Annex J
(normative)

Shop-Assembled Storage Tanks

J.1 Scope

J.1.1 This Annex provides requirements for the design and fabrication of vertical storage tanks in sizes that permit complete shop assembly and delivery to the installation site in one piece. Storage tanks designed according to this Annex shall not exceed 6 m (20 ft) in diameter.

- **J.1.2** The application of this Annex to the design and fabrication of shop-assembled storage tanks shall be mutually agreed upon by the Purchaser and the Manufacturer.

J.2 Materials

J.2.1 The material requirements of Annex A of this standard are applicable, except as noted in J.2.2.

J.2.2 The selection of shell, bottom, or lifting lug plate materials exceeding a nominal thickness of 13 mm ($^1/_2$ in.) shall be based upon the requirements of Section 4 of this standard.

J.3 Design

J.3.1 Joints

J.3.1.1 Joints shall be designed as specified in 5.1; however, lap-welded joints in bottoms are not permissible. In addition, the modifications given in J.3.1.2 through J.3.1.5 are applicable.

J.3.1.2 All shell joints shall be butt-welded so that full penetration is produced without the use of back-up bars.

J.3.1.3 Shell plates shall be sized to limit the number of plates to the smallest practical number consistent with sound economic practice. Each course should preferably be constructed of one plate.

J.3.1.4 Top angles are not required for flanged-roof tanks.

J.3.1.5 Joints in bottom plates shall be butt-welded. The welding shall produce complete penetration of the parent metal.

J.3.2 Bottoms

J.3.2.1 All bottom plates shall have a minimum nominal thickness of 6 mm (0.236 in.) (49.8 kg/m^2 [10.2 lbf/ft^2], see 4.2.1.2 and 5.4.1).

J.3.2.2 Bottoms shall be constructed of a minimum number of pieces; wherever feasible they shall be constructed of one piece.

J.3.2.3 Bottoms may be flat or flat flanged. A flat-bottom shall project at least 25 mm (1 in.) beyond the outside diameter of the weld attaching the bottom to the shell plate. A flat-flanged bottom shall have an inside corner radius that is not less than three times the bottom thickness and a straight flange that is a minimum of 19 mm ($^3/_4$ in.).

J.3.2.4 For flat bottoms, the attachment between the bottom edges of the lowest course shell plate and the bottom plate shall be a continuous fillet weld laid on each side of the shell plate. Each fillet weld shall be sized in accordance with 5.1.5.7. A flat-flanged bottom shall be attached to the shell by full-penetration butt-welds.

J.3.3 Shells

Shell plates shall be designed in accordance with the formula given in A.4.1, but the nominal thickness of shell plates shall not be less than the following:

a) for tanks with a diameter less than or equal to 3.2 m (10.5 ft) to 4.8 mm ($^3/_{16}$ in.);

b) for tanks with a diameter greater than 3.2 m (10.5 ft) to 6 mm (0.236 in.).

J.3.4 Wind Girders For Open-Top Tanks

Open-top tanks shall be provided with wind girders as specified in 5.9.

J.3.5 Roofs

J.3.5.1 General

Roofs for tanks constructed in accordance with this Annex shall be of the self-supporting type and shall conform to either J.3.5.2 or J.3.5.3. Alternate designs meeting the requirements of 5.10.2.8 are permitted with Purchaser approval.

J.3.5.2 Cone Roofs

Self-supporting cone roofs shall be designed as specified in 5.10.5, except they may be provided with a flange that will permit butt-welded attachment to the shell (see J.3.1.4). Flanges shall be formed with a minimum inside corner radius of three times the roof thickness or 19 mm ($^3/_4$ in.), whichever is larger.

J.3.5.3 Dome and Umbrella Roofs

Self-supporting dome and umbrella roofs shall be designed as specified in 5.10.6, except they may be flanged as described in J.3.5.2. For dome roofs that are flanged, the radius of curvature shall not be limited to the maximum requirements given in 5.10.6; instead, the curvature shall be limited by the depth of the roof, including the crown and knuckle depth, as listed in Table J.1a and Table J.1b.

J.3.5.4 Top Angles

When top angles are required, they shall be attached as specified in 5.10.7.

Table J.1a—Minimum Roof Depths for Shop-assembled Dome-roof Tanks (SI)

Diameter	Depth
m	mm
≤ 1.8	50
≤ 2.4	90
≤ 3.0	140
≤ 3.7	200
≤ 4.3	275
≤ 4.9	375
≤ 6.0	500

Table J.1b—Minimum Roof Depths for Shop-assembled Dome-roof Tanks (USC)

Diameter	Depth
ft	in.
6	2
8	$3^1/_2$
10	$5^1/_2$
12	8
14	11
16	15
20	20

J.3.6 Tank Connections and Appurtenances

J.3.6.1 Manholes, nozzles, and other connections in the shell shall be constructed and attached as specified in 5.7, but it is unlikely that reinforcing plates will be required for manholes and nozzles in the tank shell. The need for reinforcement shall be checked according to the procedure given in 5.7.2. Since the nominal shell-plate thicknesses required by J.3.3 will normally exceed the calculated thickness, the excess material in the shell should satisfy the reinforcement requirements in nearly all cases.

J.3.6.2 The requirements of 5.7.3 for the spacing of welds do not apply except for the requirement that the spacing between the toes of welds around a connection shall not be less than 2.5 times the shell thickness at the connection.

- **J.3.6.3** The roofs of tanks constructed in accordance with this Annex will be inherently strong because of the limitations in diameter required for shipping clearances. Thus, reinforcement of roof manholes and nozzles is not required unless specifically requested by the Purchaser or unless roof loads exceed 1.2 kPa (25 lbf/ft^2), in which case the amount and type of reinforcement shall be agreed upon by the Purchaser and the Manufacturer.

J.3.6.4 For shell manholes and nozzles the radiographic requirements of 5.7.3.4 do not apply.

J.3.6.5 For flush-type cleanout fittings, the provisions for stress relief specified in 5.7.4 and 5.7.7.3 are not required unless any plate in the assembly has a thickness greater than 16 mm ($^5/_8$ in.).

J.3.6.6 For flush-type shell connections, the provisions for stress relief specified in 5.7.4 and 5.7.8.3 are not required unless any plate in the assembly has a thickness greater than 16 mm ($^5/_8$ in.).

J.3.7 Corrosion Allowance

- **J.3.7.1** If the Purchaser requires that a corrosion allowance be provided, the allowance and the areas to which the allowance is to be added shall be specified. If a corrosion allowance is specified without an indication of the area to which it is to be added, the Manufacturer shall assume that it is to be added only to the calculated shell-plate thickness.

- **J.3.7.2** When a corrosion allowance is specified for the roof and bottom plates, it shall be added to the minimum nominal thicknesses.

J.3.8 Lifting Lugs

J.3.8.1 Lugs or clips for use in loading and unloading tanks and for use in placing tanks on foundations shall be provided on all tanks constructed in accordance with this Annex.

- **J.3.8.2** There shall be a minimum of two lugs on each tank. The location of the lugs shall be agreed upon by the Purchaser and the Manufacturer. The lugs shall preferably be located at the top of the tank, in pairs, 180 degrees apart.

J.3.8.3 Lug design shall consider the total weight of the tank (empty), including all insulation, piping, and other attached items to be lifted, multiplied by a minimum impact factor of 2.0, as well as other conditions and forces created by the lifting operation, such as impact, lateral, or eccentric loads. Resolution of these loads into member and connection forces shall be performed in accordance with generally accepted principles of structural analysis. Lugs shall be proportioned such that the allowable stress for the conditions listed above includes a factor of safety not less than 2.0 on limit states of yield, buckling, fracture, and connection design.

J.3.8.4 Lugs capable of carrying the load described in J.3.8.3 shall be designed and attached in a manner that will not damage the tank.

J.3.9 Anchoring

J.3.9.1 Because of the proportions of shop-assembled storage tanks, overturning as a result of wind loading must be considered. If necessary, adequate provisions for anchoring shall be provided. See 5.12 for tank anchorage design guidance.

J.3.9.2 In 5.12.4, e_m shall be = 41 mm + d/2 + 500E_tDT, (1.625 in. + d/2 + 6E_tDT), if flat bottom projects 25 mm (1 in.) beyond weld outside diameter as specified in J.3.2.3. In 5.12.4, e_m shall be = 25 mm + d/2 (1 in. + d/2), if flat bottom is flanged (knuckled) and does not project beyond the tank shell outer diameter.

J.4 Fabrication and Construction

J.4.1 General

J.4.1.1 Fabrication and construction shall be in accordance with the applicable provisions of Sections 6 and 7 of this standard. Erection shall be interpreted as assembly, and it shall be understood that the entire vessel is constructed in the shop and not at the field site.

J.4.1.2 Section 7.2.2 and Section 7.2.5 of this standard are not applicable to the bottoms and roofs of shop-assembled tanks.

J.4.2 Testing, Repairs, and Inspection

J.4.2.1 General

For testing of, repairs to, and inspection of shell, bottom, and roof of shop-assembled tanks, the requirements of J.4.2.2 through J.4.2.4 replace those of 7.3.2 through 7.3.7. For lifting lugs, the requirements of 7.3.2 shall still apply.

J.4.2.2 Testing

Unless otherwise specified by the Purchaser, as an alternative to the requirements of 7.3.2 through 7.3.8, a tank may be shop tested for leaks by the following method:

a) The tank bottom shall be braced by securely attaching an external stiffening member as required to prevent permanent deformation during the test.

b) All openings shall be closed with plugs or covers as needed. Bolts and gaskets of the size and type required for final installation shall be used during the test.

c) An internal air pressure of 14 kPa to 21 kPa (2 lbf/in.^{2} to 3 lbf/in.^{2}) gauge shall be applied to the tank. For tanks with a diameter of 3.7 m (12 ft) or less, a maximum pressure of 35 kPa (5 lbf/in.^{2}) gauge shall be used.

d) Soap film, linseed oil, or another material suitable for the detection of leaks shall be applied to all shell, bottom, roof, and attachment welds, and the tank shall be carefully examined for leaks.

e) After the air pressure is released, the external stiffening member shall be removed, and any weld scars shall be repaired.

J.4.2.3 Repairs

All weld defects found by the leak test or by radiographic examination shall be repaired as specified in Section 8.

J.4.2.4 Inspection

The Purchaser's inspector shall have free entry to the Manufacturer's shop at all times. The Manufacturer shall afford the Purchaser's inspector reasonable facilities to assure the inspector that the work is being performed in accordance with the requirements of this standard. All material and workmanship shall be subject to the replacement requirements of 6.2.3.

J.5 Examination of Shell Joints

J.5.1 The methods of examining shell joints described in Section 8 apply to shop-assembled tanks, but spot radiography may be omitted when a joint efficiency of 0.70 is used (see A.3.4).

J.5.2 When radiographic examination is required (joint efficiency = 0.85), the spot radiographs of vertical joints shall conform to 8.1.2.2, Item a only, excluding the 10 mm ($^3/_8$ in.) shell thickness limitation in Item a and excluding the additional random spot radiograph required by Item a. The spot radiographs of horizontal joints shall conform to 8.1.2.3.

J.6 Welding Procedure and Welder Qualifications

The requirements for qualification of welding procedures and welders given in Section 9 apply to shop-assembled tanks.

J.7 Marking

Shop-assembled tanks shall be marked in accordance with Section 10, except that 10.1.4 and 10.2 are not applicable. The nameplate (see Figure 10.1) shall indicate that the tank has been designed in accordance with this Annex.