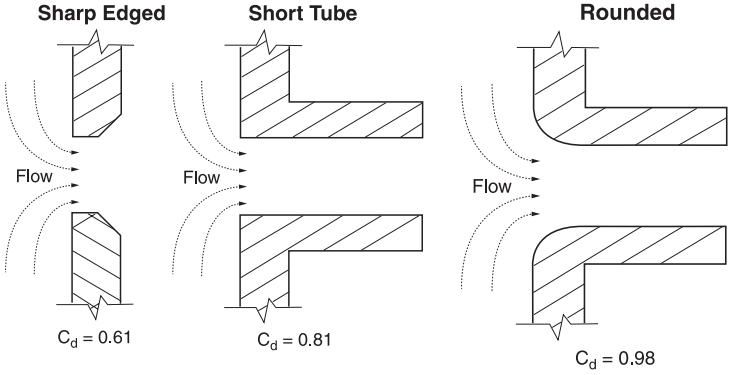
Formulas for Calculating Flow Rate From a Tank

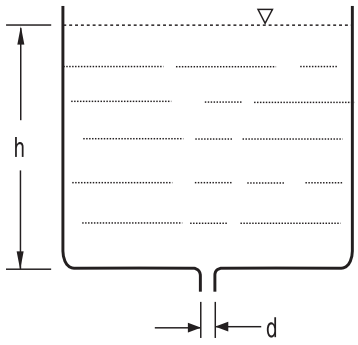
The following formulas are for calculating the rate at which a fluid will flow from a tank when the fluid level is maintained constant (h is constant). The discharge coefficient C_d depends on the configuration of the outlet. Some typical values for discharge coefficient are shown below.



Variables:
- h = Elevation of tank
- d = Diameter of tank
- a = Orifice area (ft^2)
- g = Gravitational acceleration = 32.2 ft/sec^2
- q = Volume flow rate of fluid through opening (in^3/sec)
- C_d = Discharge coefficient

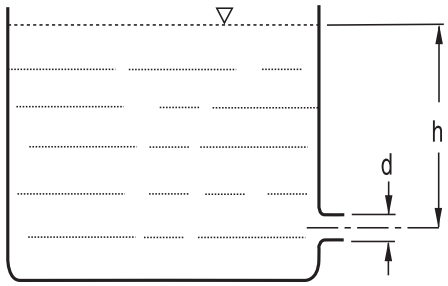
Bottom Opening

$$q = C_d(a)\sqrt{2gh}$$



Side Opening

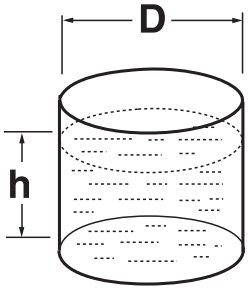
$$q = C_d(a)\sqrt{2gh}$$



EXAMPLES

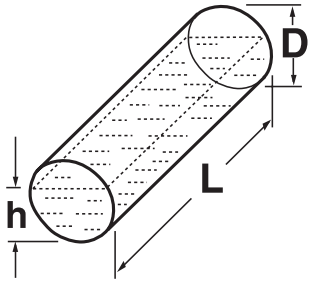
Cylindrical Vertical

$$\Delta t = \frac{\pi D^2}{C_d A}\sqrt{\frac{h}{8G}}$$



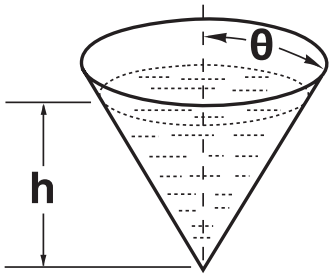
Cylindrical Horizontal

$$\Delta t = \frac{L\{D^{3/2} - (D-h)^{3/2}\}}{3C_d A}\sqrt{\frac{8}{G}}$$



Vertical

$$\Delta t = \frac{\pi h^{5/2}\tan^2\theta}{5C_d A}\sqrt{\frac{8}{G}}$$



A vertical cylindrical tank 12' in diameter is fitted with a 2"bulkhead fitting (comparable to a short tube outlet). The area of the outlet is:

$$\Delta t = \frac{\pi D^2_{orf}}{4\,(144)} = \frac{\pi\, 2^2}{4\,(144)} = 0.0218\ ft^2$$

If the tank is filled with water to a height of 20', and we assume turbulent flow, the approximate time to empty the tank is given by:

$$\Delta t = \frac{\pi\, 12^2}{0.81\,(0.0218)} \sqrt{\frac{20}{8\,(32.2)}} = 7{,}139\ sec$$

The tank should be empty in about 2 hours.

A 7' diameter by 9' long horizontal cylindrical tank has a 4" diameter sharp edged orifice outlet. The area of the outlet is:

$$\Delta t = \frac{\pi D^2_{orf}}{4\,(144)} = \frac{\pi\, 4^2}{4\,(144)} = 0.0873\ ft^2$$

If the tank is filled with water to a height of 5', and we assume turbulent flow, the approximate time to empty the tank is given by:

$$\Delta t = \frac{9\,\{7^{3/2} - (7-5)^{3/2}\}}{3\,(0.61)\,0.0873} \sqrt{\frac{8}{\ }} = 440\ sec$$

The tank should be empty in about 7 minutes.

A conical tank with a taper angle of 25° is fitted with a 2" diameter short tube type outlet. The area of the outlet is:

$$\Delta t = \frac{\pi D^2_{orf}}{4\,(144)} = \frac{\pi\, 2^2}{4\,(144)} = 0.0218\ ft^2$$

If the tank is filled with water to a height of 28', and we assume turbulent flow, the approximate time to empty the tank is given by:

$$\Delta t = \frac{\pi\,(28^{5/2})\,\tan^2 25°}{5\,(0.81)\,0.0128} \sqrt{\frac{2}{32.2}} = 8{,}000\ sec$$

The tank should be empty in about 2-1/4 hours.