

Conversion Factors

Introduction

Since flow calculations generally require the manipulation of data with a number of different units, it is usually easier to calculate complex equations by reducing the number of different factors required; although, it must be remembered that the units used must be consistent within any given equation.

This section of the Sizing & Selection manual is designed to list those conversion factors commonly used in flow calculations and valve sizing. It also presents a slightly different approach to converting one system of units to another.

Using Conversion Factors

If an object has a length of 1 foot or 12 inches, it will have the same physical size no matter what the units. It could then be written as:

$$\begin{aligned} \text{length} &= 12 \text{ inches, or} \\ \text{length} &= 1 \text{ foot} \end{aligned}$$

The numerical values are different, but the actual physical length remains the same. By dividing one set of units into the other, the conversion factor can be described as:

$$\frac{12 \text{ inches}}{1 \text{ foot}} = 1.0$$

In other words, **a conversion factor is always equal to 1**, although any different combination of units can be used. Therefore, a conversion factor can be used in any equation to change the quantity; for example, a 4 foot long pipe may be multiplied by 12 inches per foot without changing its length:

$$4 \cancel{\text{ feet}} \times \frac{12 \text{ inches}}{1 \cancel{\text{ foot}}} = 48 \text{ inches}$$

To convert the answer to a common unit such as pounds, a conversion factor must be used.

$$f = 8.5 \text{ bars} \times 2.07 \text{ inches}^2 \times \frac{14.5 \text{ pounds}}{\text{inches}^2 \times \text{bars}}$$

Cancelling out the common units, we get the force of:

$$f = 225 \text{ pounds}$$

As a second example, take a flow rate of 4500 cubic feet per hour. This flow can be converted into gallons per

minute by using two conversion factors:

$$\begin{aligned} Q &= \frac{4500 \cancel{\text{ feet}^3}}{\cancel{\text{ hour}}} \times \frac{7.481 \text{ gallons}}{1 \cancel{\text{ foot}}} \times \frac{\cancel{\text{ hour}}}{60 \text{ minutes}} \\ Q &= 561 \text{ gallons/minute} \end{aligned}$$

As shown, the common unit (feet) can be cancelled out and the same length is now converted to inches. Simple examples of conversion factors includes:

$$\begin{aligned} &\frac{1.8 \text{ degree (Rankine)}^*}{1 \text{ degree (Kelvin)}} \\ &\frac{1000 \text{ grams}}{1 \text{ kilogram}} \end{aligned}$$

Complicated conversion factors can contain more than just two simple units. For example:

$$\begin{aligned} &\frac{778 \text{ foot-pounds}_f}{\text{BTU}} \\ &\frac{32.174 \text{ foot-pounds}_m}{1 \text{ pound-second}^2} \end{aligned}$$

A relatively small number of conversion factors are needed because combining two or more factors generates a more complicated factor.

When working with units, a good rule to follow is that units should always accompany numbers, but they need not accompany algebraic terms. For example, force can be calculated by pressure multiplied by the area or:

$$F = P \times A$$

In the above case, algebraic values are given, making it unnecessary to use units for the pressure or the area. However, if the pressure is 8.5 bars with an area of 2.07 square-inches, units must be included in the equation:

$$F = 8.5 \text{ bars} \times 2.07 \text{ inches}^2$$

** These simple unit conversion factors do not work when there is a zero shift, such as degrees Fahrenheit to Celsius or a gauge pressure to absolute pressure.*

The following table provides factors arranged alphabetically according to the first unit involved in each conversion factor. All factors have numerical value greater than 1.0.

Table 20-I: Conversion Factors

2545	BTU / (horsepower-hour)	12	inches / foot
3414	BTU / (kilowatt-hour)	144	inches ² / foot ²
1000	calories / Kcalorie	1728	inches ³ / foot ³
251.99	Kcalories / BTU	231	inches ³ / gallon
641.4	Kcalories / horsepower-hr	29.92	inches-mercury / std. atmosphere
10.688	Kcalories / horsepower-min	2.036	inches-mercury / (pounds _f / inch ²)
860	Kcalories / (kilowatt-hr)	39.37	inches / meter
30.48	centimeters / foot	406.8	inches-water / (std. atmosphere)
929.03	centimeters ² / foot ²	4186	joules / Kcalorie
28,317	centimeters ³ / foot ³	1000	kilograms / ton (metric)
3785.4	centimeters ³ / gallon	100	kiloPascal / bar
16.387	centimeters ³ / inch ³	1.688	(knot-seconds) / foot
1000.027	centimeters ³ / liter	28.316	liters / foot ³
100	centimeters / meter	3.785	liters / gallon
946.36	centimeter ³ / quart	1000	meters / kilometer
91.44	centimeter / yard	1000	micrometers / centimeter
57.296	degrees / radian	1.15078	miles / (knot-hr)
360	degrees / revolution	1.467	(miles-seconds) / foot-hr
100,000	dynes / Newton	25.4	millimeter / inch
4.186 x 10 ¹⁰	ergs / calorie	1000	mils / inch
29.57	(fluid-ounce) / centimeters ³	60	minutes / hour
45360	foot ³ / (acre-foot)	128	ounces (fluid) / gallon
777.97	(foot-pounds) / BTU	16	ounces / pint
3087.4	(foot-pounds _f) / Kcalorie	8	pints / gallon
3.281	foot / meter	2.113	pints / liter
5280	feet / mile	32.174	(pounds _m -feet) / (pounds _f -second ²)
35.31	feet ³ / meter ³	14.696	(pounds _f / inch ²) / atmosphere
550	(foot-pounds _f) / (horsepower-second)	14.50	(pounds _f / inch ²) / bar
2.665 x 10 ⁶	(foot-pounds _f) / (K _w -hour)	.145	(pounds _f / inch ²) / kiloPascal
1.467	(feet / second) / (mile / hour)	2.20462	pounds / kilogram
324,851	gallon / acre-foot	32.174	pounds _m / slug
42	gallons / barrel (oil)	8.341	pounds _m water / gallon (@62F)
7.481	gallon / foot ³	2000	pounds _m / ton
1.201	gallons (British) / gallon	29.92	quarts / foot ³
264.2	gallons / meter ³	4	quarts / gallon
448.83	(gallons / minute) / (foot ³ / second)	1.0567	quarts / liter
980.665	(grams _f -centimeter) / (second ² -grams _m)	60	seconds / minute
1000	grams / kilogram	745.7	watts / horsepower
454.54	grams / pound	1	(watt-seconds) / joule
1.341	horsepower / kilowatt		

NOTE: All gallons are U.S. standard unless otherwise noted. All calories are in kilogram-calories.