CONSTRUCTION STANDARD

FOR

LARGE WELDED LOW PRESSURE STORAGE TANKS

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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

This standard gives general requirements to be met by a tank erector (or erection contractor) when submitting quotations for erection of low pressure storage tanks within the scope of API Standard 620.

It should be noted that when only purchasing of materials and equipments to be incorporated into the storage tanks are involved, the requirements of Iranian Petroleum Standard "Material and Equipment Standard for Large Welded Low Pressure Storage Tanks (IPS-M-ME-110)" shall be met.

Engineering and design of storage tanks shall be in accordance with Iranian Petroleum Standard "Engineering and Design Standard for Large Welded Low Pressure Storage Tanks (IPS-E-ME-110)".

1. SCOPE

1.1 This Construction Standard, covers the minimum requirements for site erection of large welded low pressure storage tanks designed and constructed in accordance with API Standard 620.

1.2 This Standard also covers safety requirements governing the layout and spacing and the design of dikes for large welded low pressure storage tanks, tanks for storage of liquefied hydrocarbon gases and tanks for storage of refrigerated products.

1.3 The requirements of this standard are in addition to those of API Standard 620 Seventh edition, September 1982 incorporating revision, April 1985.

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)

API Standard 620	"Recommended Rules for Design and Construction of Large, Welded, Low-pressure Storage Tanks"
API Standard 620 Appendix Q	"Low Pressure Storage Tanks for Liquefied Hydrocarbon Gases"
API Standard 620 Appendix R	"Low Pressure Storage Tanks for Refrigerated Products"

BSI (BRITISH STANDARDS INSTITUTION)

BS 4741	"Specification for Vertical Cylindrical Welded Steel Storage Tanks for Low Temperature Service Single Wall Tanks for Temperature Down to -50 °C" 1971 and 1980 Addenda
BS 5387	"Specification for Vertical Cylindrical Welded Storage Tanks for Low Temperature Service Double Wall Tanks for Temperature Down to -196°C" 1976

IPS (IRANIAN PETROLEUM STANDARDS)

IPS-M-ME-110	"Material and Equipment Standard for Large Welded Low Pressure Storage Tanks"
IPS-E-ME-110	"Engineering Standard for Large Welded Low Pressure Storage Tanks"
IPS-E-TP-100	"General Requirements for Paints"
IPS-E-CE-120	"General Requirements for Foundations"

3. UNITS

3.1 International system of units (SI) in accordance with IPS-E-GN-100 shall be used.

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

3.3 For pipe size, the international nomenclature diameter nominal written as DN 15, 25, 40, 50, etc. has been used in accordance with ISO 6708-1980, ANSI/ASME 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. 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 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 Any damage to materials 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.

4.3 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.

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

5. FOUNDATION

5.1 Unless otherwise specified, foundations for storage tanks will be provided by the "company" and will be constructed to the specified level, profiles and tolerances.

5.2 Foundations for storage tanks shall be constructed in accordance with Iranian Petroleum Standard No. IPS-C-CE-120.

5.3 Foundation levels shall be checked before and during tank erection.

5.4 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.

5.5 Before tank erection starts, the contractor after checking the foundation as regards height, shape and level shall subsequently accept the base and take over responsibility for it. This also includes the responsibility for its appearance and final shape after completion of the tank erection, excluding the influence of soil settlement.

5.6 When foundation with concrete ring walls are used,the top of the ring shall be covered with a minimum of 5mm bitumen layer.

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

6. SITE ERECTION

6.1 General

6.1.1 Site erection of large welded low-pressure storage tanks shall be in accordance with Section 4 of API Standard 620 the requirements of Appendix Q of API Standard 620 regarding erection of low pressure storage tanks for liquefied hydrocarbon gases and those of Appendix R of the said standard regarding erection of low pressure storage tanks for refrigerated products shall be also fulfilled. The following requirements are supplementary.

6.1.2 Unless otherwise agreed with the "Owner", the erection contractor shall supply all labor, false work, scaffolding, tools, welding machines, cables and electrodes for the satisfactory erection of the tank.

6.1.3 Erection holes are not permitted in plate work.

6.1.4 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 underflushing of the plate surface occurs.

6.1.5 The workmanship and finish shall be such that all requirements of the above said stipulations are met and shall be subjected to close inspection by the erector whether or not the "owner" waives any part of his own inspection.

6.1.6 An erection procedure shall be prepared prior to commencement of erection and shall be made available to the "owner" on request. The method proposed to hold the plates in position for welding should be included in the procedure.

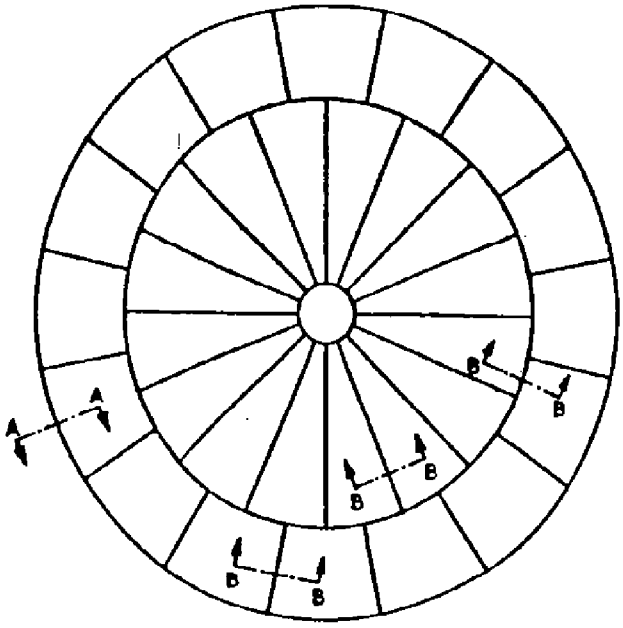
6.1.7 On all lap joints the plates shall be held in close contact during the welding operation. The surfaces where the weld metal is to be applied shall be thoroughly cleaned to bare metal before assembling.

6.2 Bottom Plating

6.2.1 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 tank erector.

6.2.2 For lap jointed bottom, plates shall be laid, commencing with the center plate and with subsequent plates lapped towards the center of tank. Layout shall be as indicated in Fig. 2.

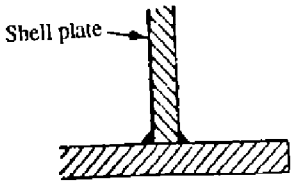
6.2.3 For butt jointed bottom, plates shall be laid and welded as indicated in Fig. 1.



Typical radial bottom layout

Layout of bottom with rectangular plates to be similar to Fig.

Section B-B

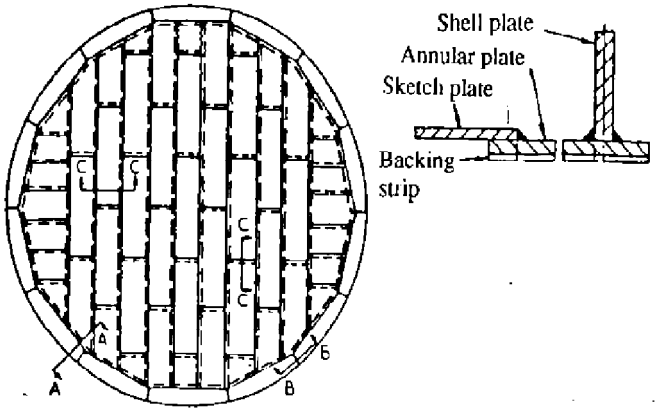


Section A-A

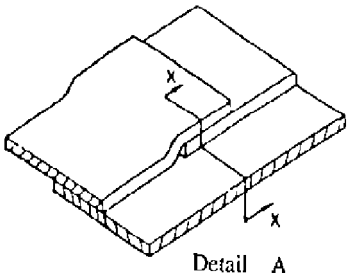
Section B-B

BUTT JOINTED BOTTOMS

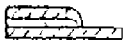
Fig. 1



Typical bottom layout

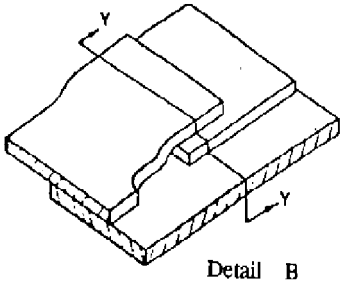


Detail A

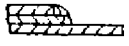


Section X-X

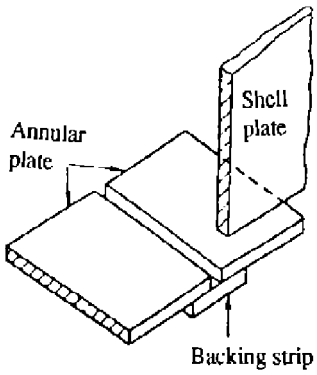
Section C-C



Detail B



Section Y-Y



For details of butt weld see Section B-B of Fig.

Annular plate joint under shell plates

Cross joints in bottom plates where three thicknesses occur

LAP JOINTED BOTTOM

Fig. 2

6.2.4 Unless otherwise specified,after the bottom plates are laid out and tack welded, they shall be joined by welding the joints in a sequence that the erector has found to result in the least distortion from shrinkage.

6.3 Shell Plating

6.3.1 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.

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

6.3.3 Protection of shell during erection

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

6.3.3.2 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.

6.4 Roof Erection

6.4.1 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.

6.4.2 The temporary support for the erection of roof framing shall remain in position until the completion of the main and secondary framing.

6.4.3 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.

6.4.4 The strength of the temporary support shall be calculated using the most unfavorable loading condition during erection.

7. WELDING

7.1 Welding of large welded low pressure storage tanks shall be in accordance with Sub-section 4.6 of API Standard 620. In the case of low pressure storage tanks for liquefied hydrocarbon gases and low pressure storage tanks for refrigerated products, welding shall be in accordance with Appendix Q and Appendix R of API Standard 620 respectively.

7.2 All welding, including repair,tank and attachment welding, shall be carried out according to the welding procedure established and by qualified welders.

7.3 The fillet welds of lap joints between the bottom plates and the fillet welds joining shell plates to bottom plates in contact with the stored liquid shall consist of a minimum of two passes.

7.4 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.

7.5 If required, weld metal and heat affected zones of butt welds for primary components (in the case of storage tanks designed according to Appendix Q and R of API Standard 620) shall be impact tested per API Standard 620 at the critical exposure temperature.

7.6 In the case of storage tanks designed and constructed in accordance with Appendix Q and R of API Standard 620, the tank erector shall check the weld hardness of the initial production weld for each welding process, filler metal, and technique used.

7.7 At the discretion of the owner, welding procedure qualification tests may not be required where:

a) The welding details specified are followed and where the brand and type of electrode employed is one with which owner has had previous satisfactory experience, and/or.

b) Previously qualified procedure test certificates are accepted by owner.

8. TOLERANCES

Tolerances on completed low-pressure storage tanks shall be per API Standard 620 Section 4 except as noted below:

8.1 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.

8.2 At horizontal and vertical joints the shell profile shall not deviate from its design form by more than the following, measured over a gage length of 1 m:

Plates up to and including 12.5 mm thick:	10 mm
Plates over 12.5 mm up to and including 25 mm thick:	8 mm
Plates over 25 mm thick:	6 mm

8.3 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.

9. INSPECTION

9.1 Inspection of large welded low-pressure storage tanks shall be in accordance with Section 5 of API Standard 620. Low-pressure storage tanks for liquefied hydrocarbon gas and those for refrigerated products shall be inspected per Appendix Q and R of API Standard 620 respectively. The followings shall be considered as supplementary.

9.2 The owner's representative 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.

9.3 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.

9.4 The use of sectioning, trepanning or other destructive methods of testing welds are not permitted.

9.5 Welds that are shown by radiography or other means 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) Crack of any form or size.
b) Incomplete fusion or incomplete penetration.
c) Slag inclusion.
d) Porosity.

9.6 Radiographic examination is not required for the examination of fillet welds.

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

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

b) The weld is free from undercutting.

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

d) 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.

e) The height and spacing of ripples are uniform.

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.

9.8 Inspection of Tank Bottom Welds

9.8.1 All bottom annular plate joints shall be radiographically inspected (if applicable).

9.8.2 Vacuum testing of all bottom plate joints shall be conducted per API Standard 620, except with a partial vacuum maintained at 41 kPa (6 psig) minimum.

9.8.3 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.

9.9 Inspection of Tanks Shell Welds

9.9.1 In addition to visual inspection, butt welds in the tank shell shall be radiographically inspected to the following minimum extent.

9.9.2 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:

9.9.2.1 All T-Junctions in shell plates over 16 mm thick, approximately 50% with the film horizontal and 50% vertical.

9.9.2.2 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.

9.9.2.3 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.

9.9.2.4 1% of the vertical seam length for plates 10 mm thick and less but with not less than one radiograph on each vertical seam.

9.9.2.5 2% of the horizontal seam length for all plate thicknesses.

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

9.9.2.7 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.

9.9.3 If the weld at either of these sections fails to comply with requirements of 9.5, additional nearby spots shall be examined until the limits of such welding are determined, or at the option of the erector, all the weldings 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 9.5 the limits of such welding shall be determined as specified for the initial section.

9.10 Inspection of Tank Roof Welds

9.10.1 When the tank shell is tested with water the roof joints shall be tested by applying an internal air pressure and using soap solution or other suitable material for the detection of leaks.

9.10.2 If specified,the tank roof joints shall be tested by means of magnetic particle, liquid penetrant or any other non-destructive method and to the extent specified.

9.11 Bottom to shell double fillet "T" joints shall be examined per API Standard 620 and as follows:

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

9.12 For tanks constructed to API Standard 620 Appendix R, all welds for attaching nonpressure parts to the bottom and shell shall be examined 100% by the liquid penetrant or magnetic particle method, as applicable, before hydrostatic testing.

9.13 Welds attaching nozzles, manholes, and flush type openings shall be examined by the magnetic particle or liquid penetrant method, as applicable.

9.14 Nozzle and manway reinforcing plates shall be tested with air pressure and soap suds after welding to the shell. No air leakage is permitted.

10. TANK TESTING

10.1 Large welded low-pressure storage tanks shall be tested per API Standard 620 Section 5, Appendix Q or Appendix R as applicable, and the following:

10.2 Tank shall be subjected to a fully hydrostatic test in which the fill height shall equal the design liquid height.

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

Tank material of construction	Stress limitation % of specified or guaranteed min. yield strength at room temperature
Ferritic Steel	90
Austenitic Stainless Steel Non Ferrous Material	100 100

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

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

10.5 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.

10.6 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.

10.7 Shell and bottom settlement measurements shall be made by the tank erector 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:

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:

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

10.8 Hydrostatic tests shall commence and finish during daylight hours.

10.9 The tank erector 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.

11. TANK ACCESSORIES

11.1 The tank erector shall install and test all accessories specified and so requested in the erection contract.

11.2 The tank erector shall install and test water deluge system piping and components (if specified), terminating at laterals at the base of the tank.

12. INSULATION, PAINT AND FIREPROOFING

12.1 If required, the tank erection contractor shall install thermal insulation as specified and after all other works of installation is completed.

12.2 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".

12.3 Fireproofing of tank supports and pipe supports (if any) within dikes of tankage in cryogenic service shall be installed by the tank erector as specified.

13. SPACING AND DIKES

13.1 Definitions

13.1.1 Tank diameter

Where tank spacing is expressed in terms of tank diameter, the diameter of the largest tank is used. For spheroids, the diameter at the maximum equator is used. For double walled tanks, the outside shell diameter is used.

13.1.2 Tank spacing is the unobstructed distance between tank shells and the nearest edge of adjacent equipment, property lines or buildings. For double walled insulated tanks the distance is measured from the outside shell containing the insulation.

13.1.3 Diversion wall is an earth or concrete wall which directs spills to a safe disposal area.

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

13.2 Diversion walls and sloping of the ground away from tanks to a remotely located retention basin is permitted, when approved by the owner’s engineer.

13.3 For anhydrous ammonia storage, only diked retention shall be used.

13.4 Earth dikes shall be used, except where space limitations require the use of concrete.

13.5 Dikes and diversion walls shall be suitable for the static hydraulic and temperature conditions which may be encountered in a spill, and shall be liquid tight.

13.6 Above-ground piping for any storage tank or group of tanks shall not run through other diked areas, or crosses intermediate dikes of paired tanks.

13.7 Piping manifolds and associated pumps and refrigeration equipment shall not be located within diked areas for refrigerated storage tanks except those for shell and tube exchangers.

13.8 Tank piping supports; and drain system piping including the block valve, for draining diked enclosures; shall be constructed of materials suitable for the lowest temperature which may be encountered during a spill.

13.9 Dike Arrangement and Capacities

13.9.1 Single tanks in diked enclosures

The capacity of the dike shall not be less than 75% of the capacity of the enclosed tank.

13.9.2 Paired tanks

Two tanks of similar basic design (i.e. both spheres or both tanks) regardless of capacity may be paired and enclosed by a single peripheral dike, provided the following requirements are fulfilled:

a) Capacity of the peripheral dike shall be 100% of the capacity of the larger tank allowing for the displacement of the second tank.

b) An intermediate dike shall be provided between paired tanks.

13.9.3 Extension of pairing principle

The pairing principle may be extended to include 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 and one group of three but not three group of three tanks. Where the pairing principle is extended to include three tanks, the capacity of the peripheral dike shall be 100% of the capacity of the largest tank allowing for the displacement of the remaining two tanks and the tanks shall be separated by intermediate dikes.

13.9.4 Minimum height of dikes

As measured from within the dike,shall be 1 m for concrete or earth dikes plus any required freeboard for earth dikes. The freeboard allowance shall be at least 200 mm. Additional freeboard may be required for soil consolidation.

13.9.5 Maximum height of dikes

As measured from inside or outside the dike, is limited as follows:

a) For tanks storing heavy stocks the dike height,excluding freeboard shall not exceed 2 m.
b) For tanks, storing light stocks the dike height shall not exceed 4 m.

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

13.10 Access and Egress

At least one stairway shall be provided over earth and concrete dikes however at least two stairways shall be provided for concrete dikes 1m 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 fire hydrant.

13.11 Earth dike construction shall be as follows:

a) For dikes constructed of granular material that is pervious to the liquid being stored 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 shall be protected against erosion.

13.12 Grading of Diked Enclosures

Grading within dikes shall be as follows:

a) For hydrocarbon storage, the grading shall direct the liquid from a leak in the tank or piping to an area within the enclosure remote from the tank and piping.

b) For ammonia storage the grading shall contain the liquid from a spill to a small area within the enclosure.

13.13 Draining Diked 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 provided with a gate valve or shear gate located in an accessible position outside the dike. The valve shall normally be kept closed. The drain system shall be either:

a) A catch basin within the diked area discharging to the sewer system or.
b) A pipe through the dike discharging to an open ditch drainage system outside the dike.