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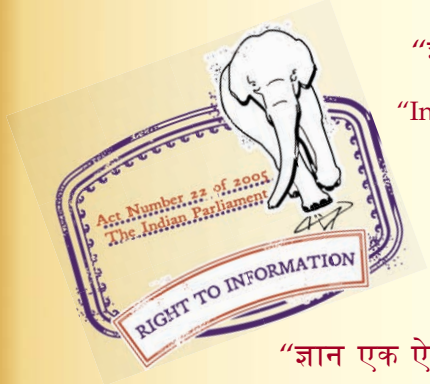

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"Knowledge is such a treasure which cannot be stolen"

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IS : 805 - 1968
(Reaffirmed 2006)

Indian Standard

CODE OF PRACTICE FOR USE OF STEEL IN GRAVITY WATER TANKS

(Sixth Reprint JUNE 1998)

UDC 621.642.3 : 628.13 : 669.14

BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
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March 1969

Indian Standard

CODE OF PRACTICE FOR USE OF STEEL IN GRAVITY WATER TANKS

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CODE OF PRACTICE FOR USE OF STEEL IN GRAVITY WATER TANKS

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 4 November 1968, after the draft finalized by the Structural Engineering Sectional Committee had been approved by the Structural and Metals Division Council and the Civil Engineering Division Council.

0.2 This code lays down the recommended practice for the design, fabrication and erection of steel gravity water tanks, either elevated, or constructed on concrete or earthy foundations. It is designed to provide the user with tanks with adequate safety and reasonable economy which can be built in any size to meet the required capacity. It was considered not necessary to include the sizes or capacity of the tanks and the dimensions and details of the appurtenances.

0.3 Taking into consideration the views of producers and consumers, the Sectional Committee felt that it should be related to the manufacturing and trade practices followed in the country in this field. Furthermore, this consideration led the Sectional Committee to derive assistance from Specification No. 11A-1938 'Gravity water-tanks and steel towers, Volume I Structural details' issued by the Associated Factory Mutual Fire Insurance Companies, USA.

0.4 This code forms one of a series of codes on use of steel in structures. Other standard codes in the series are:

IS : 800-1962 Use of structural steel in general building construction (*revised*)

IS : 801-1958 Use of cold formed light gauge steel structural members in general building construction

*IS : 802 (Part I)-1967 Use of structural steel in overhead transmission line towers : Part I Loads and permissible stresses

IS : 803-1962 Design, fabrication and erection of vertical mild steel cylindrical welded oil storage tanks

IS : 804-1967 Rectangular pressed steel tanks (*first revision*)

IS : 806-1968 Use of steel tubes in general building construction (*revised*)

*Since revised.

0.5 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test shall be rounded off in accordance with IS : 2-1960*. The number of significant places retained in the rounded off value should be the same as that of the specified value in this code.

SECTION I GENERAL

1. SCOPE

1.1 This code covers materials, design, fabrication and testing requirements for mild steel gravity water tanks for erection above ground.

2. TERMINOLOGY

2.0 For the purpose of this code, the following definitions shall apply.

2.1 Tank — Tank shall mean an elevated tank, a standard pipe or a reservoir.

2.2 Elevated Tank — Elevated tank shall mean a container or storage tank supported on a tower.

2.3 Capacity — Capacity shall mean the net volume contained between the level of the overflow and the lowest specified level.

3. MATERIAL

3.1 plates and sections in structural plates and sections used in tank construction shall comply with IS : 226-1962† or IS : 2062-1962‡ whichever is appropriate.

3.2 Rivet Steel — Rivet, which shall be used in tank construction, shall conform to IS : 1148-1964§.

3.3 Electrodes — Mild steel electrodes shall comply with the requirements of IS : 814-1967||.

3.4 Steel Mountings — Steel required for mountings shall conform to either IS : 226-1962† or IS : 2062-1962‡.

3.5 Material not covered under **3.1, 3.2, 3.3** and **3.4** and used in the construction of tanks shall conform to relevant Indian Standards.

4. FORM

4.1 The form of a steel tank shall be cylindrical with vertical axis. If supported by a steel tower without beams, a hemispherical or other

*Rules for rounding off numerical values (*revised*).
†Specification for structural steel (standard quality) (*third revision*). (Since revised).
‡Specification for structural steel (fusion welding quality). (Since revised).
§Specification for rivet bars for structural purposes (*revised*). (Since revised).
||Specification for covered electrodes for metal arc welding of mild steel (*second revision*). (Fourth revision in 1973).

acceptable form of suspended bottom shall be provided. If a large fabricated riser is used, it should be not less than 1 m in diameter. The tank may have a flat bottom when placed on steel or concrete beams, or on a concrete slab. Shapes other than the cylindrical ones may also be used with mutual agreement between the manufacturer and the purchaser.

5. INFORMATION TO BE FURNISHED BY THE PURCHASER

5.1 The purchaser shall furnish with the enquiry or order the information as included in Appendix A.

SECTION 2 LOADS AND PERMISSIBLE STRESSES

6. LOADS

6.0 The provisions of IS : 875-1964* shall be applicable unless otherwise stated.

6.1 Dead Load — The dead load shall be the estimated weight of all permanent construction and fittings.

6.2 Live Load — The live load shall be the weight of all the liquid when overflowing the top of the tank. The density of water shall be taken as 1 gm/cm^3.

6.3 Wind Load — Wind pressure shall be assumed as given in IS : 875-1964*. This pressure shall be multiplied by 0·6 to get the design pressure on cylindrical, conical, hemispherical and elliptical surfaces. This wind pressure shall be applied on the total area of projection, the point of application being the centre of gravity of the projected area.

6.4 When subjected to seismic effects the provisions contained in IS : 1893-1966† shall apply.

7. PERMISSIBLE STRESSES

7.1 The permissible stress specified in IS : 800-1962‡ and IS : 816-1956§ are basic stresses for the purposes of this code. They shall be reduced for the design of tank as specified in **7.2** and **7.3**.

7.2 Permissible Stresses for Tank Plates — The values given in IS : 800-1962‡ shall be multiplied by 0·8 to derive the permissible stress in the tank plates.

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*Code of practice for structural safety of buildings : Loading standards (*revised*).
†Criteria for earthquake resistant design of structures (*first revision*).
‡Code of practice for use of structural steel in general building construction (*revised*).
§Code of practice for use of metal arc welding for general construction in mild steel. (Since revised).

7.3 Welded Constructions —The values given in IS : 816-1956* shall be multiplied by 0·8 to derive permissible stresses for welds in tank plate construction.

7.4 For the design of supporting structure, the permissible stresses given in IS : 800-1962† and IS : 816-1956* shall be applicable.

SECTION 3 DESIGN

8. GENERAL

8.1 The provisions of IS : 800-1962† and IS : 816-1956* in conjunction with the provisions of this standard shall be applicable for design of gravity water tanks and supporting structures.

9. EFFICIENCY OF WELDED JOINTS

9.1 For joint in tanks, the efficiency factors given in **9.2** to **9.4** shall be applied to butt welds and fillet welds.

9.2 For all types of butt welds, for tank plate construction 0·85 shall be taken as the joint efficiency factor.

9.2.1 In the case of butt joints having the corresponding plate edges at an effect from each other within the permissible range specified in **28.2**, the joint shall be provided for the joint efficiency factor given in **9.2** after designing it for the eccentricity introduced, if any, by the offsetting.

9.3 For fillet welds, for tank plate construction, 0·75 shall be taken as the joint efficiency factor.

9.4 For the design of supporting structure, the full values of the weld joints shall be permitted.

10. THICKNESS OF METAL

10.1 Minimum Thickness — The minimum thickness of metal shall be 6·0 mm except in roofs and railings.

10.1.1 The controlling thickness for rolled beams and channels shall be taken as the mean thickness of the flange, regardless of the web thickness.

10.2 Thickness for Corrosion — Interior bracing, if unavoidable, shall always have an additional thickness of 1·5 mm added to the calculated thickness. The section shall be accessible for clearing. The plates of tanks to contain salt or alkaline water shall be 1·5 mm thicker than that calculated.

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*Code of practice for use of metal arc welding for general construction in mild steel. (Since revised).

†Code of practice for use of structural steel in general building construction (*revised*).

10.3 Thickness of Bottom Cylindrical Courses — The thickness of plates in the lower cylindrical courses of tanks with suspended bottoms shall be not less than 8 mm, for tank of capacity 500 000 to 700 000 litres, and 10 mm for tanks of capacity 700 000 to 1 000 000 litres. For larger tanks the thickness shall be at least 1·5 mm greater than that calculated.

11. LOAD LOCATION

11.1 The vertical joints between the shell plates shall be designed for the tension due to hydrostatic pressure on the shell.

11.2 The hydrostatic pressure shall be measured at 30 mm above the bottom rivet line in the lower horizontal joint of the shell ring in question (*see* Fig. 1). When welded, the hydrostatic pressure shall be computed at 30 cm above the centre line of the lower horizontal weld of the shell ring (for minimum thickness of material *see* **10**).

12. OPENING FOR CONNECTIONS

12.1 Manholes, pipe openings, and connections for attachments shall be reinforced by the additional steel plates of sufficient thickness and properly connected to carry the total load that would be carried by the cut out portion of the plate, without overstressing, when the average tensile stress in the net section of the cut plate exceeds that permitted under **7**.

13. CURVED-BOTTOM PLATES

13.1 Suspended bottom plates shall lap inside the plates of the lowest cylindrical course.

14. STIFFENING ANGLE

14.1 Stiffening angles shall be provided around the top of tank without roofs. The stiffening angles shall have a minimum section modulus determined by the equation

$$Z = 0{\cdot}0\,578\ D^2H$$

where

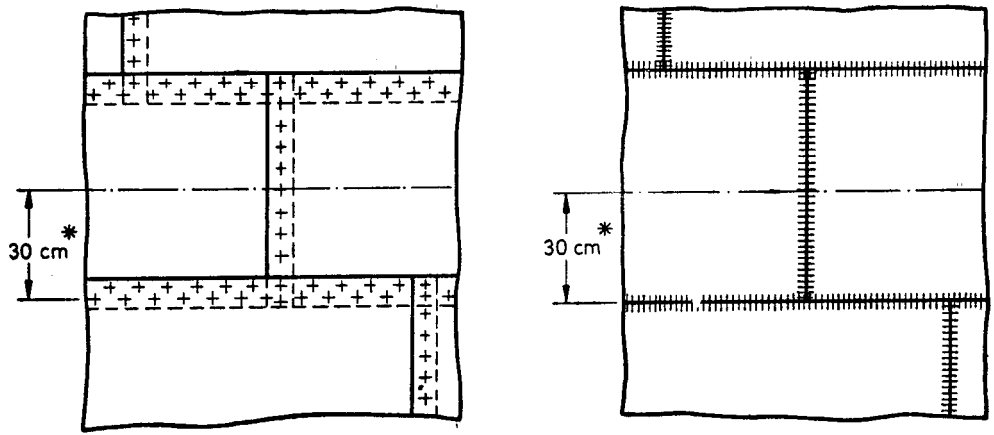
Z = modulus of section in cubic centimetres,

D = nominal diameter of tank in m, and

H = height of cylindrical portion of tank shell in metres.

15. BOTTOM ANGLE

15.1 The sides and bottoms of flat bottom tanks of riveted construction 6 m and over in diameter shall be connected by spliced angles caulked along both legs.



1A Riveted Joint

1B Welded Joint

*NOTE — The hydrostatic pressure to be measured at this height.

FIG. 1 VERTICAL JOINTS BETWEEN SHELL PLATES

16. RIVETED JOINTS

16.1 Minimum Pitch of Rivets — The minimum distance between centres of rivet holes, shall be not less than 2·5 times the diameter of the rivet hole.

16.2 Maximum Pitch of Rivets — The maximum distance between centres of rivet holes along caulking edges of plates, except at the column connections, shall not exceed 10 times the thickness of the thinnest plate for single riveted joints, or 12 times the thickness of the thinnest plate in joints having more than one row of rivets.

16.3 Staggering of Rivets — When the rivets of adjacent parallel rows are staggered, the distance between centre lines of adjacent rows shall be at least twice the diameter of the rivet hole and the section of the plate between adjacent two rivets in adjacent rows shall be at least 0·6 times the section between two rivets in the line of stress.

17. WELDED JOINTS

17.1 The joint between the shell and the flat bottom shall consist of a continuous fillet weld on both sides of the shell plate (*see* Fig. 2). Bottom plates for tank over 15 m in diameter shall be 8 mm thick.

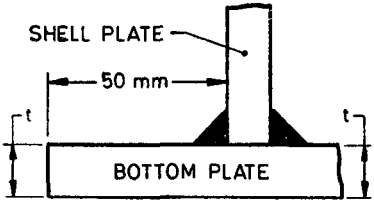


FIG. 2 WELDED CONNECTION SHELL TO FLAT BOTTOM

17.2 Single fillet lap-joints (*see* Fig. 3) may be used only on the outside of roof plates, on the inside of bottom plates resting directly on sand or concrete slab foundations, and for connecting details not in contact with water.

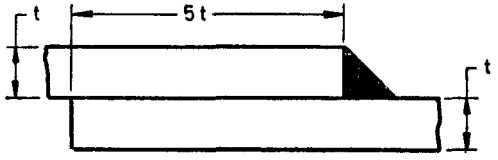


FIG. 3 SINGLE FULL-FILLET LAP JOINT

17.3 Single fillet and sealed joints (*see* Fig. 4) may be used in plates not exceeding 12 mm in thickness but not in flat bottom plates on grillage beams.

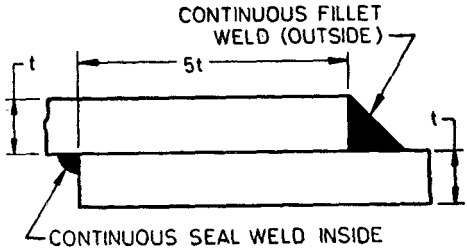


FIG. 4 SINGLE FULL-FILLET AND SEAL LAP JOINT

17.4 Doudle fillet lap-joints (*see* Fig. 5) may be used in plates not exceeding 12 mm in thickness.

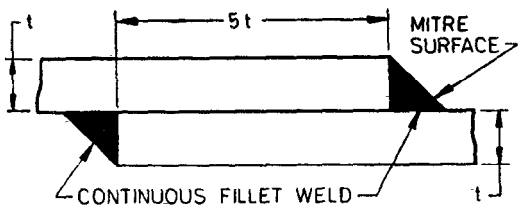


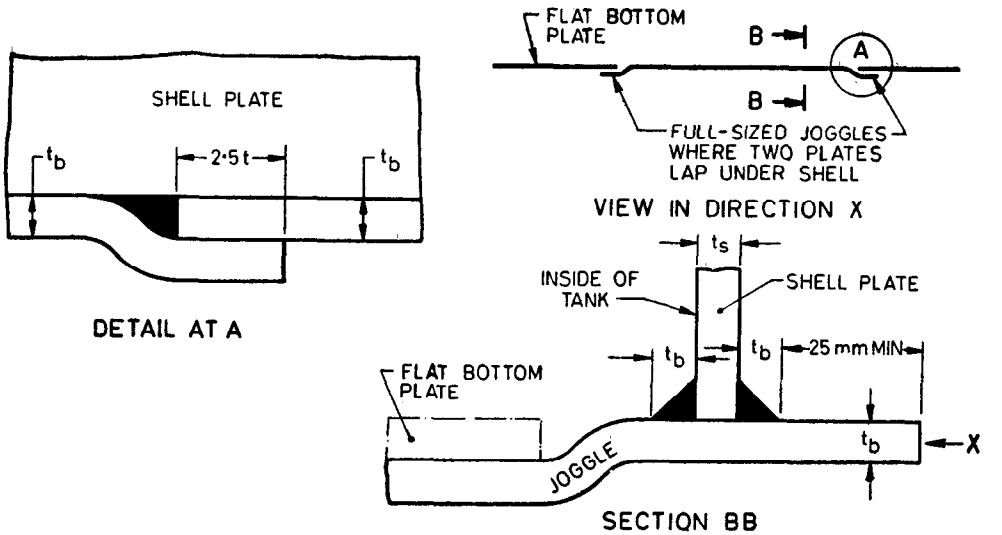
FIG. 5 DOUBLE FULL-FILLET LAP JOINT

17.5 For all butt welds, the details, that is, form of joints, angle between fusion faces, gap between parts, finish, etc, shall be arranged in accordance with Appendix C of IS : 823-1964*. The reinforcement in the case of butt welds shall not exceed 20 percent if welded from one side of the joint and 10 percent if welded from both sides of the joint.

17.6 Single bevel butt joint may be used for horizontal joints in shell plates of thickness not exceeding 12 mm. For thickness above 12 mm double bevel weld shall be used.

17.7 Where two bottom plates lap under the shell, the triangular space shall be completely filled, and a full size joggle shall be provided as shown in Fig. 6. The end joints between the sketch plates shall be arranged so that a smooth bearing for the shell is secured.

*Code of procedure for manual metal arc welding of mild steel.



NOTE — Space under shell plate completely filled with weld metal.

FIG. 6 JOGGLE JOINTS IN BOTTOM PLATES

SECTION 4 ACCESSORIES

18. CONNECTIONS

18.1 Connections shall be provided on the tank for necessary pipes, braces and walkway supports.

19. ROOF

19.1 General — A conical or dome-shaped steel or iron roof shall be provided when the tank is situated outdoors. The roof plates shall be at least 3 mm thick, joined together with rivets or bolts spaced not more than 15 cm apart, or by welding. The roof shall not be air-tight unless an adequate vent is provided to prevent appreciable variations in pressure in the tank during filling or discharge. Conical roofs with a minimum slope of 30° are considered self supporting when roof-plates are 3 mm thick on tanks not over 9 m in diameter and when plates are 5 mm thick on tanks not over 12 m in diameter. Flatter or larger roofs shall be supported by steel rafters. A cover may also be required when the tank is inside a building.

19.2 Roof Anchorage — Each roof plate shall be securely fastened to the top of the tank by two or more connections spaced systematically but not over 75 cm apart, and containing bolts or rivets at least 12 mm in diameter, or by equivalent welding. Stitch welding or short fillets shall be used.

19.3 Roof Hatch — An easily accessible hatch not less than 50 × 55 cm shall be provided in the roof. The hatch-cover shall be built of steel or iron plate at least 3 mm thick and shall open to the right on heavy hinges having non-corrodible pins. A substantial catch shall be provided to keep the cover closed. Other forms of hatch-cover may be accepted but approval of the design shall first be obtained from the inspector.

20. LADDERS

20.1 General — Inside and outside steel ladders arranged for convenient passage from one to the other and through the roof hatch shall be provided. Ladders shall not interfere with opening of the hatch-cover and shall not incline outward from the vertical at any point. Ladders fixed to the tank side are preferred. Welding of ladders to the tank shell is permitted. Ladders may be of welded construction.

20.2 Outside Fixed Ladder — An outside fixed ladder shall be provided at least 15 cm away from the tank side and rigidly bolted or welded to brackets riveted or welded to the tank plates not over 3·0 m apart. The top bracket shall not be more than 30 cm below the top of the shell and

the bottom bracket not more than 1·5 m above the base of the tank cylinder. The fixed ladder shall be in line with the roof hatch. The sides of the ladder shall extend 45 cm above the top of the tank and then bent downward in an arc to the tank roof where the ends shall be securely fastened.

20.2.1 Where the height of the tank is more than 6 m, safety cages should be provided as a protective measure.

20.3 Outside Revolving Ladder — An outside revolving ladder, if provided, in lieu of an outside fixed ladder, shall not exceed 9 m in length and shall extend from supporting tower ladder to painters' trolley. The ladder shall be rigidly bolted at the top and bottom in its normal position in line with the supporting tower ladder and just to the left of the roof hatch.

20.4 Inside Ladder — The inside ladder shall be riveted or welded to the cylindrical shell by brackets not over 3·0 m apart, the upper bracket being located at the top of the tank. The portion of the ladder in the suspended bottom shall extend to the lowest point, and be provided with brackets not over 3·0 m apart which will rest upon the tank without scraping off the paint. The brackets shall not be connected to the suspended bottom plates.

20.4.1 A ladder shall extend from the top to the bottom inside the larger riser pipes 1 m or more in diameter and shall be secured to the riser shell plates by brackets spaced not over 3·0 m apart, the upper bracket being located at the top of the riser.

20.5 Ladder Bars and Rungs — Ladder side bars shall be not less than 50 × 6 mm flat steel for fixed ladders, and 65 × 10 mm for movable ladders. Side bars shall be spaced 25 cm apart. Rungs shall be at least 16 mm round or square steel spaced 30 cm on centres. The rungs shall extend through and be firmly riveted or welded to the side bars. Ladders and connections shall be designed to support a concentrated load of 160 kg.

20.6 Painters' Trolley — Some form of trolley or other acceptable device shall be provided for all elevated tanks to facilitate repainting the outside of the tank. The connection of the trolley at the top of the tank shall be substantial. The lower end of the trolley shall be provided with a substantial U-bolt or other suitable device for the painters' use.

SECTION 5 FABRICATION

21. GENERAL

21.1 The provisions of IS : 800-1962* in conjunction with the provisions of this code shall apply for fabricating gravity water tanks.

*Code of practice for use of structural steel in general building construction (*revised*).

21.2 Where fabrication is by welding, provisions of IS : 816-1956* in conjunction with the provisions of this code shall apply.

21.3 Welding Procedure: The provisions contained in IS : 823-1964† shall apply.

22. SHAPING OF SHELL PLATES

22.1 Shell plates may be shaped to suit the curvature of the tank and the erection procedure to the following schedule:

Nominal Plate Thickness	*Nominal Tank Diameter*
mm	m
10	9 and less
12	18 and less
16	36 and less
Over 16	all sizes

Except where otherwise specified by the purchaser the shell plates shall be rolled to correct curvature.

23. CAULKING

23.1 Riveted tanks shall be made water-tight by caulking the edges of the plates with a round rosed tool before painting. Foreign material, such as lead, copper fillings, cement, etc, shall not be used in the joints.

24. FITTING ROOFS

24.1 The roof shall fit tightly to the top of the tank to prevent circulation of air over the surface of the water. To assist in obtaining a tight fit, a grid or spider consisting of steel rods spaced preferably not over 1 m apart may be placed around the top of the tank running radially inward to a ring. The spider shall not obstruct the flow of water into the overflow inlet.

25. BOTTOM PLATES ON SOIL OR CONCRETE

25.1 Coatings — Heavily tarred paper 25 cm wide shall be laid symmetrically under all seams and the outside edge to be welded in flat

*Code of practice for use of metal arc welding for general construction in mild steel. (Since revised).

†Code of procedure for manual metal arc welding of mild steel.

bottom tanks on solid foundations. The underside of all bottom plates shall be painted two coats, one in the shop, and a patch and overall coat in the field before being placed in position.

26. EDGE PREPARATION FOR WELDING OF JOINTS

26.1 In no circumstances, sheared edge without dressing shall be used for welding. Flame-cut edges shall be cleaned before welding.

26. BOTTOM JOINT — WELDING

27.1 The shell plates shall be aligned by guide lugs or tack welds to the bottom plates before continuous welding is started between the bottom edge of the shell plate and the bottom plates. These tack welds, about 12 mm long, shall be chipped out as the continuous welds progress. Considerable length of vertical seam between adjoining edges of the shell plates shall be welded up from the bottom before the continuous welding of shell to sketch plates (*see* Fig. 7) proceeds beyond that point.

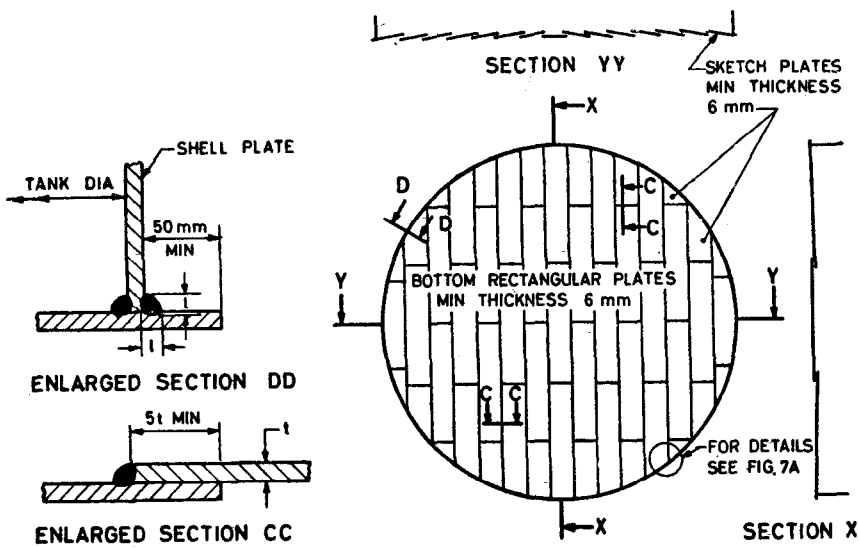


FIG. 7 TYPICAL LAYOUT OF TANK BOTTOM

(For tanks up to and including 12 m dia)

28. SHELL PLATES — MATCHING

28.1 At all fillet welds, the lapped plates shall be held in close contact during welding. Plates in which the vertical joints are to be butt welded shall be accurately matched and retained in position during welding. Tack welds may be used to hold the edges in line provided they are entirely removed so that they do not form a part of the main weld.

28.2 When assembled for welding, corresponding plate edges in butt joints shall not have an offset from each other at any point in excess of one-fourth the thickness of the thinnest plate. Bars, jacks, clamps, wedges, or other appropriate tools may be used to hold the edges to be welded in line. All shell plates shall be truly cylindrical and plumb, free from local irregularities.

28.3 If erection bolts are used for holding lap joints in line, they shall be removed before welding and replaced by light tack welds. The holes for erection bolts, as well as the holes used for lifting the plates into position, shall be sealed by full-formed rivets having heads seal-welded or by plugging with weld.

29. SHELL PLATE WELDING

29.1 General — The dimensions and shapes of the edges to be joined shall be such as to allow thorough fusion and complete penetration. On butt joints, where the width of the gap at the face of the weld is greater than 12 mm, the weld metal except the final surface layer shall be peened to relieve shrinkage stresses. This will improve the effectiveness of the finished weld.

29.2 The sequence of welding shell plates shall be such that shrinkage stresses are effectively reduced by accommodating the contraction about the weld as it cools, thus avoiding rigidity.

30. PAINTING

30.1 The whole of steelwork with the exception of rivets, bolts and nuts and machined surfaces after being thoroughly cleaned free from rust, loose scale, dust, etc, shall be given one coat of red lead paint conforming to IS : 102-1962* unless specified otherwise. All rivets, bolts, nuts and washers, etc, shall be thoroughly cleaned and dipped in boiled linseed oil. All machined surfaces shall be well coated with a mixture of white lead and tallow. Surfaces which are to be held in contact by riveting or bolting shall be painted before assembly, and the parts brought together while still wet. Unless specified otherwise, all surfaces inaccessible after riveting or intermittent welding shall be given two coats of red lead paint

*Specification for ready mixed paint, brushing, red lead, nonsetting, priming (*revised*).

conforming to IS : 2074-1962* before assembly. Welds and adjacent parent metal shall not be painted prior to cleaning, inspection and approval.

31. TESTING

31.1 Tank shell, tank bottom on grillage beams, or large riser shall be tested by filling with water and constantly inspecting all visible joints carefully. If any leaks or other defects are discovered, the water level shall be lowered immediately. Welded joints shall not be tested by hammering.

31.2 A flat bottom tank on a solid foundation shall be tested after the lowest ring of the shell, including the circumferential joint at the bottom, has been completely welded followed by welding of the contraction seams in the bottom. The outside of the shell should be sealed to the ground or other foundation with wet clay and then air forced underneath the bottom until the plates are raised a few inches. A U-tube near the centre of the bottom is used for the air collection. The seams are tested with soap solution.

31.3 The inspector may judge the quality of welds by visual inspection or by chipped out sections with a cold chisel or by having trepanned plugs removed from welds and etched, and the holes properly repaired. Rewelding shall be paid for by the purchaser unless the welds are found defective, in which case all defective welding shall be cut out and replaced at the expense of the fabricator.

32. REPAIRS

32.1 Repairs of welding by hammering of welded joints shall not be attempted while the tank is full. Welded joints shall be repaired only after lowering the water at least 60 cm below the joint to be repaired, or after completely draining. Repair shall consist of chipping or melting out of all defective metal and rewelding to give full strength.

32.2 The tank shall be entirely water-tight under test, to the satisfaction of the inspector, before painting.

*Specification for ready mixed paint, red oxide-zinc chrome, priming.

APPENDIX A

(Clause 5.1)

INFORMATION TO BE SUPPLIED WITH THE ENQUIRY AND ORDER

A-1. Capacity required in litres or dimensions in multiples of 1·25 m and if any provision is to be made for future extension.

A-2. Limiting conditions, if any, as to space and accessibility for erection and whether the tank will be erected inside a building or exposed to the atmosphere. If any partition is required, its particulars are to be given.

A-3. The fact whether the water to be stored is hard or soft to be stated. If water level indicator is to be supplied, particulars of fixing the indicator are to be given.

A-4. Any special requirements as to jointing material and as to internal and external coating or lagging.

A-5. Particulars of connections and drilling required and precise location on tank with dimensioned sketches, having regard to possible future requirements.

A-6. Whether external access ladders are required and, if so, particulars to be given.

A-7. Details of any existing or proposed supporting structure and weight of bottom of tank above ground level.

A-8. Whether transverse supporting bearers are required and, if so, particulars as to span and end support to be given.

A-9. Whether inspection will be made by the representative of the purchaser at the works of the manufacturer.

A-10. Whether erection and test are to be carried out by the manufacturer at site, if so, information as to site conditions and accessibility to be given by the purchaser, and whether water for testing will be made available by the purchaser to be stated.

A-11. Whether the tank is to be riveted or welded.

BUREAU OF INDIAN STANDARDS

Headquarters:
Manak Bhavan, 9 Bahadur Shah Zafar Marg, NEW DELHI 110002
Telephones: 323 0131, 323 3375, 323 9402
Fax : 91 11 3234062, 91 11 3239399, 91 11 3239382

Telegrams : Manaksanstha
(Common to all Offices)

	Telephone
Central Laboratory:	
Plot No. 20/9, Site IV, Sahibabad Industrial Area, Sahibabad 201010	8-77 00 32
Regional Offices:	
Central : Manak Bhavan, 9 Bahadur Shah Zafar Marg, NEW DELHI 110002	323 76 17
*Eastern : 1/14 CIT Scheme VII M, V.I.P. Road, Maniktola, CALCUTTA 700054	337 86 62
Northern : SCO 335-336, Sector 34-A, CHANDIGARH 160022	60 38 43
Southern : C.I.T. Campus, IV Cross Road, CHENNAI 600113	235 23 15
†Western : Manakalaya, E9, Behind Marol Telephone Exchange, Andheri (East), MUMBAI 400093	832 92 95
Branch Offices:	
'Pushpak', Nurmohamed Shaikh Marg, Khanpur, AHMEDABAD 380001	550 13 48
‡Peenya Industrial Area, 1st Stage, Bangalore-Tumkur Road, BANGALORE 560058	839 49 55
Gangotri Complex, 5th Floor, Bhadbhada Road, T.T. Nagar, BHOPAL 462003	55 40 21
Plot No. 62-63, Unit VI, Ganga Nagar, BHUBANESHWAR 751001	40 36 27
Kalaikathir Buildings, 670 Avinashi Road, COIMBATORE 641037	21 01 41
Plot No. 43, Sector 16 A, Mathura Road, FARIDABAD 121001	8-28 88 01
Savitri Complex, 116 G.T. Road, GHAZIABAD 201001	8-71 19 96
53/5 Ward No. 29, R.G. Barua Road, 5th By-lane, GUWAHATI 781003	54 11 37
5-8-56C, L.N. Gupta Marg, Nampally Station Road, HYDERABAD 500001	20 10 83
E-52, Chitaranjan Marg, C-Scheme, JAIPUR 302001	37 29 25
117/418 B, Sarvodaya Nagar, KANPUR 208005	21 68 76
Seth Bhawan, 2nd Floor, Behind Leela Cinema, Naval Kishore Road, LUCKNOW 226001	23 89 23
NIT Building, Second Floor, Gokulpat Market, NAGPUR 440010	52 51 71
Patliputra Industrial Estate, PATNA 800013	26 23 05
Institution of Engineers (India) Building 1332 Shivaji Nagar, PUNE 411005	32 36 35
T.C. No. 14/1421, University P.O. Palayam, THIRUVANANTHAPURAM 695034	6 21 17

*Sales Office is at 5 Chowringhee Approach, P.O. Princep Street, CALCUTTA 700072 — 27 10 85

†Sales Office is at Novelty Chambers, Grant Road, MUMBAI 400007 — 309 65 28

‡Sales Office is at 'F' Block, Unity Building, Narashimaraja Square, BANGALORE 560002 — 222 39 71

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