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PROCESS DESIGN OF LIQUID & GAS TRANSFER AND STORAGE

(PROJECT STANDARDS AND SPECIFICATIONS)

TABLE OF CONTENT

SCOPE

This Project Standards and Specifications is intended to cover the minimum requirements and criteria to be considered in process design of liquid and gas transfer and storage facilities in OGP Industries.

The requirements outlined in this Project Standards and Specifications deal with individual items of equipment and other facilities such as storage tanks and accessories, pumps/compressors and piping connection, instrumentation, fire protection and safety instruction, layout and spacing and other aspects, but all to the extent of process design consideration limits.

REFERENCES

Throughout this Standard the following dated and undated standards/codes are referred to. These referenced documents shall, to the extent specified herein, form a part of this standard. For dated references, the edition cited applies. The applicability of changes in dated references that occur after the cited date shall be mutually agreed upon by the Company and the Vendor. For undated references, the latest edition of the referenced documents (including any supplements and amendments) applies.

1. **API(American Petroleum Institute)**
   - API RP 520
     - Part : I, 7th Edition" Sizing and selection"
     - Part : II, 4th Edition "Installation"
   - API RP 521 4th Ed., 1997 - "Guide for Pressure-Relieving and Depressuring Systems"
   - API 620 10th Ed., 2002 - "Design and Construction of Large, Welded, Low Pressure Storage Tanks"
   - API 650 10th Ed., 1998 - "Welded Steel Tanks for Oil Storage"
   - API 2000 5th Ed., 1998 - "Venting Atmospheric and Low-Pressure Storage Tanks: Nonrefrigerated and Refrigerated"
   - API 2015 6th Ed., 2001 - "Requirements for Safe Entry and Cleaning of Petroleum Storage Tanks"
   - API 2508 2nd Ed., 1985 - "Design and Construction of Ethane and Ethylene Installations at Marine and Pipeline Terminals, Natural Gas Pipeline Terminals, Natural Gas Petrochemicals Plants, and Tank Farms"

- API 2510 8th Ed., 2001 - "Design and Construction of LPG Installations"
- API Recommended Practice 1626 1st Ed. 1985 - "Storing and Handling of Ethanol and Gasoline-Ethanol Blends at Distribution Terminals and Service Stations
- API Recommended Practice 1627 1st Ed. 1986 - "Storage and Handling of Gasoline- Methanol/Cosolvent Blends at Distribution Terminals and Service Stations"
- API Recommended Practice 2003 6th Ed. 1998 - "Protection against Ignitions Arising out of Static, Lightning and Stray Currents
- API Publication 2510A 2nd Ed., 1996 - "Fire-Protection Considerations for the Design and Operation of Liquefied Petroleum Gas (LPG) Storage Facilities"
- API Publication 2015B 1st Ed., 1981 - "Cleaning Open-Top and Covered Floating Roof Tanks"

2. **BSI (British Standards Institution)**
   - BS 470 1999 - "Specification for Inspection, Access and Entry Openings for Pressure Vessels"
   - BS EN 14015 - "Specification for Design and Manufacture of Site Built, Vertical, Cylindrical, Flat Bottomed, above Ground, Welded, Steel Tanks for The Storage of Liquid at Ambient Temperature and above"
   - BS 5429 Ed., 1988 - "Code of Practice for Safe Operation of Small Scale Storage Facilities for Cryogenic Liquids"
3. **ASME (American Society of Mechanical Engineers)**
   - ASME B31.3 Ed. 1987 - "Process Piping"
   - ASME B31.4 Ed. 1994 - "Pipeline Transportation Systems for Liquid hydrocarbons and other liquids"
   - ASME Codes, - "Boiler and Pressure Vessels Codes Section VIII Divisions 1 and 2"
4. **ASTM (American Society for Testing and Material)**
   - D-1250 - "Standard Guide for Use of the Petroleum measurement Tables – Vol.X1/X11"
5. **NFPA (National Fire Protection Association)**
   - NFPA 30 Ed. 2000 - "Flammable and Combustible Liquid Code"
   - NFPA 30A - "Code for Motor Fuel Dispensing - Facilities and Repair Garages"

- NFPA 59A, Ed. 2001 - "Standard for Production, Storage and Handling of LNG"
- NFPA 58 Vol. 2,Ed., 2001 - "Liquefied Petroleum Gas (LPG) Code"

6. **UBC (Uniform Building Code)**
7. **ISO (International Organization for Standardization)**
   - ISO 4266-1 : "Petroleum and liquid Petroleum products- Measurement of Level and temperature in Storage Tanks by Automatic Methods part Atmospheric Tank" 1: Measurement of Level in

DEFINITIONS AND TERMINOLOGY

Design Pressure - The pressure used in design of equipment, a vessel or tank for the purpose of determining the minimum permissible thickness or physical characteristics of its different parts. When applicable static head shall be included in the design pressure to determine the thickness of any specific part.

Dike – A structure used to establish an impounding area.

Direct vaporizer - A vaporizer in which heat furnished by a flame is directly applied to some form of heat exchange surface in contact with the liquid LP-Gas to be vaporized.

Indirect vaporizer - A vaporizer in which heat furnished by steam, hot water, the ground, surrounding air or other heating medium is applied to a vaporizing chamber or to tubing, pipe coils, or other heat exchange surface containing the liquid LP-Gas to be vaporized; the heating of the medium used being at a point remote from the vaporizer.

Liquefied Natural Gas (LNG) - A fluid in the liquid state composed predominantly of methane and which may contain minor quantities of ethane, propane, nitrogen, or other components normally found in natural gas.

Liquefied Petroleum Gas (LPG or LP-Gas) - Any material in liquid form that is composed predominantly of any of the following hydrocarbons or of a mixture thereof: propane, propylene, butanes (normal butane or isobutene), and butylenes.

Natural Gas Liquid (NGL) - A mixture of liquefied hydrocarbons extracted from natural gas by various methods to obtain a liquid product.

Standard Condition - A temperature of 15°C and a pressure of one atmosphere (101.325 kPa), which also is known as Standard Temperature and Pressure (STP).

Vaporizer - A device other than a container which receives LP-Gas in liquid form and adds sufficient heat to convert the liquid to a gaseous state.

SYMBOLS AND ABBREVIATIONS

SYMBOL/ABBREVIATION	DESCRIPTION
GPA	Gas Processors Association
LPG	Liquefied Petroleum Gas
NGL	Natural Gas Liquid
NPSH	Net Positive Suction H
OCMA	Oil Companies, Material Association
OGP	Oil, Gas and Petrochemical
RVP	Reid Vapor Pressure
STP	Standard Temperature and Pressure

UNITS

This Standard is based on International System of Units (SI) except where otherwise specified.

STORAGE AND HANDLING OF CRUDE OIL AND REFINERY PRODUCTS

General

The requirements of this Section apply to the storage of crude oil and refinery products in vertical cylindrical tanks and to storage tanks constructed of carbon steel, carbon manganese steel, tanks constructed of carbon and alloy steels or tanks constructed of non-ferrous materials.

Crude oil and the refinery products should normally be stored as follows:

a. Lighter refinery products with RVP≥79.3 kPa (abs) is preferably to be stored in pressure vessels (e.g. spheres). However, where RVP of the lighter refinery products is exceeding local atmospheric pressure, the type of storage. If refrigeration is not used shall be pressure vessel.

b. Aviation fuels shall be stored in a covered floating roof inside a fixed roof tank.

c. Crude oil, naphtha and kerosene and other hydrocarbons with closed flash points at or below 45°C, [except the cases covered in (a) and (b) above] should be stored in tanks fitted with floating roofs.

d. Gas oils, diesel oils, lubricating oils, fuel oils and residues (with closed flash points above 45°C) should be stored in tanks fitted with non-pressure fixed roof.

e. Exceptions to the above may occur, as for example with the storage of feed stock for catalytic Units where, to prevent oxidation and ingress of moisture, the feed stock may be stored in a fixed roof vertical cylindrical low pressure (21 mbar and/or 2.1 kPa) tank under a gas blanket. Alternatively, a covered floating roof may be used in a fixed roof tank and in this case a non-pressure tank may be used.

f. Exceptions may also occur where adverse climatic conditions such as heavy snowfalls, preclude the use of floating roof type tanks. Fixed roof low pressure tanks (21 mbar and/or 2.1 kPa approximately), should be used in such cases.

Design Requirements

1. Wind load

   The design wind velocity shall be according to the requirements.

2. Earthquake load

   Earthquake load shall be specified in the job specification according to the latest edition of Uniform Building Code (UBC).

   The sloshing effect due to product movement in the tank as a result of earthquake movement shall be taken into account and calculations shall be submitted for the Company's approval to ensure soundness of design.

3. Rainfall intensity

   Rainfall intensity should be specified as per site condition and the tank shall be designed accordingly except floating roof tanks. For this type of roof with the deck at its low position at operating level with drain valve(s) closed and, assuming no pontoon compartment is punctured, the deck support legs shall be designed to support the greater of the following loads:

   a. Rainfall of 115 mm of water uniformly distributed all over the deck.

   b. A live load as per project specification.

The snow load as specified in site conditions and incorporated above.

When calculating for vacuum conditions during lowering of tank product in fixed roof tanks, maximum gravity transfer conditions should also be considered.

Tank Dimensions, Capacities and Layout

1. General
   a. Tanks should conform to the standard diameters listed in Table A.1 in Appendix A. In selecting tank dimensions the highest tank compatible with permissible ground loading and economic aspect should normally be chosen.
   b. Working capacity
      - An approximation of the working capacity of tanks may be achieved by assuming a negative capacity at the top of the tank of 500 mm height for floating roofs, and an ullage space in fixed roofs of 150 mm. For fixed roof tanks the dead space at the bottom will extend to 150 mm above the suction branch. For floating roof tanks the lowest position of the roof may be assumed to be 300 mm above the suction branch. If, exceptionally, landing of the roof is permitted by the Company during normal operation, the lowest position will be 150 mm above the suction branch.
      - The working capacity of each heated tank should be based on a minimum dip of 1 m above the steam coil.
      - The actual allowances will depend on such factors as the position and size of outlet branches, the position and type of pump, rate of pumping and type of level instrumentation.
2. Layout consideration

   This Section covers the atmospheric storage and handling in refineries of crude petroleum and its products, with the exception of bitumen handling and storage, LPG pressurized and refrigerated storage. The recommendations on tankage layout contained herein will normally apply to storage in tanks outside block limits of refinery process Units. Crude oil terminals associated with production are also covered by these recommendations. The layout of tanks, as distinct from their spacing, shall take into consideration the accessibility needed for fire-fighting and the potential value of a storage tank farm in providing a buffer area between process plant and public roads, houses, etc. for environmental reasons.

The location of tankage relative to process Units must be such as to ensure maximum safety from possible incidents.

Primary requirements for the layout of refinery tank farms are summarized as follows:

a. Inter-tank spacings and separation distances between tank and boundary line and tank and other facilities are of fundamental importance (see Table 1).
b. Access roadways should be provided for approach to tank sites by mobile fire-fighting equipment and personnel.
c. The fire-water system should be laid out to provide adequate fire protection to all parts of the storage area and the transfer facilities.
d. Bunding and draining of the area surrounding the tanks should be such that a spillage from any tank can be controlled to minimize subsequent damage to the tank and its contents. They should also minimize the possibility of other tanks being involved.
e. Tank farms should preferably not be located of higher levels than process Units in the same catchment area.
f. Storage tanks holding flammable liquids should be installed in such a way that any spill will not flow towards a process area or any other source of ignition.

3. Spacing of tanks for petroleum stocks

Table 1 gives guidance on the minimum tank spacing for petroleum stocks. The following points should be noted:

a. Tanks of diameter up to 10 m are classed as Small Tanks.
b. Small Tanks may be sited together in groups, no group having an aggregate capacity of more than 8.000 m^3. Such a group may be regarded as one tank.
c. Where future changes of service of a storage tank are anticipated the layout and spacing should be designed for the most stringent case.
d. For reasons of fire-fighting access there shall not be more than two rows of tanks between adjacent access roads.
e. Fixed roof tanks with internal floating covers (see 6.3.4.3) should be treated for spacing purposes as fixed roof tanks.
f. Where fixed roof and floating roof tanks are adjacent, spacing should be on the basis of the tank(s) with the most stringent conditions.

g. Where tanks are erected on compressible soils the distance between adjacent tanks should be sufficient to avoid excessive distortion. This can be caused by additional settlements of the ground where the stressed soil zone of one tank overlaps that of the adjacent tank.

h. For unclassified petroleum stocks, spacing of tanks is governed only by constructional and operational convenience. Figs. 1 to 4 show several typical tank installations, illustrating how the spacing guides are interpreted.

No	Factor	Type of Tank Roof	Recommended Minimum Distance
1	Within a group of Small Tanks.	Fixed or floating	Determined solely by construction /maintenance/ operational convenience.
2	Between a group of Small Tanks and another group of Small Tanks or other larger tanks.	Fixed or floating	10 m minimum, otherwise determined by the size of the larger tanks (see 3 below).
3	Between adjacent individual tanks (other than Small Tanks)	a) Fixed	Half the diameter of the larger tank, but not less than 10 m and need not be more than 15 m.
		b) Floating	0.3 times the diameter of the larger tank, but not less than 10 m and need not be more than 15 m*.
4	Between a tank and the top of the inside of the wall of its compound.	Fixed or floating	Distance equal to not less than half the height of the tank. (Access around the tank at compound grade level must be maintained.)
5	Between any tank in a group of tanks and the inside top of the adjacent compound wall	Fixed or floating	Not less than 15 m.
6	Between a tank and a public boundary fence.	Fixed or floating	Not less than 30 m.
7	Between the top of the inside of the wall of a tank compound and a public boundary fence or any fixed ignition source.	-	Not less than 15 m.
8	Between a tank and the battery limit of a process plant.	Fixed or floating	Not less than 30 m.
9	Between the top of the inside of the wall of a tank compound and the battery limit of a process plant.	-	Not less than 15 m

* In the case of crude oil tankage this 15 m option does not apply.

4. Types of storage tanks

   Tanks must be built to design criteria that ensure physical integrity of the tank against all reasonably expected forces such as tank contents, ground settlement or movement, wind and snow. Suitable codes relating to the design and construction of tanks and their associated fittings are BS EN 14015 and API Standard 650.
   The main types of storage are as follows:

   a. Floating roof tanks

      Such tanks are generally used for liquids to minimize product loss and for safety and environmental reasons. There is a preference for floating roof over fixed roof tanks as the size of the tank increases, as the vapor pressure of the stored liquid increases, and when the flash point is below the storage temperature.

      The roof consists of an arrangement of buoyancy compartments (pontoons) and floats on the liquid.

      It is sealed against the walls of the tank by mechanical means or by tubular type seals. The roof is provided with support legs which can be adjusted to hold it in either of two positions. The upper position should be high enough to permit access for tank cleaning and maintenance. The lower position should keep the roof just above inlet and outlet nozzles, the drainage system, and other accessories located near the tank bottom.

      Floating roof tanks are normally equipped with rolling ladders. The tank shell is earthed and the roof and all fittings, such as the rolling ladder, are adequately bonded to the shell as a protection against lightning. All internals such as gage floats, cables and mixers must also be suitably earthed to prevent accumulation of electric charge.

   b. Fixed roof tanks

      Such tanks are generally used in refineries where the product stored does not readily vaporize at the ambient or stored temperature conditions. The size of tank and flash point of the product stored will also influence the choice of tank as noted above. These tanks are operated with a vapor space above the liquid.

      Depending on the materials to be stored, fixed roof tanks can be designed for storage at atmospheric pressure in which case they are equipped with open vents. For materials, they can be designed for pressures up to a maximum of about 50 mbar (5 kPa). Weak shell-to-roof welds can be incorporated to give protection to the tank shell in the event of excessive internal pressure. They are also designed for slight vacuum conditions not normally exceeding 6 mbar (0.6 kPa). Fixed roof tanks should be adequately earthed as a protection against lightning.

c. Fixed roof tanks with internal floating covers

Such tanks can be used, for example, where:

- Snow loading on a floating roof may be a problem;
- Contamination by rainwater of the liquid stored in a floating roof tank is unacceptable;
- There is an environmental or vapor loss problem with fixed roof tanks; or,
- Contact of the stored liquid with air should be avoided.

Pressure/vacuum valves or ventilating slits may be used. In the latter case vent outlets are required in the upper ring of the tank shell and in the highest point of the fixed roof. This will assist in reducing the gas concentration in the space between the fixed roof and the internal floating cover to below the lower flammability limit. Such vent outletsshould be constructed so as to prevent the ingress of snow and rain. When screens are provided, the mesh opening should not be less than 6 mm square.

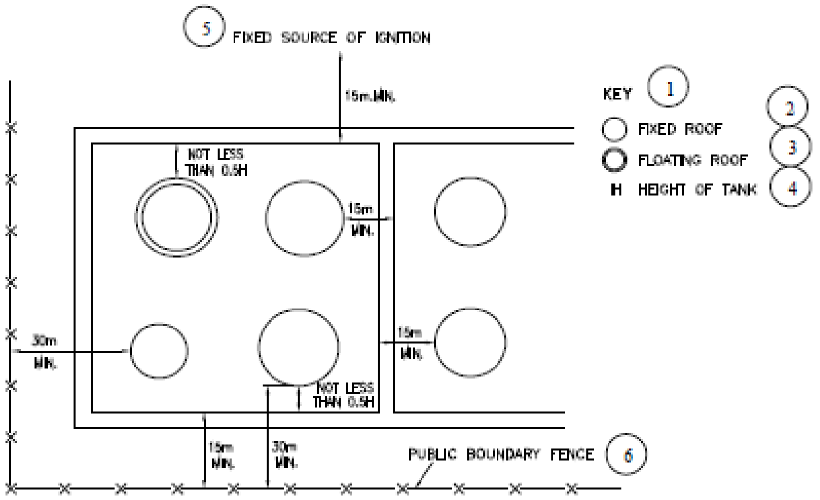


Fig. 1-Tank and Compound Wall Distances from Typical Features

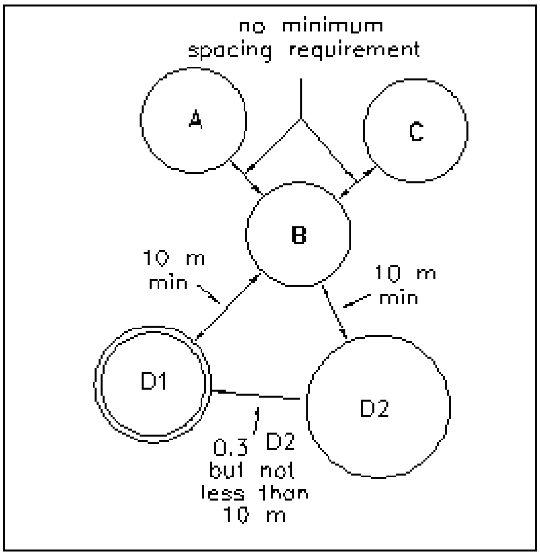


Fig. 2-Inter-Tank Spacing Between Small and Larger Tanks

Tanks A, B, C are fixed or floating roof small tanks (less than 10 m diameter) with a total capacity of less than 8000 m^3; no inter-tank spacing requirements other than for construction/ operation/maintenance convenience. Tank D1 and D2 are tanks with diameter greater than 10 m and with diameter of D2 greater than D1.

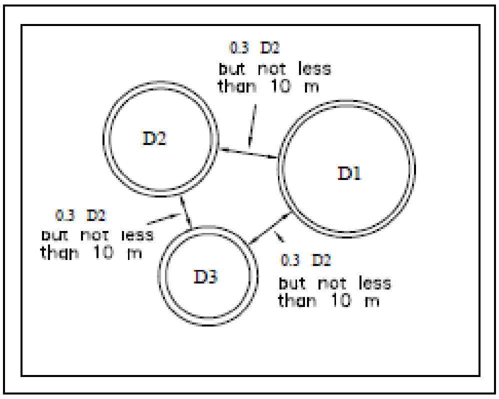


Fig. 3-Inter-Tank Spacing for Floating Roof Tanks (Greater Than 10 m Diameter)

Floating roof tanks of diameter D1 D2 D3 greater than 10 m within the same compound. D1 greater than D2 and D2 greater than D3.

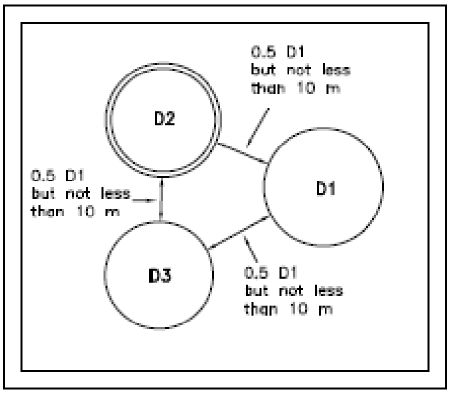
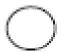
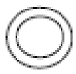


Fig. 4- Inter-Tank Spacing for Fixed and Floating Roof Tanks (Greater Than 10 m Diameter)

Fixed and floating roof tanks within the same compound, D1 greater than D2, D2 equal to D3.

<u>Key:</u>

Fixed Roof 

Floating Roof 

There has been some history of internal floating covers sinking in service; they should therefore be carefully designed to minimize such a possibility. The internal floating cover should also be designed to avoid fouling or obstruction of tank connections and of the fixed roof members and should be electrically bonded to the main tank structure. The tank should be adequately earthed as a protection against lightning.

Shell Attachments and Tank Appurtenances

1. General

   Shell attachments shall be designed in conformance with API Standard 650 and the followings:

   a. The orientation of the roof and shell fittings should permit the installed equipment to work accurately and effectively. For example, the flow from a mixer should not be hindered unduly by the siting of heaters.

b. The recommendations of ISO 4266 should be considered for automatic liquid level and temperature measuring instruments on the storage tank.

2. Shell fittings

   The checklist below covers tank shell fittings which may be required, but the number, type, size and location of fittings should be specified in design stage for each tank to the tank fabricator.

   a. Branches for tank contents such as:

      Inlet, Outlet, Gas Blanket, Pumpout, Water Draw-Off, Mixers.

   b. Branch connections for services and maintenance such as:

      Steam, Condensate, Foam (for Fire Fighting), Flush Type Clean Out Doors, Non-Flush Clean Out Doors.

      Note:

      The last two, items are not normally fitted, but when they are required, the limitations imposed by BS EN 14015 on shell design must be observed.

   c. Branch for instruments such as:

      Level Alarms, (high and low positions), Mixer Cut-Out, Float Switches, Thermowells as required

      Note:

      For fuel oil and slop tanks, thermowells should be located approximately 750 mm above the heating element. For other tanks, the position should be agreed with the Company.

   d. Other shell fittings such as:

      Fire Fighting Water Spray, Manholes and Earthing Luges which shall be as API Standard 650.

Fixed Roof Fittings

1. Manhole

   One roof manhole of diameter 600 mm, should be provided for tanks 20 m diameter or less and two for tanks over 20 m diameter.

2. Vents and relief valves

   The number and size of vents provided shall be based on the venting capacity obtained from the API 2000 and should be sufficient to prevent any increasing of pressure or vacuum (including that arising from inert gas blanketing) exceeding the design conditions specified for and approved by the Company.

For fixed roof low pressure tanks (20 mbar and/or 2 kPa) containing low flash point material a pressure and vacuum type breather valve should be designed and provided upon the approval of the Company. These valves should be fitted with a screen of appropriate mesh.

Pressure and vacuum relieving devices shall be designed in accordance with provisions of API Standard 620 and requirements above.

For fixed roof non-pressure tanks containing high flash point material, which is never heated above the flash point, free vents of the Company approved design should be provided. These free vents should be fitted with screens of appropriate mesh. If however the contents of a fixed roof tank are liable to be heated above the flash point then pressure and vacuum valves should be fitted.

3. Sample points on slops tankage

   On tanks where liquid interfaces have to be determined, sample points operable from ground level should be considered in design at appropriate vertical intervals. The points should be discharged to a common oily drain; and where necessary, the system shall be heat traced to prevent plugging.

4. Control instrumentation for slops tankage

   a. Temperature

      For heated tanks a multipoint high temperature (remote) alarm is required, with 6 sensing points at suitable vertical intervals, the lowest being 750 mm above the steam coil. The alarm is to operate in a permanently manned control room.

      On the opposite side of the tank, a temperature sensing element is required 750 mm above the steam coil, linked with the steam supply control and shut off valve. A separate thermowell with local temperature indicator is also required at this point.

      In the case of ballast tanks, as the steam coils are used only occasionally to aid sludge removal, and for all unheated tanks, one local temperature indicator is sufficient.

   b. Level

      A local level indicator should be provided, and where the type of installation demands, remote indication should in addition be considered.

A high level (remote) alarm should operate in a permanently manned control room.

5. Water drains

   Floating roof tanks should be equipped with means for draining rainwater from the upper surface of the roof. For pontoon-type roofs with internal articulated pipe drains a non-return valve should be provided near the roof end to prevent backflow of stored product on to the roof in case of a leakage in the jointed pipe.

   For double-deck type roofs this non-return valve is not necessary owing to the extra height of the double roof, but an emergency roof drain should be fitted. As an alternative to articulated pipes for draining water from tank roofs, internal flexible hoses are also used. It is essential to ensure that the hoses cannot be trapped between the roof support legs and the tank bottom.

   All tanks should be fitted with a water draw-off sump and drain line leading to a valved outlet on the tank shell, for removal of water accumulation inside the tank.

Floating Roof Fittings

1. Manholes

   Manholes should be provided to permit entry to tanks, and to facilitate gas-freeing and tank cleaning operations. Such manholes should be large enough to permit entry when full protective clothing is worn. Reference should be made to BS 470 and API Standard 650. At least one manhole should be provided in the lowest shell strake and one in the roof of a vertical tank. For tanks with diameters greater than 25 m consideration should be given to providing a minimum of two manholes in the lowest shell strake and two in the roof to facilitate tank ventilation for cleaning purposes.

   a. 600 mm diameter deck manholes should be provided for pontoon roofs, and 600 mm diameter through manholes for double deck roofs.

   b. One manhole should be fitted to roofs up to 20 m diameter and two for larger roofs.

   c. One 500 mm diameter manhole should be provided for each pontoon compartment, unless otherwise specified.

2. Vents

   Automatic bleeder vents shall be used on all floating roof tanks. Size will be specified on data sheet. Automatic bleeder vents should be made of stainless steel.

   Vendor shall submit descriptive literature on the pressure vacuum vent valves, swing lines with appurtenances and floating roof rim seals with his questions. Integral vacuum breakers and pressure relief valves may be offered as an acceptable design.

   The number of rim vents to be fitted to the roof is to be specified by the Vendor

   The Vendor should be informed of the maximum flow rates into and out of the tank to allow him to determine the size and number of bleeder vents required.

3. Heaters

   Tank heaters shall be exclusively of removable tube bundle type (whether finned or not) and shall be approved by the Company. For bitumen storages only removable bear tube bundle shall be used.

4. Drains

   Emergency open type drains may be fitted if recommended by the Vendor/fabricator to double deck type roofs or to pontoon roofs having more than 50% pontoon area. A drain plug should be provided for use when taken out of service.

5. Arrangements for sampling and dipping

   A tube DN 150 (6 inch) should be located at the gaging platform, for the combined purposes of leg guide and dipping. A separate sample hatch DN 200 (8 inch) is required with appropriate drawing approved by the Company, located under the gaging platform.

Safe Entry and Cleaning of Petroleum Storage Tank

All of the provisions regarding to safe entry and cleaning requirements given in API publication 2015 shall be considered in design of petroleum storage tanks. Provisions for cleaning of open-top and covered floating roof tanks as given in API publication 2015 B shall be considered for these specific tanks.