branch connections (tie-ins).
To save on filter capacity adjacent spray water systems, that may operate simultaneously, can be served by a common filter for both fire water supplies (the on-off control valve side and the manually operated block valve).

Horizontal "dry" piping, downstream of the block valve and of the automatic on-off valve, shall be installed with a slope of 1:200 or steeper and it shall be fitted with adequate drain facilities; weepholes in spray headers and automatic drain valves shall be provided at selected locations.

At each fire water supply side (downstream of the on-off control valve and the block valve) a 3 inch branch with valve and 2½ inch Storz/instantaneous hose connection shall be provided for water or smoke testing and, in case salt/brackish water is used, flushing with fresh water.

All overhead piping shall be adequately supported and fixed to prevent deflection and vibration. This may be executed by means of supports from the loading gantry structure. In the exceptional case that the spray water piping is supported from grade, these supports require protection from ground (pool) fires, e.g. fire proofing (see 2.10) or internal water flow.

In exceptional cases where it is envisaged that the orientation of the water spray nozzles requires adjustment after installation, a screwed double elbow shall be provided.

- Filter:

  The in-line filters shall be of a bucket-type design, with a bucket-type filter insert. Each filter shall have a minimum capacity of 800% of the nominal inlet pipe size.

  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.

- On-off control valve:

  The on-off control valve shall be a UL-1091-listed butterfly fire water valve or equivalent approved by Principal. The valve shall be tight shut off (TSO) against a maximum pressure of 16 bar(ga). When the instrument air pressure drops to 3 bar(ga) the valve shall be activated to fully open within 10 seconds. The actuator shall be sized such that the valve can be fully opened and closed under the maximum occurring pressure differential or maximum flow conditions.

- Foam/water spray nozzles:

  Medium velocity, full cone, open-type spray nozzles with external deflectors, shall be applied. Internal strainers are not allowed to avoid individual nozzles becoming blocked 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 threaded male connection (min. size: ½ inch).

  The foam/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 (not less than 20% of the average rate in any area of 100 x 100 mm).

- Climatic conditions:

  In locations susceptible to freezing, electrical trace heating (refer to DDD 33.68.30.32-Gen.) shall be applied to fire water manifolds and piping installed in access pits.

- Corrosion protection:

  Where salt/brackish water is used, the flanged cross-over piping from underground to above ground and piping to the automatic on-off valve or block valve shall be internally coated; preferably by epoxy paint (minimum 400 microns dry film thickness) or alternatively by cement lining (DEP 31.38.01.12-Gen., class 1803).

(iv) Instrumentation and electrical

The solenoid valve shall be electrically operated and be suitable for the applicable zone of the Hazardous Area Classification (refer to IP Model Code of Safe Practice - Part 15). Instrument air supply pressure: min. 3 bar(ga), max. 7 bar(ga).

Instrument and cabling shall be applied in accordance with DEP 32.37.20.10-Gen.: "Instrument signal lines", section 5.5: Protection of cables against fires.

Power cabling shall be fire resistant in accordance with DEP 33.64.10.10-Gen. (Refer to MESC 68.48.5x).

(e) Material selection

(i) Piping

The piping/fitting material shall be selected from the applicable piping classes (DEP 31.38.01.12-Gen.). The maximum pressure upstream the on-off control valve is 16 bar(ga). The "dry" pipe sections shall be flanged for all sizes and shall be hot dip galvanised after pre-fabrication in accordance with DEP 31.38.01.12-Gen. (class 1810).

(ii) In-line filter

The filter housing shall be carbon steel; for use in salt/brackish water it shall be internally epoxy coated (min. 400 microns).

Filter element material to be stainless steel (316L) or Monel 400.

(iii) On-off control valve

Valve to have carbon steel body (plus internal rubber lining) and corrosion resistant internals. Refer to relevant MESC description.

(iv) Foam/water spray nozzles

Nozzle material to be stainless steel (316) or Monel 400.

(v) Solenoid valve

Body material: brass.

(f) Skid mounted unit

When a skid mounted unit (comprising foam concentrate storage tank, inductor/pump plus proportioner and interconnecting piping) is required, this unit shall be provided with adequate access to the equipment by means of stairs and platforms with railings.

The unit shall be provided with the integral instruments and junction boxes.

The limits of supply (interfaces) shall be indicated clearly.

(g) Scope

For scope of work and supply see section 4.

2.4.3 Dry risers for foam (solution)

For design requirements, see 2.1.5: Dry risers.

2.4.4 Foam concentrate storage facilities

(a) Purpose

A foam concentrate storage facility is required to assist in efficiently replenishing concentrate into stationary and mobile foam systems, e.g. foam stations, fire fighting vehicles and foam trolleys. The total quantity of foam concentrate on site (including that contained in fire trucks, etc.) shall be based on the largest credible scenario plus 100%spare.

(b) Location

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 may be required to facilitate logistics during emergencies.

(c) Operation

Refer to Appendix 16.

Filling of foam concentrate carriers should be by gravity. The bottom of the foam concentrate storage vessel shall be installed at an elevated level such that foam concentrate carriers and/or fire 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 concentrate carrier vessel. As an alternative a simple loading arm may be preferred, provided with fresh water flushing facilities.

In order to be able to circulate the foam concentrate at weekly intervals a circulation pump shall be installed.

The circulation pump shall also be used to fill the storage vessel from a bulk supply source or from drums. In the event that a bulk supply cannot be guaranteed, a drum unloading facility shall be provided.

The entire facility shall be provided with a concrete slab, which drains, via a normally closed valve, into the NNC (Normally Not Contaminated) drain system.

Lighting shall be provided for night time operations (Refer to DEP 33.64.10.10-Gen.).

(d) Design

The foam concentrate storage facility consists of an elevated foam concentrate storage vessel, foam concentrate circulation pump and storage vessel filling/discharge facilities. Refer to Appendix 16.

(i) Foam concentrate storage vessel

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 mbar (ga) overpressure and 5 mbar (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 overfill.

Amended Per Circular 64/97

The vessel shall comply with the specified design code (e.g. BS 5500 or equivalent approved by the Principal).

As the concentrate will foul sight glasses, a membrane type construction shall be applied. Refer to Appendix 17. The top of the standpipe shall be provided with a breather. As an alternative a magnetic type level gauge may be used where the top of the standpipe shall be connected to the vapour space in the dome.

A heat shield shall be provided against sun radiation, as this may heat the foam concentrate and cause accelerated deterioration. 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. 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.

(ii) Foam concentrate circulation pump

The foam concentrate circulation pump should be sized to achieve a vessel hold-up time of 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.

(iii) Storage vessel filling/discharge facilities

For bulk supply filling a 2½ inch nominal diameter suction hose connection shall be provided. For topping up the foam concentrate vessel from drums by means of a diaphragm pump, the circulation discharge line may be provided with a ¾ inch nominal diameter hose connection.

A drum unloading facility comprises a collecting pit (nominal size 1 m^3) and a drum storage/unloading rack. A cover shall be provided to avoid dirt entering the pit. The drum storage rack shall be sized to accommodate at least three pallets of 200 litre drums, drum handling equipment and sufficient space to manoeuvre drums.The gravity discharge facility shall be six inch nominal diameter.

(e) Material selection

Mechanical

The foam concentrate vessel should be constructed from glass-fibre reinforced polyester. Refer to DEP 31.22.30.14-Gen.

Metallic materials may be used as an alternative. Depending on the type of foam to be stored the following metallic materials may be used:

Concentrate	**Vessel material**
Fluoro Protein	Carbon steel; to be internally coated with an amine cured epoxy paint
AFFF	AISI 316L
Alcohol Resistant	AISI 316L.

The choice of any of the above materials (including GRE) shall be verified with the foam concentrate supplier/manufacturer. Any alternative requires Principal's approval.

All *piping* components in permanent contact with foam concentrate shall be stainless steel (DEP 31.38.01.12-Gen., class 1303). If the facility is located off plot, glass fibre reinforced epoxy (DEP 31.38.01.12-Gen., class 1705) may be used as an alternative.

For the testing of the foam concentrate *circulation pump* refer to DEP 31.29.02.11-Gen. Material selection shall be as below:

Housing, Rotor	Ni-Resistant D2 Cast Iron or AISI 304 or 306
Shaft	AISI 316
Bearings, Glands	Standard manufacturers proposal

Grades are indicative only; nearest equivalent may be put forward for approval by Principal.

The *collecting pit plus* cover shall be fabricated from glass fibre reinforced polyester.

The air driven *diaphragm pump* shall be of a standard supply type with adequate fresh water flushing and draining facilities.

2.4.4.1 Foam station

(a) Purpose

A foam station is required either to supply foam solution to a particular area of the installation to extinguish the fire entirely in the estimated time, or to supply foam solution during the time required for the First Intervention Team to line up the foam concentrate supply.

The design of the foam station shall be such that the foam application solution is supplied within two minutes after activation of the station. Ref. DEP 80.47.10.30-Gen.

(b) Location

The foam station shall be installed at a safe distance from the credible fire area. For this reason heat radiation calculations are required. Such calculations shall be approved by Principal.

(c) Operation

See Appendix 18.

A local control panel and logic system shall be included to start and stop foam solution supply to user. The foam station shall only be permitted to start after the fire water flow to the user has been established. The suction valve shall be opened before the concentrate pump is started against a closed discharge valve.

Preferably the opening of the foam concentrate discharge valve shall be automatic.

The spare concentrate pump shall start up automatically in case the main pump fails to build a minimum pressure of 10 bar within 20 seconds.
Provided fire water flow to the user has been established start-up of any pump shall be possible from the local control panel or the foam station itself.

Upon the decision to change over from foam to water it shall be possible to close the discharge valve at the local control panel or manually at the foam station itself. If it is decided to shut off one or more of the users the foam concentrate pump shall continue to run and the foam concentrate shall circulate into the foam concentrate vessel.

Except for the foam concentrate vessel itself fresh water flushing facilities shall be provided for the foam concentrate pumps and piping to rinse the system after use and testing with foam concentrate. The flushing connection(s) and drain(s) shall be provided with an interlocking system to avoid flushing liquid entering the foam concentrate storage vessel.

By means of a maintenance-overriding facility it shall be possible to circulate the concentrate via the vessel monthly for at least half an hour. Under this condition the foam solution piping shall be kept dry.

The normally "dry" piping system shall be flushed clean with fresh water after testing or use.

(d) Design

The foam station shall preferably be skid-mounted and it shall consist of a foam concentrate vessel, foam concentrate pumps, foam concentrate mixer (proportioner), interconnecting piping and a control panel.

(i) Foam concentrate vessel

The size of the foam concentrate storage vessel shall be based on the largest credible fire that can occur in the area served by the foam station (see Appendix 1 and DEP 80.47.10.30-Gen.). In addition the size of the foam concentrate vessel shall cater for at least one foam hose stream (200 l/min foam solution, 7 bar(ga) at foam nozzle inlet) as supplementary protection against small (5 m diameter max.) spill fires, and a 100% spare capacity to cover aforementioned scenario and hose stream.

For further vessel requirements, e.g. heat shielding against sun radiation, tracing in cold climates, re-circulation, etc., refer to 2.4.4.

(ii) Mixing point (proportioner)

At the mixing point the concentrate is added to the fire water to produce a foam solution. The foam concentrate is transported from the storage vessel to the mixing point by means of a foam concentrate pump. Other means of transporting foam concentrate are not recommended because of limitations in testing, circulation and re-filling.

Correct dosing of concentrate into water is achieved by means of a proportioner. A typical proportioner, to be suitable for flow rates between 10 and 100% of the design capacity, has a pressure loss of 10% of the inlet pressure.

Taking into account fluctuating foam solution demands, piping design pressure, pressure loss in the foam solution supply piping and minimum operation pressure of the users, e.g. stationary monitor(s), the use of inductors is not recommended because their inherent pressure loss is typically 30% of the inlet pressure and their flow rate cannot be varied outside 95 to 100% of the design capacity.

For proportioning systems it is essential that the foam system components are checked for compatibility regarding fire water supply pressure, pump duty, proportioner capacity and minimum inlet pressure, foam solution delivery rate to monitors and monitor duty. A differential pressure of one bar shall be maintained between foam concentrate and fire water supply to the proportioner. Therefore hydraulic calculations shall be made for the entire foam system. These calculations shall also address pressure pulses resulting from liquid filling of the normally dry foam solution supply lines.

(iii) Foam concentrate pump

The foam concentrate pump shall be electrically driven. The 100% spare pump shall be diesel driven. Its 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 2.1.2.

For foam solution demands up to 240 m^3/h both foam concentrate pumps may be driven by a water turbine (typical water consumption at 10 bar(ga) fire water mains pressure is 25% of the fire water demand).

(e) Material selection

(i) Mechanical

For equipment in *permanent* contact with foam concentrate refer to section 2.4.4.

The foam solution piping is normally dry. All *flanged* carbon steel piping shall be in accordance with piping class 1810 (DEP 31.38.01.12-Gen.). After *fabrication* the piping shall be hot dip galvanized in accordance with ISO 1461.

To avoid flushing with fresh water where manning levels are limited, 90/10 copper-nickel (ASTM B466/B467 C70600 or equivalent approved by Principal) or 6% molybdenum stainless steel (UNS S31254 or equivalent approved by Principal) may be used.

For the testing of foam concentrate pumps refer to DEP 31.29.02.11-Gen. Material selection shall be as below:

Housing, Impeller	Ni-Resistant D2 Cast Iron or AISI 304 or 316
Shaft	AISI 316
Bearings, Glands	Standard manufacturers proposal

The water turbine casing should be ASTM A240-TP304; the Pelton wheel should be phosphor bronze.

Manufacturer's selection to be approved by Principal.

(ii) Instrumentation and electrical

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

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

2.5 DRY CHEMICAL POWDER SYSTEMS

For purpose and location, see DEP 80.47.10.30-Gen. Design requirements shall be in accordance with NFPA-17.

2.6 CARBON DIOXIDE SYSTEMS

(a) Purpose

The application of carbon dioxide reduces the oxygen concentration thus achieving fire extinguishment.

If installed in an enclosure, non-spared equipment which is:
- capital intensive;
- of strategic importance in avoiding consequential losses;
- subject to a long delivery time;

shall be provided with a carbon dioxide extinguishing system in each compartment enclosure, provided no other fire control agent is suitable (see also 2.7). Each system comprises a dedicated gas and fire detection and protection system.

REDUCTION OF OXYGEN CONCENTRATION IS A SERIOUS HAZARD TO PERSONNEL. In addition the release of carbon dioxide directly aimed at personnel may cause "cold" burns, ear injury, reduced visibility and loss of balance.

(b) Location

A typical example is a gas turbine with an acoustic enclosure. Normally the enclosure comprises at least a turbine compartment and an auxiliaries compartment (see Appendix 19).

(c) Operation

The purpose of the system is to inert an enclosed area by reducing the oxygen to fuel ratio thus acting as a fire preventor or fire suppressor. Refer to Appendix 22.

Under normal operating conditions the detection and protection system shall be in the **automatic** mode. This mode shall be shown by a green lamp in the following locations:

- the fire and gas detection panel in the control room,
- the carbon dioxide control panel located near the enclosure,
- above each enclosure door.

The activation of one fire or gas detector shall generate a pre-alarm indication, while the coincident activation of two or more of the same detectors shall generate an emergency alarm tripping the gas turbine and fuel shut off (refer to Appendix 23). Only when two or more of the same type of **fire** detectors have been activated shall visual and audible evacuation alarms located inside the enclosure shall be raised to urge any personnel to vacate the enclosure immediately. Ventilation dampers shall be closed.
Carbon dioxide release into the enclosure shall be started after at least 20 seconds have elapsed from the moment of raising the evacuation alarm. The actual setting shall be based on "dry" (practice) evacuation runs, including time to identify the warning signal. The actual release of carbon dioxide shall be shown, by means of a flashing red lamp, in the following locations:

- above each enclosure door,
- on the main fire and gas detection panel in the control room,
- on the control panel located outside the enclosure.

The evacuation alarms and appropriate status light shall remain in operation until it has been established that the carbon dioxide level in the compartment is safe for entering without breathing apparatus. Therefore manual reset of the system shall only be possible by means of a lockable push button on the control panel located near the enclosure.

Manual initial carbon dioxide release (inclusive preceding visual and audible evacuation alarms) shall be possible from the fire and gas panel in the control room and from the control panel located outside the enclosure. The switch shall have a protective cover.

A **mechanical** activation device for initial plus subsequent carbon dioxide release (inclusive preceding evacuation alarms and time delay) shall be located in an easily accessible place near the carbon dioxide containers. This mode of activation shall not make use of the secure air supply (SAS) system.

In order to allow overheated components to cool down below the auto-ignition temperature of the combustible material the enclosure shall be provided with an "extended" discharge system to maintain the minimum required carbon dioxide concentration for a sufficient period of time. The extended discharge system is activated by the initial release system by means of one minute delay.

The spare carbon dioxide bottles shall be permanently connected to the carbon dioxide system by means of a normally closed valve (to be specified: activation incl. audible and visual alarms).

As personnel may stay inside the enclosure for longer periods to perform e.g. maintenance, the enclosure shall be provided with a two-position switch (lockable in each position) on the carbon dioxide extinguishing control panel of the system located outside the enclosure. The positions shall be marked:

- carbon dioxide release "automatic"
- carbon dioxide release "inhibited".

The "inhibited" status shall be shown, by means a white lamp on the fire and gas detection panel in the control room, on the panel located outside the enclosure, above each compartment door and on the carbon dioxide cabinet in the field auxiliary room. During the "Inhibited" mode the detection systems remain operational, while manual release (inclusive preceding audible plus visual evacuation alarms and delays) shall **only** be possible from the control panel located outside the enclosure.
This two-position switch shall also be used when replacing carbon dioxide bottles.

At the carbon dioxide control panel located near the enclosure two sets of self contained breathing apparatus shall be installed for personnel rescue purposes.

To perform functional testing, a lockable maintenance override facility shall be provided on the carbon dioxide cabinet in the field auxiliary room. This facility shall inhibit the detection systems and carbon dioxide release. While the maintenance override is operative the visual evacuation alarm shall be active. The **"operative"** status of the override facility shall be indicated on:

- the fire and gas detection panel in the control room,
- the panel located outside the enclosure,
- the cabinet in the field auxiliary room,
- a status light located above each compartment door.

(d) Design

(i) General

Refer to Appendix 21

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

Each gas turbine enclosure shall be provided with a separate carbon dioxide system, including storage cylinders for initial, extended and spare discharge. The carbon dioxide system shall be piped to each compartment.

Enclosure doors shall open outwards. They shall be equipped with spring loaded closing dampers and anti-panic bars on the inside. Each door shall de fitted with a ten seconds delay proximity switch of a type which requires approval by the principal. A non-closed door shall be indicated as a pre-alarm only on the fire and gas detection panel in the control room.

Each enclosure door shall be fitted with a warning sign on the outside. Such a sign shall at least address the following aspects:

- immediate evacuation on alarm
- prohibited entry if alarm is active

Carbon dioxide capacity calculations and storage requirements shall be submitted to the Principal. The calculations shall address the initial discharge, the extended discharge, the spare discharge and the discharge required for testing.

The design, fabrication, testing and inspection of the high pressure carbon dioxide cylinders shall comply with BS 5045 Part 2 or Principal approved alternative.

For a typical division between purchaser and vendor see Appendix 20.

(ii) Detection

Amended Per Circular 41/99

For a summary of the alarm, control and trip functions refer to Tables 1 and 2 (Appendices 22 and 23 respectively). The logic diagram shall be accompanied by a matrix and narrative description covering all features incorporated.

- Fire detection

  Solar-blind infrared (IR) flame detectors shall be provided such that any fire inside the turbine and load compartments can be detected. Principal to approve the detector type.
  Each IR detector shall be mounted on a swing frame to enable easy access for maintenance.
  Due to the detector's limited self-checking capabilities three detectors shall be installed at each position. Where the same area can be completely supervised from more than one location, the number of detectors per location may be reduced as long as the 2 out of 3 voting principle is adhered to. Detection by an individual detector shall initiate a common pre-alarm. The coincident detection by two or more detector heads shall: initiate a fire alarm, shut down the turbine, shut down and block-in the ventilation system and release carbon dioxide into all compartments of the enclosure.

  Rate-of-rise compensated heat detectors shall be positioned in each compartment close to the air outlet of the ventilation system. Three heat detectors shall be installed at this position, with a 2 out of 3 voting system for both detector heads. The actions upon detection shall be identical to those for the IR detectors.

- Gas detection

  As a minimum flammable gas detectors shall be provided for the following locations:

  - in the **ventilation** air inlet,
  - air outlet of the ventilation system for the gas turbine compartment.

  Three detectors shall be installed at each location. The detectors shall have setpoints at 10% vol. Lower Flammable Limit (LFL) and at 45% vol. LFL. Detection of gas by a single detector head at 10% vol. or 45% vol. LFL will raise a pre-alarm. Detection of gas by any 2-out-of-3 detectors heads installed per location at 45% vol. LFL shall raise a gas alarm and shall shut down the gas turbine.

  The ventilation system for the gas turbine enclosure shall remain in operation unless gas is detected in the **ventilation** air inlet.

(iii) Piping

In view of the large difference in capacity requirements of the initial and extended discharges, separate piping shall be installed for each system. The selection of piping material shall be based on DEP 31.38.01.10-Gen.

(iv) Area classification

With reference to IP Model Code of Safe Practice - Part 15, all equipment **inside** the enclosure shall be suitable for operation in hazardous area Zone 1. Equipment installed **outside** the enclosure shall be suitable for hazardous area Zone 2. Apparatus sub-group, temperature class and enclosure protection are dependent on the concentration and type of media present.

(v) Electrical

Power supply shall conform to DEP 32.30.20.11-Gen.

As discharge of carbon dioxide is known to produce an electrostatic charge, earthing shall be provided in accordance with DEP 33.64.10.10-Gen.

(vi) Instrumentation

Instrument air supply lines shall be connected to the secure air supply (SAS) system. In addition, to avoid any carbon dioxide release without prior activation of the evacuation alarms, the automatic release valves shall be kept closed on air failure. For the same reason solenoid valves shall be normally de-energised.
The use of an independent nitrogen system as an alternative to instrument air supply requires approval by the Principal.

Facilities shall be provided for functional and operational integrity testing of each detector circuit (inclusive each detector head) and each alarm, annunciation and protection circuit. Integrity testing shall be controlled from the carbon dioxide cabinet in the Field Auxiliary Room (FAR). Therefore the cabinet shall be equipped with a (line) monitoring module with a fault read-out/display unit and associated key-board. Any occurring faults shall be annunciated on the fire and gas detection panel in the control room by means of the general fault indication lamp.

Equipment susceptible to radio frequency interference shall comply with requirements described in DEP 32.31.00.32-Gen.

Facilities shall be provided to check the quantity of CO_2 stored in the cylinder.

Cabling shall be applied in accordance with DEP 32.37.20.10-Gen.

2.7 HALON SYSTEMS

There is hardly ever a justification to apply halon systems in onshore facilities.

Guidance is given in: "Recommendations for alternatives to fire fighting halons", November 1990, issued by the Shell Safety and Health Committee.

2.8 STEAM SYSTEMS

(a) Purpose

Steam can be used to smother fires or to dilute gas/air mixtures in enclosed areas, to avoid the escalation of flange fires in hydrogen service and on equipment handling flammable products on or above auto-ignition temperature.

(b) Location

Steam systems for fire protection purposes shall be installed in accordance with DEP 80.47.10.30-Gen.

(c) Operation

Steam systems for fire protection shall be operable from grade. The manually controlled block valve shall be positioned at least 30 m away from the credible fire hazard, and upstream of the prevailing wind direction a sign board shall positioned indicating the purpose of the valve.

(d) Design

(i) General

Typical applications are: furnaces, vent stacks and flanged connections in hydrogen service (see - iii). For furnaces, operating pressures of steam systems for fire protection shall be designed to operate against the expected back pressure. For the required steam quantities reference is made to API 560.

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.

(ii) Piping

Downstream of the manually controlled block valve, sloping piping shall be installed and be provided with 6 mm diameter drain holes at low points. For further requirements see DEP 31.38.01.11-Gen.

(iii) Hydrogen service

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 38.141/142/143/144.

(e) Material selection

Reference is made to DEP 31.38.01.10-Gen.

2.9 NITROGEN SYSTEMS

Nitrogen systems are not described, as such systems are primarily used for purging purposes and for protection against product quality degradation (blanketing).

2.10 FIRE PROOFING

Fireproofing is considered a passive fire protection system, i.e. it does not require means of activation.

For fireproofing of structural steel refer to DEP 34.19.20.11-Gen.

For the application of fireproofing on process equipment advice shall be obtained from the Principal.

3. SCOPE OF WORK

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.

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

3.1 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 coordination 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.

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.

3.2 SCOPE OF MATERIAL SUPPLY

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.

3.3 SCOPE OF ERECTION

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

3.4 ACCEPTANCE TEST

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.

3.5 TYPICAL PROJECT INFORMATION

- Plot plan(s)

- Piping general arrangement drawings
- Equipment layout drawing(s)
- Utility engineering flow diagram - Fire water system
- Firewater ring main general arrangement drawing
- Equipment list
- Local codes
- Single line wiring diagrams

4. 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).

Amended Per Circular 64/97

SHELL STANDARDS

Index to DEP publications and standard specifications	DEP 00.00.05.05-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.
Pressure vessels (Supplements to BS 5500)	DEP 31.22.10.32-Gen.
Design and calculations of glass-fibre reinforced epoxy coated vessels and equipment	DEP 31.22.30.14-Gen.
Guide for the selection of hoisting facilities and weather protection for rotating equipment	DEP 31.25.00.10-Gen.
Selection, testing and installation of pumps.	DEP 31.29.02.11-Gen.
Piping classes, Part 1 - Basis of design	DEP 31.38.01.10-Gen.
Piping - general requirements	DEP 31.38.01.11-Gen.
Piping classes	DEP 31.38.01.12-Gen.
Requirements for glass-fibre reinforced epoxy and polyester pipes and fittings	DEP 31.38.70.37-Gen.

Amended Per Circular 41/99

The instrumentation of fire and gas detection systems	DEP 32.30.20.11-Gen.
Instruments for measurement and control	DEP 32.31.00.32-Gen.
Instrumentation for package units	DEP 32.31.09.31-Gen.
Instrument signal lines	DEP 32.37.20.10-Gen.
System cabling	DEP 32.37.20.31-Gen.
Electrical Engineering Guidelines	DEP 33.64.10.10-Gen.
Electrical heat tracing	DDD 33.68.30.32-Gen.
Site preparation and earth works	DEP 34.11.00.11-Gen.
Fire hazards and fire proofing/cold splash protection of steel structures	DEP 34.19.20.11-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.
Fire-fighting agents	DEP 80.47.10.10-Gen.
Requirements for fire protection in onshore oil and gas processing and petrochemical installations	DEP 80.47.10.30-Gen.
Portable and mobile equipment for fire fighting	DEP 80.47.10.32-Gen.
EP Safety Manual, Section 23	EP 55000-23

AMERICAN STANDARDS

Low expansion foam and combined agents systems	NFPA 11
Medium and high expansion foam agents	NFPA 11A
Carbon dioxide extinguishing systems	NFPA 12
Halon 1301 extinguishing systems	NFPA 12A
Halon 1201 extinguishing systems	NFPA 12B
The installation of sprinkler systems	NFPA 13
Water Spray Fixed Systems	NFPA 15
Deluge foam-water sprinkler and foam-water spray systems	NFPA 16
Dry chemical powder extinguishing systems	NFPA 17
Centrifugal fire pumps	NFPA 20

Issued by:
National Fire Protection Association
Batterymarch Park, Quincy, MA 02269
USA

Butterfly valves for fire protection service	UL 1091
Rapid rise fire tests of protection material for structural steel	UL 1709

Issued by:
Underwriters Laboratories Incorporated
333, Pfingsten Road
Northbrook, IL 60062
USA

Fired heaters for general refinery services	API 560

Issued by:
American Petroleum Institute
Publication and Distribution Section
2101 L Street N.W.
Washington, D.C. 2003J
USA

BRITISH STANDARDS

Specification for transportable gas containers; Part 2 - Steel containers up to 130 litres water capacity with welded seams	BS 5045: Part 2
Pressure vessels	BS 5500

Issued by:
British Standards Association
Linford Wood
Milton Keynes MK14 6LE UK

Refining Safety Code - Part 3 of the Institute of Petroleum Model Code of Safe Practice in the Petroleum Industry

Area Classification Code for Petroleum Installations - Part 15 of the Institute of Petroleum Model Code of Safe Practice in the Petroleum Industry

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

INTERNATIONAL STANDARDS

Metallic coatings: Requirements for hot dip galvanized coatings on fabricated products	ISO 1461

Issued by:
Central Secretariat of ISO 1,
rue de Varembé
1211 Geneva 20
Switzerland
Copies can be obtained through the National Standards Organization.

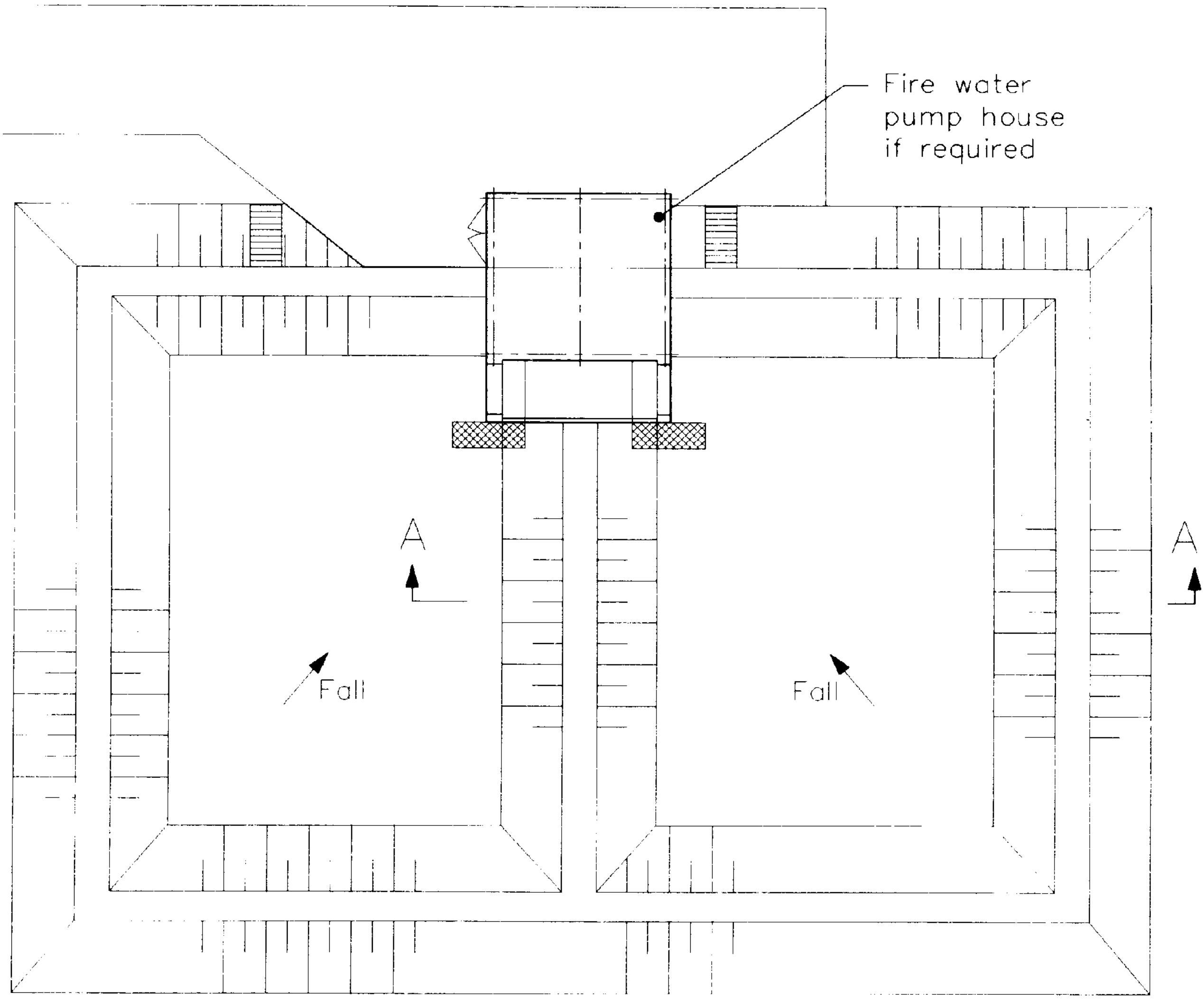
5. STANDARD DRAWINGS

NOTE: In this DEP reference is made to the following standard drawings, of which the latest issue shall be used.

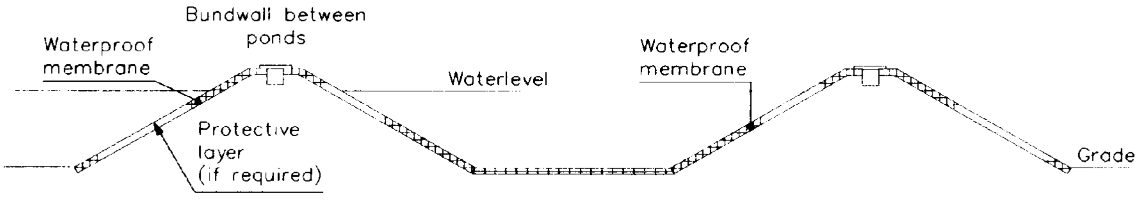
Traffic barrier for hydrant	S 13.008
Steam ring to horizontal flange DN 150 (6 in) and above in hydrogen service	S 38.141
Two steam rings to horizontal flange DN 150 (6 in) and above in hydrogen service (with spectacle blind, spade, spacer or orifice)	S 38.142
Steam ring to vertical flange DN 150 (6 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, spacer or orifice)	S 38.144
Steam lance	S 88.005
Single foam pourer for floating roof tanks	S 88.009
Foam pourers for floating roof tanks	S 88.010
Two-way or four-way hydrant for GRE underground piping in non-freezing areas	S 88.013
Two-way hydrant header	S 88.016
Four-way hydrant header	S 88.017
Four-way hydrant header with monitor connection	S 88.018
Tubing for fire detection for pumps (underneath pipe racks)	S 88.020
Tubing for fire detection for pumps (outside pipe racks)	S 88.021
Sub-surface foam system for flammable and combustible liquids	S 88.022
Semi sub-surface foam system	S 88.023

6. APPENDICES

APPENDIX 1 EARTH BUNDWALL BASIN FOR FIRE WATER STORAGE

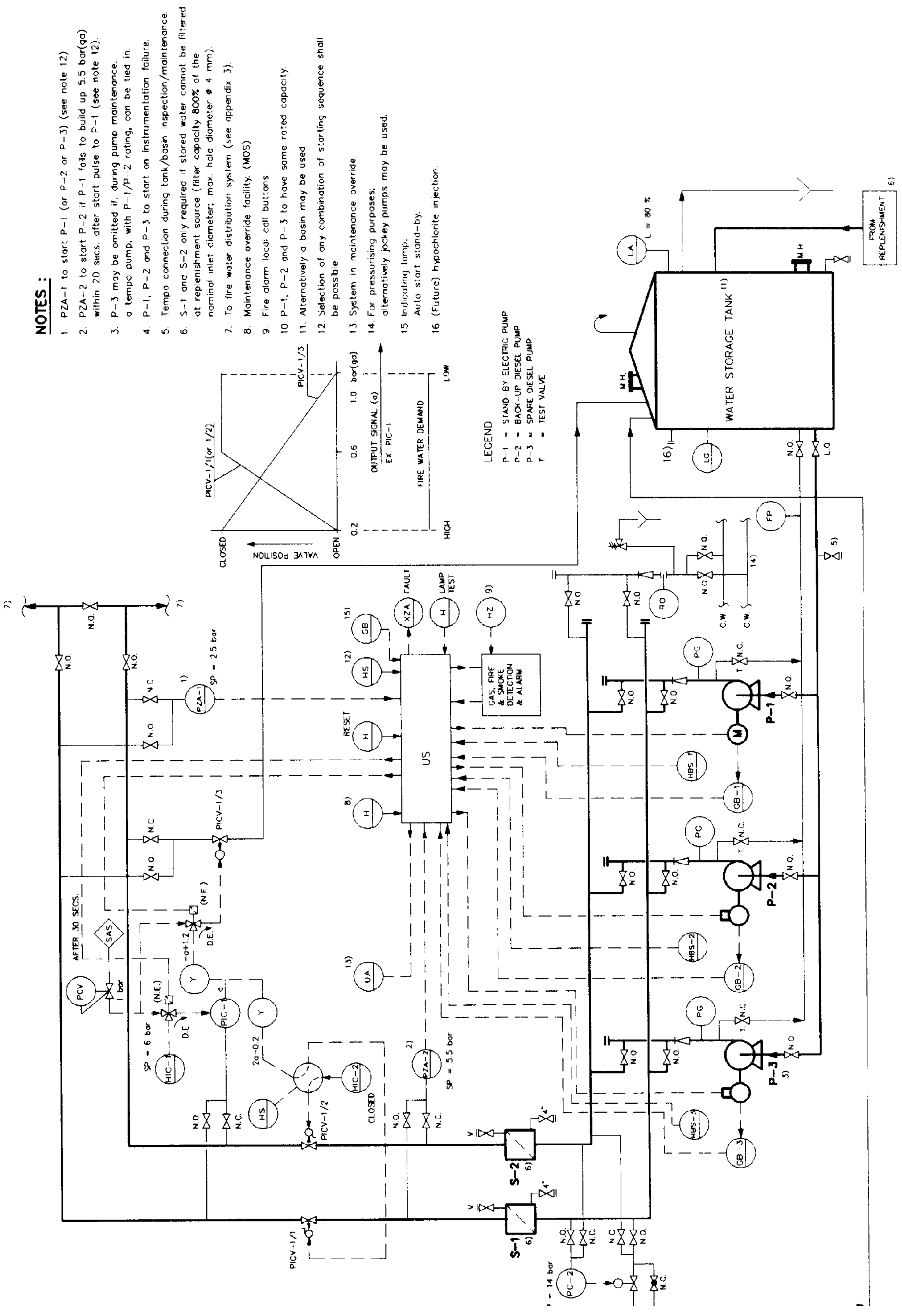


GENERAL ARRANGEMENT

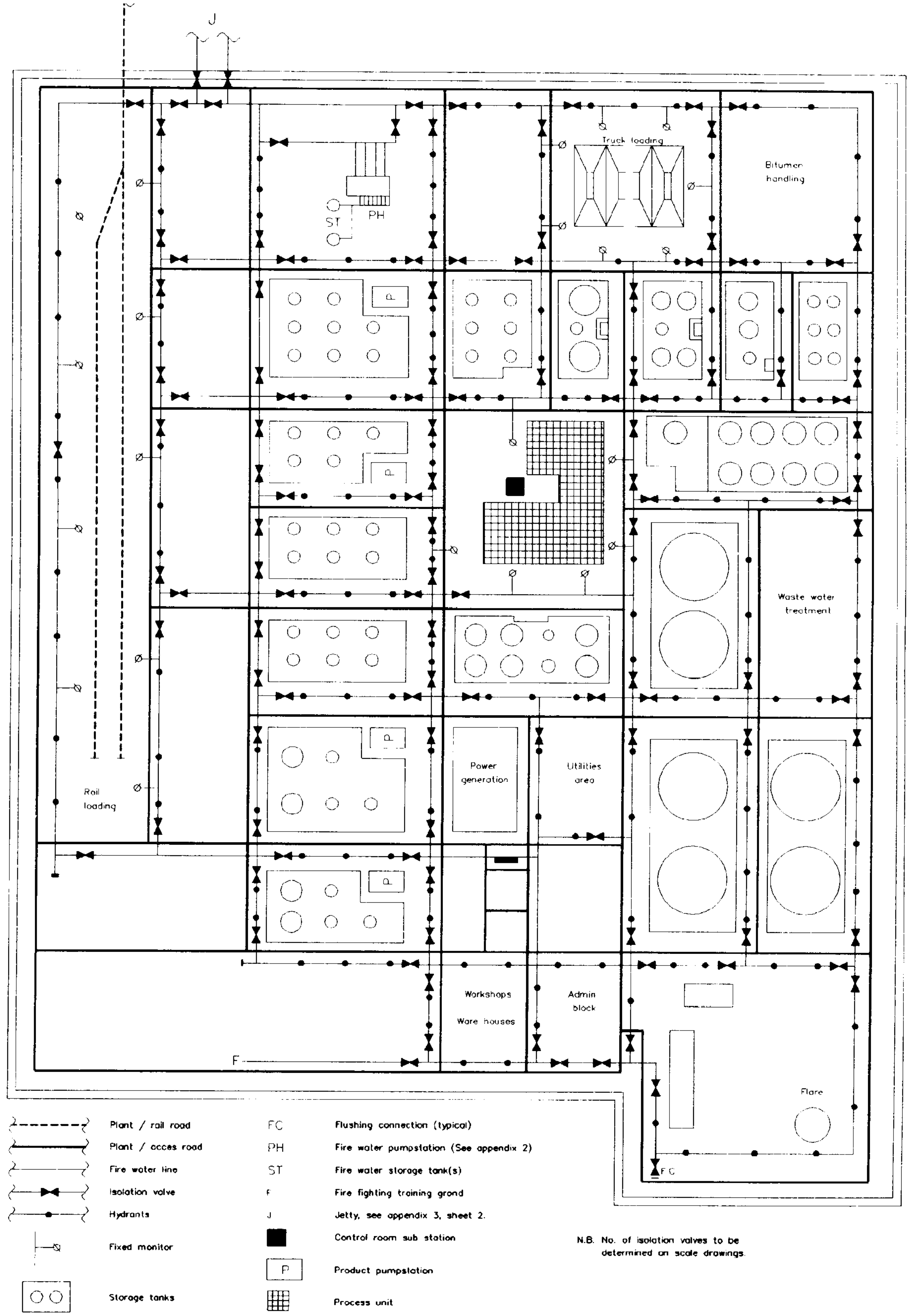


Section A--A

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

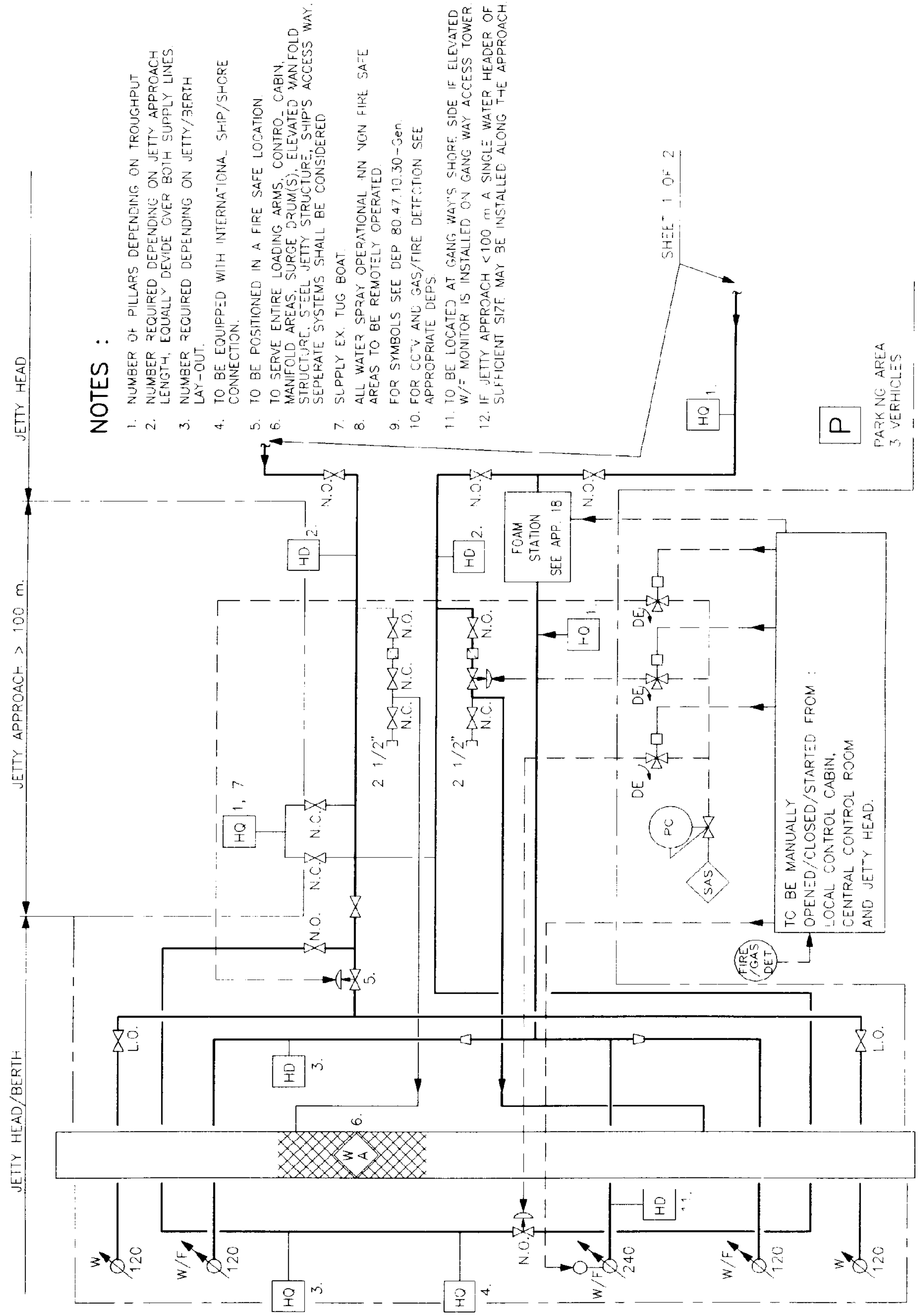


APPENDIX 3 **TYPICAL SKETCH OF FIRE WATER MAINS**
Page 1 of 2 **(TAKING SUCTION FROM STORED WATER)**

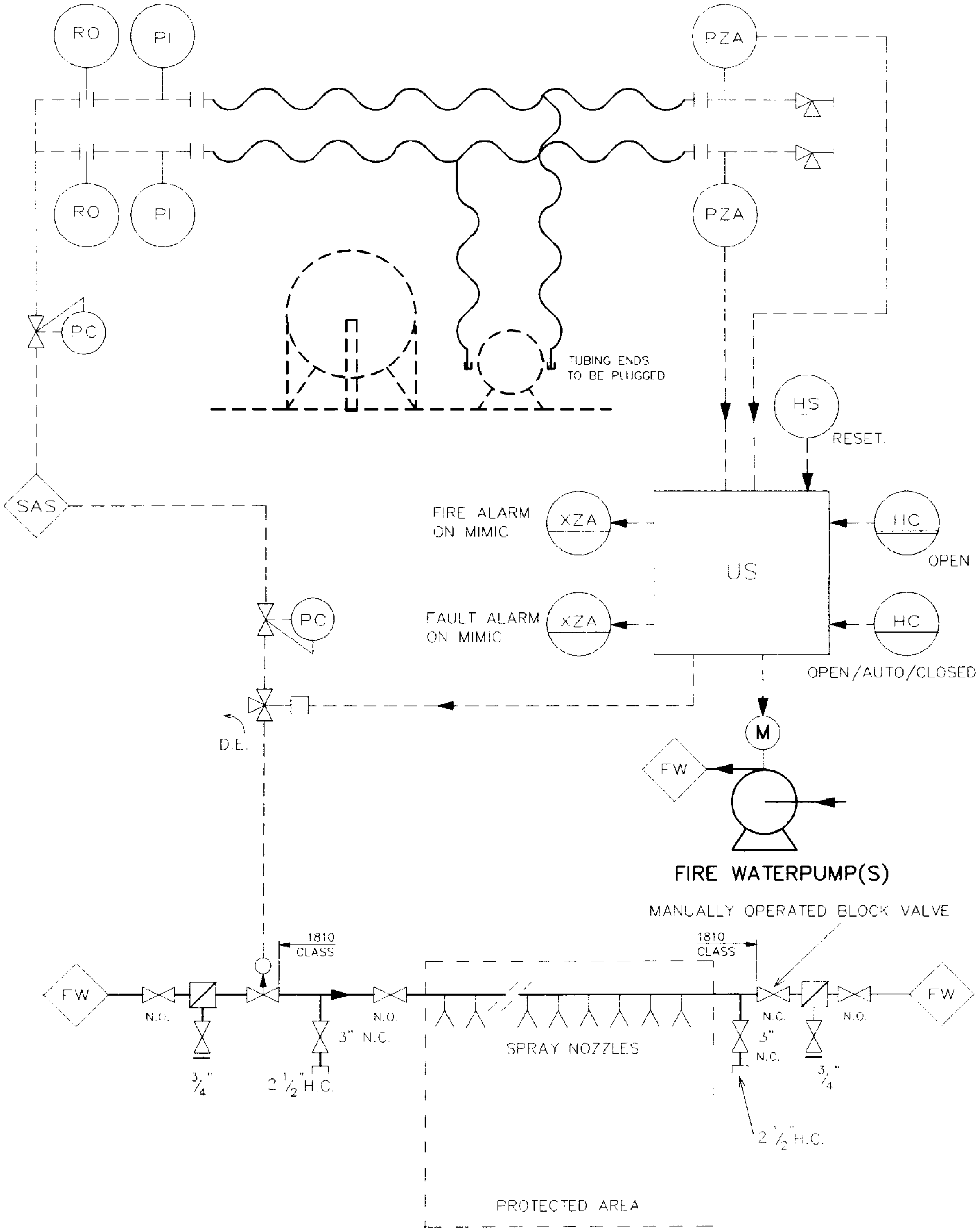


APPENDIX 3 TYPICAL JETTY FIRE FIGHTING SYSTEM

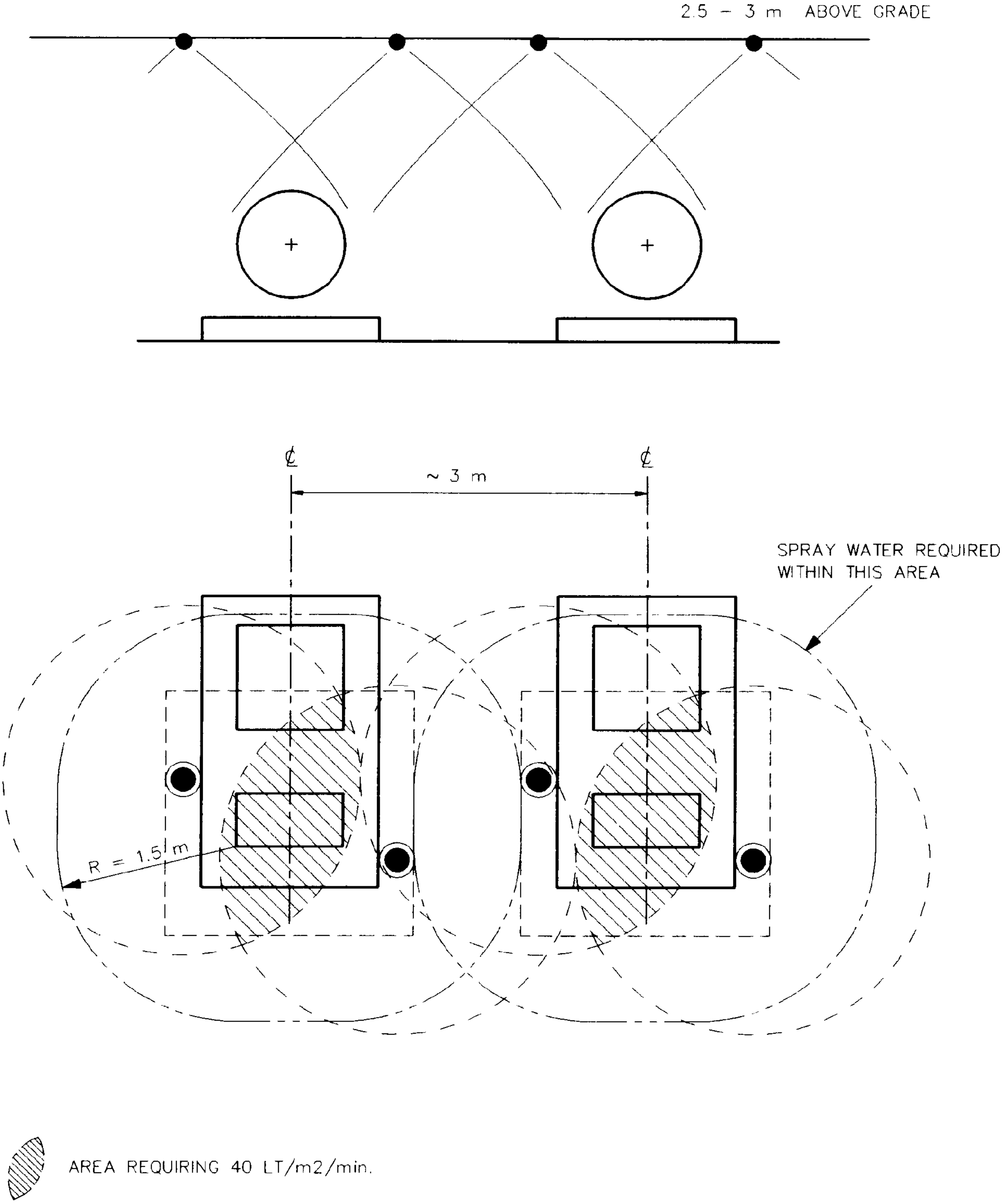
Page 2 of 2



APPENDIX 4 WATER SPRAY SYSTEM FOR FIRE PROTECTION OF EQUIPMENT AND LPG SPHERES

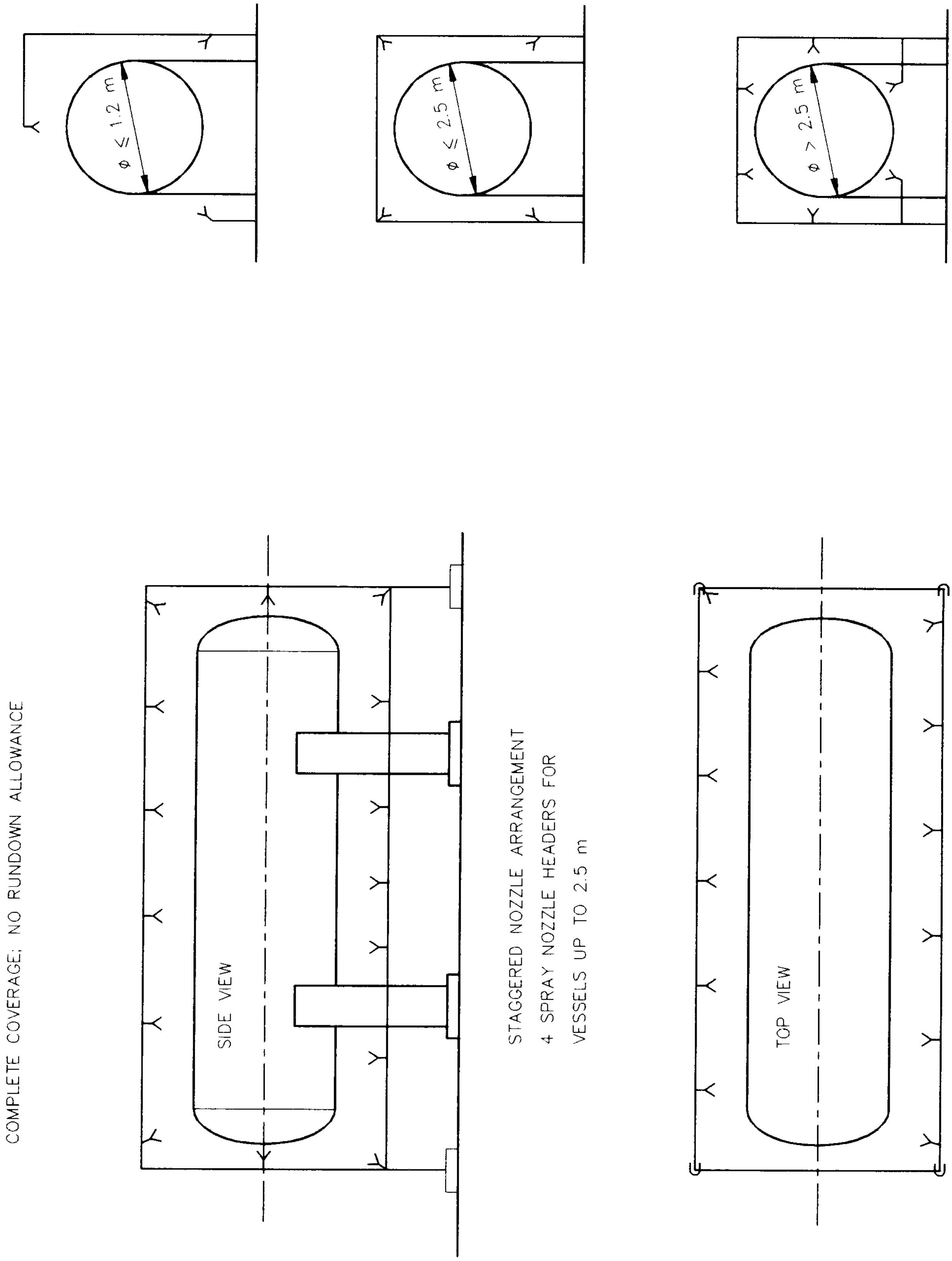


APPENDIX 5 TYPICAL SPRAY NOZZLE ARRANGEMENT FOR PUMPS

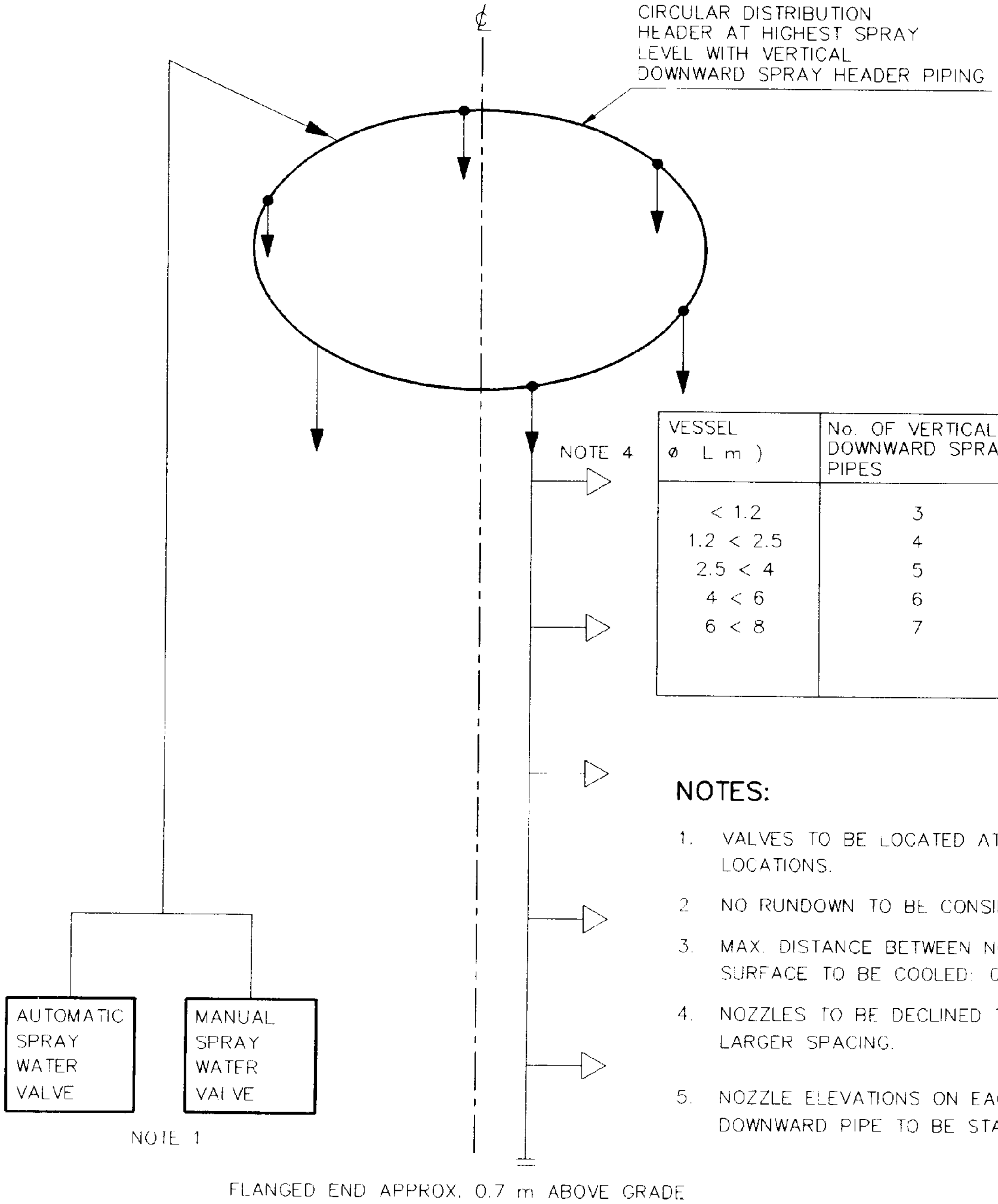


EACH NOZZLE (WITH 8 mm BORE) TO PROVIDE 20 LT/m2/min.

APPENDIX 6 TYPICAL SPRAY NOZZLE ARRANGEMENT FOR HORIZONTAL VESSELS AND HORIZONTAL HEAT EXCHANGERS



APPENDIX 7 TYPICAL SPRAY NOZZLE ARRANGEMENT FOR VERTICAL VESSELS AND COLUMNS

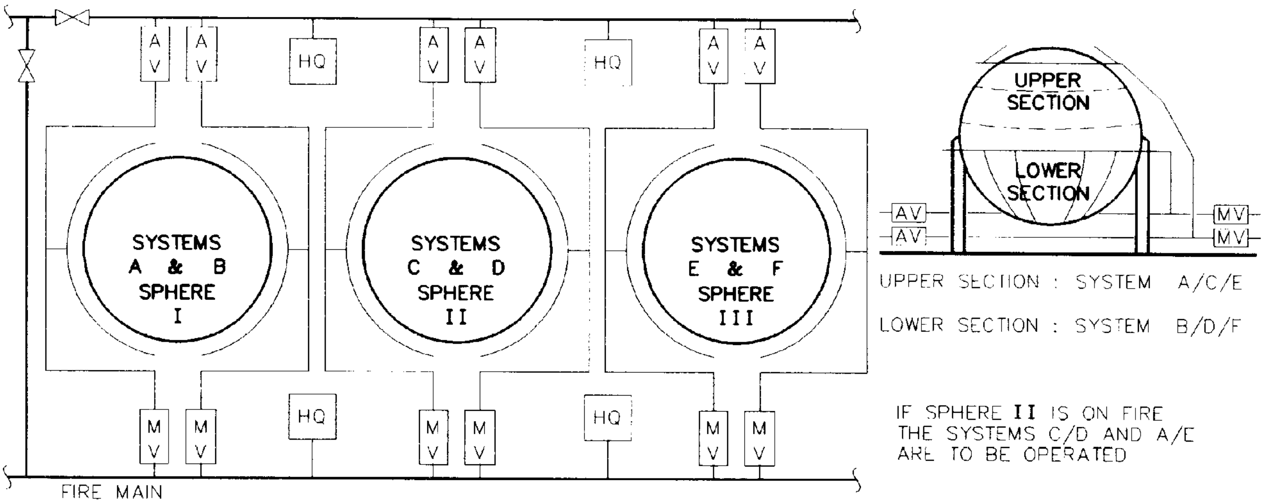


VESSEL ø L m)	No. OF VERTICAL DOWNWARD SPRAY PIPES	SPRAY ANGLES OF NOZZLES
< 1.2	3	75°
1.2 < 2.5	4	75 – 105°
2.5 < 4	5	105 – 120°
4 < 6	6	120 – 130°
6 < 8	7	130 – 135°

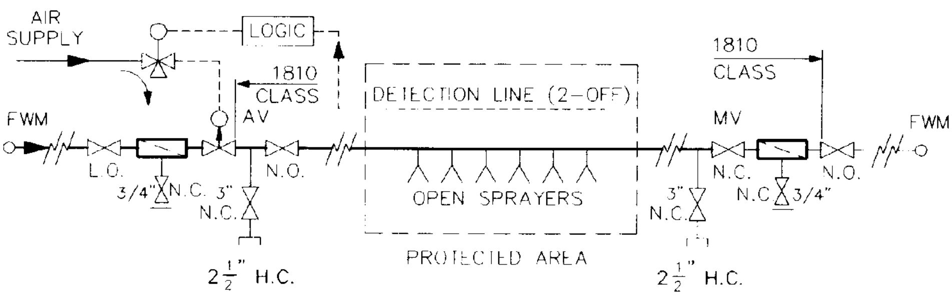
NOTES:

1. VALVES TO BE LOCATED AT OPPOSITE LOCATIONS.
2. NO RUNDOWN TO BE CONSIDERED.
3. MAX. DISTANCE BETWEEN NOZZLE TIP AND SURFACE TO BE COOLED: 0.6 m
4. NOZZLES TO BE DECLINED TO ACHIEVE LARGER SPACING.
5. NOZZLE ELEVATIONS ON EACH DOWNWARD PIPE TO BE STAGGERED.

APPENDIX 8 TYPICAL PROTECTION OF SPHERICAL PRESSURE VESSELS



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



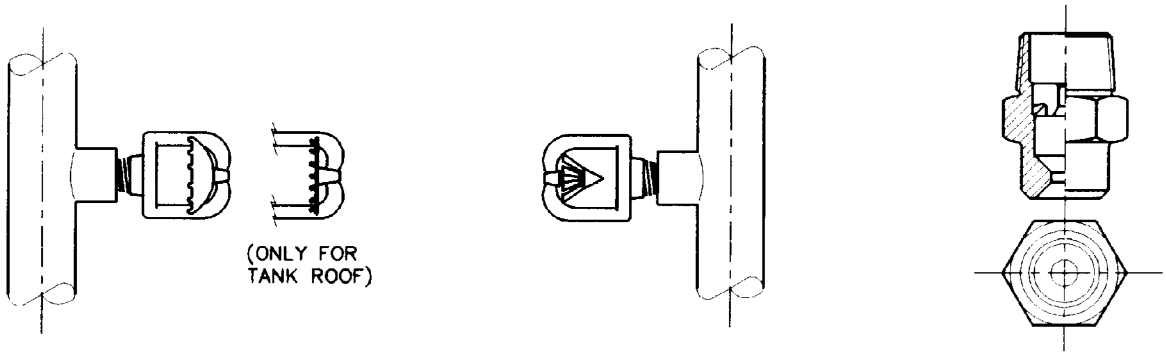
GENERAL SCHEMATIC OF SPRAY SYSTEM (SEE ALSO APPENDIX 4)

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

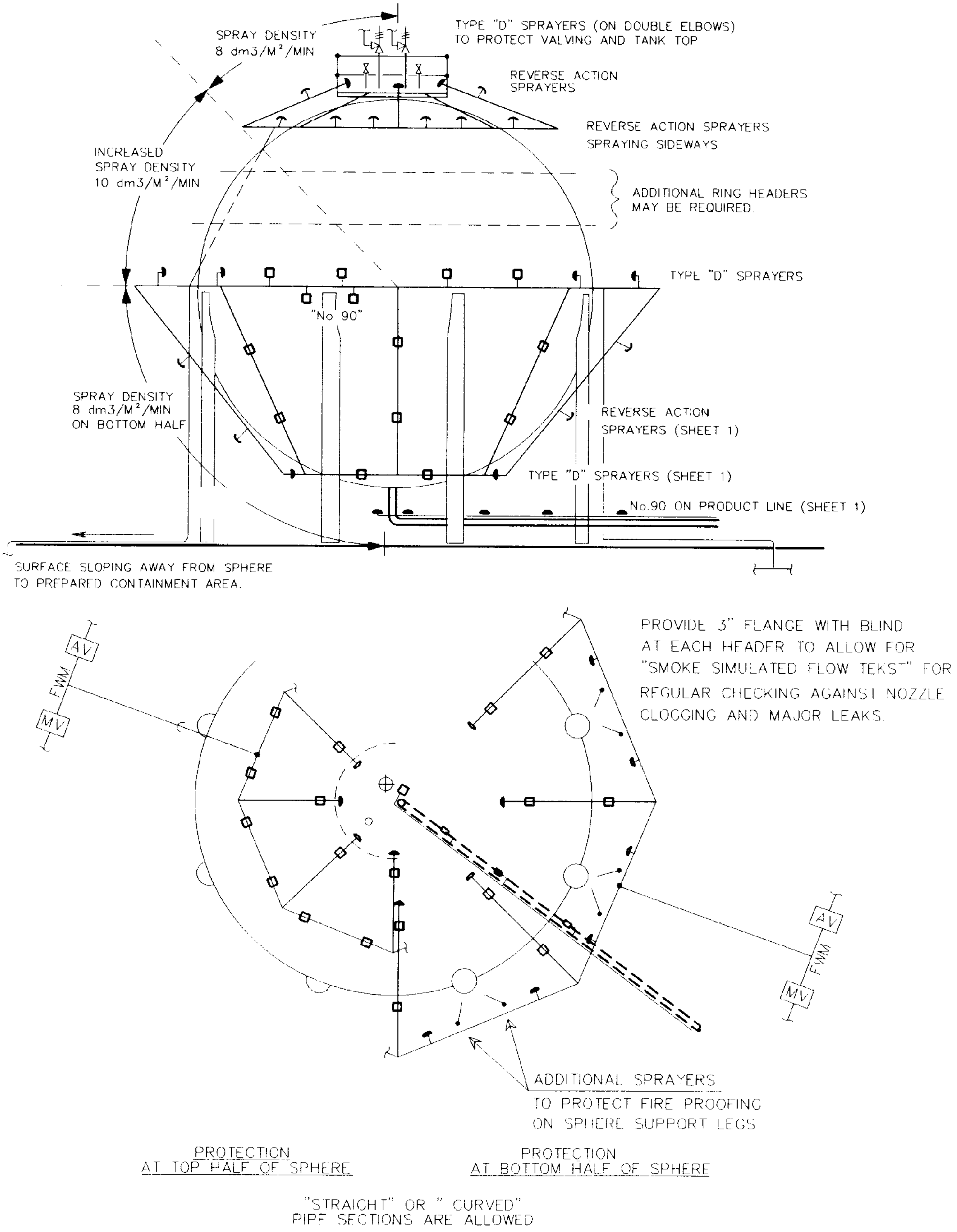
NOZZLE TYPES :

"REVERSE ACTION" WATER SPRAYERS — TYPE "D" WATER SPRAYER — TYPE NO. 90 PROJECTOR

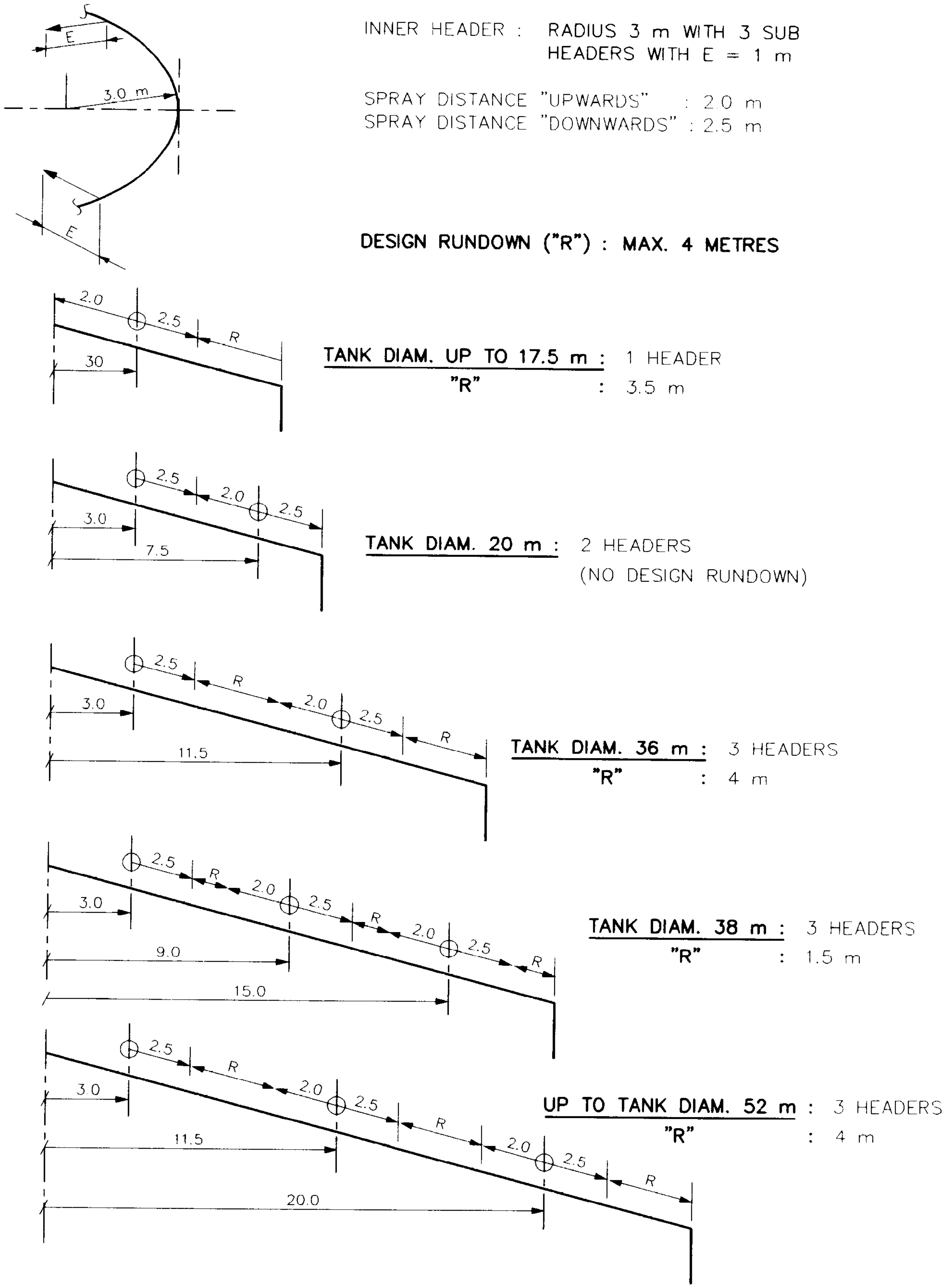


APPENDIX 8 TYPICAL PROTECTION OF SPHERICAL PRESSURE VESSELS

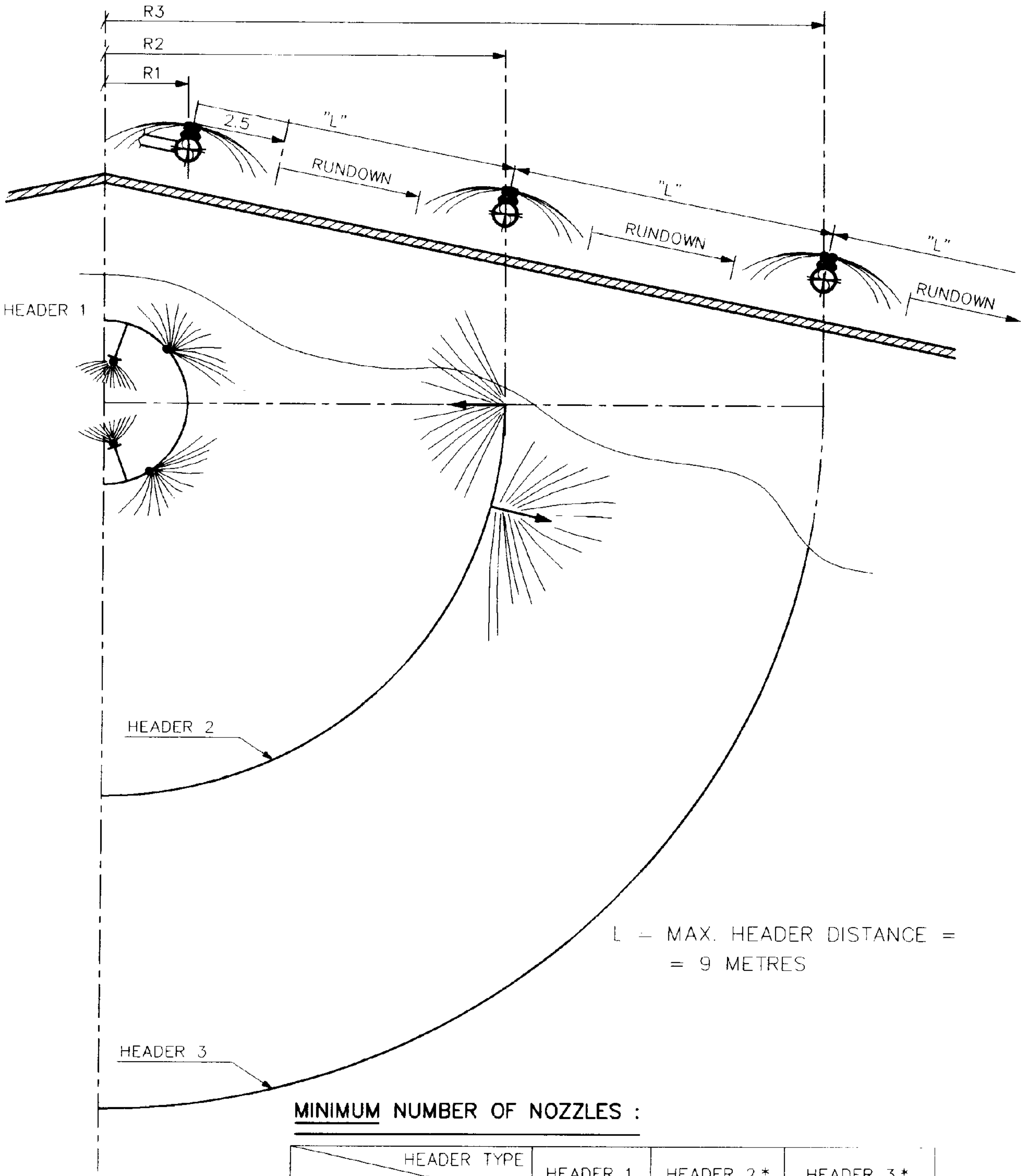
Page 2 of 2



APPENDIX 9 TYPICAL HEADER ARRANGEMENT ON TANK ROOF



APPENDIX 10 TYPICAL NOZZLE ARRANGEMENT ON TANK ROOF SUPPLY HEADERS



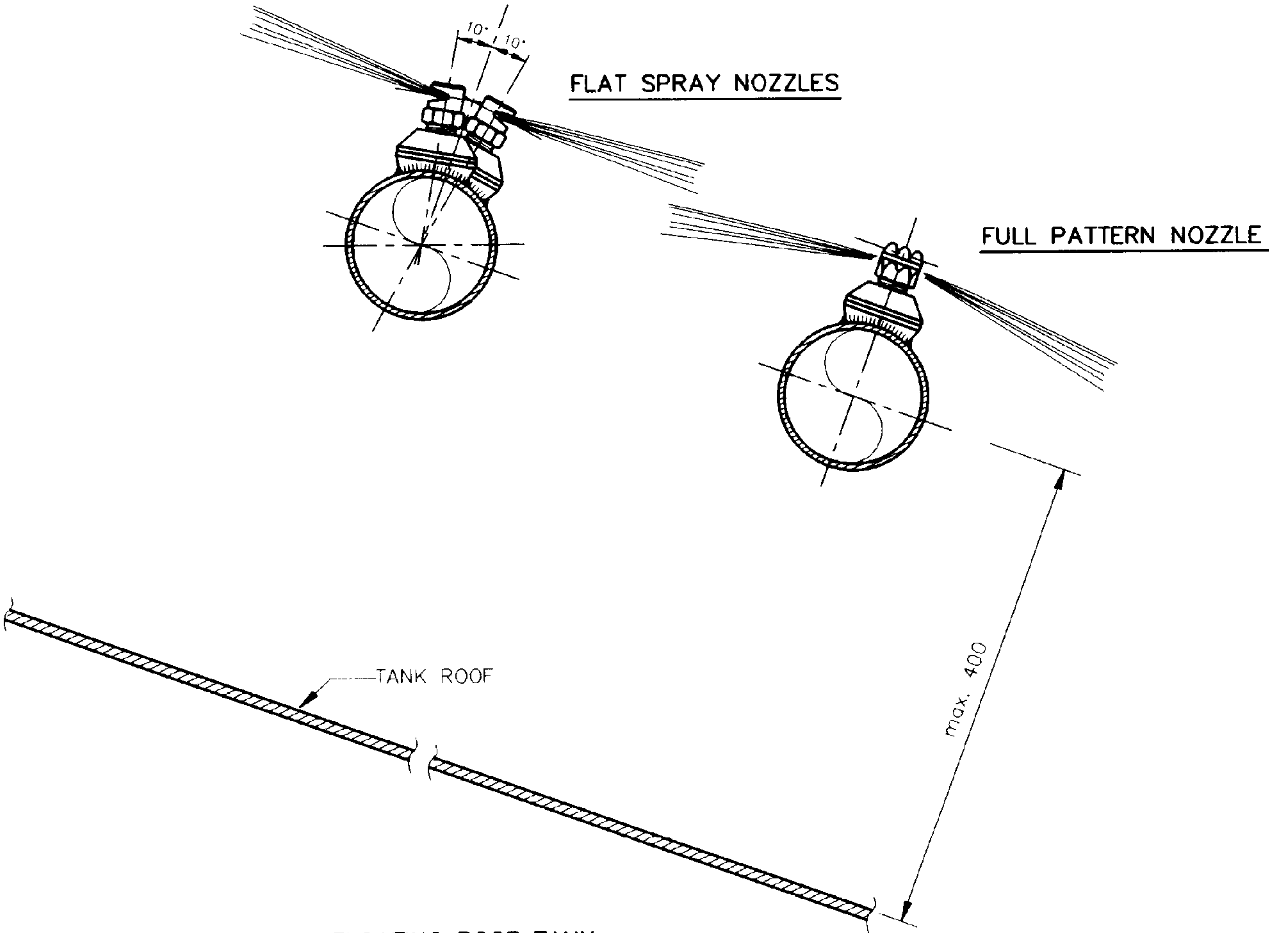
MINIMUM NUMBER OF NOZZLES :

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

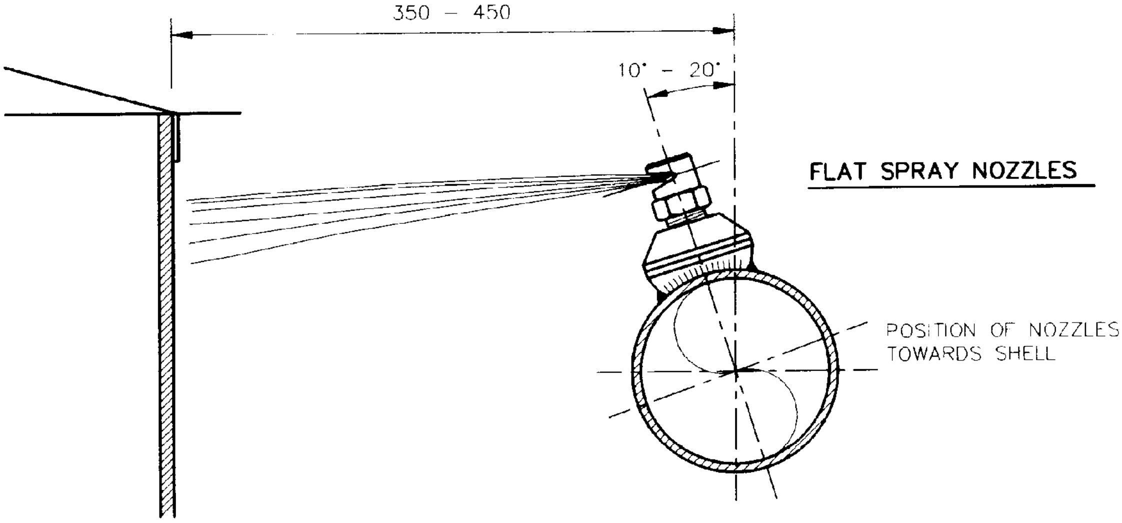
* No. OF NOZZLES DEPENDS ON HEADER DIAM.

APPENDIX 11 TANK SPRAYER TYPICAL ARRANGEMENT

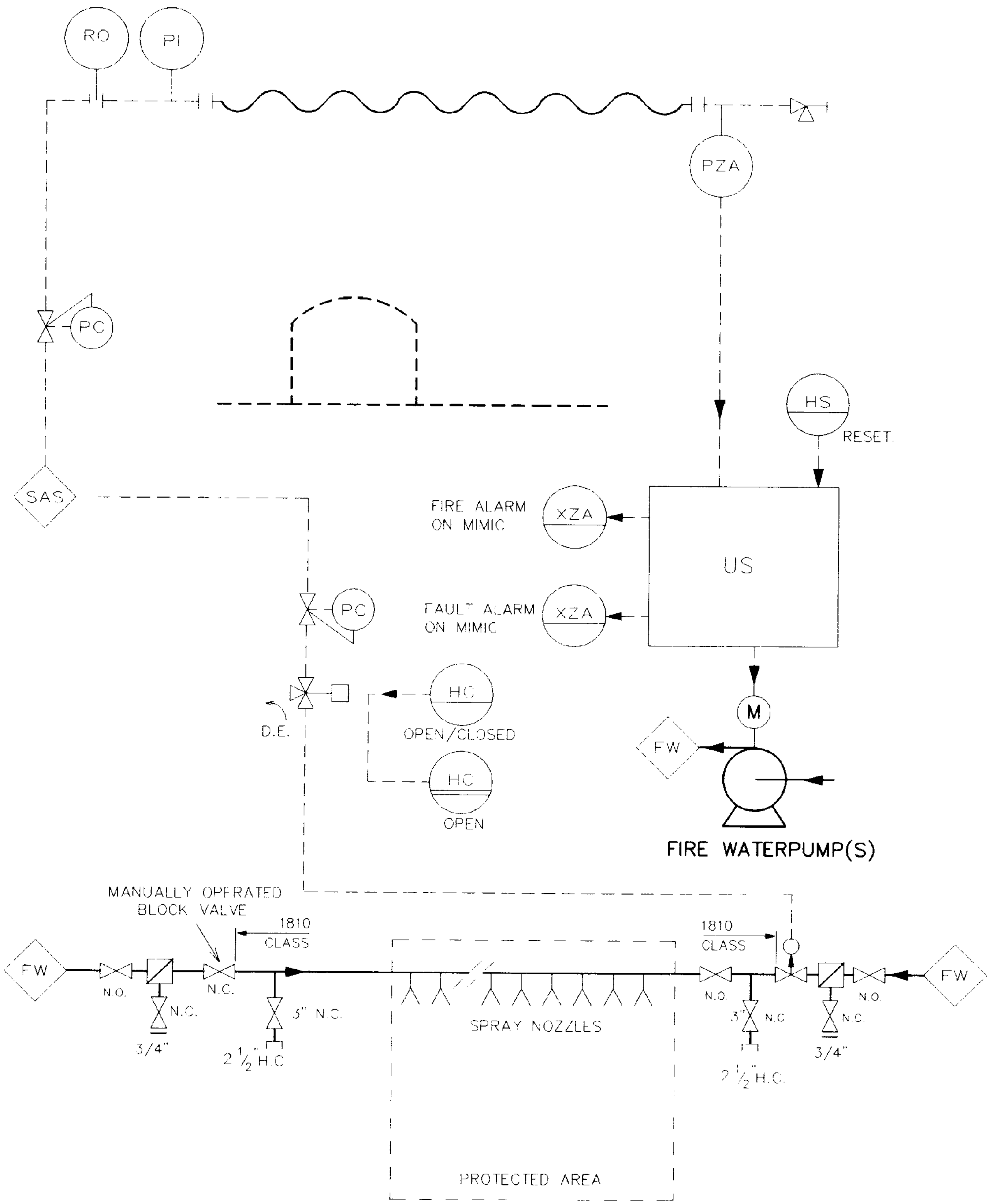
CONE ROOF TANK



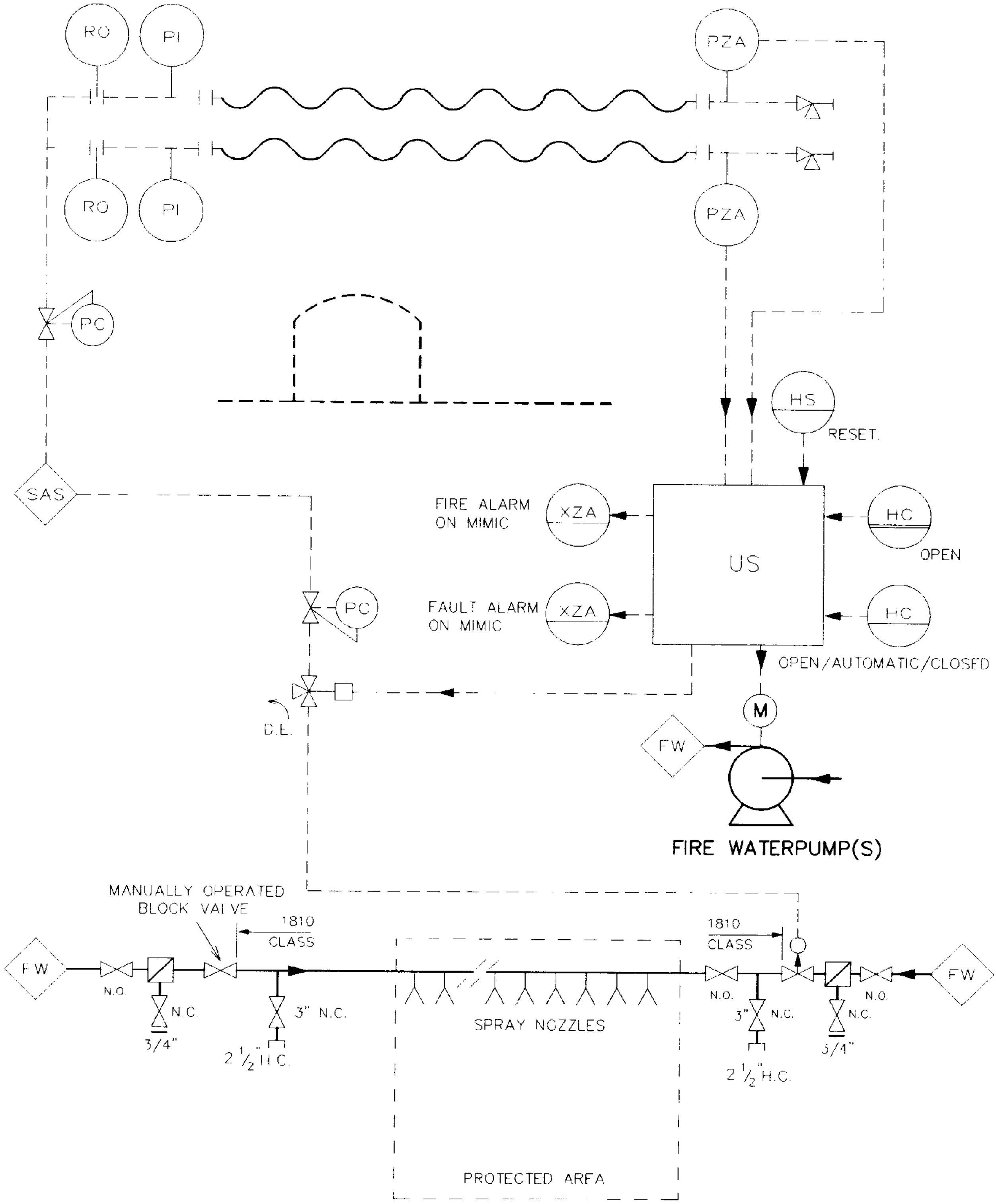
SHELL OF CONE ROOF OR FLOATING ROOF TANK



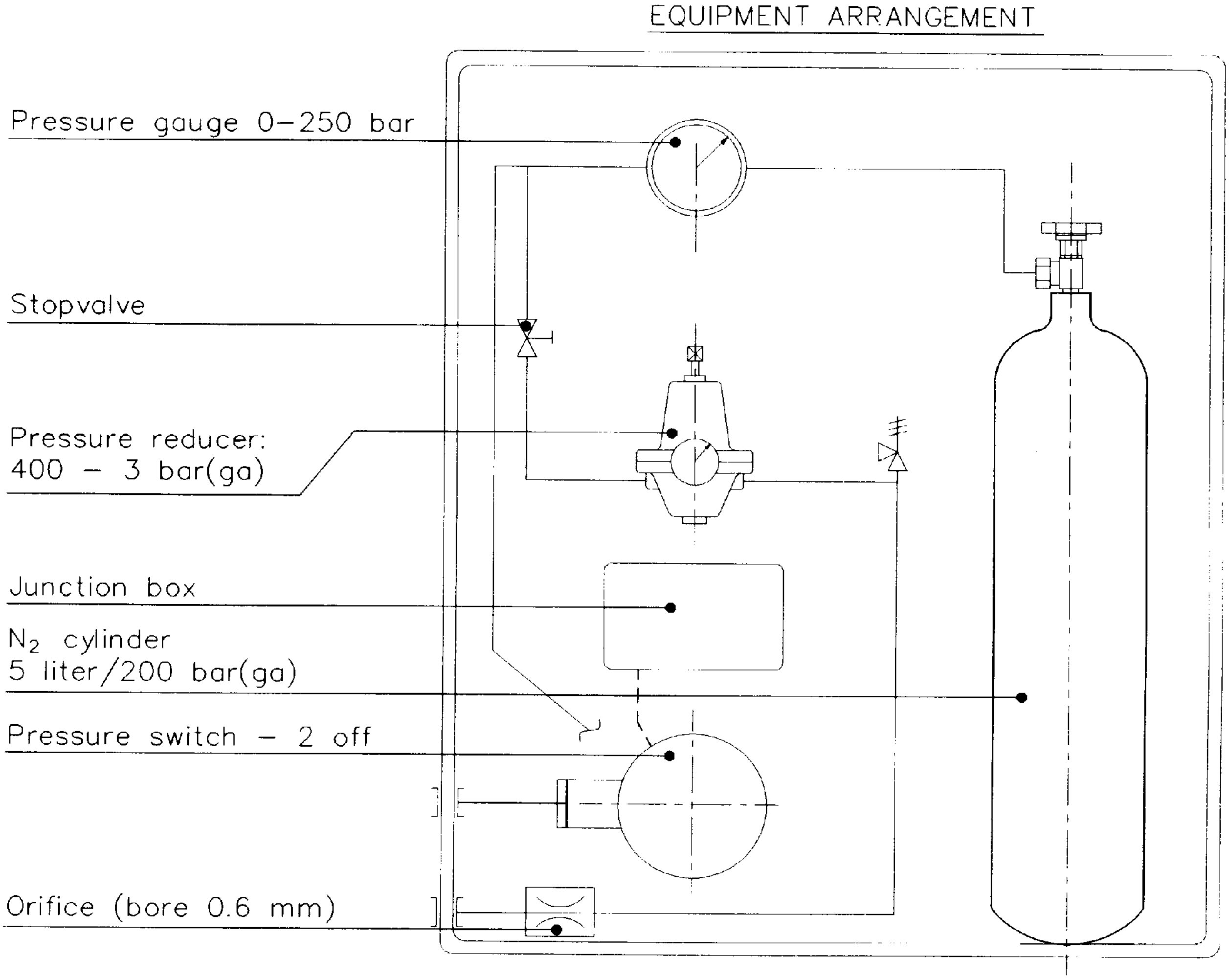
APPENDIX 12 WATER SPRAY SYSTEM FOR FIRE PROTECTION OF STEEL LNG TANKS

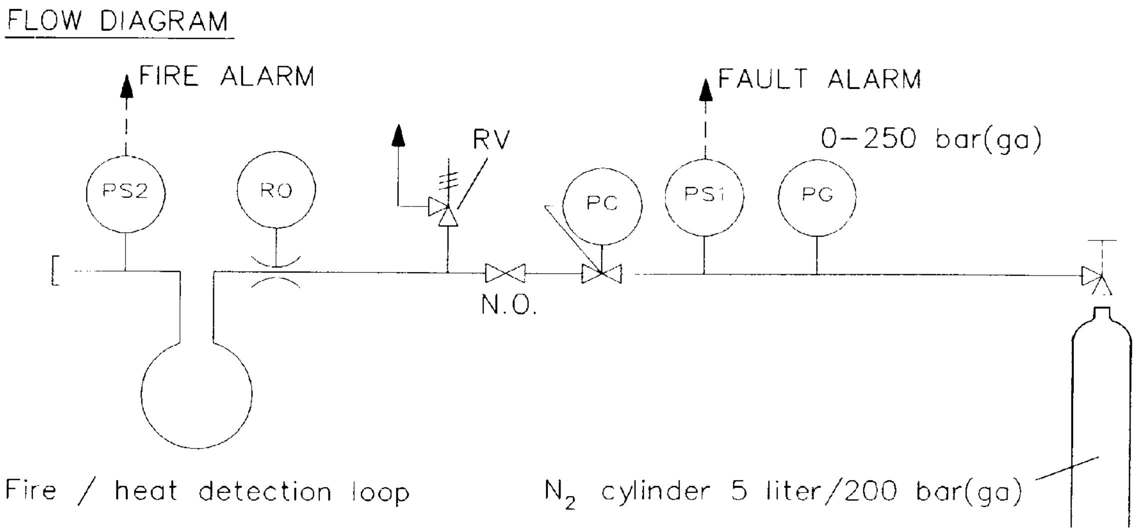


APPENDIX 13 WATER SPRAY SYSTEM FOR FIRE PROTECTION OF CONCRETE LNG TANKS



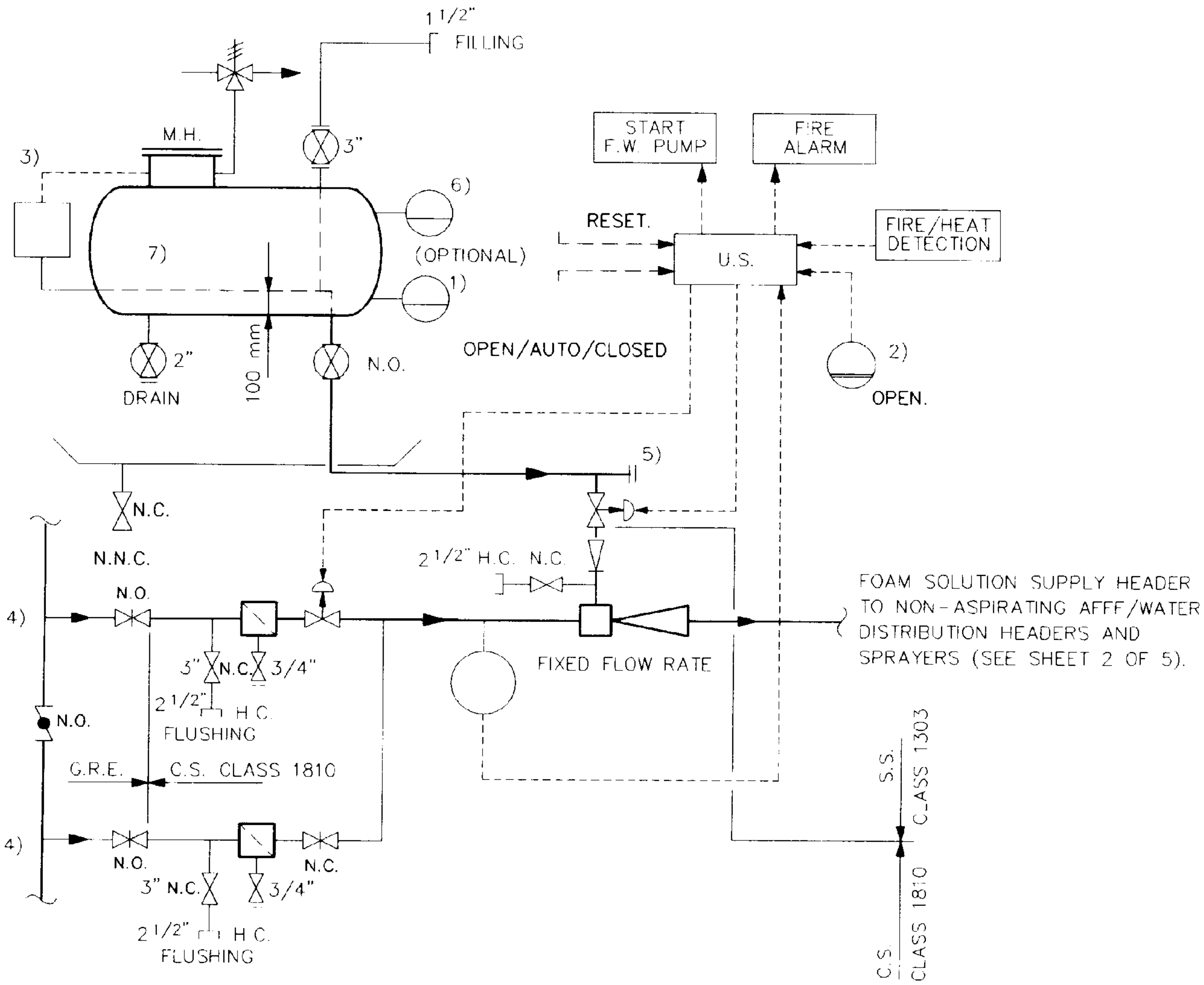
APPENDIX 14 NITROGEN UNIT FOR HEAT/FIRE DETECTION





APPENDIX 15 TYPICAL NON-ASPIRATING AFFF FOAM SPRAY SYSTEMS

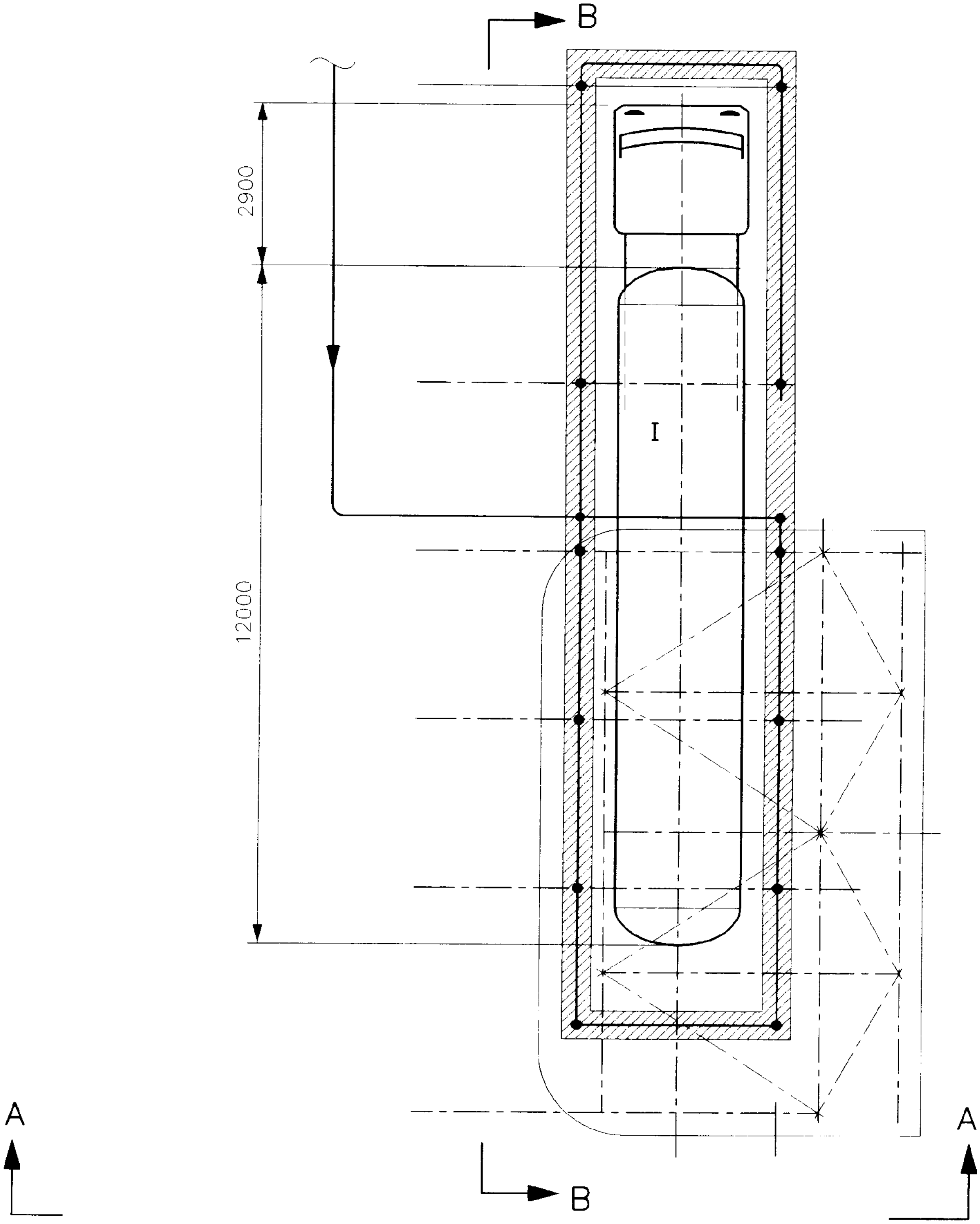
Page 1 of 5 (VIEW C-C)



NOTES:

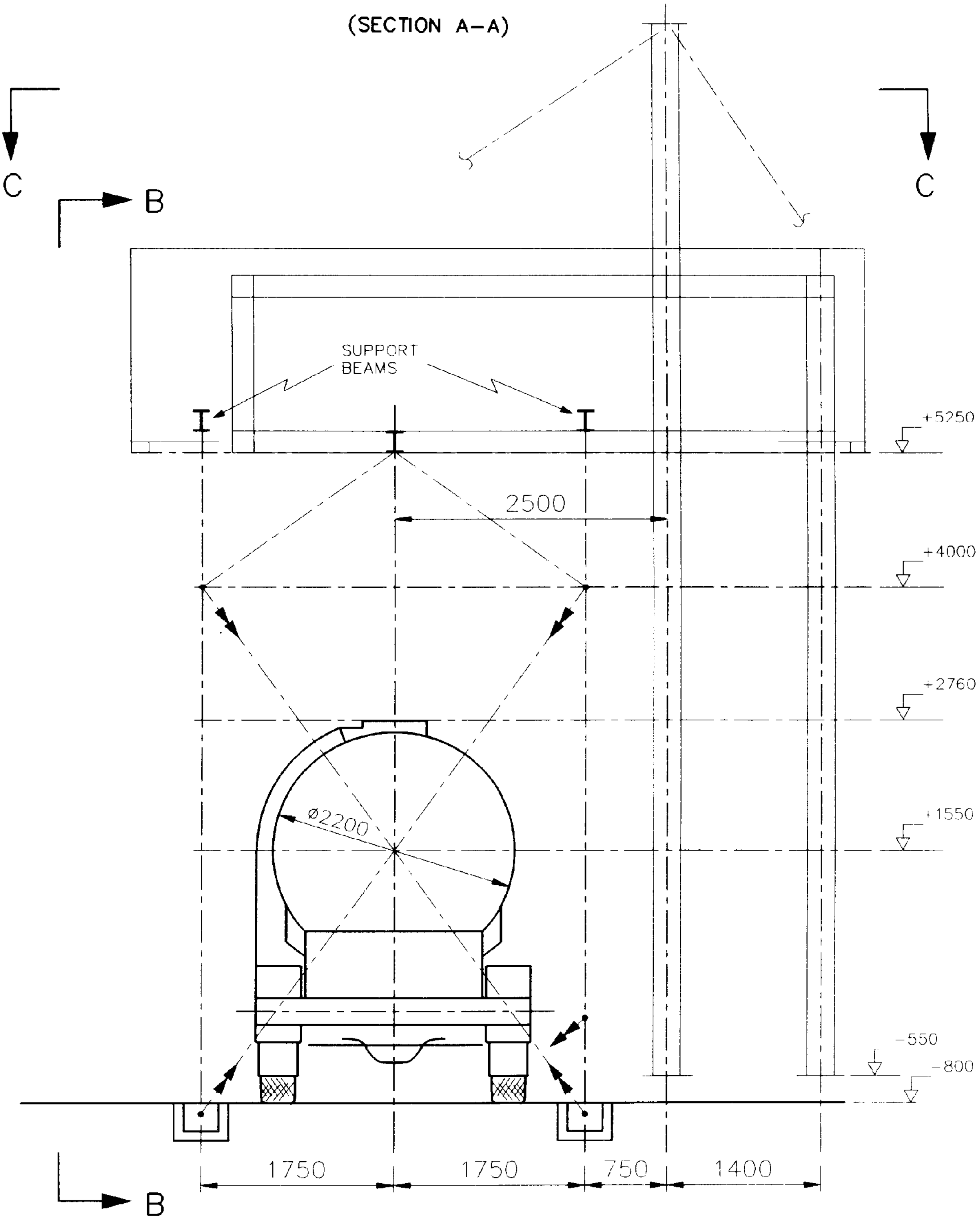
1) SET AT 80% MAX. FILLING LEVEL.
2) LOCATED AT LOADING BAY.
3) MEMBRANE TYPE LEVEL GAUGE (SEE APPENDIX 17), VAPOUR RETURN ONLY REQUIRED FOR ALTERNATIVE MAGNETIC TYPE.
4) FROM F.W. (RING) MAIN AT OPPOSITE LOCATIONS.
5) ONLY REQUIRED FOR MORE THAN ONE LOADING BAY.
6) ONLY IF TRACING/HEATING IS REQUIRED (FROST AREAS)
7) FOR VESSEL SIZE SEE DEP. 80.47.10.30 – Gen.

APPENDIX 15 **FIXED AUTOMATIC AFFF SPRAY SYSTEMS**
Page 2 of 5 (SECTION C-C)



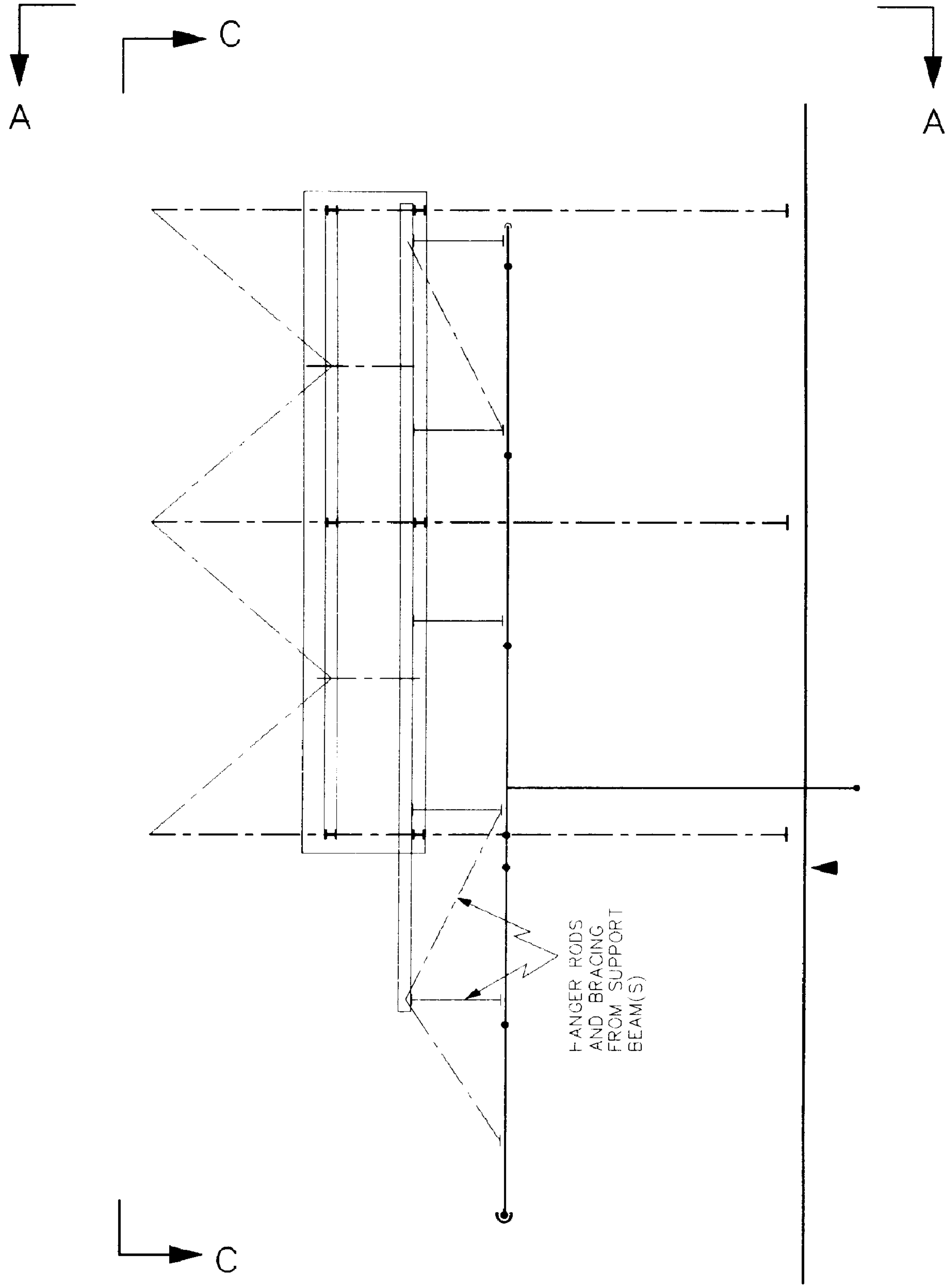
NOTES: ALL DIMENSIONS TYPICAL.
I : TANKCAR LOCATION FOR REAR LOADING.
II : TANKCAR LOCATION FOR MIDDLE TANK LOADING.
SEE SHEET 4 OF 5 FOR SECTION B-B
SEE SHEET 3 OF 5 FOR SECTION A-A

APPENDIX 15 **FIXED AUTOMATIC AFFF SPRAY SYSTEMS**
Page 3 of 5 (SECTION A-A)



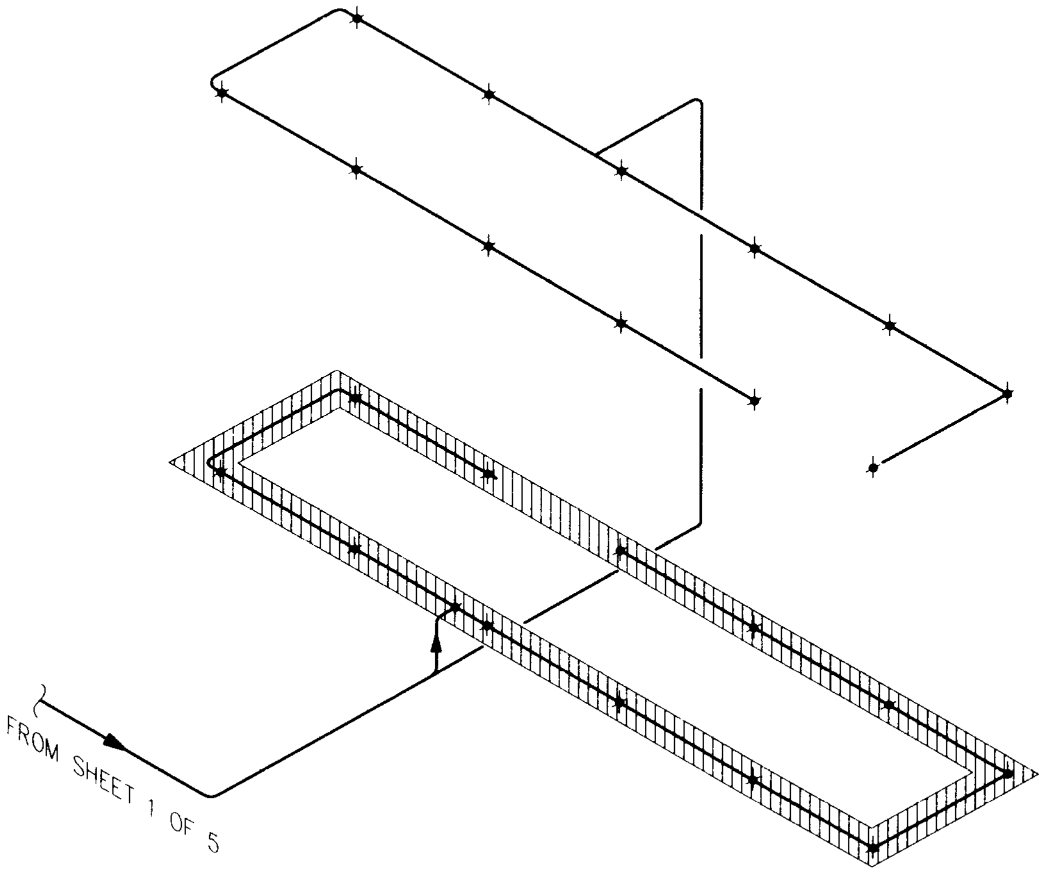
NOTE: ALL DIMENSIONS TYPICAL.
SEE SHEET 4 OF 5 FOR SECTION B-B
SEE SHEET 2 OF 5 FOR SECTION C-C

APPENDIX 15 **FIXED AUTOMATIC AFFF SPRAY SYSTEMS**
Page 4 of 5 (SECTION B-B)

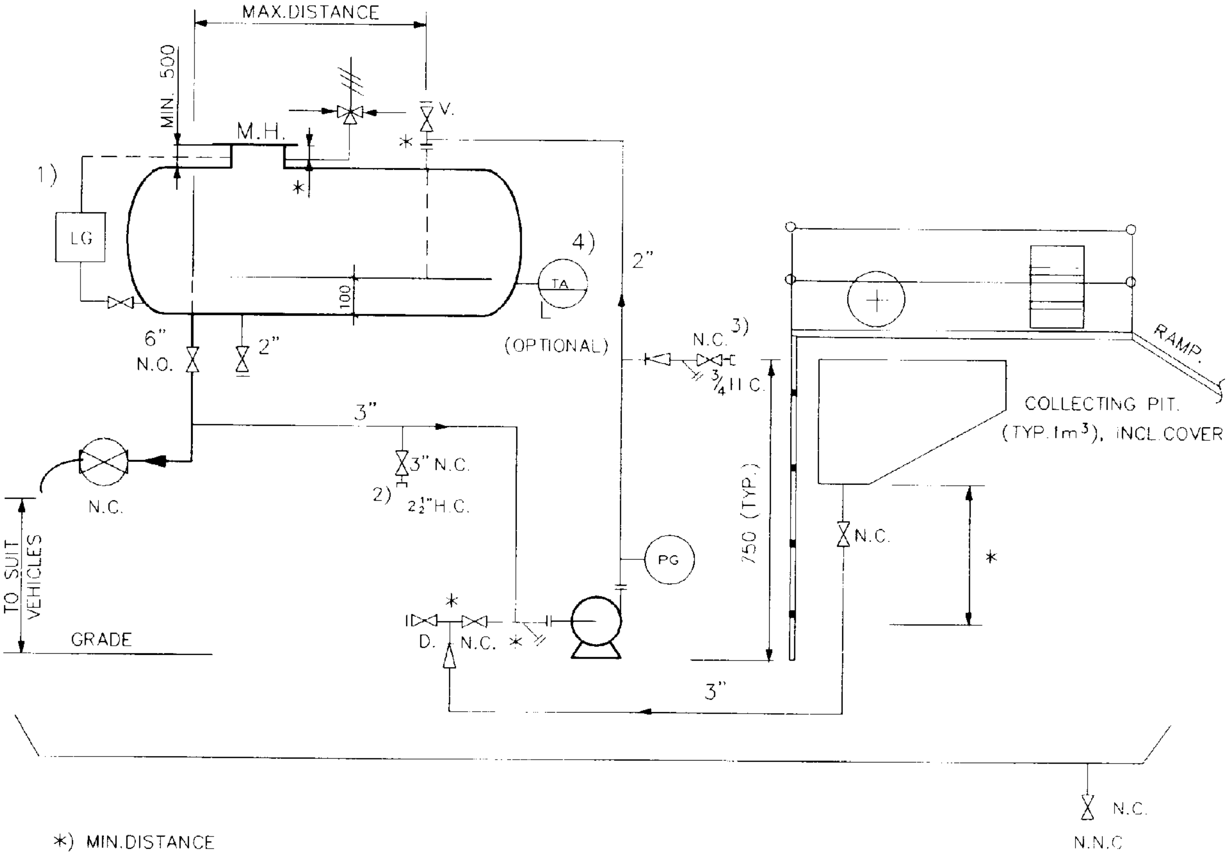


NOTE: SEE SHEET 3 OF 5 FOR SECTION A-A
SEE SHEET 2 OF 5 FOR SECTION C-C
SPRAYERS IN GULLEYS OMITTED

APPENDIX 15 FIXED AUTOMATIC AFFF SPRAY SYSTEMS
Page 5 of 5



APPENDIX 16 TYPICAL FOAM CONCENTRATE STORAGE FACILITY



*) MIN.DISTANCE

1) MEMBRAME TYPE LEVEL GAUGE (SEE APPENDIX 17); VAPOUR RETURN ONLY REQUIRED FOR ALTERNATE MAGNETIC TYPE LEVEL GAUGE

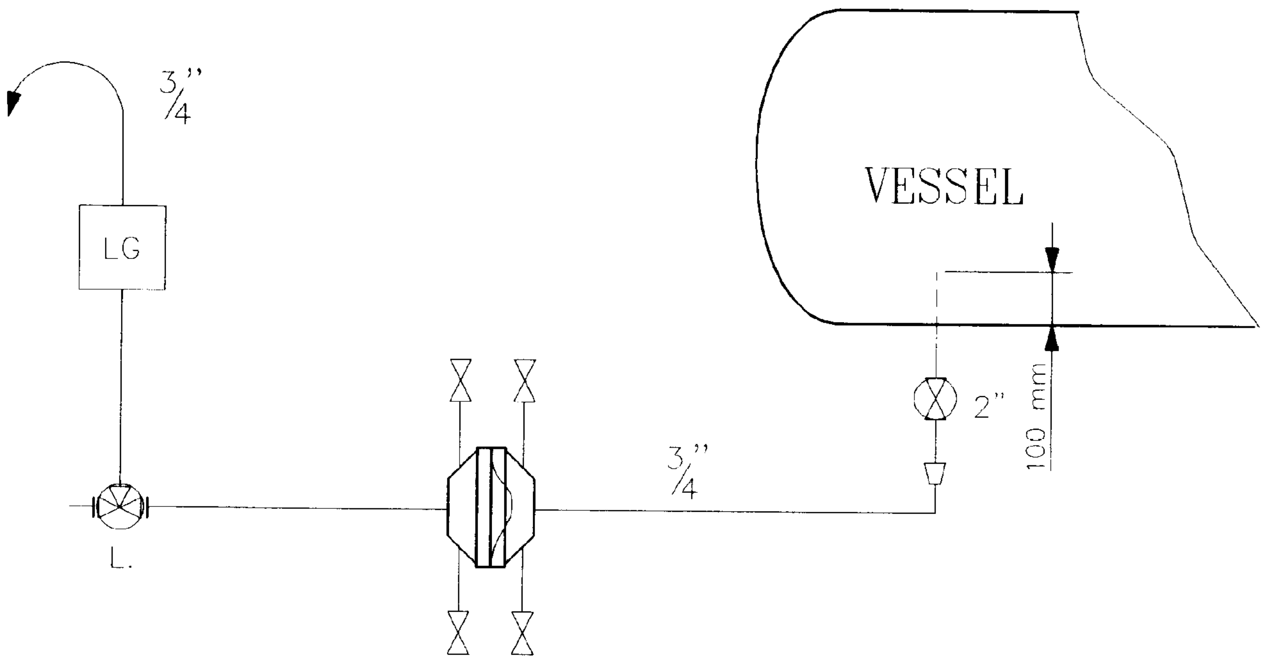
2) FIRE HOSE CONNECTION FOR STORAGE VESSEL BULK LOADING & WHEELED EQUIPMENT FILLING

3) TOPPING - UP

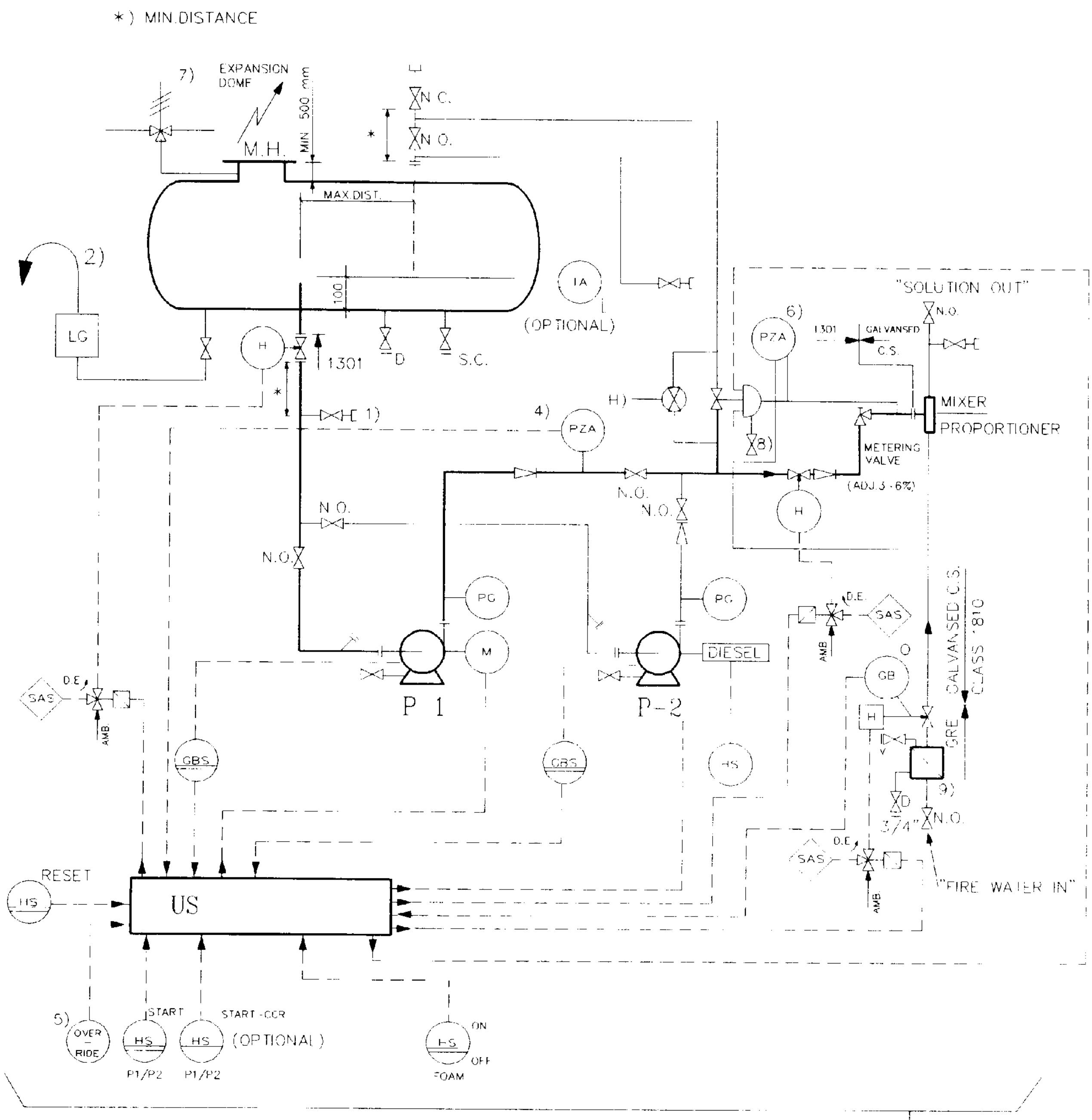
4) ONLY IF TRACING / HEATING IS REQUIRED

5) LEVEL INDICATION VISIBLE AT PUMP CONTROL PANEL

APPENDIX 17 TYPICAL MEMBRANE TYPE LEVEL GAUGE



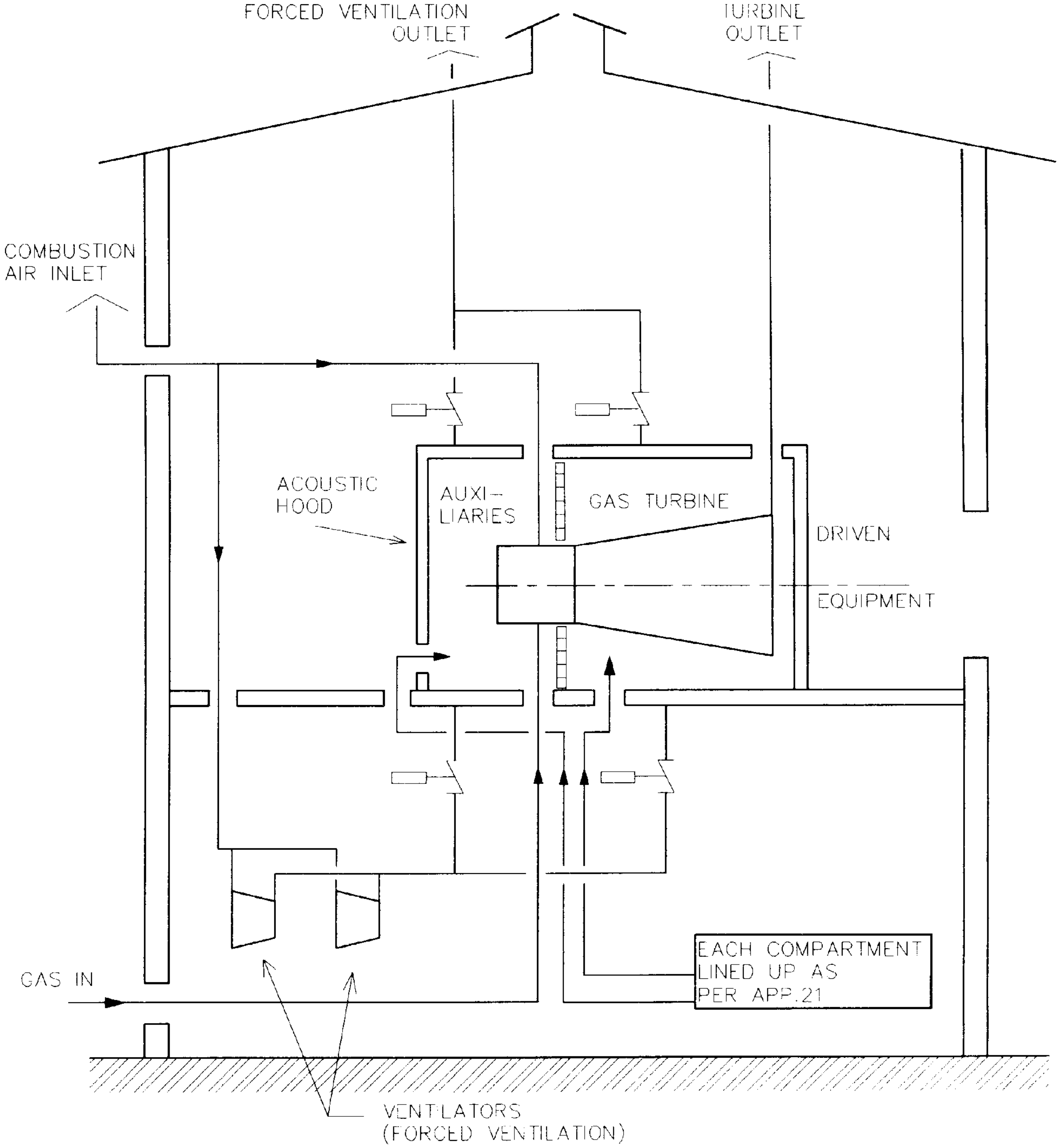
APPENDIX 18 TYPICAL FOAM STATION FLOW SCHEME



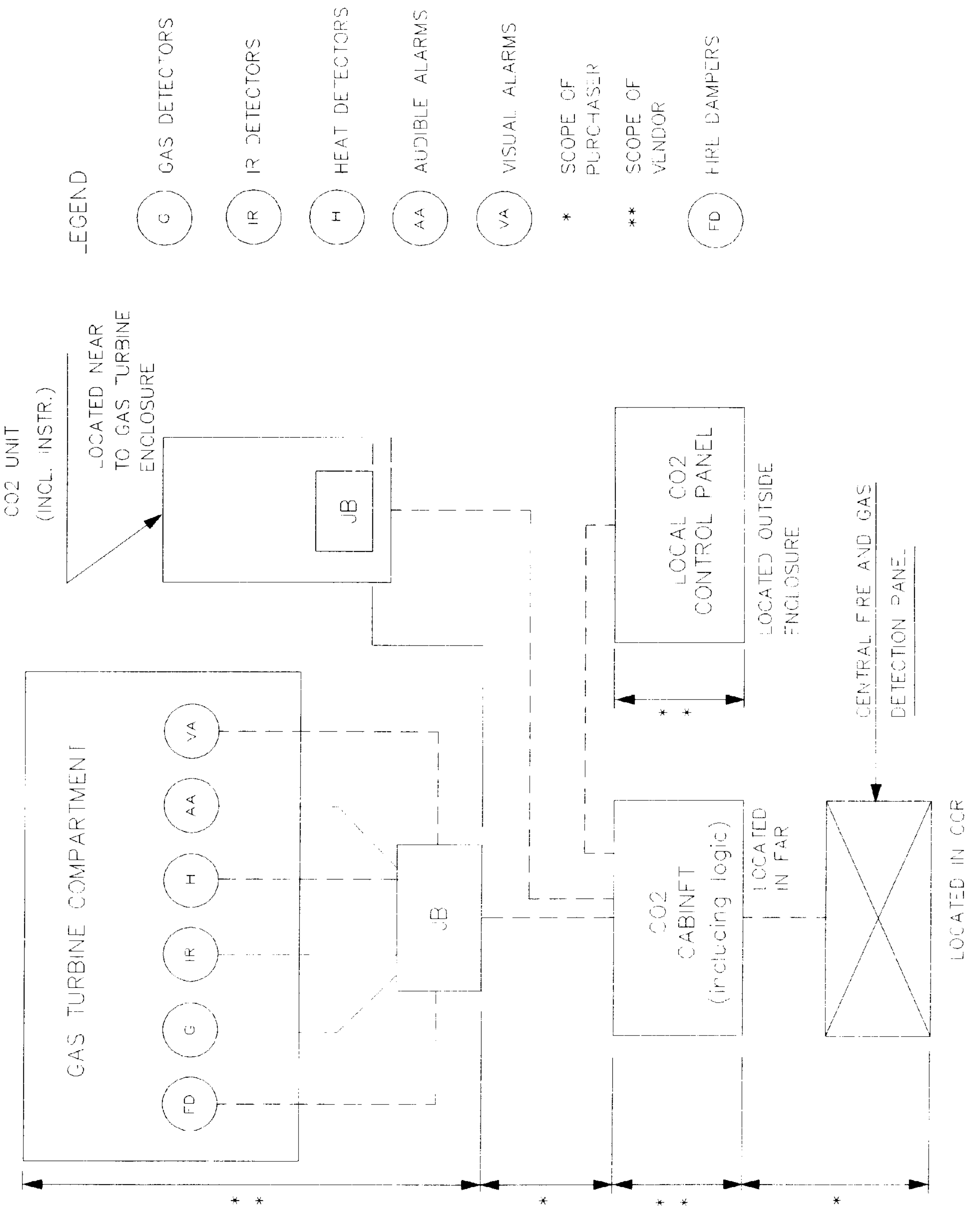
1) FOR FLUSHING & TEST RUN
2) MEMBRAME OR MAGNETIC TYPE
3) HOSE CONNECTION COMPATIBLE WITH FIRE FIGHTING VEHICLE
4) P_2 TO BE STARTED IN CASE P_1 FAILS TO PROVIDE PRESSURE WITHIN 20 SECS.
5) FOR CIRCULATION OF FOAM CONCENTRATE / MAINTENANCE
6) TO BE VISIBLE FROM MANUAL CONTROL
7) TO BE SIZED FOR OVERFLOW
8) FOR FLUSHING
9) BUCKET TYPEE FILTER;
MIN. CAPACITY 800% OF INLET PIPE SIZE

/usr/project/dep/80471031/app18

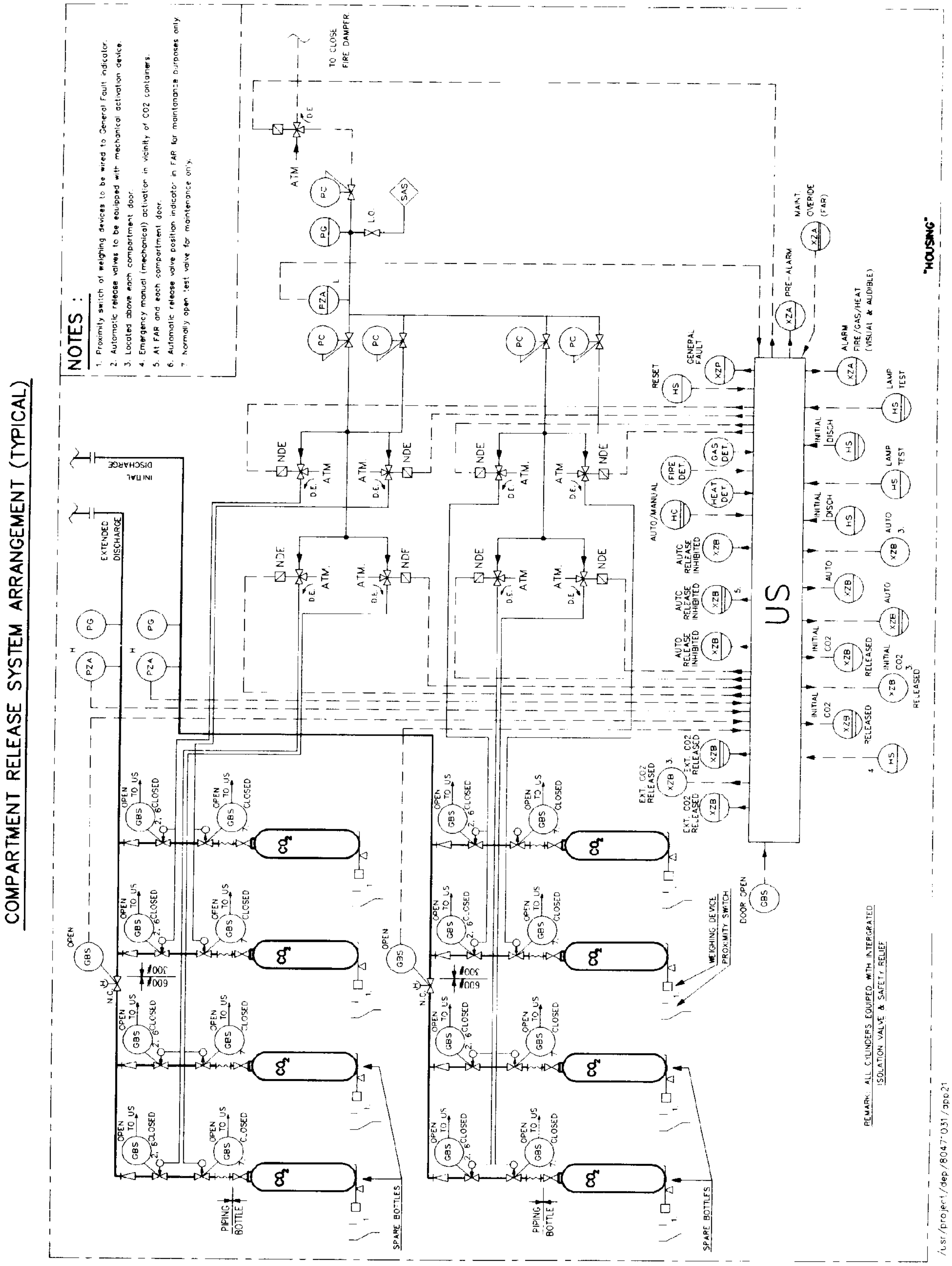
APPENDIX 19 TYPICAL LAYOUT FOR GAS TURBINE CARBON DIOXIDE EXTINGUISHING SYSTEM



APPENDIX 20 CARBON DIOXIDE EXTINGUISHING SYSTEM FOR GAS TURBINES (SCOPE OF WORK/INTERFACES)



APPENDIX 21 TYPICAL RELEASE SYSTEM FOR CARBON DIOXIDE EXTINGUISHING SYSTEM



APPENDIX 22 TABLE 1 - CONTROL FUNCTION FOR LOGIC SYSTEM

X = Applicable
- = Not applicable

	Stop Ventilators	Close Dampers	Stop Turbine	Compartment Carbon Dioxide Release	Emergency Alarm (Fire)	Inhibit Restart of Turbine
1. *Automatic Actions*						
a. Gas in common ventilation air and combustion air intake - high (2 of 3 gas detectors)	X	X	X	-	-	X
b. Gas in auxiliary or turbine compartment -high (2 of 3 gas detectors)	-	-	X	-	-	X
c. Fire in compartments (2 or more UV detectors, 2 heat detectors)	X	X	X	X	X	X
2. *Manual Actions*						
a. Turbine trip						
- Fire and gas detection panel in main control room	-	-	X	-	-	-
- Local CO_2 panel	-	-	X	-	-	-
b. Compartment Carbon Dioxide Release						
- Fire and gas detection console in main control room	X	X	X	X	X	X
- Local CO_2 panel	X	X	X	X	X	X

APPENDIX 23 TABLE 2 - ALARM ANNUNCIATING FUNCTIONS

C = Common pre-alarm
P = Pre-alarm (dedicated)
T = Trip alarm
E = Emergency (/Fire) alarm
- = Not applicable

	Local CO_2 Panel	Panel in Main Control Room	Panel in Field Auxiliary Room	Inside Compartment	Outside Compartment, above doors
a. Gas in common ventilation and combustion air intake:					
Individual gas detector - low/high	-	C	-	C	C
2 of 3 gas detectors - high	T/E	T/E	T/E	E	E
b. Gas in auxiliary or turbine compartment:					
Individual gas detector - low/high	C	C	C	C	C
2 of 3 gas detectors - high	T/E	T/E	T/E	E	E
c. Fire in compartments					
One IR detector or one heat detector	-	C	-	C	C
2 or more IR detectors or heat detectors	T/E*	T/E	T/E	E	E
d. Manual release of carbon dioxide	T/E*	T/E	T/E	E	E
e. Power failure on CO_2 system (incl. detection)	-	C	P	-	-
f. Low carbon dioxide weight	-	C	P	-	-
g. Pressure switch downstream of automatic release valves operated (Carbon dioxide discharged)	E	E	E	-	E

NOTE: * This alarm denotes "Carbon dioxide discharged" alarm.