ENGINEERING STANDARD

FOR

ATMOSPHERIC ABOVE GROUND

WELDED STEEL STORAGE TANK

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0. INTRODUCTION

"Storage Tanks" are broad and contain variable types and usages of paramount importance therefore, a group of Engineering Standards are prepared to cover the subject. This group includes the following standards:

STANDARD CODE	STANDARD TITLE
IPS-E-ME-100-92	"Atmospheric Above Ground Welded Steel Storage Tanks"
IPS-E-ME-110-92	"Large Welded Low Pressure Storage Tanks"
IPS-E-ME-120-92	"Aviation Turbine Fuel Storage Tanks"
IPS-E-ME-130-92	"Pressure Storage Spheres (for LPG)"

This Engineering Standard is intended for design of storage tanks being used in oil refineries, chemical plants, marketing installations, gas plants and, where applicable, in exploration, production, transportation and new ventures. The requirements given herein supplement and modify those of API Standard 650 "Welded Steel Tanks for Oil Storage" eighth edition, November 1988.

For ease of reference, the clause or section numbering of API Standard 650 for the items supplemented are given at the beginning of each paragraph. Clauses or paragraphs of API Standard 650 not mentioned remain unaltered.

For the purpose of this specification, the following definitions shall hold:

Sub. (Substitution) : The API Std. Clause is deleted and replaced by a new clause.

Del. (Deletion) : The API Std. Clause is deleted without any replacement .

Add. (Addition) : A new clause with a new number is added.

Mod. (Modification) : Part of the API Std. Clause is modified, and/or a new description and/or condition is added to that clause.

1. SCOPE

1.1 (1.1.1 Mod.)

This Engineering Standard covers the minimum design requirements for vertical cylindrical above ground atmospheric welded steel storage tanks. Atmospheric storage tanks are those designed to operate at ambient temperature and above and from 0.6 kPa (6 mbar) vacuum up to 5.6 kPa (56 mbar=22 in H_2O) pressure.

1.2 (1.1.2 Mod.)

This Standard covers atmospheric storage tanks with fixed (cone and dome) and floating (pontoon and double deck) roofs. Storage tanks with internal floating roof are not covered here.

1.3 (1.3 Add.)

Design requirements for large welded Low pressure storage tanks, aviation turbine fuel storage tanks and pressure storage spheres are covered in IPS-E-ME-110, IPS-E-ME-120 and IPS-E-ME-130 respectively.

2. REFERENCES

Throughout this Standard the following standards and codes are referred to. The editions of these standards and codes that are in effect at the time of publication of this Standard shall, to the extent specified herein, form a part of this Standard. The applicability of changes in standards and codes that occur after the date of this Standard shall be mutually agreed upon by the Company and the consultant.

API (AMERICAN PETROLEUM INSTITUTE)

API Std. 650 -88	"Welded Steel Tanks For Oil Storage"
API Std. 2000	"Venting Atmospheric and Low Pressure Storage Tanks"

ASTM (AMERICAN SOCIETY FOR TESTING AND MATERIALS)

E-23	"Methods for Notched Bar Impact Testing of Metallic Materials"
A-333	"Specification for Seamless and Welded Steel Pipe for Low Temperature Service"

BSI (BRITISH STANDARDS INSTITUTION)

BS 2654	"Manufacture of Vertical Steel Welded Non refrigerated Storage Tanks with Butt Welded Shells for Petroleum Industry"

ANSI (AMERICAN NATIONAL STANDARD INSTITUTE)

ANSI A 14.3	"Fixed Ladders, Safety Requirements for"

IPS (IRANIAN PETROLEUM STANDARDS)

IPS-M-ME-100	"Atmospheric Above Ground Welded Steel Storage Tanks"
IPS-C-ME-100	"Atmospheric Above Ground Welded Steel Storage Tanks"
IPS-I-ME-100	"Atmospheric Above Ground Welded Steel Storage Tanks"

3. UNITS

International System of Units (SI) in accordance with IPS-E-GN-100 shall be used.

Whenever reference is made to API/ASME or any other Standard, equivalent SI unit system for dimensions, fasteners and flanges shall be substituted.

For pipe size the international nomenclature "diameter nominal" written as DN 15, 25, 40, 50, etc. has been used in accordance with ISO 6708-1980, ANSI/ASME B16.5-1981 and ANSI/ASME B31.3-1983 (see Appendix A). Also for pipe flanges pressure temperature ratings "pressure nominal" written as PN 20, 50, 68, etc. has been used in accordance with said Standards (see Appendix B).

4. DESIGN

4.1 General

4.1.1 Design of vertical above ground atmospheric welded storage tanks shall conform to API standard 650-88 and its relevant appendices as amplified and modified herein.

4.2 Design Data (3.2.1 Mod.)

4.2.1 Capacities for individual tanks include allowance for freeboard vapor space and inaccessible bottom and no further allowance is required in establishing tank size. Capacity of floating roof tanks shall be the net volume under the roof deck with seals in full operation.

Any deviations from this standard or from API 650 and its appendices shall be clearly stated and shall receive the written approval of the owner.

4.2.2 The design metal temperature shall be the lower of the lowest one day mean ambient temperature plus 10°C and the minimum temperature of the contents. The mean temperature is defined as one half of the sum of maximum temperature and minimum temperature.

4.2.3 For seismic loading and wind velocity reference is made to Iranian Petroleum Standard for Loads "IPS-E-CE-500".

4.2.4 In the design of Storage Tanks, seismic loading according to zone three of uniform building code or IPS-E-CE-120 shall be considered.

Design shall be in accordance with Appendix E of API 650.

4.2.5 The stability of tanks against earthquakes, wind and internal pressure specified in Appendix E of API 650, shall be checked by design calculations, where the tanks are operated under internal pressures, the loads for stability calculations shall be a combination of the earthquake or wind load, whichever is greater, and the internal pressure.

4.2.6 Unless otherwise specified, maximum aromatic content of the product contained shall be taken as 40% (m/m).

4.2.7 Atmospheric storage tanks shall be designed for the rainfall intensity as specified on site condition except for open top floating roof tanks. For this type of tanks, 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 250 mm of water uniformly distributed all over the deck;
b) a live load of 1200 N/m^2.

4.2.8 Soil conditions such as bearing pressure of soil, or uneven settlement of foundation on which the tanks are to be built shall be considered in the tank design.

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

4.2.10 When specified, corrosion allowance shall be 2.5 mm for plates up to and including 12.5 mm thickness and 1.25 mm for plates more than 12.5 mm thickness. Basic design tankage shall have no corrosion allowance.

4.3 Bottom Design

4.3.1 (3.5.3 Mod.)

Atmospheric storage tanks exceeding 12.5 m in diameter shall have a ring of annular plates having the following minimum thicknesses:

a) 8 mm, when the bottom course of shell plating is 19 mm thick or less;
b) 10 mm, when the bottom course of shell plating is over 19 mm up to and including 32 mm thick;
c) 12.5 mm, when the bottom course of shell plating is over 32 mm thick.

4.3.2 (3.5.1 Add.)

Storage tanks upto and including 12.5 m in diameter may be provided with sketch plates (sketch plates are bottom plates upon which the shell rests). The thickness of bottom plates including sketch plates shall be 6 mm minimum excluded of any corrosion allowance.

4.3.3 (3.4.3 Add.)

For storage tanks up to and including 12.5 m in diameter the ends of the joints in sketch plates under the bottom course of shell plates shall be hammered down, welded and ground flat.

4.3.4 (3.5.5 Add.)

The material of annular bottom plates shall be of the same specification and quality as the lowest shell course.

4.3.5 (5.2.2.2 Mod.)

Unless otherwise required,bottoms shall be laid, commencing with the center plate and with subsequent plates lapped towards the center of the tank and the layout shall be as indicated in Figure 1.

4.3.6 (3.5.6 Add.)

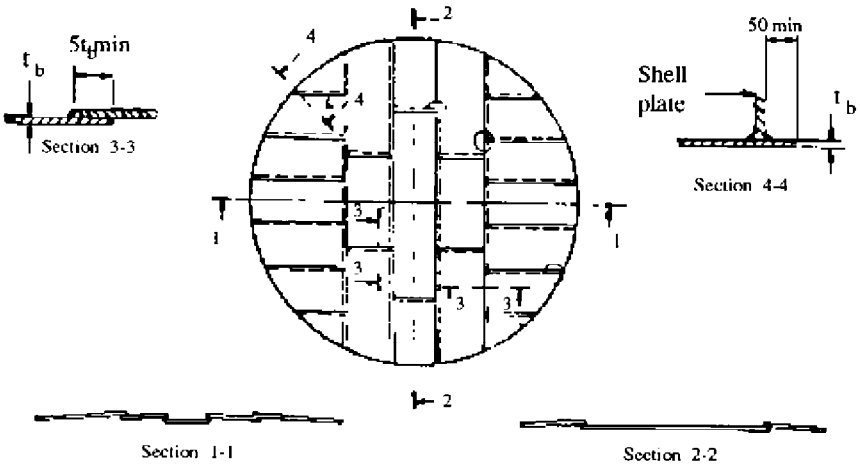
When the storage tank is to be placed on a concrete foundation ring no backing strips shall be used for butt welding radial seams connecting the ends of the annular segmental plates. The welding shall be done from top and underside to get a full penetration butt weld without obstruction for the concrete ring under the annular plate.

4.3.7 (3.5.7 Add.)

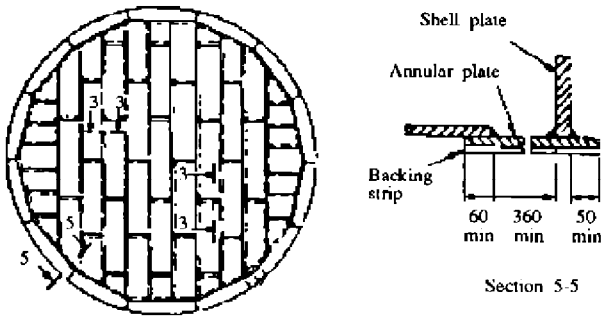
Pad plates shall be used where accessories are fixed to the tank bottom or where they may touch the tank bottom. Pad plates should preferably be of circular shape, if square or rectangular plates are used, they shall have rounded corners.

4.3.8 (3.5.8 Add.)

In fixed roof storage tanks, the bottom slope shall be outward and the slope shall be 1 mm/120 mm.



(a) Typical bottom layout for tanks up to and including 12.5 m diameter



(b) Typical bottom layout for tanks over 12.5 m diameter

TYPICAL BOTTOM LAYOUTS FOR TANKS
Fig. 1

4.4 Shell Design

4.4.1 (3.6.1.1 Add.)

For fixed roof storage tanks, the height specified shall be from bottom of shell to the top of top angle.

For floating roof tanks, the height specified shall be from the bottom of the shell up to the maximum filling height. Shell extension of a sufficient height shall be provided (as required) to accommodate the roof above this specified height, and shall be designed such that no damage will occur to the roof seal if the tank is overfilled.

4.4.2 (3.6.3.1 Add.)

When the purchaser has not specified the 1-foot method, calculation of shell thickness by the variable design point method should be used. Provided the condition in 3.6.4.5 of API 650 is met.

4.4.3 (3.9.1 Add.)

Where a curb angle is required at the top of the shell of floating roof tanks, the horizontal leg shall extend outward.

4.4.4 (3.1.5.8b Add.)

A mouse hole (20 mm radius) shall be made in the joining sections next to the tank shell to prevent fusion between butt weld and tank shell.

4.5 Roof Design

4.5.1 Fixed roof design

4.5.1.1 (3.10.2 Add.)

One of the two following types of roof shall be specified:

a) the self supporting cone, dome or umbrella roof;
b) the column supported roof.

4.5.1.2 (3.10.2.1 Add.)

Unless specifically agreed by the purchaser, the weight of any insulation shall be added to the minimum superimposed load.

4.5.1.3 (3.10.4.6 Add.)

When column supported roofs are required, the base of the column(s) shall be designed to ensure that the loading imposed on the tank bottom and the foundation do not exceed design limits.

4.5.1.4 (3.10.4.8 Add.)

Column supported roofs will not be specified where significant foundation settlement is anticipated but may be specified in cases where relatively small differential center to edge settlement is anticipated during the hydrostatic test. Column(s) shall therefore be designed to permit relevelling after completion of this hydrostatic test.

4.5.1.5 (3.10.2.5 Add.)

For tanks exceeding 12.5 m in diameter,roof plates shall not be attached to the roof supporting structure.

4.5.1.6 (3.10.2.3 Add.)

Plates of fixed roof shall be lapped with the lower edge of the upper plate underneath the upper edge of the lower plates, in order to avoid the risk of condensed moisture becoming trapped in the lap joint on the underside of the roof. The lap shall be at least 25 mm.

4.5.2 Floating roof design

4.5.2.1 Design of floating roof for atmospheric storage tanks shall be in accordance with Appendix C of API Standard 650 modified and amplified herein. The rules of this part does not apply to the design of floating covers installed in fixed roof tanks.

4.5.2.2 (C-1 Add.)

Pan type floating roofs shall not be permitted.

4.5.2.3 (C-3.1 Add.)

All floating roofs shall be designed so that the vapor spaces are minimum.

4.5.2.4 (C-3.12 Add.)

Floating roofs shall be designed for elastic stability against "gross out of plane" buckling and "Local" buckling of the outer pontoon due to the radial load imposed by deflection of the center deck. The radial load shall be determined from the 250 mm rainfall loading condition as specified in 4.2.7, or punctured center deck loading condition, whichever governs.

For preventation of "gross out of plane" buckling, the following relationship shall be satisfied:

a) for fully stiffened pontoons:

$$P < 2.526 \times 10^{4} \frac{E I_x}{R^3}$$

b) for partially stiffened Pontoons:

$$P < 3.784 \times 10^{3} \frac{E I_x}{R^3}$$

Where:

P = Design radial inward load, newtons per millimeter.
E = Modules of elasticity, kPa.
I_x = Moment of inertia of full pontoon cross section with respect to horizontal axis through its centroid, mm^4.
R = Mean radius of pontoon ring, mm.

c) the radially unsupported width of partially stiffened plates shall not exceed 3 meters.

4.5.2.5 (C-3.3.5 Add.)

Unless otherwise specified, double deck floating roofs shall be provided for storage tanks over 84 m diameter and for smaller tanks when required by the purchaser.

4.5.2.6 Rim seals (C-3.13 Add.)

a) Moving part pins shall be 18/8 stainless steel. Also if the hanger mechanism is in the vapor space below the seal, stainless steel shunts 50 mm wide × 0.6 mm thick × 400 mm long shall be provided between the shoe and roof above the seal area. At least one shunt shall be provided for each hanger.

b) Toroidal type seals shall be equipped with a weather shield.

c) Roof seals shall contact the shell above the liquid level for at least 90% of circumference. The maximum permissible gap between the primary seal and the tank shell is 6 mm.

d) If liquid filled tube seals are required, the seal shall be sectionalised i.e. discontinuous, in order to prevent the complete loss of sealing in the event of leakage.

4.5.2.7 (C-3.14 Mod.)

Floating roofs are to be provided with the mountings listed in Fig. 2. In the case of double deck roofs, manholes, in addition to pontoon manholes, shall be provided for access between decks. Such access manholes shall be spaced on distances not exceeding 30 m.

4.5.2.8 (C-3.10.1 Mod.)

Floating roof supports shall be adjustable to two following positions:

a) The lower position shall permit the roof to go 1 m above the tank bottom without interference with any internal accessories or roof seal mechanism.

b) The upper position (for cleaning and maintenance) shall provide for a clearance of 2 m between the lowest portion of the roof and the tank bottom.

4.5.2.9 (C-3.10.3 Add.)

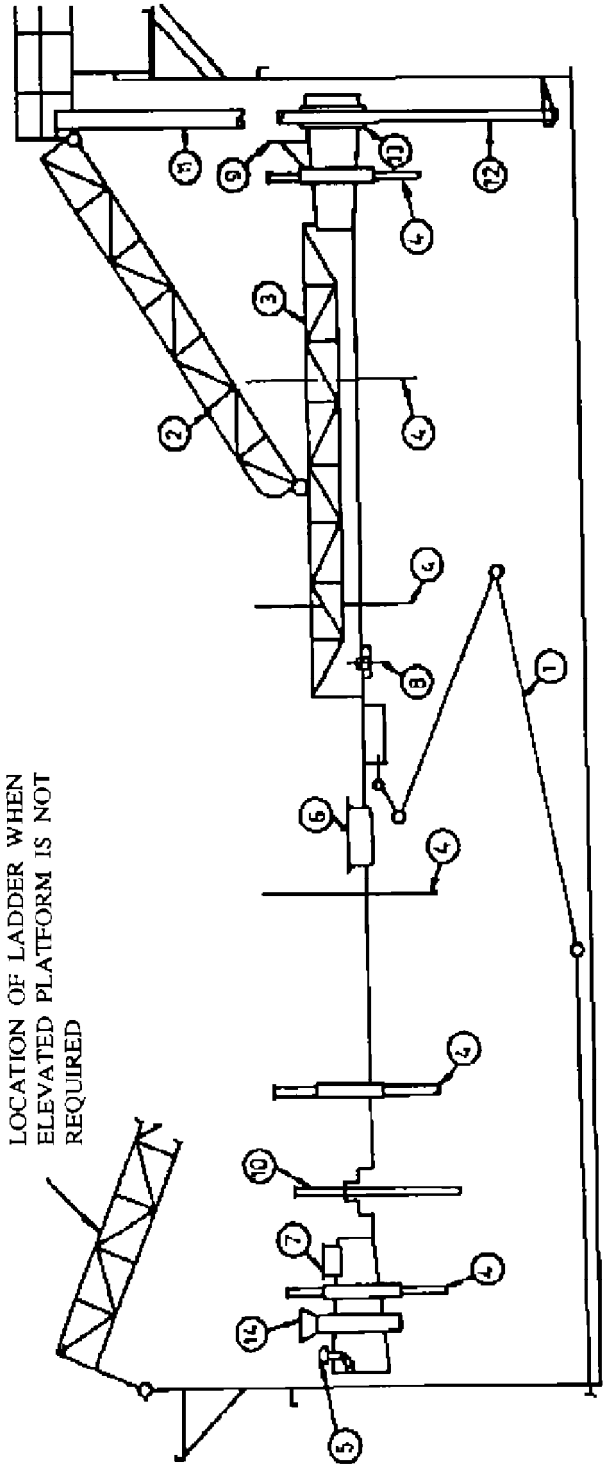
Floating roof supports shall be made of carbon steel pipe, schedule 80 minimum thickness. Legs shall be provided with a 50 mm × 25 mm notch at the bottom to provide drainage.

4.5.2.10 (C-3.10.4 Add.)

The length of the leg support sleeves shall be such that any opening will be above the liquid level when the deck is deflected by the 250 mm rainfall or punctured center deck condition. In no case shall the height of the support sleeves for single deck pontoon roofs be less than the tank diameter divided by 60.

4.5.2.11 (C-3.13 Add.)

Adequate means shall be provided to prevent electrical charge on the floating roof causing sparking in or above the seal. In the case of liquid filled tube seals a galvanized steel weathershield shall be provided which shall also permit the discharge of static or lightning induced electrical charges from the roof to the shell without causing sparking.



TYPICAL MOUNTINGS FOR FLOATING ROOFS
Fig. 2

4.6 Appurtenances and Accessories (3.8 Add.)

4.6.1 Design of appurtenances and accessories for atmospheric storage tanks shall be in accordance with API Standard 650 and the following supplementary notes :

4.6.2 Breather valves

The number and size of breather valves and free vents required should be specified separately owing to the large variations in pumping rate requirements, etc. The flow capacities of the breather valves shall be based on data received from the valve manufacturer.

4.6.3 Free vents

When deciding on the number of free vents required, their capacity shall be taken at a pressure of 750 Pa (7.5 mbar) and a vacuum of 250 Pa (2.5 mbar).

The venting capacity required shall be determined in accordance with the rules specified in API Std. 2000. These requirements shall be considered as minimum requirements. The capacity of vents and relief valves shall always be more than adequate.

The venting requirements shall include the following conditions:

- Inbreathing resulting from a maximum outflow of oil from the tank.

- Inbreathing resulting from contraction of vapors caused by a maximum decrease in atmospheric temperature, see also 4.6.5.

- Outbreathing resulting from a maximum inflow of oil into the tank and maximum evaporation caused by such inflow.

- Outbreathing resulting from expansion and evaporation due to a maximum increase in atmospheric temperature (thermal breathing).

- Outbreathing, resulting from pressure rise.

4.6.4 Roof nozzles (3.8.5 Add.)

Wire netting in the openings of free vents and breather valves to prevent nesting of birds shall have openings of 6 mm square as a minimum. The use of fine mesh screens as anti flash protection is not recommended because of the danger of blockage, especially under winter conditions.

4.6.5 Thermal venting

Special attention is required to the influence of a sudden drop in temperature due to rainfall, on the venting requirements of tanks containing warm oil and of tanks in tropical areas. A drop of 15-20°C or more in 15 minutes may be experienced.

Where these conditions apply the venting capacity for tanks with low pumping rates in particular, shall be increased by at least 20% of the thermal venting capacity requirements.

4.6.6 Roof and shell manholes (3.7.5 & 3.8.4 Add.)

The minimum number and size of shell and roof manholes shall be as per Table 1 below:

TABLE 1 - NUMBER AND SIZE OF MANHOLES

NOMINAL TANK DIAMETER	SHELL		ROOF			
	ALL TANKS TYPES		FIXED ROOF TANK		FLOATING ROOF TANK	
m	Number	mm	Number	mm	Number	mm
3-6	1	600	1	500	1	900
>6-9	2	600	2	500	1	900
>9-12	2	600	2	500	2	900
>12-18	1 1	600 900	2	500	2	900
>18-27	1 1	600 900	2	600	2	900
>27-60	2 1	600 900	2	600	2	900
>60	2 2	600 900	2	600	2	900

Note:

In addition, floating roofs shall be provided with at least one 500 mm manhole for each pontoon compartment. Where two deck manholes are required, they shall be located at diametrically opposite positions. An emergency vent cover shall be fitted to one manway on each cone roof tank.

4.6.7 Roof nozzles for breather valves, free vents, dip hatches and slot dipping devices

Fixed roof tanks shall be fitted with roof nozzles suitable for cone or dome roofs to enable these fittings to be mounted truly vertical and to provide clearance when roof insulation is fitted.

For floating roof tanks the same applies to the dip hatches and breather valves.

4.6.8 Stairways (3.8.9 Mod.)

Tanks requiring gaging or sampling from the roof shall be provided with a spiral stairway, and a platform for access to gage or sampling hatch.

A spiral stairway shall be provided for access to floating roof tanks. In addition, a top platform with a guard railing shall be provided from the top of this stairway to the gage well and the roof ladder.

Stairway design and construction shall be per API 650, and the followings:

a) Maximum angle with a horizontal line shall be 45 degrees.

b) Minimum effective tread width shall be 200 mm.

c) Minimum effective width of stair shall be 750 mm except where connecting to 600 mm wide walkways in which case the effective width shall be 600 mm.

d) Stair landings shall not be less than 750 mm in the direction of the stairway.

e) On cone roof storage tanks a handrail shall be provided extending all around the periphery of the tank.

4.6.9 Ladders (3.8.9 Add.)

Tanks not equipped with spiral stairways shall be provided with an external vertical ladder.

Ladders and safety cages shall be per ANSI A14.3 except as modified below:

a) Where ladders are the only means of access, they shall provide for side step access to platforms unless through ladder type is approved by the Owner's Engineer.

b) Where ladders serve as a secondary access to platforms, they may be either the side step or through ladder type installation.

c) Chains with safety hooks shall be provided across ladder openings at each platform landing.

d) Ladder safety device shall not be used in lieu of cage protection.

e) Ladders shall be designed for a moving concentrated load of 227 kg.

4.6.10 Roof ladders for floating roof storage tanks (C 3.7 Mod.)

If the tank diameter is equal to or greater than the height, a rolling type roof ladder with self leveling treads shall be furnished having a minimum angle of 30 degrees from the vertical.

If the tank diameter is less than the tank height, it shall have a vertical roof ladder.

4.6.11 Floating roof tanks, roof drains (C 3.8 Mod.)

The design and use of roof drains shall be as follows:

a) Floating roofs shall be provided with articulated (Swivel) pipe or proper flexible hose drains. The inlet for these drains shall have a swing type check valve to prevent product from flowing onto the roof if the pipe or hose drain fails.

b) Emergency drains shall not be installed in pontoon type roofs as the oil level in the tank is always higher than the rain water level on the center deck of the roof. The minimum size of the roof drains shall be DN 65 for tanks up to and including 20 m, DN 100 for tanks over 20 m and DN 150 for tanks of 60 m or more in diameter.

c) In areas with excessive rainfall in short periods, e.g. the tropics, it is recommended to install two roof drains. Under normal circumstances tanks shall be operated with open roof drains.

4.6.12 Floating roof tanks, roof vents (C 3.9 Mod.)

Automatic bleeder vent

Each roof shall be equipped with a bleeder vent, designed to open automatically when the roof lowers to 75 mm above its lowest operating position or lower leg setting, and to close automatically when the roof raises more than 75 mm above its lowest position.

Rim seal vent

When flexible steel shoe type seals are employed, the roof shall be equipped with a vent or vents between the roof rim and the seal shoe. These vents shall release excess air or noncondensable vapors entering the tank through the filling line.

4.6.13 Drawoff sumps (3.8.6 Add.)

4.6.13.1 Storage tanks in hydrocarbon service shall be provided with a minimum of one water drawoff sump for tanks over 6 m in diameter and a minimum of two drawoff sumps for tanks over 30 m in diameter.

4.6.13.2 End of drawoff pipe shall be 100 mm above bottom of sump.

4.6.13.3 Drawoff sumps shall be fitted so as to clear the lap joints in the bottom plates and shall not be placed in the annular plate.

4.6.13.4 When flush type suction nozzles are used, the maximum size water drawoff connection shall be DN 150.

4.6.13.5 Water drawoff line shall be fitted with non freezing, stainless steel trim drain valve.

4.6.14 Shell nozzles for inlet and outlet (3.7.6.3 Add.)

The size of shell inlet and outlet nozzles will be specified on the requisition.

Bottom outlets are permitted only in hard foundations, e.g. rock, where soil settlements can be neglected.

4.6.15 Swing pipes and accessories (3.7.6.4 Add.)

To assist in drawing off product above the level of any water contamination and in blending operations, tanks may be fitted with swing pipes operated by a hand winch at ground level.

Swing pipes shall be fitted to the outlet or service connection, never,to the inlet or receipt connection. A special note will be made on the requisition when a swing pipe is required.

4.6.16 Dip hatches (3.8.5.3 Add.)

Unless otherwise specified, all tanks shall be supplied with one DN 200 dip hatch if additional dip hatches are required, a special note shall be made when ordering. Dip hatches are also available as a fitting incorporated in the top of the free vent thereby reducing the number of nozzles that would otherwise be required on large tanks. All hatches shall be spark proof self closing type.

4.6.17 Heating coils (3.7.6.4 Add.)

If specified on the requisition, heating coils shall be fitted to tanks when products will be maintained at above ambient temperatures to facilitate pumping, e.g. on lubricating oil, furnace oil, or bitumen storage tanks. In tanks where water may be present on the bottom e.g. crude oil tanks the heating coils shall be placed sufficiently above the bottom to prevent heating of the water. The heating surface shall be in accordance with the requirements specified. Schedule 80 pipe shall be used for all heater coils.

If heating coils are not specified, heater nozzles shall be provided upon request. In that case, the heater nozzles shall be furnished with a 200 mm long internal projection beveled for welding.

4.6.18 Suction heater

If specified on the requisition,suction heaters shall be provided to tanks fitted with coils when additional localized heat is required at the outlet connection. These heaters are usually of the nested tube type, and are suitable for steam or hot oil systems.

4.6.19 Side entry mixers (3.7.6.5 Add.)

Side entry mixers may be required to improve mixing of the product or to reduce the formation of sludge. If side entry mixers will be installed, the required shell connections shall be specified on the requisition.

Side entry mixers shall be placed on manhole type shell nozzles to allow easy removal for maintenance without entering the tank.

4.6.20 Sample connections and thermo-indicators (3.7.6 Add.)

If specified on the requisition, sample connections and thermo-indicators shall be provided adjacent to the spiral stairway. Flanged connections may be preferred to prevent leakage.

For fixed roof tanks, a DN 25 threaded connection shall be furnished for thermowell installation.

4.6.21 Water spray system

If specified on the requisition, a water spray system shall be supplied.

The system shall be designed to keep the fixed roof tanks cool in the event of a fire in an adjacent tank.

4.6.22 Fire fighting system (3.10.2 Add.)

Normally for fixed roof tanks, the system to be used shall be of the sub surface or semi sub surface type. Floating roof tanks depending on the area of the roof shall be provided with a foam dam and one or more foam risers.

The atmospheric storage tanks, whether fixed or floating roof type shall be provided with appropriate fire fighting system. Foam connections shall be supplied as specified.

For more information and detail engineering on fire fighting procedures, reference is made to IPS-E-SF-140 "Foam Generating and Proportioning Systems".

4.6.23 Liquid level Indicators (3.8 Add.)

Ground reading automatic gages shall be provided for storage tanks. Cone roof tanks shall have gages complete with enclosed tape and hydraulic seal, float and guide wires. All tapes shall be graduated in standard metric system. Float wells shall be provided for automatic tank gages or floating roof tanks.

4.6.24 Cleanout doors (3.77 Add.)

Cleanout doors shall be fitted to asphalt and crude oil storage tanks. Design of cleanout doors shall be in accordance with API 650.

4.6.25 Asphalt storage tanks shall be provided with air distribution rings at the bottom of the tank for mixing purposes.

4.6.26 Earthing connections (Section 3 Add.)

Storage tanks shall be provided with earthing connections. A typical detail of earthing is shown in Figure 3 bellow.

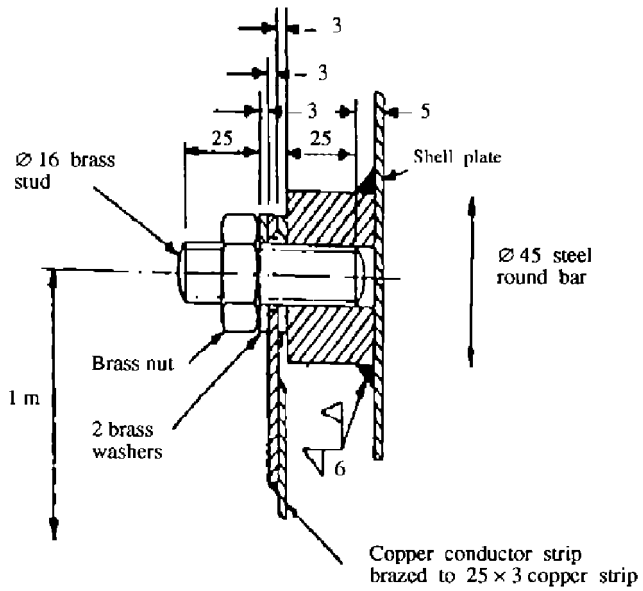
For floating roof earthing refer to para. 4.5.2.6 a and 4.5.2.11 of this standard.

Tanks upto 30 m diameter shall have two earthing connections. Tanks over 30 m diameter shall have three earthing connections. Each earth connection shall have sufficient cross section to earth the whole tank and shall not be less than 35 mm^2.

4.6.27 (3.9.4 Add.)

On floating roof storage tanks, top wind girder may be designed to be used as walkway provided handrail is furnished all around.

4.6.28 For typical mountings for floating roof, reference is made to para. 4.5.2.8 and Fig. 2 of this Engineering Standard.



Note:

All dimensions are in millimeters, unless otherwise stated. For fillet weld dimensions refer to leg length.

TYPICAL DETAIL OF EARTHING BOSS
Fig. 3

4.7 Tank Anchorage (3.11 Add.)

4.7.1 Tank anchorage shall be provided for fixed roof tank if,with one of the following conditions, there may be a tendency for the shell and the bottom plate, close to the shell, to lift off its foundations:

a) Uplift on an empty tank due to internal design pressure counteracted by the effective weight of roof and shell.

b) Uplift due to internal design pressure in combination with wind loading counteracted by the effective weight of roof and shell, plus the effective weight of product considered by the user to be always present in the tank.

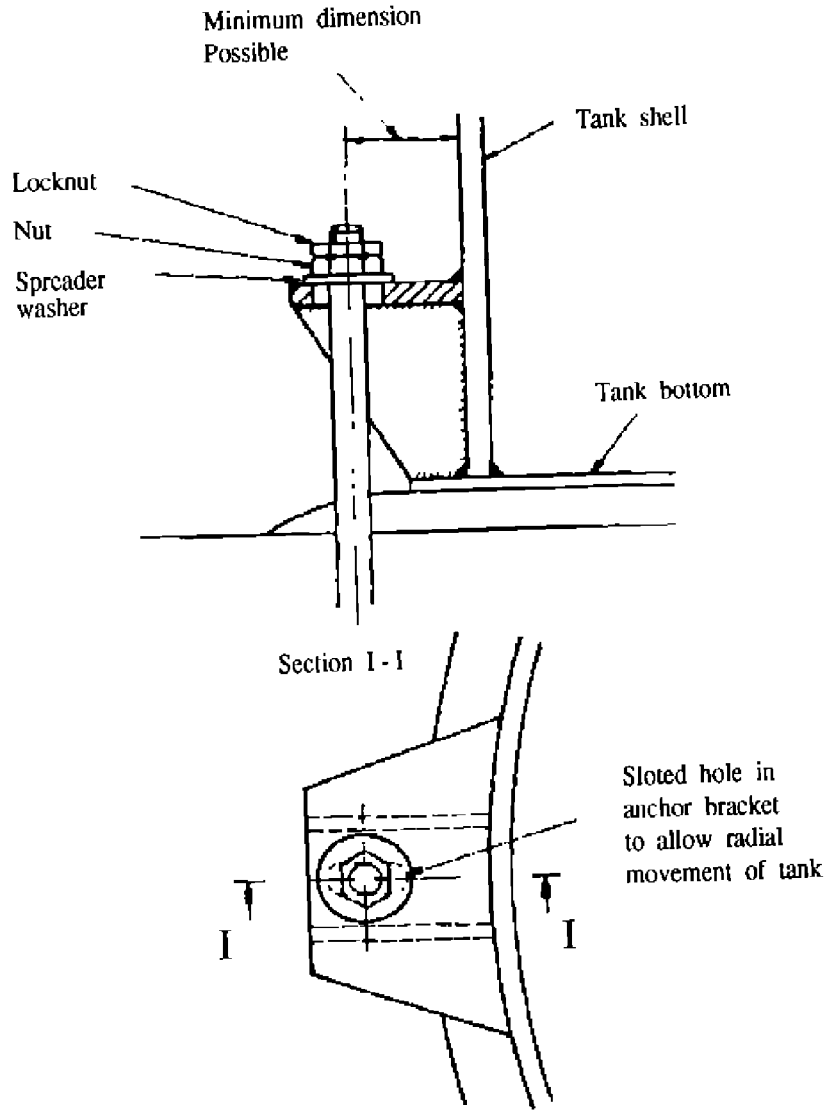
Tank weights shall be considered after deducting any corrosion allowance.

4.7.2 Unstable tanks shall be provided with anchor bolts and concrete foundation rings in order to prevent uplift.

4.7.3 It is recommended that no initial tension be applied to the anchorage, so that it becomes effective only should an uplift force develop in the shell of the tank. Steps shall be taken before the tank goes into service to ensure that anchorage bolts cannot work loose or become ineffective over a long period.

4.7.4 The anchorage shall not be attached to the bottom plate only but principally to the shell. The design shall accommodate movements of the tank due to thermal changes and hydrostatic pressure and reduce any induced stresses in the shell to a minimum. A typical tank anchorage detail is shown in Figure 4.

4.7.5 The anchor bolts should preferably be designed in such a manner that they can be fixed to the tank shell and the concrete foundation after the erection of the tank, in order to prevent damage to the anchor bolts during erection.



TYPICAL TANK ANCHORAGE DETAIL
Fig. 4

5. MATERIAL SELECTION

5.1 Material for atmospheric storage tanks shall comply with the requirements of Section 2 of API Standard 650. Additional requirements are as follows:

5.2 (2.2.6.1 Mod.)

Where materials, other than those specified in API 650 are to be used, the following requirements shall be met:

5.2.1 (2.2.6.4 Mod.)

The ladle chemical analysis of steel shall show:

C	**Max.**	**0.25%**
Mn	**Max.**	**1.20%**
Si	**Max.**	**0.40%**
P	**Max.**	**0.04%**
S	**Max.**	**0.05%**

5.2.2 (2.2.6.5 Mod.)

For the sake of good weldability, the carbon equivalent as determined by the following formula on the base of check analysis shall not exceed 0.43% (m/m):

Carbon equivalent = Ceq = C+Mn/6

5.2.3 (2.2.6.6 Add.)

Bessemer and rimming steels shall not be permitted to be used.

5.2.4 (2.2.6.7 Add.)

Mill certificates shall show all required properties of the material.

5.3 (3.3.2 Mod.)

Unless otherwise specified, no allowance shall be made for corrosion in determining the minimum plate thicknesses.

5.4 (2.2.2 Add.)

Where reference is made to ASTM steel specifications, other equivalent steels may be used with the prior approval of the owner.

5.5 (2.2.93 Mod.)

Isothermal lines specified in para. 2.2.9.3 and figure 2-2 of API 650 shall not be used. The lowest one day mean ambient temperature for each tank will be given in the tank specification sheet or purchase order.

5.6 (2.2.8 Mod.)

Impact test requirement for shell and bottom annular plates shall be as follows:

5.6.1 For plates with thickness not exceeding 13 mm with specified minimum tensile strength up to and including 490 N/mm^2, impact tests are not required.

5.6.2 For materials with minimum tensile strength lower than or equal to 430 N/mm^2 and thicker than 13 mm, impact test shall not show less than 27J charpy V at 20°C or at test temperature specified whichever is lower.

5.6.3 For materials with minimum tensile strength greater than 430 N/mm^2 and less than or equal to 490 N/mm^2 and thicker than 13 mm, impact test shall not show less than 41J charpy V at -5°C or at test temperature specified whichever is the lower.

5.6.4 For materials with minimum tensile strength greater than 490 N/mm^2 and all thicknesses, impact test shall not show less than 41J charpy V at -15°C or at the specified test temperature whichever is the lower.

5.6.5 It is not necessary to impact test materials with thickness less than 20 mm and specified minimum yield strength not exceeding 300 N/mm^2 provided that the design metal temperature is +10°C or above.

5.6.6 Impact testing shall be conducted per ASTM E23 using charpy Vee (type A) Specimen at design metal temperature.

The specimens shall be taken per ASTM A 370 for plates and per ASTM A 333 for pipes. Three specimens shall be tested and the value taken being the minimum average of the three results.

5.7 For more requirements on materials to be incorporated into atmospheric storage tanks, reference is made to Iranian Petroleum Standard No. IPS-M-ME-100.

5.8 Location, Layout and Spacing of Tanks

5.8.1 Location of tanks

Tanks shall be located to permit maximum dissipation of vapors by free circulation of air. Ground contours and other obstacles shall be taken into account for their effects on air circulation.

Tanks shall be arranged in rows not more than two deep. Every tank shall be adjacent to a road or accessway.

5.8.2 Proximity to boundaries and other facilities

The minimum spacing from tanks to boundaries or between tanks and other facilities shall be as shown in the following table:

BOUNDARY LINES OR OTHER FACILITIES	MINIMUM SPACING OF DOME ROOF TANKS	MINIMUM SPACING OF SPHERES OR SPHEROIDS
PROPERTY LINES ADJACENT TO LAND WHICH IS DEVELOPED OR COULD BE BUILT UPON, PUBLIC HIGHWAYS AND MAIN LINE RAILROADS	60 m (1)	60 m (1)
UTILITY PLANTS, BUILDINGS OF HIGH OCCUPANCY (OFFICES, SHOPS, LABS, WAREHOUSES, ETC.)	1.½ TANK DIAMETER BUT NOT LESS THAN 45 m. NEED NOT EXCEED 60 m(1)	60 m(1)
PROCESS EQUIPMENT (OR NEAREST PROCESS UNIT LIMITS IF FIRM LAYOUT NOT AVAILABLE)	1 TANK DIAMETER BUT NOT LESS THAN 45 m. NEED NOT EXCEED 60 m (1)	60 m(1)
NON REFRIGERATED PRESSURE STORAGE FACILITIES	1 TANK DIAMETER BUT NOT LESS THAN 30 m. NEED NOT EXCEED 60 m	¾ TANK DIAMETER BUT NOT LESS THAN 30 m, NEED NOT EXCEED 60 m
ATMOSPHERIC STORAGE TANKS (STOCK CLOSED CUP FLASH POINT UNDER 55°C)	1 TANK DIAMETER BUT NOT LESS THAN 30 m, NEED NOT EXCEED 60 m	1 TANK DIAMETER BUT NOT LESS THAN 30 m, NEED NOT EXCEED 60 m
ATMOSPHERIC STORAGE TANKS (STOCK CLOSED CUP FLASH POINT 55°C OR HIGHER	½ TANK DIAMETER, BUT NOT LESS THAN 30 m NEED NOT EXCEED 45 m	½ TANK DIAMETER BUT NOT LESS THAN 30 m. NEED NOT EXCEED 45 m.

Note :

1) Distance from boundary line or facility to centerline of peripheral dike wall surrounding the storage tank shall not be less than 30 m at any point.

Spacing between refrigerated storage tanks shall be as follows:

I) Dome roof tanks : one tank diameter;
II) Spheres or spheroids : ¾ tank diameter;
III) Dome roof tanks and spheres or spheroids : one tank diameter.

6. FABRICATION

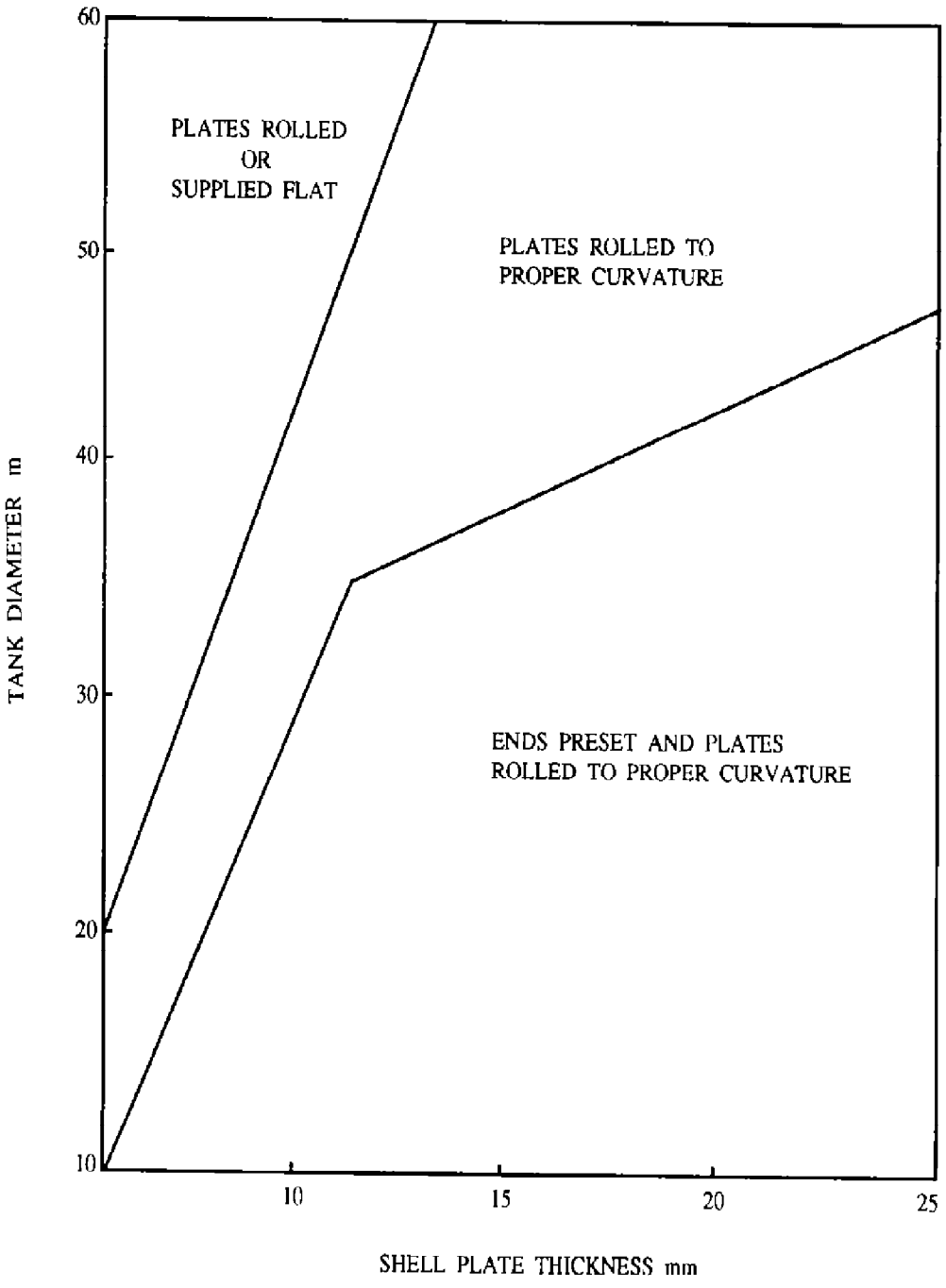
6.1 (4.1.1.2 Add.)

The requirements of Section 7 of Iranian Petroleum Standard No. IPS-M-ME-100 "Material and Equipment Standard for Atmospheric above Ground Welded Steel Storage Tanks" shall also be fulfilled.

6.2 (4.1.3 Mod.)

Shell plates shall be supplied flat, rolled to the proper curvature, or rolled to the proper curvature with their end preset as required by the relationship between tank diameter and shell plate thickness shown in Fig. 5.

In the case of plates not covered in Fig. 5 the rolling and end pressing requirements shall be agreed with the purchaser.



ROLLING AND END PRESSING OF SHELL PLATES
Fig. 5

7. WELDING

7.1 Joint Design

7.1.1 Vertical joints (3.1.5.2a Add.)

a) open gap square butt joints for plate thicknesses of 6 mm may be used;

b) single vee butt joint may be used for plate thicknesses of 6 mm or more, but shall not be used for plate thicknesses exceeding 13 mm;

c) double vee butt joints may be used for plate thicknesses over 8 mm and shall be used for plate thicknesses over 13 mm.

7.1.2 Horizontal joints (3.1.5.3a Add.)

a) open gap square butt joints may be used where the thickness of the thinner plate does not exceed 8 mm;

b) single bevel butt joints may be used for plate thicknesses upto 8 mm and shall be used where the thickness of the thinner plate exceeds 8 mm but does not exceed 13 mm;

c) double bevel butt joints may be used for plate thicknesses over 6 mm and shall be used for plate thicknesses exceeding 13 mm.

7.1.3 Bottom plate joints

7.1.3.1 (3.1.5.4 Add.)

Minimum lap shall be five times the thickness of the plate. If a full fillet weld cannot constantly be achieved, the fillet weld shall be made in two layers.

7.1.4 Bottom to shell plate joint (3.1.5.7 Mod.)

a) the shell plates shall be continuously welded on both sides to the bottom sketch plates or annulars. See Section 5-5 of Figure 1.

b) the leg length of both fillet welds shall be equal to the thickness of the bottom plates or annulars;

c) when the shell plate thickness is less than the bottom plate or annular thickness, the leg length of the fillet weld shall not exceed the thickness of the shell plate by more than 1.5 mm.

7.2 Shell Butt Joints (3.1.5.1 Add.)

In Single vee or single bevel shell butt joints the Vee or bevel shall be made on the outside of the tank, unless otherwise specified.

7.3 (3.1.5.2b Mod.)

The vertical joints in the adjacent shell courses shall be staggered 1/3 of the length of the plate where practicable, and not less than five times the thickness of the thicker plate.

7.4 (3.1.5.1 Add.)

The internal surface of tanks shall be aligned.

7.5 (5.3.1 Add.)

Hardness of weld metal and the related heat affected zone (HAZ) of all welds shall not exceed 225 brinell.

8. SITE ERECTION

8.1 (5.1 Mod.)

The requirements of Iranian Petroleum Standard IPS-C-ME-100 "Construction and Quality Control Standard for Atmospheric Above Ground Welded Steel Storage Tanks" shall also be fulfilled.

9. INSPECTION AND TEST

9.1 (C-4.5 Mod.)

Roof drains together with any flexible coupling incorporated with them shall be subjected to a hydrostatic test pressure of 350 kPa (3.5 bar) gage. The tank shall be empty during this test. To ensure freedom from internal obstructions, the drain piping should be flushed through before testing.

9.2 (5.3.6 Add.)

Heating coils or other heating devices containing fluid under pressure, if fitted, shall be tested hydrostatically, whilst the tank is empty,to a pressure of 1.5 times working pressure, but not less than 700 kPa (7 bar) gage.

9.3 Tank Bottom Welds Tests

9.3.1 (5.3.4 Mod.)

After welding of the bottom plates of a storage tank has been completed and before any surface coating is applied, all lap welds shall be tested to ensure that the tank bottom is free from leaks. The bottom plates weld shall in any case be tested before water is let into the tank for hydrostatic testing.

Tank bottom welds should be tested using vacuum box test as specified in Sub-section 5.3.3 of API Standard 650.

9.3.2 (5.3.4b Mod.)

Alternatively, if a vacuum testing box is not available, the bottom seams may be tested by pumping air beneath the bottom plates to a pressure just sufficient to lift them off the foundation, but to a maximum of 0.7 kPa (7 mbar.)

The pressure shall be held by sealing off the periphery with a temporary dam of clay or other suitable material around the tank bottom. This method shall not be used for floating roof tanks and be limited to smaller tanks only, if used at all.

9.3.3 (5.3.4 C Add)

After jacking up of a tank for relevelling, the tank bottom shall again be tested for leaks.

9.3.4 (6.1.2.10 Mod.)

Annular plate butt joints shall be radiographed as specified in Table 1. If for any reason, radiography is not possible, the joints may be magnetic particle tested from the topside after completion of the root pass and again after completion of the full weld.

9.4 Bottom to Shell Joint (5.3.2.2 Mod.)

9.4.1 The inner fillet weld shall be inspected prior to welding the outside fillet weld. Leak testing shall be performed with penetrating oil or any other approved method, after removal of slag. Oil shall be removed before welding the outer fillet.

9.4.2 Inner fillet weld shall be examined for the crack using either the liquid penetrant or magnetic particle method.

9.5 Shell Joints

9.5.1 (6.1.2.2a Mod.)

Storage tank shell vertical, horizontal and T-Joints shall be inspected by radiography method. The extent and location of radiography shall be as specified in Table 2 of this Standard.

Acceptance levels for radiographic examination shall be in accordance with Table 3 of this Standard.

9.6 Roof Welds

9.6.1 Floating roof testing (C.4.1 Mod.)

a) The center deck plate, pontoon bottom plate and rim plate welded joints shall be tested by spraying with a penetrating oil, such as light gas oil, on the bottom side and inspecting visually on the top side and inside of rim plates.

Either of the methods of test specified in (b) or (c) below, shall be applicable.

b) The fillet welds connecting the bulk heads between pontoons to the inner and outer rim plates and to the pontoon bottom shall be examined for leaks using penetrating oil prior to the installation of the pontoon top plates. When continuously welded, the welds connecting the pontoon top plates shall be inspected visually for pinholes or defective welding.

c) Alternatively, when the compartments are completely welded, each completed compartment of pontoon roof shall be individually tested with an air pressure of 300 Pa (3 mbar) gage, a soapy water solution being applied to all welded joints under pressure which have not been previously tested with penetrating oil.

9.6.2 Fixed roof testing (5.3.7.1 a Mod.)

a) When the tank shell is tested with water the roof joints shall be tested by applying an internal air pressure equal to 750 Pa (7.5 mbar) for non pressure tanks and 300 Pa(3 mbar) above the design pressure of the tank for pressure tanks.

b) In the case of column supported roof tanks, the air test pressure shall be limited to that pressure equivalent to the weight of the roof plates unless specified otherwise.

c) Soap solution or other suitable material shall be used for the detection of leaks.

TABLE 2 - EXTENT OF RADIOGRAPHY PER TANK

THINNER PLATE THICKNESS	VERTICAL WELDS AND T-JOINTS	HORIZONTAL SEAMS	ANNULAR BOTTOM BUTT WELDS*
OVER 25 mm	10% OF TOTAL SEAM LENGTH PLUS ALL T-JUNCTIONS**	2% OF SEAM LENGTH	—
OVER 13 mm UP TO AND INCLUDING 25 mm	10% OF TOTAL LENGTH, AT LEAST HALF OF THE RADIOGRAPHS TO INCLUDE T-JUNCTIONS	2% OF SEAM LENGTH	—
UP TO AND INCLUDING 13 mm	1% OF TOTAL VERTICAL SEAM LENGTH	1% OF SEAM LENGTH	—
ANNULAR PLATES OVER 10 mm	—	—	ALL JOINTS
ANNULAR PLATES OVER 8 mm UP TO AND INCLUDING 10 mm	—	—	HALF THE NUMBER OF JOINTS
ANNULAR PLATES UP TO AND INCLUDING 8 mm	—	—	A QUARTER OF THE No. OF JOINT, WITH A min. OF 4 RADIOGRAPHS

*** The length to be radiographed shall consist of that length from the outside of the annular plate to a point 250 mm inside the tank**

**** 50% of radiographs with film horizontal and 50% of radiographs with film vertical.**

TABLE 3 - ACCEPTANCE LEVELS FOR RADIOGRAPHIC EXAMINATION

DEFECT TYPE	PERMITTED MAXIMUM
CRACK LACK OF FUSION INCOMPLETE PENETRATION	NOT PERMITTED NOT PERMITTED NOT PERMITTED
ISOLATED PORES	∅ <
UNIFORMLY DISTRIBUTED OR LOCALIZED POROSITY	2% BY AREA* (AS SEEN IN A RADIOGRAPH)
LINEAR POROSITY	LINEAR POROSITY IN VERTICAL WELDS PARALLEL TO THE AXIS OF THE WELD MAY INDICATE LACK OF FUSION OR LACK OF PENETRATION AND THEREFORE IS NOT PERMITTED
WORMHOLES, ISOLATED	LENGTH < 6 mm
WORMHOLES, ALIGNED	AS LINEAR POROSITY
INDIVIDUAL SLAG INCLUSIONS PARALLEL TO MAJOR WELD AXIS **Note:** **Inclusions to be separated on the major axis by a distance equal to or greater than the length of the longer inclusion and the sum of the lengths of the inclusions shall not exceed the total weld length being examined.**	LENGTH < T

*** Area to be considered should be the length of the weld affected by porosity multiplied by the maximum width of the weld locally.**

Note:

In this table the following symbols are used:

∅ is a defect diameter (in mm)

t is the thickness of thinner plate being joined (in mm)

10. STORAGE TANK FOUNDATION

10.1 (B 3.5 Add.)

When the profile of the surface is complete it should be covered with a smooth bitumen sand mix that is 50 mm thick to weatherproof the foundation and provide a layer sufficiently firm to carry the necessary traffic and facilitate welding of the bottom plates. This layer will also retard corrosion of the tank bottom. This bitumen sand surfacing should extend outside the tank periphery to protect the external surface of the foundation and may need retrimming after the water test and from time to time during operation to maintain suitable water drainage away from the tank. Bitumen sand surfacing should be omitted where cathodic protection of the tank bottom is adopted.

10.2 (B 3.6 Add.)

A suitable bitumen sand can be produced by hot mixing in the following proportions by mass:

a) 9 ±0.5% (m/m)non toxic cut back bitumen (i.e. fluxed with kerosene and not creosote*).

b) 10 ±1.0% (m/m) filler: either limestone dust passing a sieve of nominal aperture size 75 μm complying with portland cement.

c) 81 ±1.5% (m/m) clean dry washed sand.

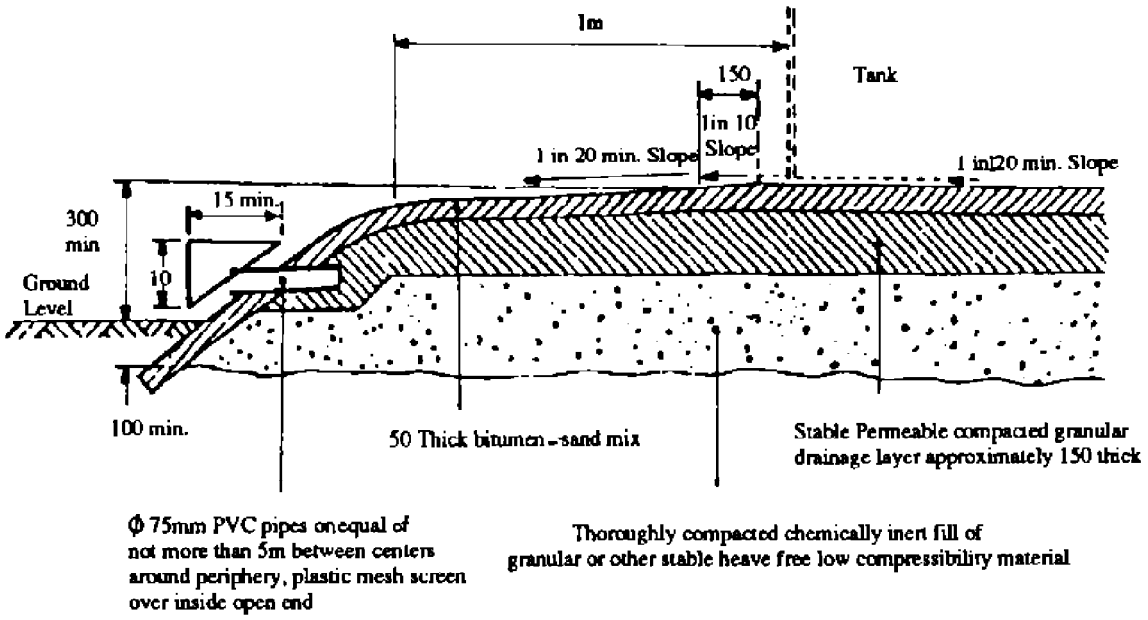
10.3 (B 4.1.1 C Mod.)

A series of 75 mm diameter PVC pipes should be placed around the perimeter of the drainage layer and protrude through the bitsand facing to the berm to give warning of any bottom plate leakage. The pipes should be at not more than 5 m intervals and the inlet should be covered with a mesh screen to prevent clogging by material from the drainage layer. In special cases it may be necessary to introduce an impermeable layer below the base of the foundation pad see Fig. 6.

10.4 (B 4.2.3 Mod.)

When concrete foundation rings are used, the top of the ring shall be covered with a bitumen layer of at least 5 mm.

*** Creosote fluxed bitumen is not considered to be acceptable in view of its acid content.**



Note:

All dimensions are in millimeters, unless otherwise stated.

TYPICAL TANK FOUNDATION
Fig. 6

11. INSULATION (3.12 Add.)

11.1 Design and application of insulation to atmospheric storage tanks shall be in accordance with relevant Iranian Petroleum Standard and Appendix B of BSI Standard No. BS 2654 "Manufacture of Vertical Steel Welded Non Refrigerated Storage Tanks with Butt Welded Shells for the Petroleum Industry".

APPENDICES

APPENDIX A
PIPE COMPONENTS - NOMINAL SIZE

The purpose of this Appendix is to present an equivalent identity for the piping components nominal size in Imperial System and SI System.

TABLE A1

Nominal Size		Nominal Size		Nominal Size		Nominal Size	
DN (1)	NPS (2)	DN (1)	NPS (2)	DN (1)	NPS (2)	DN (1)	NPS (2)
15	½	100	4	500	20	1000	40
20	¾	125	5	600	24	1050	42
25	1	150	6	650	26	1100	44
32	1¼	200	8	700	28	1150	46
40	1½	250	10	750	30	1200	48
50	2	300	12	800	32	1300	52
65	2½	350	14	850	34	1400	56
80	3	400	16	900	36	1500	60
90	3½	450	18	950	38	1800	72

1) Diameter Nominal, mm.

2) Nominal Pipe Size, Inch.

APPENDIX B
PIPE FLANGES, PRESSURE - TEMPERATURE RATINGS

The purpose of this Appendix is to present an equivalent identity for the pipe flange nominal pressure temperature ratings in Imperial System and SI System.

TABLE B1

PN (1)	ANSI EQUIVALENT (2)
20	150
50	300
68	400
100	600
150	900
250	1500
420	2500

1) Pressure Nominal (PN), bar gage.

2) Pounds per square inch gage, (Psig).