GENERAL STANDARD

FOR

LARGE WELDED LOW PRESSURE

STORAGE TANKS

FIRST EDITION

OCTOBER 2005

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0. INTRODUCTIONS

This standard specification gives the amendments and supplements to API Standard 620, Tenth Edition Feb. 2002 and Addendum 1, June 2004 “Design and Construction of Large, Welded, Low-Pressure Storage Tanks”.

It is intended that API standard together with this Standard shall be used for “large welded low pressure storage tank” for use in oil refineries, chemical plants, gas plants and where applicable, in exploration and production and new ventures.

For ease of reference, the clause or section numbering of API standard 620 has been used throughout this Standard.

All clauses in API standard 620 that are not mentioned here in this Standard remain unaltered and shall be considered as part of this Standard.

Note: This Standard is a revised version and combination of three previous standards IPS-C-ME-110(0), IPS-E-ME-110(0), and IPS-M-ME-110(0). The original (0) edition of three standards is now withdrawn.

Guidance for use of this Standard:

The following annotations as specified here under, have been used at the bottom right hand side of each clause or paragraph to indicate the type of change made to the equivalent clause or paragraph of reference standards.

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

Del. (Deletion): The API standard clause is deleted without any replacement.

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

Mod. (Modification): Part of the API standard clause is modified and/or a new description and/or condition are added to that clause. **(Add)**

SECTION 1-SCOPE

1.1 GENERAL

1.1.1 This Standard covers the minimum requirements for design, material, construction, inspection and testing of vertical above ground single wall and double wall storage tanks with cone and dome roofs. Moreover it includes also general requirements about quotation, secrecy, packaging, shipment and guarantee of such equipments. **(Add)**

1.1.2 International system of unit (SI) in accordance with IPS-E-GN-100 and APPENDICES X & Y shall be used wherever reference is made to API/ASME or shall be substituted by any other standard equivalent SI unit system for dimensions, fasteners and flanges. For pipe size the international nomenclature "diameter nominal" written as DN 1, 25, 40, 50 etc., has been used in accordance with ISO 6708-1980, ANSI/ASME B 16.5-1981 and ANSI/ASME B31.3-1983. Also for pipe flanges pressure temperature ratings "pressure nominal" written as PN 20, 50, 68, etc., has been used in accordance with said standards. **(Add)**

1.4 CONFLICTING REQUIREMENTS

In case of conflict between documents relating to the inquiry or purchase order the following

priority of Documents, shall apply.

-First priority: purchase order (including attachments) and variations thereto

-Second priority: data-requisition sheets and drawings

-Third priority: this specification

All conflicting requirements shall be referred to the purchaser in writing. The purchaser will issue conforming documentation if needed for clarification. **(Add)**

SECTION 2- 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.

BSI (BRITISH STANDARD INSTITUTION)

BS 4741 "Vertical Cylindrical Welded Tanks for Low Temperature Service Single Wall Tanks for Temperature Down To -50 C "and "Amendment ADM 306331" Jan. 1980

BS 5387 "Vertical Cylindrical Welded Storage Tanks for Low temperature Service Double Wall Tanks for Temperature Down To -196 C"

ASME (AMERICAN SOCIETY OF MECHANICAL ENGINEERS)

ASME B1.1 "Unified Inch Screw Threads"

ASSE (AMERICAN SOCIETY OF SAFETY ENGINEERS)

ASSE A14.3 "Safety Requirements for Fixed Ladders"

IPS (IRANIAN PETROLEUM STANDARD)

IPS-E-GN-100 "Engineering Standard for Units"

IPS-E-CE-500 "Engineering Standard for Loads"

IPS-E-SF- 140 "Engineering Standard for Foam Generating And Proportioning System"

IPS-E-TP-100 "General Requirements for Paints"

IPS-E-CE-120 "General Requirements for Foundations" **(Mod)**

SECTION 3 – DEFINITIONS

3.4.16 Purchaser

The party or parties entering into contract or agreement to purchase tank(s) and/or component(s) in accordance with the requirements of this Standard and specially refer to as company.

Note: any specific application of the terms and responsibilities for the parties defined above, are a matter for the conditions of contract on project. **(Add)**

3.4.17 Company/Owner

Refers to one of the related and / or affiliated companies of the Iranian Ministry of Petroleum such as:

a) National Iranian Oil Company (NIOC)

b) National Iranian Gas Company (NIGC)

c) National petrochemical company (NPC) **(Add)**

3.4.18 Supplier/Vendor

Refers to person(s) or party (ies) entering into a contract or agreement to supply and/or fabricate the material(s) in accordance with the requirements of this standard. **(Add)**

3.4.19 Manufacturer

The party that manufactures or produces tank and / or component covered by this Standard. **(Add)**

3.4.20 Inspector

The representative of the purchaser / company who is entrusted with inspection of products and production records and observance of production operations and quality control tests. **(Add)**

3.4.21 Construction Equipment

Means all tools, lifting and other equipment, transport, other construction plant, marine craft, temporary buildings, and other appliances or things of whatever nature require by contractor for the performance of the works but does not include materials or other things intended to form or forming part of the permanent works.

(Add)

3.4.22 Contractor

Means the company, firm or consortium that has signed, and entered into the

Contract, and is responsible to perform his duties according to the Contract Documents. **(Add)**

3.4.23 Technical Specification

Means the requisition(s) and drawing together with all other specifications, procedures and technical requirements of the contract. **(Add)**

3.4.24 Materials

Means any materials, equipment, supplies and other items incorporated in or intended to be incorporated in the permanent works which are supplied by the contractor. **(Add)**

SECTION 4 – MATERIALS

4.1 GENERAL

4.1.1.1 Mill certificates for the material of all major parts of the storage tanks are required. The mill certificates shall show all the required properties of material including chemical analysis and mechanical test certificates. **(Add)**

4.1.1.2 Vendor shall provide all materials as specified on the tank and accessories data sheets required for the complete fabrication of storage tanks. Purchaser may supply instrumentation, fire fighting attachments, etc. Vendor shall make provisions for proper attachments of storage tanks. **(Add)**

4.1.1.3 Quotation

Refer to Appendix S for general information to be submitted in the quotation. **(Add)**

4.1.1.4 Secrecy

See Appendix T for secrecy requirements. **(Add)**

4.1.1.5 Packaging

General requirements for packaging are covered in Appendix U of this Standard. **(Add)**

4.1.1.6 Shipment

Refer to Appendix V of this Standard for general requirements for shipment. **(Add)**

4.1.1.7 Guarantee

See Appendix W of this Standard for general requirements for guarantee. **(Add)**

4.1.5 Toughness Requirements **(Add)**

4.1.5.1 Special considerations shall be given to charpy V-notch impact requirement in selection of material for storage tanks to be erected at sites with low ambient temperatures (sub zero temperatures) and also for tanks designed and constructed to appendices Q and R. For storage tanks described in 4.3.5.1, permanent attachments like reinforcement pads, nozzle bodies, flanges, etc. shall meet the notch ductility requirements of tank shell plates. **(Add)**

4.2 PLATES

4.2.1 General

4.2.1.4 the carbon equivalent shall not exceed 0.43% for plates and sectional less than 25 mm thick and 0.42% for plates and sections 25 mm thick and over, where calculated from the ladle analysis using the formula:

$$C_{eq} = C + \frac{Mn}{6} + \frac{Cr + Mo + V}{5} + \frac{Ni + Cu}{15}$$

(Add)

4.2.1.5 A check analysis may be required in which case

$C + \frac{Mn}{6}$ Shall not exceed **0.43%**

(Add)

4.2.2 low-stress design

d. Roof plates and roof support structural members which are exposed to temperatures between -50°C and +5°C can be considered as secondary members provided the combined tensile and bending stresses in this components under design conditions are equal to or less than 41.4 mPa. **(Add)**

4.3 PIPE, FLANGE, FORGING, AND CASTING

Where connections are made to external piping, the material and all other requirements for nozzles, flanges, bolting, gasketing and all pipe shall be met as specified in that piping class. **(Mod)**

4.3.4 Castings and Forgings

4.3.4.1 Casting shall not be used as primary components in liquefied hydrocarbon and refrigerated storage tanks which conform to appendices Q and R of API standard 620. **(Add)**

4.4 BOLTING MATERIAL

4.4.1 Bolt and nut threads shall conform to ASME B1.1 coarse series class 2A and 2B respectively. **(Add)**

4.5 STRUCTURAL SHAPES

Materials for permanent structural attachments, welded to the shell, shall have the same chemical and mechanical properties as the tank shell materials. **(Mod)**

SECTION 5-DESIGN

5.4 LOADINGS

d. The roof and supporting structure shall be designed to support a minimum superimposed load of 1.2 kn/mm^2 of projected area. This superimposed load is the sum of either internal vacuum 0.6 kPa (6 mbar) and snow load, or internal vacuum 0.6 kPa (6 mbar) and live load. **(Mod)**

e. For seismic loading and wind velocity reference is made to Iranian Petroleum Standard for loads IPS-E-CE-500. **(Mod)**

5.7 CORROSION ALLOWANCE

Minimum corrosion allowances shall be as follows:

Primary and secondary components, except anchor bolts and hold-down straps, as given in Table 5-11 below:

Table 5-11 MINIMUM CORROSION ALLOWANCE

MATERIAL OF CONSTRUCTION	MIN. CORROSION ALLOWANCE
Carbon And Low Alloy Steel	1.6 mm
Intermediate Alloy Steels(1)	0.8 mm
High Alloy Steel(2)	0.8 mm
Alloy Non-Ferrous Material	0.8 mm

Notes:

1) **Includes all steels with an alloy content of 3-1/2 to 9% Ni.**
2) **Includes all steels with an alloy content of 12% Cr or greater.**

(Add)

5.10 DESIGN OF SIDEWALLS, ROOFS, AND BOTTOMS

5.10.3 Required Thickness

5.10.3.7 Roof Plate Thickness **(Add)**

5.10.3.7.1 Single Wall Storage Tank **(Add)**

5.10.3.7.1.1 All roofs shall be of the self supporting type where the entire load is supported by the tank periphery. **(Add)**

5.10.3.7.1.2 Where a dome roof is adopted the radius of curvature shall be in the range of **0.8** to **1.5** times the diameter of the tank. **(Add)**

5.10.3.7.1.3 Roof Plating With Supporting Structure:

a) Roof plating shall not be attached to the roof supporting structure.

b) The minimum thickness of all roof plating shall be 5 mm exclusive of corrosion allowance.

c) Seams in roof plating which is included as part of the compression area shall be butt-welded. The remaining seams in the roof plating may also be butt-welding or welded lap joints may be used.

d) The plate thickness shall be checked for internal pressure using the following equation. The joint efficiency shall be taken as 1.0 for butt-welded, 0.35 for single-sided lap welds and 0.65 for double-sided lap welds. The allowable stress shall be taken as two-thirds of the yield strength.

$$t_r = \frac{PR_r}{20SE}$$ **For pressure**

Where:

t_r = Roof plate thickness (mm).

P = Internal pressure (mbar).

R_r = Radius of curvature of roofs (m).

S = Allowable design stress (N/mm^2).

E = Joint efficiency factor. **(Add)**

5.10.3.7.1.4 Roof Plating Without Supporting Structure (Memberance Roofs)

a) All memberance roofs shall be of butt-welded or double lap welded construction. These roofs shall be checked for internal pressure according to formula given in 5.10.3.7.1 and also shall be checked to resist buckling according to the following formula:

$$t_r = 40R_r\left(\frac{10P_e}{E}\right)^{\frac{1}{2}}$$

Where:

t_r = Roof plate thickness (mm).

R_r = Radius of curvature of roof (m).

P_e = External loading (KN/m^2).

E = Young's modulus (N/m^2). **(Add)**

5.10.3.7.2 Double Wall Storage Tank

For low pressure vertical cylindrical double wall storage tanks roof design shall be in accordance with the following: **(Add)**

5.10.3.7.2.1 Outer Tank Roof

It is recommended that the roof shall be of the self supporting dome or cone roof type; in the latter case the roof slope shall be 1 in 5 unless otherwise specified.

a) In case of roof plating without supporting structure (membrane roofs), these roofs shall be checked for internal pressure and buckling accordance to 5.10.3.7.1.1 and 5.10.3.7.1.2 of this standard.

b) In case of roof plating without supporting structure (membrane roofs), these roofs shall be checked for internal pressure and buckling according to 5.3.1.4 and 5.3.1.5 (b) of this Standard. **(Add)**

5.10.3.7.2.2 Inner Tank Roof

a) The roof shall be one of the following types:

- Roof plating with supporting structure.

- Roof plating without supporting structure (membrane).

- Column supported roof.

- Suspended roof, supported from outer tank roof.

b) Column supported roofs shall be of the from generally described for roof plating with supporting structure but with additional support provided by vertical column(s).

c) A suspended roof generally is in the form of a nominally flat surface suspended by hangers attached to the outer tank roof.

Since a suspended roof does not seal gas, the outer tank contains the gas pressure whilst the inner tank contains the hydrostatic pressure of the contained product. **(Add)**

5.11.2.3 Anchorage

5.11.2.3.1 Single-Wall Storage Tank

For vertical cylindrical single-wall storage tanks, design of anchorage shall be in accordance with the followings: **(Add)**

5.11.2.3.1.1 Tank anchorage shall be provided if under the worst conditions of operation there may be a tendency for the shell and the bottom plate close to the shell to lift off its foundation. **(Add)**

5.11.2.3.1.2 The design uplift on the anchorage shall take into account the following conditions:

a) Design roof vapor pressure.

b) Wind uplift pressure.

c) Wind overturning pressure.

d) Seismic force, not in combination with (b) and (c)

e) Weight of uninsulated shell, roof and Associated Structure.

f) Weight of shell and roof insulation.

g) Test roof vapor pressure. **(Add)**

5.11.2.3.1.3 The anchorage shall be attached to the shell in preference to the annular bottom plate. The design shall accommodate movements of the tank due to thermal changes and reduce any induced bending stresses in the shell to a minimum. A typical example is shown in Figure 5-15 but other designs are permissible. **(Add)**

5.11.2.3.1.4 The design temperature for anchorage and anchorage attachments shall be the design metal temperature of the tank unless it can be shown that a higher temperature will in practice be obtained. If so, this higher temperature may be used by agreement between the owner and the designer. Heat transfer from the warmer parts of the structure shall be such that unacceptable characteristics do not develop which may lead to failure of the anchorage, excessive ice formation or water condensation. **(Add)**

5.11.2.3.1.5 Under the design conditions listed in 5.27.7.2 but excluding test conditions, the anchorage design stress shall not exceed 2/3 of the yield strength. **(Add)**

5.11.2.3.1.6 Anchorage spacing. It is recommended that anchorage points should be spaced at a minimum of **1 m** and at a maximum of 3 m and should, as far as possible, be spaced evenly around the circumference of the tank. **(Add)**

5.11.2.3.1.7 Any anchor bar, bolt or strap should have a minimum cross-sectional area of 500 mm^2. **(Add)**

5.11.2.3.1.8 The anchorage shall be capable of resisting an uplift test pressure equal to 1.25 times the design anchorage uplift force during testing. For this condition the stress in the anchorage shall not exceed

0.85 times the minimum yield strength of the anchorage material, taking into account any initial tension in the anchorage members resulting from bolting loads or loads due to transient or long term thermal movements.

It is recommended that no initial tension be applied to the anchorage so that it is only loaded 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. **(Add)**

5.11.2.3.2 Double-Wall Storage Tank

For vertical cylindrical double-wall storage tanks, design of anchorage shall be according to the following:

(Add)

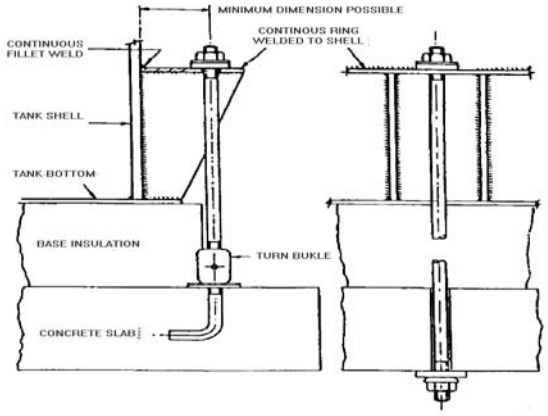
5.11.2.3.2.1 Tank anchorage to resist uplift due to internal gas pressure, wind or seismic forces shall be provided if there is a possibility for the shell and adjacent bottom plate to lift off its seating under any conditions of operation and testing.

The designer of the tank foundations shall be responsible for the adequacy of the anchorage connection to the tank foundations. **(Add)**

5.11.2.3.2.2 When considering the need for anchorage, the internal and external tanks shall be regarded as completely independent structures in which neither contributes anything to the other in the resistance to uplift. A suspended roof shall be considered as an integral part of the outer tank for the purposes of anchorage.

(Add)

5.11.2.3.2.3 Both inner and outer tanks shall be checked for all possible combinations of loadings in order to establish the worst conditions of uplift, and the anchorage and its attachments to the shell and foundations for each tank shall be designed accordingly. **(Add)**



TYPICAL TANK ANCHORAGE DETAILS

Figure 5-15

5.11.2.3.2.4 Where insulation of loose-fill type is used in the annular interspace between two tank shells, this insulation shall not be regarded as providing resistance to uplift.

Any insulation firmly attached to either tank may be regarded as resisting uplift on the particular tank to which it is attached.

Note: It is not normal to apply insulation in any interspace until after satisfactory testing of both tanks is completed. **(Add)**

5.11.2.3.2.5 The inner tank anchorage designer shall take into account at least the following:

a) Service loads

The uplift produced by roof design vapor pressure with seismic loads. The resistance to uplift produced by shell, roof, roof structure, roof insulation and any permanently attached insulation.

b) Test loads

-The uplift produced by roof test vapor pressure.

-The resistance to uplift produced by shell and roof structure. **(Add)**

5.11.2.3.2.6 The outer tank anchorage designer shall take into account at least the following:

a) Service loads

The uplift produced by interspace design pressure with either,

1) Wind uplift and overturning, or;

2) Seismic loads.

But not (1) and (2) simultaneously. The resistance to uplift produced by shell, roof, roof structure, any associated structure attached to shell or roof, any permanently attached insulation.

b) Test loads

The uplift produced by interspace test pressure, plus 60**%** of wind uplift and overturning. The resistance to uplift produced by shell, roof, roof structure and any associated structure attached to the shell or roof. **(Add)**

5.11.2.3.2.7 The anchorage shall be attached to shells and not to bottom plates. All anchorages shall be firmly embedded into the foundations and on no account shall inner tank anchorages be embedded in the base insulation for the purpose of resisting uplift.

The design shall accommodate movements of the tank due to thermal changes and minimize induced bending stresses in the shell. Any additional stress induced in the shell by the anchorage attachment to the shell shall be checked to ensure that the safe stress level of the shell is not exceeded at the condition of anchorage load being considered.

Heat breaks may be required at the anchorage of inner tanks to prevent chilling of the outer tank and foundations. **(Add)**

5.11.2.3.2.8 The design temperature for anchorage and anchorage attachments shall be the design metal temperature of the tank unless an alternative can be justified. If so, the temperature used shall be agreed between the owner and designer. Heat transfer to the colder parts of the structure shall be such that unacceptable characteristics, such as ice formation or water condensation, cannot result in failure of the anchorage of tanks. **(Add)**

5.11.2.3.2.9 In service conditions, the allowable stress for an anchorage shall not exceed 0.5 of yield strength for the material of construction. **(Add)**

5.11.2.3.2.10 As a general practice it is recommended that a corrosion allowance of 1 mm on all surfaces shall be added for all anchorage parts. **(Add)**

5.11.2.3.2.11 The anchorage shall be capable of resisting the uplift produced by the test loads as defined in 5.7.2.5 and 5.7.2.6. For this condition the stress in the anchorage shall not exceed 0.85 times the minimum yield strength of the anchorage material, taking into account any initial tension in the anchorage members resulting from bolting loads or loads due to transient of long term thermal movements.

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. **(Add)**

5.11.2.3.2.12 It is recommended that anchorage points should be spaced at a minimum of 1 m and at a maximum of 3 m and should, as far as possible, be spaced evenly around the circumference of the tank. **(Add)**

5.11.2.3.2.13 Any anchor bar, bolt or strap should have a minimum cross-sectional area of 500 mm^2. **(Add)**

5.12 DESIGN OF ROOF AND BOTTOM KNUCKLE REGIONS AND COMPRESSION-RINGGIRDERS

5.12.4 Compression Rings

5.12.4.3 Compression area defines as below:

a) This is the region at the junction of the shell and the roof which is considered to resist forces imposed by the internal pressure. The maximum widths of plate making up the compression region shall be as shown in Fig 1(a) and (b).

b) The area to be provided shall be not less than that determined by the following equation:

$$A = \frac{50PR^2}{S_c \tan\theta}$$

Where:

A = Area required, mm^2

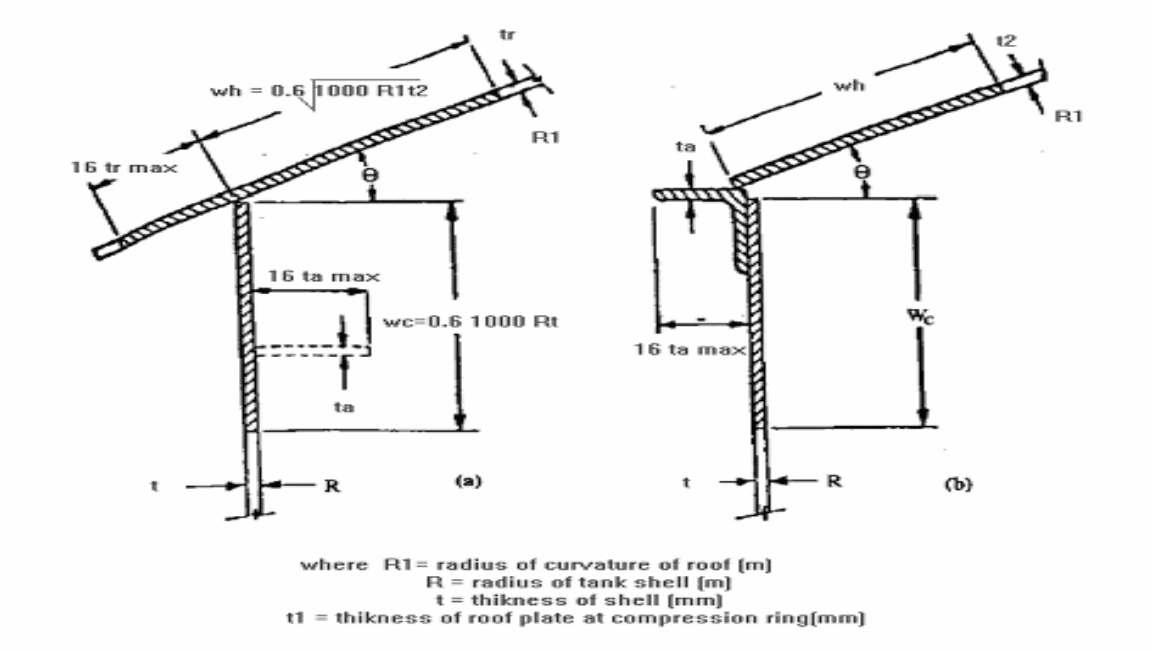
P = Internal pressure, mbar

Θ = Slope of meridian at roof-shell connection, degrees

R = Radius of tank, m

S_c = Allowable compressive stress, N/mm^2 (which unless otherwise specified, shall be taken as 120 N/mm^2)

a) If a horizontal girder is required to provide additional cross-sectional area, this girder shall be placed as close to the junction as possible and the distance of any part of its cross-section from the junction shall not exceed W_C (see Figure 5-16). **(Mod)**



where R1 = radius of curvature of roof (m)
R = radius of tank shell (m)
t = thikness of shell (mm)
t1 = thikness of roof plate at compression ring(mm)

SHELL/ROOF COMPRESSION AREAS

Figure 5-16

5.13 DESIGN OF INTERNAL AND EXTERNAL STRUCTURAL MEMBERS

5.13.6 Ladders and Stairways **(Add)**

5.13.6.1 Storage tanks shall be provided with spiral stairways. The minimum clear walking space shall be 600 mm. **(Add)**

5.13.6.2 The angle of stairways to horizontal plane shall not exceed 45°. **(Add)**

5.13.6.3 The stairway treads shall be of the non-slip type. The rise shall be 200 mm with a minimum width of 200 mm measured at the midlength of tread. **(Add)**

5.13.6.4 Stairway shall be capable of supporting a superimposed load of 2.4 KN/m^2. It is recommended that where the vertical rise of stairways is more than 6 m, intermediate landing or landings should be provided.

(Add)

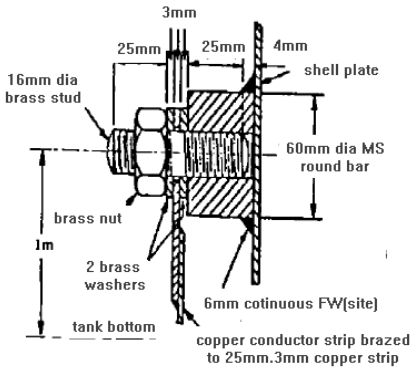
5.13.6.5 Hand railing shall be provided on stairways. When required hand railing shall also be provided around and to the tank roof. **(Add)**

5.13.6.6 For storage tanks over 12.5 m diameter, where access is required to fittings at or near to the center of the roof, hand railing and treads shall be provided. **(Add)**

5.13.6.7 Fixed steel ladders exceeding 4 m in height shall be provided with safety cages. **(Add)**

5.28 EARTHING CONNECTIONS

All tanks shall be fitted with suitable earthing connections. A typical type of connection is shown in Figure 5-17 below. **(Add)**



TYPICAL DETAIL OF EARTHING BOSS (SUPPLIED WITH TANK) SITE

WELDED TO TANK SHELL PLATES

Figure 5-17

SECTION 6 – FABRICATION

6.1 GENERAL

6.1.1 Vendor shall submit the following drawings and documents for approval within the time specified by purchaser and before start of fabrication. Four copies of each drawing shall be submitted for approval. A separate set of drawings for each requisition is required. **(Add)**

6.1.1.1 All shop fabrication drawings. **(Add)**

6.1.1.2 A general arrangement drawing for each tank. This drawing shall be to scale and shall show the position of all mountings and accessories required, with reference to the relevant detail drawings. **(Add)**

6.1.1.3 Static calculations for all members of the tank for which the sizes are not shown on the reference drawings. **(Add)**

6.1.1.4 Marking diagram. **(Add)**

6.1.1.5 In the event that only departure from the reference drawings is proposed with regard to the materials to be incorporated, detail drawings showing the proposed changes shall be submitted for approval. **(Add)**

6.1.1.6 Detail specifications or drawings of any additional materials to be supplied such as pressure and vacuum relieving devices shall be also submitted for approval. **(Add)**

6.1.1.7 An erection procedure shall be prepared prior to commencement of erection and shall be made available to the “owner” for approval. The method proposed to hold the plates in position for welding should be included in the procedure. **(Add)**

6.1.2 The erection contractor shall inspect and keep stock of all materials delivered at site and be fully responsible for their safekeeping. All fittings, valves, plates, etc. shall be properly laid out on wooden support clear of soil. Special care shall be taken that damage does not occur to joint faces of valves and flanges or to beveled ends of fittings. **(Add)**

6.1.3 Any damage to material shall be corrected to the satisfaction of the owner prior to erection. Particular attention shall be paid to the removal of buckles and distortions in the shell and bottom plates. **(Add)**

6.1.4 Welding electrodes shall be stored in their original packets or cartons in a dry place adequately protected from weather effects. Hydrogen controlled electrodes shall be stored and baked in accordance with the electrode manufacturer’s recommendations. **(Add)**

6.1.5 The responsibility for the supply of site erection equipment, labor, false work, etc. lies with the erection contractor. **(Add)**

6.1.7 Temporary attachments such as clamps, lugs and other devices to assist in erection may be attached to the tank plates by welding provided when removing such attachments from shell plates, the attachment shall be burned 3mm to 6mm proud of the plate surface, or alternatively, weaken the securing weld by chipping or gouging, taking care not to damage the parent plate, and knock off the attachment. The resultant scar shall then be ground to a smooth profile, ensuring no under flushing of the plate surface occurs. Furthermore erection holes are not permitted in plate work. **(Add)**

6.2 WORKMANSHIP

6.2.3 Shell plate edges on completion of machining shall be straight. Deviations, if any, shall not be in excess of ±1 mm. **(Add)**

6.3 CUTTING PLATES

6.3.1 Special consideration shall be given to the need to protect welding margins, machined surfaces, etc. from corrosion during shipment and construction. **(Add)**

6.5.4 Local Deviations

6.5.4.1 The local departure from the design form for the shell horizontally and vertically shall not exceed the following where measured over a gage length of 2.5m remote from the weld seams:

Plates up to and including 12.5 mm thick:	**16 mm**
Plates over 12.5 mm up to and including 25 mm thick:	**13 mm**
Plates over 25 mm thick:	**10 mm**

Such departures from the design form shall be gradual over the gage length and sharp changes in form are not permitted. **(Add)**

6.5.4.2 Plates to be joined by butt welding shall be matched accurately and in position during welding operation. Misalignment of the center line of the plates shall not exceed the following:

a) In completed vertical joints, 10% of the plate thickness, or 1.5 mm for plates 19 mm thick and under, and 3 mm for plates over 19 mm thick, whichever is the larger.

b) In completed horizontal joints, 20% of the upper plate thickness, or 1.5 mm for plates

8 mm thick and under, and 3 mm for plates over 8 mm thick, whichever is the smaller. **(Add)**

6.5.6 FOUNDATION

6.5.6.1.1 Foundations for storage tanks shall be constructed in accordance with Iranian Petroleum Standard No. IPS-C-CE-120. **(Add)**

6.5.6.2 Foundation levels shall be checked before and during tank erection. **(Mod)**

6.5.6.4 If tank foundations are finished off with a sand-bitumen mix as a water proof seal, steel plates should be placed temporarily across the edge of the tank foundation in order to protect it whilst the bottom plates are being dragged into position. **(Add)**

6.5.6.5 After checking height, shape and level of the tank foundation by the contractor prior to restarting tank erection, the contractor shall accepts the fall responsibility of any future of the tank, excluding the influence of soil settlement. **(Add)**

6.5.6.6 When foundation with concrete ring walls are used, the top of the ring shall be covered with a minimum of 5mm bitumen layer. **(Add)**

6.5.6.7 If soil settlement is observed, the contractor shall inform the owner immediately. **(Add)**

6.5.7 Measurements

Shell and bottom settlement measurements shall be made by the erection contractor per the following:

a) Shell measurements shall be made after tank erection, prior to hydrostatic testing and during water filling at the ½, ¾, and full levels corresponding to design liquid height.

Level readings shall be accurate to within ±1.5mm. The minimum number of measurement locations shall be as given below:

Table 6-4

Tank diameter m	Number of measurement locations (equally spaced around the tank shell)
< 46	16
> 46 to 69	24
>69 to 99	32
> 99	48

b) Bottom internal measurements shall be made after hydrostatic testing. Such measurements shall be made at 10 m intervals and the following:

Table 6-5

Tank Diameter m	Number of Diameter axes
< 46	**4**
> 46 to 69	**6**
> 69 to 99	**8**
> 99	**10**

(Mod)

6.6 DETAILS OF WELDING

6.6.1 General

6.6.1.5 The manufacturer shall show on a drawing the applicable welding procedure and non destructive tests required. **(Add)**

6.7 QUALIFICATION OF WELDING PROCEDURE

6.7.1.1 All welding procedures submitted shall be identified with the specific item and purchase order numbers. **(Add)**

6.9 MATCHING PLATES

6.9.1.5 Tack welds shall be made with the same type of electrode that is used for depositing the root pass.

(Add)

6.9.1.6 Back up rings or strips, when permitted shall have the same chemical analysis and mechanical properties as the base plate. **(Add)**

6.9.2 Plates shall be welded so that the vertical joints in the adjacent shell course are staggered at least 1/3 of the length of this plate, where practicable, and are off set from each other at least 5 times the thickness of the thicker plate. **(Sub)**

6.9.3 The sequence employed both for the tack welding and final welding of the bottom, shell and roof plates shall be arranged to minimize the distortion due to weld shrinkage. **(Add)**

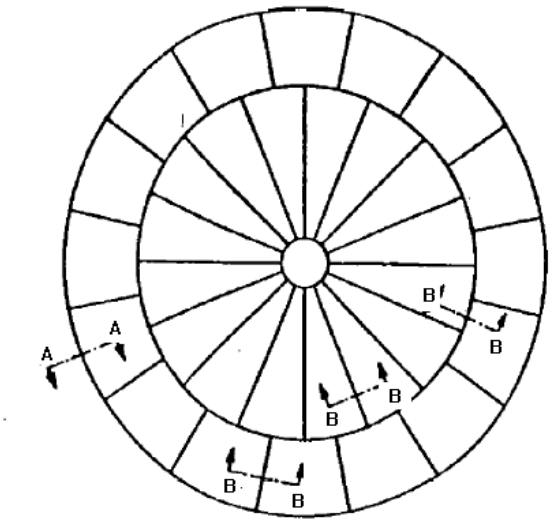
6.9.4 Bottom Plating **(Add)**

6.9.4.1 Bottom plating shall be in accordance with the storage tank constructional drawing. Attention shall be paid to erection marks made on bottom plates according to a marking diagram which is supplied by the tank plate manufacturer for the use of erection contractor. **(Add)**

6.9.4.2 For lap jointed bottom, plates shall be laid, commencing with the center plate and with subsequent plates lapped towards the center of tank as indicated in Figure 6-3. **(Add)**

6.9.4.3 For butt jointed bottom, plates shall be laid and welded as indicated in Figure 6-2. **(Add)**

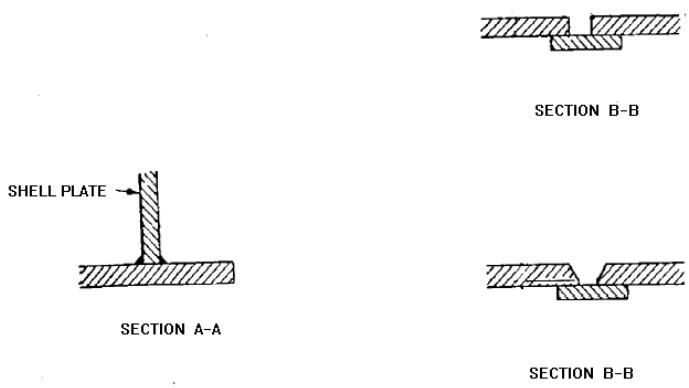
6.9.4.4 The fillet welds of lap joints between the bottom plates and the fillet welds joining shell plates to bottom plates shall consist of a minimum of two passes. **(Add)**



TYPICAL RADIAL BOOTTOM LAYOUT

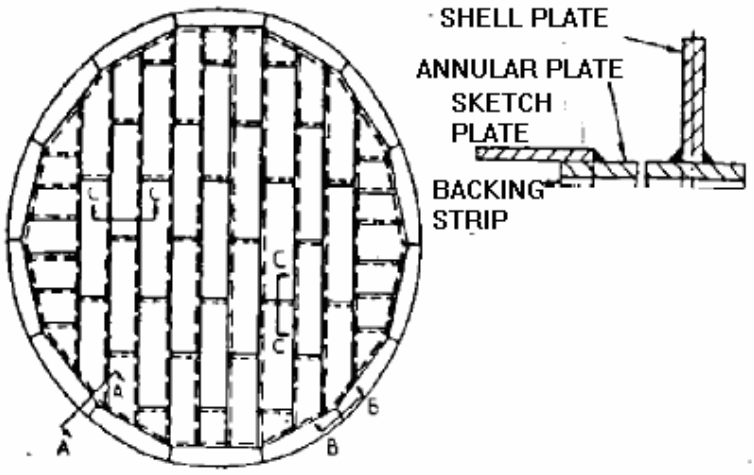
Layout of bottom with rectangular plates

To be similar to Figure 6-3

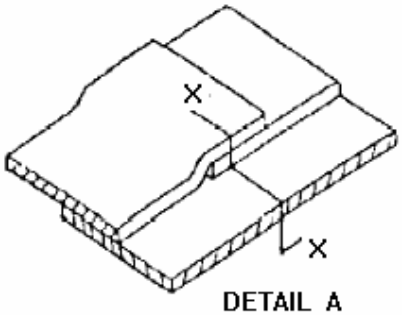


BUTT JOINTED BOTTOMS

Figure 6-2



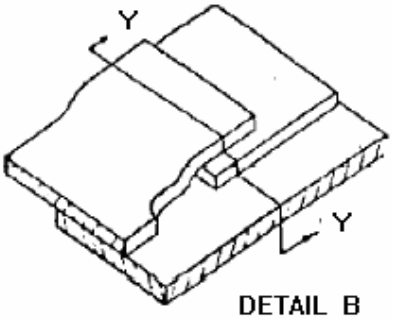
TYPICAL BOTTOM LAYOUT



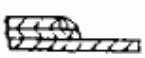
DETAIL A

SECTION C-C

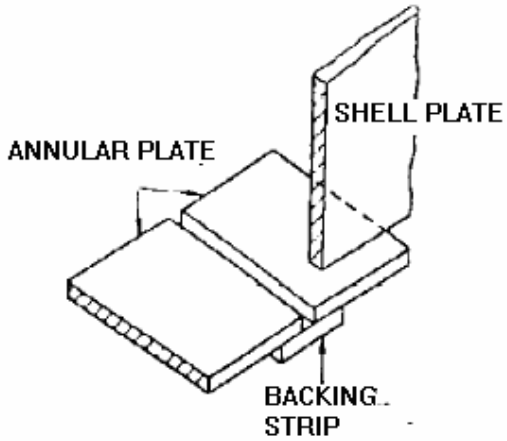
SECTION X-X



DETAIL B



section Y-Y



for details of bult weld see section B-B of fig (6-2)

annular plate joint under shell plates

cross jionts in bottom plates where three thicknesses occur

L

AP JOINTED BOTTOM

Figure 6-3

6.9.5 Shell Plating **(Add)**

6.9.5.1 In setting out the bottom course of shell plates, allowance shall be made for the contraction of the vertical joints during welding while the plates are being plumbed and checked for circularity, and before they are tack-welded to the bottom, they shall be held in position by metal clamps or other devices attached to the bottom plates. **(Add)**

6.9.5.2 Protection of shell during erection **(Add)**

6.9.5.2.1 The erection contractor shall employ suitable methods for the protection of shell during erection which has been agreed with the owner. When required by the owner, full details of these methods shall be made available. **(Add)**

6.9.5.2.2 The use of steel wire guys or cables may not necessarily be adequate and consideration should be given to the use of temporary wind girders. **(Add)**

6.9.6 Roof Erection **(Add)**

6.9.6.1 Before erection of the roof framing begins, the tank shell shall be carefully checked for uneven settlement, and any misalignment of the top of the shell shall be corrected before the roof members are positioned. **(Add)**

6.9.6.2 The temporary support for the erection of roof framing shall remain in position until the completion of the main and secondary framing. **(Add)**

6.9.6.3 When assembling roof sheets on the roof framing care shall be taken that no excessive unsymmetrical loading is applied to the roof members due to stacking of roof sheets. **(Add)**

6.9.6.4 The strength of the temporary support shall be calculated using the most unfavorable loading condition during erection. **(Add)**

6.9.7 Attachment Welds

Attachment welds for tank anchors, shell stiffeners, insulation support, stairway clips, pipe supports and similar components shall be continuously fillet welded unless otherwise specified by company. **(Add)**

6.10 CLEANING SURFACES TO BE WELDED

6.10.1.1 Stairways, hand railing and all structural members manufactured from carbon steel shall be thoroughly cleaned and free of rust and scale by pickling, or blast cleaning, and painted immediately after cleaning with a primer coat of paint. The method and extent of surface cleaning and painting for all other materials will be specified by the purchaser. **(Add)**

6.18 THERMAL STRESS RELIEF

6.18.2.6 Stress relief procedure specification and certificates shall be submitted for purchaser's approval. **(Add)**

6.20 HARDNESS

6.20.1 Hardness of hot formed sections and of weld metal and the related Heat Affected Zone (HAZ) of all welds shall not exceed 225 brinell for P-1 material. **(Add)**

6.20.2 In the case of storage tanks designed and constructed in accordance with Appendix Q and R, the erection contractor shall check the weld hardness of the initial production weld for each welding process, filler metal, and technique used. **(Add)**

SECTION 7 – INSPECTION, EXAMINATION AND TESTING

7.7 STAMPING OF PLATES

All plates and structural members shall be marked in accordance with a marking diagram to be supplied by the manufacturer which shall also bear such other marks as may be required to facilitate erection. Erection marks shall be painted clearly on plates and structural members in symbols at least 50 mm high, where practical, and in the case of curved plates, such marks shall be on the inside surface.

When required, erection marks may be hard stamped in symbols not less than 13 mm high which in the case of plates shall be in the corner approximately 150 mm from either edge. **(Mod)**

7.7.1 Painted or stenciled markings shall not be applied until the priming coat is thoroughly dry. **(Add)**

7.13 DATA REQUIRED FROM MANUFACTURER ON COMPLETED TANKS

7.13.1 As mentioned in 6.6.1.6, non destructive inspection procedure and test requirements for each weld shall be shown on a drawing prepared by the fabricator. Such drawing shall be submitted for purchaser's approval. **(Add)**

7.15 EXAMINATION METHOD AND ACCEPTANCE CRITERIA

7.15.1 Radiographic Method

7.15.1.1.1 Quality control shall be done progressively throughout the job. **(Add)**

7.15.1.4 If, in the opinion of the inspector, the radiographs show objectionable defects, the defective welding shall be cut out and rewelded as directed by the inspector. **(Mod)**

7.15.1.7 Aluminum welds shall meet the requirements of API 620 for ferrous materials. **(Add)**

7.15.5 Visual Examination Method

7.15.5.1 All sites welding shall be subjected to close visual inspection by competent welding inspectors of the contractor as the welding progresses, and any faults or bad practices shall be corrected as soon as possible. **(Mod)**

7.15.5.2 All welds should be visually inspected. Visual inspection shall show that the following requirements are met:

e) The weld is made in accordance with the design requirements.

f) The profile of butt welds is uniform, slightly convex and free from overlap at the toes of the weld.

g) The profile of fillet welds is such that leg lengths are equal within 1.5 mm and the surface of the weld is slightly convex and free from overlap at the toes of the weld.

h) The height and spacing of ripples are uniform.

i) There are no pronounced lumps or cavities caused by starting or finishing a weld bead.

k) The surface of the weld is free from cavities and trapped slag, and does not display any porosity.

(Mod)

7.16 INSPECTION OF WELDS

7.16.2 Fillet Welds

7.16.2.1 Radiographic examination is not required for the examination of fillet welds. **(Add)**

7.17 RADIOGRAPHIC EXAMINATION REQUIREMENTS

7.17.1 Application

7.17.1.1.1 All bottom annular plate joints shall be radiographically inspected (if applicable). **(Add)**

7.17.3 Number and Location of Spot Examination

7.17.3.1 In addition to visual inspection, butt welds in the tank shell shall be radiographically inspected to the following minimum extent. **(Mod)**

7.17.3.2 One radiograph shall be taken from the first 2 m of completed vertical joint of each type and thickness welded by each welder, thereafter without regard to the number of welders working thereon the following incidence of radiography shall be maintained: **(Sub)**

7.17.3.2.1 All T-Junctions in shell plates over 16 mm and less than 32 mm thick, approximately 50% with the film horizontal and 50% vertical. **(Add)**

7.17.3.2.2 10% of the vertical seam length for plates over 16 mm thick in addition to the radiographs covered by 9.9.2.1 but not less than one radiograph on each vertical seam. **(Add)**

7.17.3.2.3 10% of the vertical seam length for plates over 10 mm thick up to and including 16 mm thick, at least half of these radiographs shall include the T-junction and there shall be not less than one radiograph on each vertical seam. **(Add)**

7.17.3.2.4 1% of the vertical seam length for plates 10 mm thick and less but with not less than one radiograph on each vertical seam. **(Add)**

7.17.3.2.5 2% of the horizontal seam length for all plate thicknesses. **(Add)**

7.17.3.2.6 Butt-welds around the periphery of an insert plate shall be radiographed over the whole of their length. **(Add)**

7.17.3.2.7 When a section of horizontal weld is shown by a radiograph not to comply with this specification, or the limits of the defective welding are not defined by such radiography, two adjacent spots shall be examined by radiography. **(Add)**

7.17.3.2.8 If the weld at either of these sections fails to comply with requirements of 7.5.3.1, additional nearby spots shall be examined until the limits of such welding are determined, or at the option of the erector, all the welding performed by the welder on that joint shall be replaced, in which case the inspector shall have the option of requiring that one radiograph be taken at any selected location on any other joint which the same welder has welded. If any such additional spot fails to comply with the requirements of 7.5.3.1 the limits of such welding shall be determined as specified for the initial section. **(Add)**

7.17.5 Magnetic Particle and Liquid Penetrant Requirements **(Add)**

7.17.5.1 If specified, the tank roof joints shall be tested by means of magnetic particle, liquid penetrant or any other nondestructive method and to the extent specified. **(Add)**

7.17.5.2 Bottom to shell double fillet "T" joints shall be examined as follows:

The inner fillet weld shall be examined for toe cracks using either the magnetic particle or liquid penetrant method. **(Add)**

7.17.5.3 Welds attaching nozzles, manholes, and flush type openings shall be examined by the magnetic particle or liquid penetrant method, as applicable. **(Add)**

7.17.5.4 Full penetration welds:

a) If the joint is made by a welding process other than submerged arc or Co_2 in the spray mode, the

reverse side of the root pass shall be examined by the liquid penetrant or magnetic particle method for absence of liner-like flaws before weld metal is applied from the reverse side.

b) If submerged arc or Co_2 in the spray mode processes are used no root inspection is required. **(Add)**

7.17.5.5 Annular plate butt joints shall be 100% radiographed or shall be examined by the magnetic particle or liquid penetrant methods (as applicable) form the topside after completion of the root pass and again after completion of the full weld. **(Add)**

7.18 STANDARD HYDROSTATIC AND PNEUMATIC TESTS

7.18.1 General

7.18.1.1 Hydrostatic test water quality shall be per the following:

a) Carbon steel tanks: if salt water is used for testing and will remain in the tank for more than 30 days, an oxygen scavenger and a corrosion inhibitor shall be added.

After testing, the tank shall be drained and thoroughly rinsed with clean, fresh or salt water.

b) Austenitic stainless steels and aluminum: Only water having less than 150 ppm (150mg/kg) chloride ion shall be used.

Potable water will meet these requirements. Proposals to use water deviating from these requirements shall be submitted for approval to the owner's engineer. **(Mod)**

7.18.1.2 Hydrostatic tests shall commence and finish during daylight hours. **(Add)**

7.18.1.3 The erection contractor shall:

a) Hydrostatically test the tank, including, filling and emptying.

b) Furnish, lay and remove all lines required for testing, from the water supply point and to the water disposal point.

c) Clean out any standing water, silt or other dirt, left in the tank after hydrostatic testing so that the tank interior is "broom" clean and ready for operation. **(Add)**

7.18.1.4 The erection contractor shall install and test all accessories specified and so requested in the erection contract. **(Add)**

7.18.2 Test Preliminaries

7.18.2.4 Vacuum testing of all bottom plate joints shall be conducted except with a partial vacuum maintained at 41 kPa (6 psig) minimum. **(Mod)**

7.18.2.4.1 If a vacuum box is not available, the bottom seams may be tested by pumping air beneath the bottom plates. For detection of leak, soap suds or some alternative substance shall be applied to all joints.

(Add)

7.18.2.7 Nozzle and manway reinforcing plates shall be tested with air pressure and soap suds after welding to the shell. No air leakage is permitted. **(Add)**

7.18.3 Combination Hydrostatic-Pneumatic Tests

7.18.3.1 When the tank shell is tested with water, the roof shall be tested by pumping air under the roof plates while the tank is still full of water. For detection of leaks, soap suds or some alternative substance shall be applied to all roof joints. **(Mod)**

7.18.3.2 The hydrostatic test shall not produce a stress in the bottom shell course which will exceed the following stress limits:

Table 7-2

TANK MATERIAL OF CONSTRUCTION	STRESS LIMITATION % of specified or guaranteed min yield strength at room temp.
Ferritic Steel	90
Austenitic Stainless Steel	100
Non Ferous Material	100

(Mod)

7.18.3.5 Tanks requiring extended filling periods, due to soil stability consideration, will be specified.

(Mod)

7.18.7 Rate of Water Filling and Water Temperature

The water filling rate for testing shall not exceed the following:

Table 7-3

Bottom Course Thickness mm	Tank portion	Filling rate mm/h
< 22	Top course	300
	Blow top course	450
≥ 22	Top third	225
	Middle third	300
	Bottom third	450

(Mod)

7.21 INSULATION, PAINT AND FIREPROOFING **(Add)**

7.21.1 If required, the tank erection contractor shall install thermal insulation as specified and after all other works of installation is completed. **(Add)**

7.21.2 If required, external or internal painting of storage tanks shall be furnished in accordance with Table 1 and Appendix C of Iranian Petroleum Standard IPS-E-TP-100 "General Requirements for Paints". **(Add)**

7.21.3 Fireproofing of tank supports and pipe supports (if any) within dikes of tankage in cryogenic service shall be installed by the erection contractor as specified. **(Add)**

SECTION 9 – PRESSURE- AND VACUUM-RELIEVING DEVICES

9.2 PRESSURE LIMITS

9.2.4 Consideration shall be given to the effects of the followings when determining the required maximum flow capacities.

a) Loss of product.

b) Control valve failure.

c) Liquid over filling.

d) Vapor displaced during filling.

e) Rate of withdrawal of product.

f) Suction capacity of the compressor.

g) Heat leakage to the tank from the atmosphere.

h) Barometric pressure variation.

i) Fire exposure.

j) Any other special circumstances. **(Add)**

9.2.5 The relief system shall be capable of relieving the flow capacity for the largest single contingency or maximum possible combination of them. **(Add)**

9.2.6 A single pressure relief valve may be sized to satisfy the requirements. However, to facilitate inspection and maintenance, a duplicate valve of the same capacity shall be fitted. **(Add)**

9.2.7 When multiple valves are required to give the necessary venting capacity, they should all be of the same size and capacity and at least one additional valve should be fitted for each of the normal and emergency systems. **(Add)**

APPENDIX C

SUGGESTED PRACTICE REGARDING FOUNDATIONS

C.3 Design

C.3.1 Foundation design is influenced by the following conditions: **(Add)**

C.3.1.1 Density and temperature of product stored

These will influence foundation loading. **(Add)**

C.3.1.2 Tank dimensions

Height will affect foundation loading and diameter will affect thermal contraction and anchorage design.**(Add)**

C.3.1.3 Sub-strata conditions

These will affect the general stability of the structure, and will affect differential peripheral and edge-to center settlements that in turn may affect the efficiency of the base insulation. Excessive settlements may lead to breakdown of the insulation and damage to the tank (See C.3.2)**.** **(Add)**

C.3.1.4 Frost heave problems

Frost heave, which may result from freezing the ground or the foundations, has to be prevented. **(Add)**

C.3.1.5 Total operating and/or test loading of the foundations

All loadings specified in this standard for the design and testing of the tanks and anchorages have to be taken into consideration. By agreement between all parties concerned, consideration may be given to short-time foundation overload during the water test. **(Add)**

C.3.1.6 Seismic loadings

For the purposes of foundation design the uplift should be computed from the anchorage design loads. It is recommended that a safety factor of not less than 1.5 should be applied to the above anchorage design load.

(Add)

C.3.2 Settlement limitations

It is suggested that, having taken into account the foregoing factors which may influence the possible settlement under hydraulic test and subsequently in service, the civil engineer should design the foundation to limit possible settlements as follows:

Differential settlement across the foundation (i.e. tilt of the base slab as a whole), should not exceed the equivalent of 25 mm across a tank diameter of 30 m.

Differential settlement between edge and center should not exceed the equivalent of 5 mm in 15 m. Where the foundation design incorporates a ring beam, care should be taken to ensure that relative settlement characteristics of the ring wall and the infill are not such as to result, in a differential settlement local to the inner wall of the ring beam.

Differential settlement around the periphery should not exceed 13 mm over any 9 m length and should be limited to 25 mm between any two points around the periphery.

The datum for the measurement of these differential settlements is the original construction profile for the top of the base slab. **(Add)**

APPENDIX Q

LOW PRESSURE STORAGE TANKS FOR

LIQUEFIED HYDROCARBON GASES

Q.5.2 COMBINATION OF DESIGN LOADS

For vertical cylindrical low-pressure storage tanks, double wall tanks for temperatures down to -196 C, the shell thickness shall be established as follows: (design pressure shall not exceed 14 kPa(140 mbar) gage internal pressure and 0.6 kPa(6mbar) gage internal vacuum). **(Mod)**

Q.5.2.1 Inner Tank

Q.5.2.1.1 Calculated Minimum Shell Plate Thickness:

$$t = \frac{D[98W(H-0.3)+P]}{20S} + C$$

Where:

t = calculated minimum shell plate's thickness (mm).

H = height from bottom of course under consideration to the highest liquid level (m).

D = tank diameter (m).

P = design pressure (mbar)

W = maximum density of contained liquid under storage conditions (g/ml)

S = Allowable design stress (N/mm^2). The maximum allowable design stress is used shall not exceed the lowest value of the following properties, divided by the appropriate factor taken from Table Q-7 below, in no case the maximum allowable design stress shall exceed 260 N/mm^2 for 9% Ni and stainless steel or 93 N/mm^2 for aluminum.

C = corrosion allowance (mm)

Table Q-7 FACTORS FOR CALCULATION OF MAX. ALLOWABLE DESIGN STRESS

1	2	3	4
MATERIAL	FACTOR FOR LOWEST VALUE OF ROOM TEMPERATURE STRENGTH OF PARENT PLATE OR WELD METAL:		
	TENSILE STRENGTH	0.2% PROOF STRENGTH	1% PROOF STRENGTH
9% NICKEL STEEL	2.35	1.5	-
STAINLESS STEL	2.5	-	1.5
ALUMINUM	2.67	1.33	-

(Add)

Q.5.2.2 Outer Tank

Q.5.2.2.1 Calculated Minimum Shell Plate Thickness:

$$t = \frac{PD}{20SE}$$

Where:

t = Calculated minimum shell plate's thickness (mm).

P = Internal pressure, this being a combination of internal gas pressure plus insulation pressure (mbar).

S = Allowable design stress (N/mm^2).

D = Tank diameter (m).

E = Joint efficiency factor. **(Add)**

Q.5.3 MINIMUM WALL REQUIREMENT

Q.5.3.1 Outer Tank

In no case the nominal thickness of shell plates shall be less than the values specified in Table below:

TABLE Q-8 NOMINAL THICKNESS OF SHELL PLATES

NOMINAL TANK DIAMETER (mm)	NOMINAL SHELL THICKNESS* (mm)
<15	5
≥ 15 to 36	6
≥ 36 to 60	8
≥ 60 to 75	10
> 75	12.5

*** Including corrosion allowance.** **(Mod)**

Q.5.3.2 Inner Tank

In no case the nominal thickness of shell plates shall be less than 5 mm. for construction purposes it is recommended that the nominal thickness not be less than D/6 mm (D is tank diameter in meters). This minimum thickness may include any corrosion allowance provided that the shell is shown by calculation to be safe in the corroded condition calculated from formula mentioned in Q.5.2.2.1 above. The maximum shell plate thicknesses shall be as specified in table below:

TABLE Q-9 MAXIMUM SHELL PLATE THICKNESS FOR INNER TANK

SHELL PLATE MATERIAL	MAX. SHELL PLATE THICKNESS (mm)
9% Nickel Steel	20
Austenitic Stainless Steel	25
Aluminum Alloy	55

(Sub)

Q.7 Requirements for Fabrication, Openings and Inspection

Q.7.1 Welding Of Primary Components

Q.7.1.1

e. If double fillet joint is used the fillets shall be made with a minimum of two passes, and the minimum size of fillet shall be equal to the annular plate thickness. Tack welds for shell-to-bottom fillet welds, if used, shall be removed prior to welding fillets. **(Mod)**

Q.7.14 INSULATION **(Add)**

Q.7.14.1 General

Low-temperature storage tanks require to be insulated because of the nature of the product stored Sufficient insulation is required to minimize heat in leakage, to maintain the outer tank at approximately ambient temperature, to minimize condensation and icing effects. The requirements of this clause are to be regarded as minimal and the detailed design of the insulation system should be undertaken in cooperation with competent insulation engineers.

The design of the base insulation and the tank foundation should be considered together and, where foundations are to be constructed at ground level without an air space, the need for foundation heating should be considered for the prevention of ground heave due to frost. **(Add)**

Q.7.14.2 The design of insulation should take into account any thermal movement of the tank likely to be encountered in service and suitable expansion and contraction joints should be embodied at points of discontinuity such as roof to shell connections. **(Add)**

Q.7.14.3 The insulation should contain, or inherently should be, a vapor barrier. It should be weatherproofed and where desirable, fire resistant. **(Add)**

APPENDIX R

LOW PREESURE SRORAGE TANKS

FOR REFRIGERATED PRODUCTS

R.4 Design of Single-Wall Tank

R.4.1 Shell Design

For vertical cylindrical low-pressure storage tanks, single wall tanks for temperatures down to -50 C, the shell thickness shall be greater of the values computed from the following two formulas:

(Design shall not exceed 14 kPa (140 mbar) gage internal vapor pressure):

$$t = \frac{D[98W_t(H-0.3)+1.25P]}{20S_t}$$

$$t = \frac{D[98W(H-0.3)+P]}{20S} + C$$

Where:

t = calculated minimum thickness (mm).

H = Height from bottom of course under consideration to the top shell or to the maximum design product level (m).

D = tank diameter (m).

W = Maximum density of contained liquid under storage conditions (g/ml).

W_t = density of test liquid but shall not be less than 1.0 (g/ml).

S = Allowable design stress. The maximum allowable design stress in any plate in service shall be the lesser of 260 N/mm^2 or 2/3 of the minimum yield strength of the shall plate material (N/mm^2).

S_t = Allowable stress under test. The maximum allowable stress in any plate under test shall be limited to 0.85 of the minimum specified yield strength (N/mm^2).

P = Design pressure (mbar)

C = Corrosion allowance (mm) **(Add)**

R.7 Requirements for Fabrication, Openings and Inspection

R.7.1 Welding Of Primary Components

R.7.1.1

e. If double fillet joint is used the fillets shall be made with a minimum of two passes, and the minimum size of fillet shall be equal to the annular plate thickness. Tack welds for shell-to-bottom fillet welds, if used, shall be removed prior to welding fillets. **(Mod)**

R.7.9 INSULATION **(Add)**

R.7.9.1 General

Low-temperature storage tanks require to be insulated because of the nature of the product stored Sufficient insulation is required to minimize heat in leakage, to maintain the outer tank at approximately ambient temperature, to minimize condensation and icing effects. The requirements of this clause are to be regarded as minimal and the detailed design of the insulation system should be undertaken in cooperation with competent insulation engineers.

The design of the base insulation and the tank foundation should be considered together and, where foundations are to be constructed at ground level without an air space, the need for foundation heating should be considered for the prevention of ground heave due to frost. **(Add)**

R.7.9.2 The design of insulation should take into account any thermal movement of the tank likely to be encountered in service and suitable expansion and contraction joints should be embodied at points of discontinuity such as roof to shell connections. **(Add)**

R.7.9.3 The insulation should contain, or inherently should be, a vapor barrier. It should be weatherproofed and where desirable, fire resistant. **(Add)**

APPENDIX S

QUOTATION (New Appendix Add)

S.1 The following information shall be submitted in the quotation:

S.1.1 Price

S.1.2 Estimated total shipping weight of materials for each tank with accessories.

S.1.3 Delivery time of the materials

S.1.4 Steel grades offered

S.1.5 Plate thicknesses

S.1.6 Any deviations or exclusions from the stipulations referred to in this specification. If no deviations or exclusions are mentioned in the quotation, it will be deemed to be fully in compliance with said stipulations.

Vendor is free to offer as an alternative, before the purchase order is placed, deviations from the required standards, if these result in a reduction in costs.

S.1.7 The names of subcontractors, if any for the fabrication or any part thereof. Such subcontractors shall be subject to acceptance by purchaser.

S.2 Any purchase order will be subject to all terms, conditions, etc. forming part of the inquiry and any agreed amendments to it.

APPENDIX T

SECRECY (New Appendix Add)

Vendor shall not disclose or issue to third parties without the written consent of purchaser any documents, etc. placed at his disposal by purchaser or any documents prepared by him in connection with inquiries and purchase orders for purposes other than the preparation of a quotation or carrying out such purchase orders.

APPENDIX U

PACKAGING (New Appendix Add)

U.1 When considering the following instructions, due regards shall be paid to handling facilities in transit and at the destination, and also to any special packaging instruction given in the purchase order.

U.2 Structural materials and plates shall be treated as follows:

U.2.1 To prevent damage in transit all roof plates shall be bundled by welded clips as shown in Appendix U Figure U-1 attached. The maximum weight of a single bundle shall not exceed approximately 1½ tons. Bundling shall not take place until the paint is thoroughly dry.

U.2.2 All shell and bottom plates shall be bundled as described under U.2.1 above, except that maximum weight of a single bundle shall not exceed approximately 2 tons.

U.2.3 All structural members, such as roof framing, curb angles, wind girders, hand rails and stair treads, shall be bundled and secured by bolting or tack welding. To prevent the nuts from loosening during transit, either the threads must be damaged or the nuts spot welded to the bolts. The weight of a single bundle shall not exceed approximately one ton.

U.2.4 All gusset plates, cleats, etc. shall be securely bundled by bolting, each bundle weighing approximately 1/4 ton.

U.2.5 All small parts such as bolts, nuts, and erection key plates. Shim plates, wedges, etc. shall be bagged and packed separately, and shall be enclosed in stout wooden cases. The minimum thickness of timber used for the cases shall be 22 mm. The total weight of each case shall not exceed approximately 1/2 ton.

U.3 Roof and shell manholes, nozzles, bottom sumps and clean outs, etc. may be shipped loose. Manhole and clean out cover shall be bolted on with gasket in position. Flange of nozzles, etc. Shall be adequately protected to prevent damage in transit.

Roof vents dip hatches and similar small fittings shall be packed complete with gasket, etc. in stout wooden case, and shall be securely fixed there to prevent damage in transit.

Cases shall be made of timber not less than 22 mm thick strongly battened, and banded with tensioned steel strapping. The weight of any case shall not exceed ½ ton

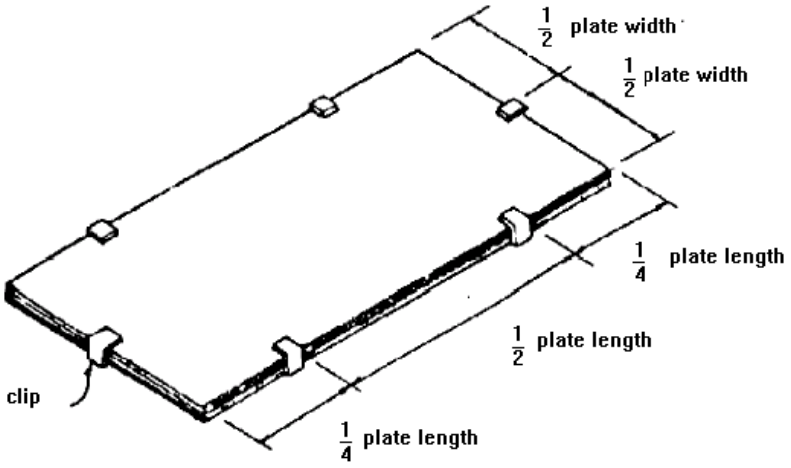
U.4 All welding electrodes, rods, wires and fluxes shall be packed in such a manner as to keep them in first class condition during transport and storage.

Welding electrodes shall be supplied in containers which give adequate protection against damage and moisture in transit and in storage on site.

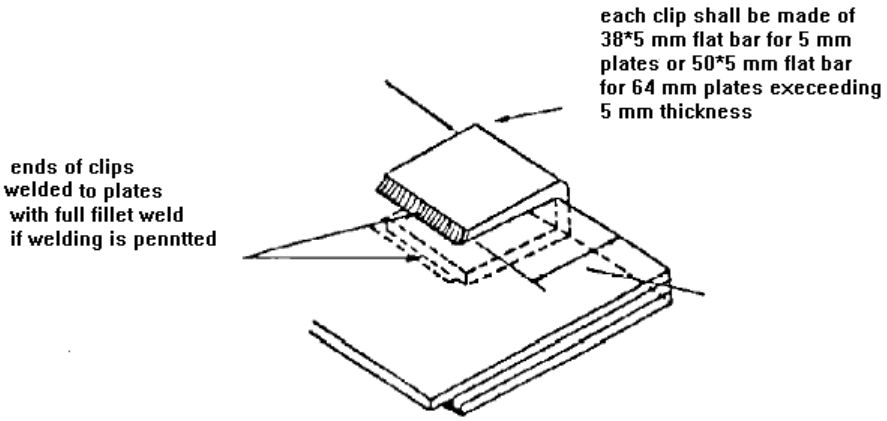
The type of packing to be employed shall be specified by the electrode manufacturer.

APPENDIX U (continued)

BUNDLING METHOD



Note 1: Use 6 numbers of clips for each bundle except where plate length exceeds 4 m in that case use three clips on each side which is 8 clips per bundle.



Note 2: When welding is not permitted use other safe methods for bundling.

BUNDLING OF ROOF, SHELL AND BOTTOM PLATES

Figure U-1

APPENDIX V

SHIPMENT (New Appendix Add)

V.1 Plates and storage tank material shall be loaded in such a manner as to ensure delivery without damage.

V.2 Shipping marks shall be provided as follows:

V.2.1 Whenever possible, the shipping marks and any other desired particulars shall be stenciled on each bundle, case or package. Stenciled marks shall be at least 50 mm high. If stenciling cannot be applied, the information shall be suitably stamped on a metal label, securely attached to the package. Stamped symbols shall be at least 13 mm high.

V.2.2 If any confusion is likely to arise in reception, storing or distribution of the materials (e.g. in the case of purchase orders comprising materials for more than one tank), all parts shall have painted on them a further distinctive mark in addition to any erection or shipping marks. Such additional marking shall consist of a colored band or other mark as agreed with purchaser.

V.2.3 All identification marks shall be applied on at least two sides of each package.

V.3 Each package, case and bundle shall be accompanied with a packing list.

APPENDIX W

GUARANTEE (New Appendix Add)

W.1 Vendor shall guarantee that the materials delivered to be incorporated into storage tank(s) are in accordance with the purchase order and will be free from any defects in design, workmanship and material and that they will give proper service under the operating and design conditions as specified, for a period of 18 months, reckoned from the day on which the tanks are delivered.

W.2 The period of 18 months specified above shall be extended by any period(s) during which the tanks after delivery are out of action as a result of any defect covered by this guarantee.

W.3 In the event of defects covered by this guarantee purchaser shall notify Vendor as soon as possible and vendor shall without delay remedy or repair free of charge (cost of labor and transportation not excluded) the tank(s) having such defects, or authorize purchaser to do so. In the latter event vendor shall reimburse to purchaser the actual out of pocket costs, excluding over heads and similar administrative costs.

W.4 Remedying and repairing may be affected by purchaser without prior approval by vendor in cases where it would be unreasonable to demand that prior approval be obtained. In such cases vendor and purchaser shall agree which party shall bear the costs and expenses thereof or in what proportion these costs and expenses shall be divided between them. This guarantee shall remain in effect, provided the remedying and repairing do not result in any detriment to the tank (s).

W.5 In no event will this guarantee cover defects due to normal wear and tear, disregard by purchaser or his consignee of operating instructions, excessive over loading by purchaser or his consignee or unsuitable operating conditions.

APPENDIX X

PIPE COMPONENTS NOMINAL SIZE (New Appendix Add)

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

TABLE X-1

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 (DN), mm.

2) Nominal Pipe Size (NPS), inch.

APPENDIX Y

PIPE FLANGES, PRESSURE-TEMPERATURE RATINGS (New Appendix Add)

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 Y-1

PN (1)	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).