CONSTRUCTION STANDARD

FOR

ATMOSPHERIC ABOVE GROUND WELDED STEEL

STORAGE TANKS

CONTENTS :

PAGE No.

APPENDICES :

0. INTRODUCTION

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

STANDARD CODE	STANDARD TITLE
IPS-C-ME-100	"Atmospheric above Ground Welded Steel Storage Tanks"
IPS-C-ME-110	"Large Welded Low Pressure Storage Tanks"
IPS-C-ME-120	"Aviation Turbine Fuel Storage Tanks"
IPS-C-ME-130	"Pressure Storage Spheres (For LPG)"

However when purchasing and quality control of materials to be incorporated into storage tanks, Engineering and design or periodic inspection is concerned, reference is made to types M, E and I standards.

1. SCOPE

1.1 This construction standard, covers minimum requirements for site erection of atmospheric, above ground, welded storage tanks designed and constructed in accordance with API Standard 650 and its appendices.

1.2 This standard also covers safety requirements governing the layout and spacing of atmospheric storage tanks. This also includes the design of dikes.

1.3 This standard gives general requirements to be met by a tank erector (or erection contractor) when submitting quotations for above ground atmospheric welded storage tanks.

1.4 It should be noted that when only purchasing of materials and equipment to be incorporated into the storage tanks are involved, the requirements of Iranian Petroleum Material and Equipment Standard for atmospheric above ground welded steel Storage Tanks (IPS-M-ME-100) shall be met.

1.5 Engineering and design of storage tanks shall be in accordance with Iranian Petroleum Engineering Standard for atmospheric above ground welded steel Storage Tanks (IPS-E-ME-100).

1.6 The requirements of this standard are in addition to those of API Standard 650 8th edition, November 1988.

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 contractor.

API (AMERICAN PETROLEUM INSTITUTE)

Standard 650	"Welded Steel Tanks for Oil Storage"

IPS (IRANIAN PETROLEUM STANDARDS)

IPS-E-TP-100	"General Requirement for Paints"
IPS-M-ME-100	"Atmospheric above Ground Welded Steel Storage Tanks"
IPS-E-ME-100	"Atmospheric above Ground Welded Steel Storage Tanks"
IPS-E-CE-I20	"Foundations"
IPS-E-GN-100	"Units"

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. (see Appendix A) has been used in accordance with ISO 6708-1980, ANSI/ASME B 16.5-1981 and ANSI/ASME B31.3-1983 for pipe flanges pressure temperature ratings, the international nomenclature pressure nominal written as PN 20, 50, etc. (see Appendix B) has been used.

4. MATERIAL

4.1 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 supports, clear of the soil. Special care shall be taken that damage does not occur to joint faces of valves and flanges or to beveled ends of fittings.

4.2 All materials shall be examined and repaired as necessary at the site before being erected, to ensure that any damage incured in transit is made good to the satisfaction of the owner's representative. Particular attention shall be paid to the avoid of buckles and distortions in plates.

4.3 Welding electrodes shall be stored in their original pockets 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.

4.4 The responsibility for the supply of site erection equipment, labor, false work, etc., lies with the erection contractor.

5. FOUNDATION

5.1 Storage tanks shall be erected at site proposed by the company.

5.2 Unless otherwise specified, foundations for tanks will be constructed to the specified levels, profiles and tolerances.

5.3 Foundations for storage tanks shall be constructed in accordance with Iranian Petroleum Standard IPS-E-CE-120.

5.4 For tank, to have a shell which is truly circular and free from buckles and flat spots, the foundation shall remain level as the tank shell is erected. For this reason the foundation shall be checked, not only at the commencement of operations, but several times during the various stages of tank erection. The measurements shall be stated in a report. This final report shall be handed to the owner for maintenance purposes.

5.5 Whichever type of construction is chosen, the surface immediately under the shell plates shall be laid so that the difference from a mean level does not exceed plus or minus 6 mm in 10 m and plus or minus 12 mm between any two points around the periphery. Close tolerances in the tank foundation peripheral levels are particularly necessary for floating roof tanks.

Uneven foundation and settlement can result in the shell assuming an oval shape at the top, causing the floating roof to stick.

5.6 An indication that the tank is settling unevently is the appearance of gaps in the circumferential seams, and departure of the shell from the perpendicular. If these signs appear, no attempt should be made to close the gap by pulling with the key plates and wedges or cutting of plates.

5.7 The tank level should be checked and corrected by leveling, if necessary. If the gap is due to inaccurate fabrication, plate edges should to the amount approved by the company or his representative be built up with weld metal, and the joint welded.

5.8 Pulling the plates to close the gap will cause deformations of the tank shell. To obtain a perpendicular and circular shell, a level tank foundation is essential.

5.9 If tank foundations are finished off with a sand bitumen mix as a water proof seal coat, 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.

5.10 Acceptance of Foundations

5.10.1 Before erection starts the contractor shall check the foundations of the tanks as regards height, shape and level and will subsequently accept the base and take over responsibility for it.

5.10.2 This also includes the responsibility for its appearance and final shape after completion of the tank erection, excluding the influence of soil settlement.

5.10.3 If soil settlement is observed the contractor shall inform the owner immediately.

5.10.4 The contractor will be made aware of the predicted soil settlements stated in the soil investigation report.

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

5.12 For small tanks a concrete raft is sometimes used as a foundation, in this case the top of the concrete raft shall be covered with a layer of sand bitumen mixture of at least 50 mm.

6. SITE ERECTION

6.1 General

6.1.1 Site erection of atmospheric above ground welded storage tanks shall be in accordance with Section 5 of API Standard 650 and the following supplementary requirements:

6.1.2 Erector shall supply all labor, supervision, materials, tools and inspection materials in addition to the requirements in the conditions of contract to erect the storage tank(s).

6.1.3 Erection holes shall not be permitted in plate work.

6.1.4 Lugs, nuts, clamps, and other devices to assist in erection may be attached to the tank plates by welding provided all such attachments required only for the purposes of erection shall ultimately be removed, any noticeable projections of weld metal remaining shall be carefully ground or chipped away.

Plates shall not be gouged or torn in the process of removing attachments, and any indentations caused thereby shall be filled with weld metal and ground flush with the plate surface according to the approved procedure.

6.2 Erection Methods

6.2.1 Welded vertical storage tanks can be erected in several ways

Erection contractors normally have a specific individual method,which they have adopted as the result of experience, and have developed the erection technique most suitable for economical working and good workmanship by their field crews. The main well-known methods of erection are given below; no one particular is specified for use.

6.2.2 Progressive assembly method

In the progressive assembly method, the bottom plates are assembled and welded first. Thereafter the shell plates are erected, held in place, tacked and completely welded. This shall be done course by course, working upwards to the top curb angle. No course shall be added as long as the previous course has not been entirely welded. The erection and completion of the roof framing and roof plates then follow.

6.2.3 Complete assembly followed by welding of horizontal seams

In the complete assembly method, the bottom plates are assembled and welded first. Thereafter the shell plates are erected, held in place, tacked and only the vertical seams completely welded, leaving the horizontal seams unwelded. This shall be done course by course, working upwards to the top curb angle. No course shall be added as long as the vertical seams of the previous course have not been entirely welded.

The erection and completion of the roof framing and roof plates then follow.

Finally the horizontal seams are welded working upwards from the bottom course or downwards from the top curb angle.

6.2.4 Jacking up method

Some contractors employ a system of erection in which the bottom plates are completed. The top course is erected on the bottom plates, the roof framing and sheeting are completed and a number of jacks are then assembled around the structure.

By means of these jacks the completed top course together with the roof framing and sheeting is lifted to a height sufficient to insert the next lower course. The jacking method and the supporting of the partly erected shell, shall have no adverse effect on the roundness of the shell.

The welding is completed at each stage of lift until all courses of the shell plates have been inserted and the finished height is reached.

The final operation is the welding of the bottom course to the bottom plates.

6.2.5 Floatation method

The floatation method is used for floating roof tanks. After the completion of the bottom plating and erection and welding of the two lower courses of the tank, the floating roof is assembled on the tank bottom and completed. The tank is then filled with water and, using the floating roof as a working platform, the third and subsequent courses are erected and welded, water being pumped in as each course is completed.

This method may only be used at locations where soil settlement is very limited and with the written agreement of the owner. The predicted soil settlements of the soil investigation report shall be taken into account.

A small crane is usually erected on the floating roof, hoisting the shell plates into position.

6.2.6 Prefabrication

For a hazardous location and/or close to existing tanks already storing light products, tanks can be prefabricated and moved to their permanent site, either by:

6.2.6.1 Prefabrication of the tank in the workshop. The maximum dimensions depend on the possibilities and limitations with respect to transport.

Generally this method shall be limited to tanks with diameters up to 12 meters.

6.2.6.2 Prefabrication of the tank, on a temporary foundation at a safe location nearby. The complete tank is then moved to its permanent foundation, e.g. by crane, on rollers or by air cushion.

6.2.6.3 The water test shall be carried out when the tank is standing on its permanent foundation.

6.2.6.4 This method may only be used with the written agreement of the owner.

6.3 Bottom Plating

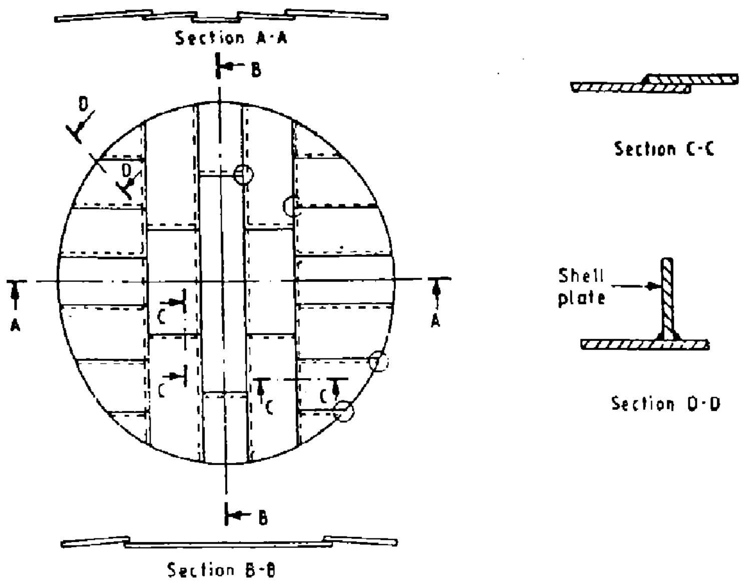
6.3.1 Bottom plating shall be in accordance with the storage tank constructional drawing. Attention shall be paid to erection marks made on bottom plates according to a marking diagram which is supplied by the tank plate fabricator for the use of tank erector.

6.3.2 Manual gas cutting may be used for trimming the corners of bottom or roof plates where two lapped joints intersect and for cutting openings for fittings positioned on site.

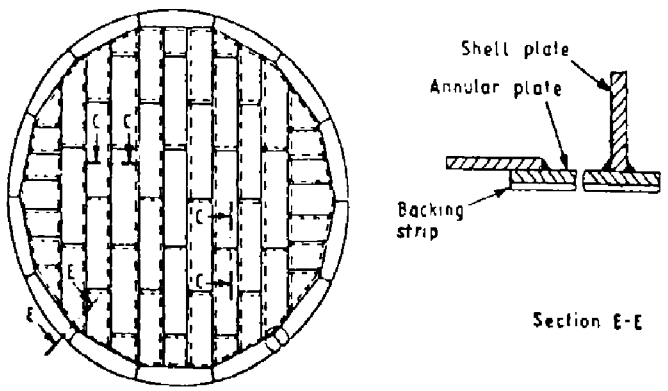
6.3.3 Unless otherwise specified, after the bottom plates are laid out and tacked, they shall be joined by welding the joints in a sequence that the erector has found to result in the least distortion from shrinkage and thus to provide as nearly as possible a plane surface.

6.3.4 Welding of the shell to the bottom shall be practically completed before the start of the completion of welding of bottom joints that may have been left open to compensate for shrinkage of any welds previously made.

6.3.5 Bottom plates shall be laid, commencing with the center plate and with subsequent plates lapped towards the center of the tank. Layout shall be as indicated in Fig. 1.



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. For layout of plates similar to sections A-A and B-B see(a).

TYPICAL BOTTOM LAYOUTS FOR TANKS
Fig. 1

6.4 Shell Plating

6.4.1 The method proposed to hold the plates in position for welding shall be approved by the owner.

6.4.2 The course of shell plates to be erected first shall be held in position by metal clamps or other devices attached to the bottom plates whilst it is plumbed and checked for circularity and before it is tack welded or welded. In setting out this course, care shall be taken to ensure that due allowance is made for the contraction of the vertical joints during welding.

6.4.3 Before final welding of the bottom course of shell plates begins, a check should be made to ensure that the alignment of the plates and the width of the gaps between them are correct and that any inaccuracies after welding will be within the tolerances mentioned in Section 8 of this standard. If the tolerances are expected to be exceeded, the plates shall be re-aligned before final welding begins.

6.4.4 Protection of shell during erection

6.4.4.1 The erection contractor shall employ suitable methods for the protection of the shell during erection which have been agreed with the owner. When required by the owner, full details of these methods shall be made available for his approval.

6.4.4.2 The factors to be taken into account when determining the suitability of the proposed method of protection shall be:

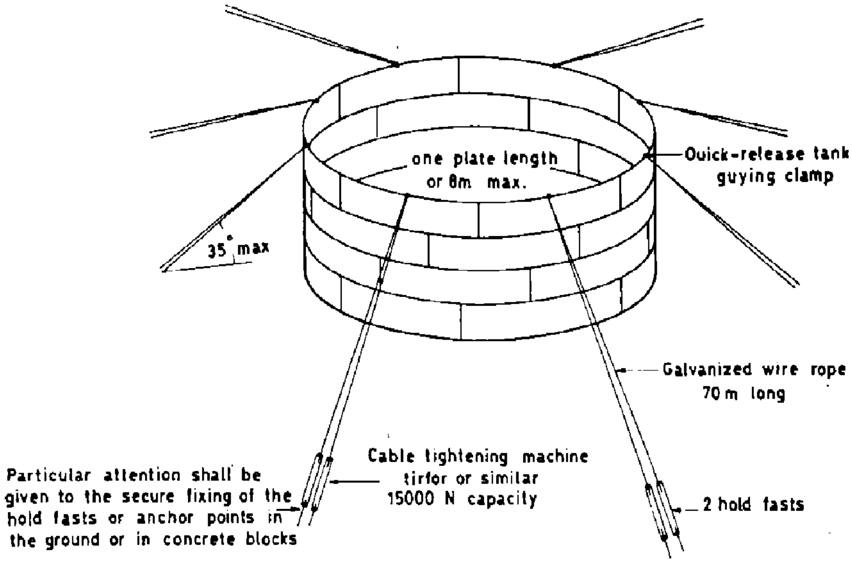
- **a)** Tank size.
- **b)** Construction method.
- **c)** Location and degree of exposure to wind loads.
- **d)** Number and type of key plate equipment.
- **e)** Availability of reliable meteorological data during all periods of erection.

6.4.4.3 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.

6.4.4.4 If wire guys or braces are used as means of safeguarding, a minimum of one guy every 8 meters of circumference is recommended. These shall remain in place until welding of the shell plates and erection of the roof framing has been completed, or, with open top tanks, until the wind girder has been completed. The reliability of the anchor blocks for the guys especially in weak, muddy soils shall be given particular attention. A sample of tank guying is shown in Fig. 2.

6.4.5 After the first course has been erected and welded, the internal radius, measured horizontally from the center of the tank to any point on the inside of the tank shell, shall not differ from the nominal internal radius by more than the following:

For tanks with a diameter ≤ 12.5 m	13 mm
For tanks with a diameter > 12.5 m ≤ 45 m	19 mm
For tanks with a diameter > 45 m	25 mm



RECOMMENDED SYSTEM FOR TANK GUYING

Fig. 2

The system of guying shown is recommended for all vertical storage tanks in course of construction and should be installed on the erection of the third course shell plates and progressively moved up to the top edge of the uppermost course of plates as erection proceeds.

12 mm diameter galvanized wire ropes are used to form a double guy approximately 30 m long. This passes through a snatch block attached to the quick-release clamp on the shell plate.

The efficiency of the anchorage is fully developed only when the angle between the guy and ground is not greater than 35°.

The guy rope should be taut and in line with the center of the tank at the point where it is connected.

TABLE OF DISTANCE TO GIVE ANGLE OF 35° FOR GUY

HEIGHT ABOVE GROUND LEVEL m	MIN. DISTANCE FROM TANK TO ANCHORAGE m
3.0	4.6
4.6	6.7
6.1	8.8
7.6	11.2
9.1	13.1
10.7	15.2
12.2	17.7
13.7	19.8
15.2	22.0
16.8	24.0
18.3	26.0

6.5 Roof Erection

6.5.1 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.

6.5.2 Temporary supports for the erection of the roof framing shall not be removed until the erection of the main and secondary framing is completed.

With dome roofs, the temporary center support shall not be removed until radial rafters, purlings and bracings are erected, completed and welded, and all roof sheets are tack-welded into position. The positioning of the roof trusses shall be done very accurately to prevent misalignment.

6.5.3 When assembling roof sheets on the framing, excessive unsymmetrical loads shall be avoided and not more than three roof sheets shall be stacked at anyone point.

For dome roofs, the roof sheets shall be assembled symmetrically, working from the center outwards.

6.5.4 The strength of erection poles used for temporary support of the roof structure shall be checked by calculation for the maximum load to be carried. In particular the resistance to buckling shall be checked. The erection contractor shall make a calculation showing strength and safety of the erection poles to be used.

7. WELDING

7.1 All welding, including repair, tack and attachment welding, shall be carried out according to Sub-section 5.2 of API Standard 650 and the following supplementary requirements.

7.2 All welding of tank plates, steel framing, structural attachments and mountings done in the field shall be carried out by qualified welders or welding operators.

7.3 The erection contractor shall weld test plates using his procedures to demonstrate to owner's representative that these procedures are suitable for making welds which conform to the specified requirements.

7.4 The sequence employed for tack welding and welding the bottom, shell and roof plates shall be such that the distortion due to welding shrinkage is minimized.

7.5 Tack welds used in the assembly of the vertical joints of tank shells and horizontal joints to be manually welded shall be removed and shall not remain in the finished joint.

Tack welds in the bottom, shell-to-bottom, roof and automatically welded horizontal joints of the tank shell and other joints, need not be removed provided they are sound and the subsequent weld runs are thoroughly fused into the tack welds.

7.6 Each run of weld metal shall be cleaned of slag and other deposits before the next run is applied. Slag shall also be removed from finished welds before inspection. Where air-arc gouging is used, the surfaces shall be chipped or ground back to bright metal before welding.

7.7 Peening of butt welds shall not be carried out except to the extent necessary to clean the weld.

7.8 No restraint of bottom plates by weights during welding is permitted.

7.9 In vertical joints in shell plates exceeding 13 mm thick all, but the root, runs shall be welded by the 'upwards' technique. Root runs by either the 'upwards' technique or by vertical-down welding in such plates over 13 mm shall be permitted but, in the latter case, the weld metal shall be completely removed by gouging or other suitable means to sound clean metal, before welding on the reverse side.

8. TOLERANCES

8.1 Shell Tolerances

8.1.1 After completion, the overall height of the shell shall not be out of vertical by more than 1 in 200. This Standard of verticality should apply to each individual course which should be erected within the same tolerance.

8.1.2 Plates to be joined by butt welding shall be matched accurately and retained in position during the 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 smaller.

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.

8.1.3 Local departures from the design form for the shell horizontally and vertically should not exceed the following when measured over a gage length of 2.5 m remote from weld seams:

Plates ≤ 12. mm thick	16 mm
Plates > 12.5 mm ≤ 25 mm thick	13 mm
Plates > 25 mm thick	10 mm

Such departures from the design form shall be gradual over the gage length, sharp changes in form are not permitted.

8.1.4 Deviation both inside and outside the tank of shell plate vertical joints from a true circle generated by tank radius, over a 1 m horizontal span centered on the weld, (peaking) shall be within 10 mm.

8.1.5 Deviation both inside and outside the tank of horizontal joints over a 1 m vertical span centered on the weld, from a vertical line (BANDING) shall be within 10 mm.

8.1.6 The tank shell shall be carefully checked for circularity, dimensions and level before the roof members (fixed roof tank)or the primary wind girder (floating roof tank) are erected.

8.2 Floating Roof Tolerances

8.2.1 The variations in the gap between the shell and the periphery of the roof on completion of erection of roof shall not exceed ±13 mm from the nominal gap.

8.2.2 At any elevation of the roof other than that at which it was erected, this difference in gap shall not exceed 50 mm unless some other value has been agreed for a particular seal design.

9. INSPECTION

9.1 The owner’s representative or his assigned inspector shall at all times have free access to all parts of the site while the work covered by the contract is in progress. The tank erection contractor shall afford him all reasonable facilities for ensuring that the work is being carried out in accordance with the requirements of this specification.

9.2 All site 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.

Particular attention shall be paid to the vertical and horizontal joints in the shell plates, butt joints in bottom annular plates and other joints that pass under the shell plates.

All these joints shall be thoroughly de-slagged by chipping and brushing, and examined between each run of weld metal for faults such as lack of fusion, surface cracks, slag inclusions and undercutting. Special care shall be taken in examination of double-vee or double-bevel joints before welding the second side.

9.3 Visual Inspection of Welds

9.3.1 All welds should be visually inspected.

9.3.2 Visual inspection shall show that the following requirements are met:

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

b) 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.

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

d) The height and spacing of ripples are uniform.

e) The weld is free from undercutting.

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

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

9.4 Weld Defects

9.4.1 Welds that are shown by radiography to have any of the defects or imperfections named in the following shall be judged to be unacceptable,and the owner's welding inspector or representative shall decide to what extent the welds shall be repaired.

a) Cracks of any form or size, incomplete fusion or incomplete penetration.
b) Slag inclusions.
c) Porosity.

9.5 Inspection and Testing of Tanks Bottom Welds

9.5.1 Annular plate butt joins shall be radiographed per Table 1 or shall be magnetic particle inspected from the top-side after completion of the root pass and again after completion of the full weld.

9.5.2 Bottom to shell joint shall be inspected as follows:

a) The inner fillet weld shall be inspected prior to welding the outside fillet weld. Leak testing shall be performed with penetrating oil after removal of slag. Oil shall be removed before welding the outer fillet.

b) Examination for inner fillet toe cracks shall be performed, using either the liquid penetrant or magnetic particle method.

c) The gap between the bottom shell ring and the lap-welded bottom plates at the radial weld locations shall be a maximum of 3 mm.

9.5.3 All bottom plates welds shall be tested using a vacuum box which enables any leak in the seams to be positively located by visual examination (see Sub-section 5.3.3 of API Standard 650). 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 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.

For detection of leaks, soap suds or some alternative substance shall be applied to all joints.

The test shall preferably be made as soon as possible after welding of the bottom, removal of slag,and wire brushing, but before any surface coating is applied. The bottom plates shall in any case be tested before water is let into the tank for hydrostatic testing.
After jacking-up of a tank for relevelling,the tank bottom shall again be tested for leaks.

9.5.4 Radiographic examination of fillet welds shall not be required.

9.6 Inspection of Tank Shell Welds

9.6.1 Inspection of tank shell welds shall be in accordance with Section 6 of API Standard 650. The following requirements are supplementary.

9.6.2 The extent of radiography shall be not less than that listed in Table 1 for each plate thickness, but shall include one radiograph taken from the first completed vertical joint for each welding process and thickness, if differing by more than ±3 mm, welded by each welder.

Thereafter, without regard to the number of welders working thereon, the same incidence of radiography shall be maintained.

TABLE 1 - EXTENT OF RADIOGRAPHY PER TANK

THINNER PLATE THICKNESS	VERTICAL WELDS AND T-JOINTS	HORIZONTAL SEAMES	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 SEAM 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 No. OF JOINTS
ANNULAR PLATES UP TO AND INCLUDING 8 mm	—	—	A QUARTER OF THE No. OF JOINTS, WITH A MINIMUM 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.**

Note:

Welds part to be radiographed will be selected by the owner's representative.

9.6.3 Butt welds around the periphery of an insert plate shall be radiographed over the whole of their length.

9.6.4 Acceptance levels for weld defects which shall be imposed during erection are given in Table 2.

TABLE 2 - 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).

9.7 Inspection of Tank Roof Welds

9.7.1 Atmospheric storage tanks roof welds shall be inspected in accordance with API 650.

10. TANK TESTING

10.1 A product connection shall not be made to the storage tank for any purpose until the tank is tested and accepted to be filled with product by owner's representative.

10.2 Pneumatic testing of the reinforcing plates shall be done at a pressure of 1 bar prior to the shell water test.

10.3 The roof drain of the floating roof storage tanks shall be installed prior to the hydraulic test on the tank and during this test the drain shall be examined to ensure that it is not leaking due to external pressure.

10.4 Roof manholes shall be open while filling or emptying a fixed roof tank for test purposes, so that the tank is not damaged by excessive vacuum or pressure loading.

10.5 Hydrostatic test of the tank include filling and emptying. The temperature of the test water shall be not lower than 20°C.

10.6 Initial Filling

10.6.1 While it is normal practice to test all tanks by filling with water before commissioning, this filling should be done under controlled conditions to ensure that foundation failure does not occur during filling. The hydrostatic test pressure is an integral part of the foundation design and should be agreed with a soil mechanics specialist.

10.6.2 All tank tests will be carried out to provide adequate measure load/settlement records.

10.6.3 The first tank in a new area will be the most critical and subsequent testing arrangements on other tanks should be adjusted in the light of the first test results where the tanks are on similar sub-soil conditions.

10.6.4 The water filling rate for testing shall not exceed than the rates shown in Table 3 or design criteria whichever is the lesser.

TABLE 3

BOTTOM COURSE THICKNESS mm	TANK PORTION	FILLING RATE mm/hr
< 22	TOP COURSE BELOW TOP COURSE	300 450
≥ 22	TOP THIRD MIDDLE THIRD BOTTOM THIRD	225 300 450

10.6.5 A minimum of four points on tanks up to 25 m diameter and eight points on tanks over 25 m diameter should be marked around the base of the tank for subsequent leveling reference. A greater number of points may be required for large tanks and/or where a complex settlement pattern is expected. Before water is added to the tank, the levels at each reference point should be recorded. Permanent reference levels have to be established in locations unaffected by tank loading.

10.6.6 Typically, where settlements of over 300 mm may be expected, water should be added to the tank at about 0.6 m per day until about 3 m of water is stored. At such a head, filling should cease and levels at the reference points should be recorded daily. Daily reference point levels should be plotted on a timescale to follow the pattern of settlement.

10.6.7 When the daily rate of settlement begins to decrease, water should be added to the tank in decreasing increments of head when the settlement graph shows that the rate of settlement under each new increment of load is reducing.

As the water load nears the full capacity of the tank, water should preferably be added after an early morning check of reference levels so that further readings can be taken during the day and the tank offloaded should the rate of settlement increase unduly. On very weak soils, these tests may extend over considerable periods and where such conditions apply, the tank builder should be advised so that adequate provisions can be made in his program for the necessary testing and acceptance procedure.

10.6.8 As a guide, when ground conditions are good and settlement is expected to be negligible, the tank may be half-filled with water as quickly as practicable, having regard to its size, the pumping facilities and water supply available. No further filling should proceed until levels have been taken and checked against the readings when empty to ensure that no uneven settlement is occurring in which case filling can proceed until the tank is three-quarters full, when level readings should be taken again. Provided the tank remains level with only slight settlement due to load, filling can then proceed until the tank is full, when level readings are again repeated. The full water load should be maintained for 48h and provided levels remain sensibly consistent, the tank can be offloaded prior to calibration for service.

10.6.9 Uneven settlement of the tank on its foundation shall be reported immediately to the owners representative, and filling shall be stopped at any signs of excessive settlement pending a decision by the owner's representative on the action to be taken.

10.7 Shell Testing

10.7.1 The shells of fixed roof tanks shall be tested after completion of the roof, and those of open top or floating roof tanks after completion of the wind girder.

10.7.2 Continuous inspection shall be maintained for the whole filling period. All leaks found shall be repaired with the water level at least 300 mm below the point being repaired.

10.7.3 Any tank showing evidence of leakage from the bottom during water test should be emptied immediately. The source of such leaks should be determined and rectified. Where there is risk that the leakage may have caused washout of the foundation material, the foundations are to be inspected. The repair of the foundation should be subject to special consideration and approval by the Company.

10.8 Floating Roof Testing

10.8.1 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.

10.8.2 Each completed compartment of pontoon roof shall be individually tested with an air pressure of 7 mbar gage, a soapy water solution being applied to all welded joints under pressure which have not been previously tested with penetrating oil.

10.8.3 The roof shall be given a floatation test while the tank is being filled with water and emptied. During this test, the upper side of the lower deck and all pontoon compartments shall be examined for leaks. Rainwater shall be prevented from entering the pontoon compartments during this test.

It is recommended that a similar tightness check is made during the first filling with oil, as the roof will immerse deeper in oil than in water.

10.8.4 Roof drain pipe systems shall be tested with water to a pressure of 3.5 bar.

10.8.5 The sealing mechanism shall be checked to ensure proper functioning over the full height of the shell.

10.9 Fixed-Roof Testing

10.9.1 When the tank shell is tested with water the roof joints shall be tested by applying an internal air pressure equal to 7.5 mbar for non-pressure tanks and 3 mbar above the design pressure of the tank for pressure tanks.

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

Attention is drawn to the need for careful control and monitoring of pressures during this testing. Climatic changes can cause sharp fluctuations in test pressures and provision should be made for the safe relief of pressure or vacuum in the event of such fluctuations.

10.9.2 Pressure and vacuum relief vents shall normally be installed after completion of the tank water test or alternatively shall be blanked-off during the testing of the roof. After installation or immediately following the roof pressure test all vents shall be carefully examined to ensure that all packing and blanks have been removed and that all moving parts function normally.

10.10 Anchorages

If tank anchorages are provided, they should be checked and readjusted, if necessary, with the tank full of water and prior to the air pressure test.

10.11 On completion of all tests, the entire storage tank must be free from leaks to the satisfaction of the owner inspector.

10.12 Hydrostatic tests shall commence and finish during daylight hours.

11. PAINTING

11.1 If required, external or internal painting of storage tanks shall be in accordance with Table 1 and Appendix c of Iranian Petroleum Standard IPS-E-TP-100 "Paints"

12. SPACING AND DIKES

12.1 Definitions

12.1.1 Tank spacing is the unobstructed distance between tank shells, or between tank shells and the nearest edge of adjacent equipment, property lines or buildings.

12.1.2 Dike is an earth or concrete wall providing a specified liquid retention capacity .

12.1.3 Toe wall is a low earth, concrete, or masonry unit curb without capacity requirements for the retention of small leaks or spills.

12.1.4 Diversion wall is an earth or concrete wall which diverts spills to a safe disposal area.

12.1.5 Low-flash stocks are those having a closed cup flash point under 55°C (such as gasoline, kerosene, jet fuels, some heating oils, diesel fuels) and other stock that may be stored at temperatures above or within 8°C of its flash point (such as some heated asphalts). Crude oils are not included in this category.

12.1.6 High flash stocks are those having closed cup flash point of 55°C or over (such as heavy fuel oils, lubricating oils, transformer oils and some asphalts). This category does not include any stock that may be stored at temperatures above or within 8°C of its flash points.

12.2 Earth dikes shall be used except where space limitations require the use of concrete. Proposals to provide concrete dikes over 2 m high, shall be approved by owner’s engineer.

12.3 All dikes, diversion walls and toe walls shall be suitable for the static hydraulic and temperature conditions which may be encountered, and shall be liquid tight.

12.4 Above ground tank piping for any tank or group of tanks enclosed by a dike shall not run through other diked areas. However, piping of tankage within a group may cross intermediate toe walls within that group. This qualification does not apply to intermediate dikes of paired tanks.

12.5 Pumps shall be located outside the diked area, unless a high flash viscous stock requires the pump to be located within the diked area.

12.6 Other equipment, such as air illuminators, filter and air cooled heat exchangers, shall be located outside the diked area. Shell and tube exchangers and coolers integral with the piping system may be located within the diked area.

12.7 Dike Arrangement

12.7.1 Dike arrangement for low-flash stocks shall be as follows:

a) Tankage may be grouped within a single dike, provided a combined capacity of 48000 m^3 is not exceeded. Each tank with a capacity of 8000 m^3 or greater or group of tanks with a capacity of more than 8000 m^3 shall be separated from other tanks in the same group by toe wall.

b) Two tanks with a combined capacity exceeding 48000 m^3, regardless of individual capacity, may be paired within a single dike. An intermediate dike shall be provided between paired tanks.

c) Single tanks which cannot be grouped or paired shall be enclosed by individual dikes.

d) If roofs are other than floating roofs, the tank diameter shall be limited to 45 m.

12.7.2 Dike arrangement for crude oil stocks shall be as follows:

a) Floating roof tanks shall be enclosed by individual dikes, or paired within a single dike. An intermediate dike shall be provided between paired tanks.

b) Fixed roof tanks shall be enclosed by individual dikes. Pairing is not allowed.

12.7.3 For high flash stocks, any number of tanks regardless of total capacity, may be grouped within a single dike or toe wall.

12.7.4 The pairing principle for arrangement of low-flash stocks or crude oil in floating roof tanks may be extended to include a total of three tanks, but only in the case of an odd number of tanks. For example, nine tanks may be arranged in three groups of two tanks each plus one group of three, but not three groups of three tanks. The tanks shall be separated by intermediate dikes.

12.8 Dike Capacities

12.8.1 For low flash stocks and crude oils, dike net capacities shall be as per Table 4.

TABLE 4 - DIKE CAPACITIES

TYPES OF STOCKS AND TANKAGE	ONE TANK	PAIRED TANKS	GROUPED TANKS
LOW FLASH STOCKS IN FIXED OR FLOATING ROOF TANKS	75% CAPACITY OF ENCLOSED TANK	75% CAPACITY OF LARGEST TANK ALLOWING FOR THE DISPLACEMENT OF OTHER TANK(S)	100% CAPACITY OF LARGEST TANK ALLOWING FOR THE DISPLACEMENT OF ALL OTHER TANK(S)
CRUDE STOCKS ON FLOATING ROOF TANKS	75% CAPACITY OF ENCLOSED TANK	75% CAPACITY OF LARGEST TANK ALLOWING FOR THE DISPLACEMENT OF OTHER TANKS	NOT PERMISSIBLE
CRUDE STOCKS IN FIXED ROOF TANKS	100% CAPACITY OF ENCLOSED TANK	NOT PERMISSIBLE	NOT PERMISSIBLE

12.8.2 For high-flash stocks there are no minimum retention capacity requirements, however tanks in such services shall be surrounded by a peripheral toe wall.

12.8.3 Where the terrain slope from tankage containing high-flash or low-flash or crude stocks is towards critical areas, means shall be provided to prevent dike over-flow from reaching these areas. Preferentially, this shall be accomplished by installing curbs, diversion ditches or dikes or by regrading the terrain. Increasing the dike height to contain the capacity of the largest tank is also acceptable.

12.9 Minimum height of dikes, measured from within the dike shall be 300 mm for concrete dikes, and 450 mm plus any required freeboard for earth dikes. The freeboard allowance shall be at least 200 mm. Additional freeboard may be required for soil consolidation.

12.10 Maximum Height of Dikes

The required capacity normally shall be provided with dikes no higher than 2 m as measured from outside of the dike on the side adjacent to the road or accessway. This height does not include freeboard.

12.11 Height of intermediate dikes between paired tanks shall be 300 mm less than the height of the peripheral dike both measurements include freeboard.

12.12 Minimum height of toe walls shall be 450 mm (excluding freeboard) if of earth construction, and 300 mm if constructed of concrete or masonry.

12.13 Access and Egress

At least one stairway shall be provided over earth and concrete dikes, however, at least two stair ways shall be provided for concrete dikes 1 m or more high and earth dikes over 2 m high. When two stairways are provided they shall be on opposite sides of the dike enclosure. At least one stairway shall be located as close as possible to a fire hydrant.

12.14 Earth dike or toe wall construction shall be as follows:

a) When granular material that is previous to the liquid being stored is used the slopes subject to the liquid exposure shall be covered with a blanket of impervious material such as clay. This blanket layer shall be at least 150 mm thick (measured perpendicular to the slope) after compaction.

b) The surface of the dike or toe wall shall be protected against erosion.

12.15 Draining Diked or Toe Wall Enclosures

Where rain water will not percolate through the bottom of the enclosure within 24 hours, a drain system shall be installed to provide for rain run off. The drain system shall be either:

a) A sealed catch basin within the enclosure, discharging to the sewer system.

Where the diked area is specified as an auxiliary rainwater retention basin, a valve shall be provided in the catch basin line to the sewer in an accessible location outside the dike.

b) A pipe through the dike or toe wall discharging to an open ditch draining system outside the enclosure and provided with a valve or shear gate in an accessible position outside the dike.

12.16 Grading of diked or toe wall enclosures shall direct the liquid from a leak in the vessels or piping to an area within the enclosure that is remote from the vessels and piping.

12.17 Tanks Spacing

12.17.1 Minimum spacing between tanks shall be as shown in Table 5.

TABLE 5 - TANKS SPACING

MINIMUM SPACING BETWEEN:			
TYPE OF STOCKS AND TANKAGE	SINGLE OR PAIRED TANKS	GROUPED TANKS	ADJACENT ROWS OF TANKS IN SEPARATE GROUPS
LOW-FLASH STOCKS IN FLOATING ROOF TANKS	¾ TANK DIAMETER. NEED NOT EXCEED 60 m	½ TANK DIAMETER NEED NOT EXCEED 60 m	¾ TANK DIAMETER, NOT LESS THAN 22.5 m. NEED NOT EXCEED 60 m
LOW-FLASH STOCKS IN FIXED ROOF TANKS	1 TANK DIAMETER	½ TANK DIAMETER	1 TANK DIAMETER. NOT LESS THAN 30 m
CRUDE OIL STOCKS IN FLOATING ROOF TANKS	¾ TANK DIAMETER. NEED NOT EXCEED 60 m	NOT PERMITTED	—
CRUDE OIL STOCKS IN FIXED ROOF TANKS	1.½ TANK DIAMETER. (PAIRING NOT PERMITTED)	NOT PERMITTED	—
HIGH FLASH STOCKS IN ANY TYPE TANK	½ TANK DIAMETER NEED NOT EXCEED 60 m	½ TANK DIAMETER. NEED NOT EXCEED 60 m	½ TANK DIAMETER NOT LESS THAN 15 m. NEED NOT EXCEED 60 m

Notes:

1) Spacing between high-flash and low-flash tank groups shall be governed by the low flash criteria.

2) A minimum spacing of 3 m shall be provided between any tank shell and the peripheral dike or toe wall.

3) Finished stocks with a closed cup flash point above 93°C may be spaced a minimum of 1.5 m apart provided that all of the following requirements are met:

I) The stock is stored at ambient temperature, or if heated, not above 93°C and not within 28°C of its flash point.
II) The stock is not received directly from a process unit where upset conditions could lower its flash point below the the limits of subpara.I. above.
III) There are no tanks storing low-flash stocks within the same group.

4) Finished stocks with a closed cup flash point of 55°C or higher but less than 93°C may be spaced 1/6 of the sum of their diameters apart except;

Where the diameter of one tank is less than one-half the diameter of the adjacent tank, the spacing between the tanks shall not be less than one-half the diameter of the smaller tank, provided that all of the following requirements are met:

I) The spacing between tanks is not less than 1.5 m.
II) The stock is not heated above 93°C and not within 28°C of its flash point.
III) Grouped tanks do not exceed a total capacity of 16000 m^3 and there are no tanks storing low-flash stocks within the same group.
IV) The stock is not received directly from a process unit where upset conditions could lower its flash point below the limits of subpara.II. above.

12.18 Storage tanks containing crude oil or low-flash stocks shall be located in areas remote from process units, property lines, and other areas of high occupancy.

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 A.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 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 B.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).