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Storage Tanks

Storage tanks are two types: fixed rood and floating roof. Most fluids held at atmospheric or low pressure are contained in cylindrical tanks of welded construction. Vertical cylindrical tanks consist of a vertical shell welded to the bottom plate and top conical roof.

Code of Practice:
Design specification of storage tanks with adequate safety are provided by codes such as API-650, API-620, API 12C, IS803.

Materials of Construction:
The materials used in the construction of storage vessels are usually metals, alloys, clad-metals, or materials with linings which are suitable for containing the fluid. Where no appreciable corrosion problem exists, the cheapest and most easily fabricated construction material is usually mild steep plate. The common mild steel plate materials are: ASTM A7, A36, A-283 Grade C or D, IS 226, IS 2062.

Optimum tank proportions:
Before a storage tank can be designed, the proportion of height to diameter must be established. The diameters of standard steel tanks for storage at atmospheric pressure usually range from 10 to 220 ft, and heights vary from 6 to 64 ft. The optimum proportions of a tank are often influenced by the cost of the foundations and the cost of the land in the tank area as well as by the cost of the bottom, shell, and roof.

Shell Design:
The majority of tanks and vessels are cylindrical because a cylinder has great structural strength and is easy to fabricate. Thickness of shell (*t*) is calculated based on the membrane theory as applicable to a thin walled vessel. For cylindrical thin walled vessel, the circumferential stress is the controlling one.

$$t = \frac{pd}{2fE} + C$$

where p = pressure inside the vessel
d = inside diameter
f = allowable stress of material
E = joint efficiency
C = corrosion allowance

The pressure inside the vessel is due to the hydrostatic head of liquid contents. Pressure acting on the shell decreases with height (*H*) from the bottom of the vessel.

$$p = \rho g H$$

Since the welding of shell with the bottom plates is providing stiffness, at least up to 1 feet (0.3 m) from the bottom, the above formula is corrected as,

$$p = \rho g (H - 0.3)$$

If the density of storage fluid is less than that of water, then ρ is taken as 1000 kg/m^3. This is due to the reason that once after the vessel is fabricated, it will be undergoing hydro test using water; and the vessel should not fail during this test.

Bottom plate design:

Normally bottom plates are fully supported on a well consolidated and leveled ground. The bottom plates are, therefore subjected to direct pressure of liquid and not to any bending moment. However, the bottom plates near the shell joint are highly stressed due to the bending moment caused by the pressure of the liquid on shell. Further, although the bottom plates are supposed to be uniformly supported by the ground, it is possible, particularly in the case of large tanks, that certain proportions of the ground may settle unevenly and the support may not be uniform. Therefore, all bottom plates should have the minimum nominal thickness of 6 mm. For tanks greater than 12 m diameter, the minimum thickness should be 8 mm.

Roof plate design

Self-supporting cone roofs are expected to meet the following specifications:

Maximum θ = 37o; Minimum sin θ = 0.165 (slope 1 in 6)

where θ is the included angle between conical roof with the horizontal.

Minimum thickness of roof plate (in mm) is calculated from:

$$t = \frac{D}{5 \sin \theta}$$

Where D is the diameter of tank in m.

Maximum thickness of self-supporting roof is to be 12 mm.

Roof plates are sometime stiffened with rafter angles to provide good strength at reduced thickness of roof.

Reinforcements

Openings in tank shells larger than 64 mm in diameter have to be reinforced. The minimum cross sectional area of reinforcement shall not be less than the product of diameter of hole cut and the shell plate thickness.