Heads for Vessels

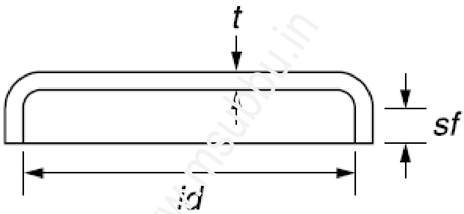
The heads are normally made from the same material as the shell and may be welded to the shell itself. They also may be integral with the shell in forged or cast construction. The heads may be of various types such as: Flanged, Ellipsoidal, Torispherical, Hemispherical, Conical. Most common is of course the torispherical head, which is characterized by inside diameter, crown radius, and knuckle radius. The designer selects a head configuration that minimizes the total cost of the plate material and its formation

The thickness values of the elliptical and torispherical heads are typically the same as the cylindrical shell sections to which they are attached.

ASME Section VIII Division 1 provides the following equations for internal pressure. The actual thickness of heads includes the design thickness as calculated from the following equations plus that due to corrosion allowance.

(a) Flanged-only heads:

These heads are normally found in vessels operating at low pressures. They are also used in high pressure applications where the diameter is small.



(b) Hemispherical heads:

Generally, the required thickness of hemispherical heads is half of that of cylindrical shells with equivalent diameter and material. Hemispherical heads are very economical when constructed of expensive alloys such as nickel or titanium. In carbon steel, hemispherical heads are not as economical as torispherical or ellipsoidal heads because of the high cost of fabrication.

The design thickness (t) of a hemispherical head is given by:

$$t = \frac{PR}{2SE - 0.2P}$$

where P = design pressure, R = inside radius vessel, E = joint efficiency (max of 1).

(c) Ellipsoidal heads:

Ellipsoidal and torispherical heads are very popular in pressure vessels.
The design thickness of ellipsoidal head is given by:

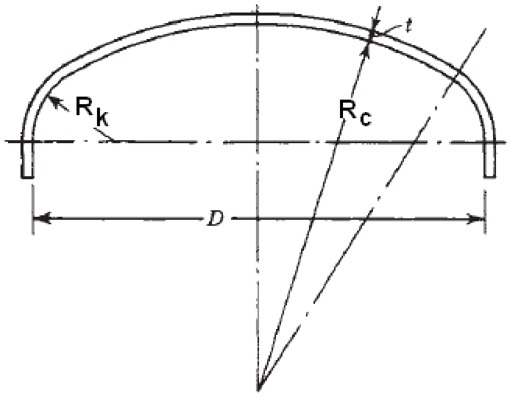
$$t = \frac{PDK}{2SE - 0.2P}$$

where D is inside diameter of vessel.
and K is the stress intensity factor, given by:

$$K = \frac{1}{6}\left[2 + \left(\frac{a}{b}\right)^2\right]$$

where *a* and *b* are the semi-major and semi-minor axes of the ellipse.
For a ellipsoidal head with a major axis : minor axis ratio of 2:1, *K* equals 1.

(d) Torispherical heads:



These heads have the crown radius equal to less than the diameter of the head. To reduce the stresses at the corner of the head, a knuckle is formed with a radius of at least 6% of inside diameter. The thickness of such heads is given by:

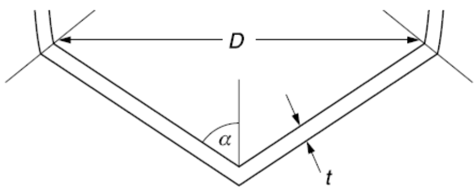
$$t = \frac{P R_c M}{2SE - 0.2P}$$

where *M* is stress intensity factor, given by:

$$M = \frac{1}{4}\left(3 + \sqrt{\frac{R_c}{R_k}}\right)$$

where R_c is crown radius, and R_k is knuckle radius.

(e) Conical heads:



Thickness of conical heads with semi-apex angle α is given by:

$$t = \frac{PD}{2\cos\alpha(SE - 0.6P)}$$

where *D* is inside diameter of the cone.

They are used as bottoms for evaporators, spray dryers, crystallizers and settling tanks, for removal of solids from the equipments.