Summary of common Pressure Units

Version 1.00, 12/15/2003

Portland State Aerospace Society <http://www.psas.pdx.edu>

There are too many pressure units in common use. This is not nearly all of them. For PSAS, try to stick with Pa, or if you must psi.

To → / ↓From	Atm	Bars	Lb/in^2 (psi)	in of Hg (0 °C)	in of H_2O (3.98 °C)	torr (mm of Hg)	cm of H_2O (3.98 °C)	Lb/ft^2	kgf/m^2	Pa	microns	dynes/cm^2
Atmosphere (Atm)	1	1.01325	14.695949	29.92126	406.782	760	1033.227	2116.22	10332.27	101325	760×10^3	1.01325×10^6
Bars	0.986923	1	14.50377	29.53	401.463	750.062	1019.72	2088.54	10197.2	10^5	750.062×10^3	10^6
Lb/in^2 (psi)	6.8046×10^{-2}	6.89476×10^{-2}	1	2.03602	27.6799	51.715	70.30696	144	703.07	6894.76	51.715×10^3	68947.6
in of Hg (0 °C)	3.342105×10^{-2}	3.38639×10^{-2}	0.491154	1	13.5951	25.4	34.5315	70.7262	345.315	3386.39	2.54×10^4	33863.9
in of H_2O (3.98 °C)	2.45832×10^{-3}	2.49089×10^{-3}	3.61273×10^{-2}	7.35559×10^{-2}	1	1.86832	2.54	5.20233	25.40	249.089	1.86832×10^3	2490.89
torr (mm of Hg)	1/760	1.33322×10^{-3}	1.93368×10^{-2}	3.93701×10^{-2}	0.53524	1	1.35951	2.7845	13.5951	133.322	1000	1333.22
cm of H_2O (3.98 °C)	9.67841×10^{-4}	9.80665×10^{-4}	1.42233×10^{-2}	2.8959×10^{-2}	0.393701	0.735559	1	2.04816	10	98.0665	735.559	980.665
Lb/ft^2	4.7254×10^{-4}	4.78803×10^{-4}	6.944444×10^{-3}	1.4139×10^{-2}	0.192222	0.359132	0.4882428	1	4.882428	47.8803	359.13	478.803
kgf/m^2	9.67841×10^{-5}	9.80665×10^{-5}	1.42233×10^{-3}	2.8959×10^{-3}	3.93701×10^{-2}	7.35559×10^{-2}	0.1	0.204816	1	9.80665	73.5559	98.0665
Pa	9.86923×10^{-6}	10^{-5}	1.450377×10^{-4}	2.953×10^{-4}	4.01463×10^{-3}	7.50062×10^{-3}	1.01972×10^{-2}	2.08854×10^{-2}	1.01972×10^{-1}	1	7.50062	10
microns	1.31579×10^{-6}	1.33322×10^{-6}	1.93368×10^{-5}	3.93701×10^{-5}	5.3524×10^{-4}	10^{-3}	1.35951×10^{-3}	2.7845×10^{-3}	1.35951×10^{-2}	0.133322	1	1.33322
dynes/cm^2	9.86923×10^{-7}	10^{-6}	1.450377×10^{-5}	2.953×10^{-5}	4.01463×10^{-4}	7.50062×10^{-4}	1.01972×10^{-3}	2.08854×10^{-3}	1.01972×10^{-2}	0.1	750.062×10^{-3}	1

Pressure Units conversion table to five decimal places, ordered by size of unit: (exact conversions are outlined with a box)

■ Selected exact relations

1 Bar = 10^5 Pa = 10^6 dynes/cm^2

1 Atm = 760 torr = 101325 Pa

1 gee = 980665 m/s^2

1 pound = 0.45359237 kg

1 torr = 1000 microns

1 inch = 2.54 cm

■ Introduction

Measurements of pressure quantify the mechanical force exerted per area of surface. Since force is mass times acceleration, and area has dimensions of length squared, the dimensions of pressure are

$$\text{force} / \text{area} = \text{mass} * \text{acceleration} \Big/ \text{length}^2 = m * \frac{L}{t^2} \Big/ L^2 = \frac{m}{t^2\, L}$$

Since a force can conveniently be measured by comparing it to the weight of a known mass, many common units of pressure involve the Earth-gravity acceleration factor (g). Since (g) varies by on order one part in 1000 depending on where and when on the Earth's surface the measurement is made, literal use of weight to measure pressure has a low precision. To make the units consistent, an internationally recognized value for (g) has been established, see below.

■ Definitions

The Pascal (Pa) is the SI unit of pressure. One Pascal is defined as one Newton per square meter.

The dyne $/ \text{cm}^2$ is the cgs unit of pressure. The dyne is the cgs unit of force, defined as one $\text{g}\cdot\text{cm} / \text{s}^2$

The torr is designed to replace the mm of Hg. The torr is defined to be 1/760 of a standard atmosphere. A torr is not exactly equal to the international standard millimeter of mercury, but it is within a factor of 1/7000000 which is close enough.

An Atmosphere (Atm), or international standard atmosphere, is defined as 101325 Pa .

The Bar is yet another international unit of pressure. 1 Bar = 10^5 Pa . The justification for the Bar is that it is related to other SI units by a power of 10, yet one Bar is close to one Atmosphere. When quoted in milliBars, air pressure is always close to 1000.

One pound mass (lbm) is defined to be exactly 0.45359237kg

One standard gravity (gee) is defined as 9.80665 m/s^2

One pound force (lbf) is the force acting on a 1 pound mass that produces an acceleration of one gee.

One inch is defined as exactly 2.54 cm

■ Conversions derived (for the skeptical)

▪ preliminaries

$$1\ \text{gee} = 9.80665\ \frac{m}{s^2} \left(100\ \frac{cm}{m}\right) \Big/ \left(2.54\ \frac{cm}{in}\right) \Big/ \left(12\ \frac{in}{ft}\right) = 32.17405\ \frac{ft}{s^2} \qquad (1)$$

The temperature at which water is densest is 3.98°C, at this temperature water weighs very close to 1 gram per cubic centimeter. In fact, this was the idea behind the original definition of the gram. So when pressure is measured in terms of cm of water, it can be assumed that the reference area is one square centimeter, and the unit force is that exerted by one cubic centimeter of water (therefore one gram) under the influence of a standard gravity. This force is

$$1\ \text{gram-force} = \frac{1}{1000}\ \text{gee} \times \text{kg} = \frac{9.80665}{1000}\ \frac{\text{kg m}}{\text{s}^2} = 9.80665 \times 10^{-3}\ \text{N} \tag{2}$$

For English units:

$$1\ \text{lbf} = 1\ \text{gee} \times \text{lbm} = 9.80665\ \frac{\text{m}}{\text{s}^2} \times 0.45359237\ \text{kg} = 4.44822\ \text{N} \tag{3}$$

- **psi**

$$1\ \text{psi} = 1\ \frac{\text{lbf}}{\text{in}^2} = \frac{4.44822 \times 10^{-3}\ \text{N}}{\text{in}^2} \Big/ \left(2.54\ \frac{\text{cm}}{\text{in}} \times \frac{1}{100}\ \frac{\text{m}}{\text{cm}}\right)^2 = 6894.76\ \text{Pa} \tag{4}$$

$$1\ \text{psi} = 6894.76\ \text{Pa} \Big/ \left(101325\ \frac{\text{Pa}}{\text{Atm}}\right) = 6.8046 \times 10^{-2}\ \text{Atm} \tag{5}$$

$$1\ \text{psi} = 6894.76\ \text{Pa} \Big/ \left(10^5\ \frac{\text{Pa}}{\text{Bar}}\right) = 6.89476 \times 10^{-2}\ \text{Bar} \tag{6}$$

$$1\ \text{psi} = 6.8046 \times 10^{-2}\ \text{Atm} \times 760\ \frac{\text{torr}}{\text{Atm}} = 51.715\ \text{torr} \tag{7}$$

$$1\ \text{psi} = 51.715\ \text{torr} \doteq 51.715\ \text{mm of Hg @ 0 °C} \Big/ \left(25.4\ \frac{\text{mm}}{\text{in}}\right) = 2.03602\ \text{in of Hg @ 0 °C} \tag{8}$$

$$1\ \text{cm of}\ H_2O\ @\ 3.98\ °\text{C} = \frac{1}{1000}\ \frac{\text{gee} \times \text{kg}}{\text{cm}^2} \times \left(100\ \frac{\text{cm}}{\text{m}}\right)^2 = 98.0665\ \text{Pa} \tag{9}$$

$$1\ \text{cm of}\ H_2O\ @\ 3.98\,°C = 98.0665\,\text{Pa} \Big/ \left(6894.76\ \frac{\text{Pa}}{\text{psi}}\right) = 0.0142233\,\text{psi} \tag{10}$$

$$1\,\text{psi} \Big/ \left(0.0142233\ \frac{\text{psi}}{\text{cm of}\ H_2O}\right) = 70.307\,\text{cm of}\ H_2O\ @\ 3.98\,°C \tag{11}$$

$$70.307\,\text{cm of}\ H_2O\ @\ 3.98\,°C \Big/ \left(2.54\ \frac{\text{cm}}{\text{in}}\right) = 27.6799\ \ \text{in of}\ H_2O\ @\ 3.98\,°C \tag{12}$$

$$1\,\text{kgf} = 1\,\text{kg} \times 1\,\text{gee} = 9.80665\,\text{N} \tag{13}$$

$$1\,\text{psi} = 6894.76\,\text{Pa} = 6894.76\ \frac{\text{N}}{\text{m}^2} \Big/ \left(9.80665\ \frac{\text{N}}{\text{kgf}}\right) = 703.07\ \frac{\text{kgf}}{\text{m}^2} \tag{14}$$

- **Atm**

$$1\,\text{Atm} = 101325\,\text{Pa} \Big/ \left(6894.9\ \frac{\text{psi}}{\text{Pa}}\right) = 14.6959\,\text{psi} \times \left(12\ \frac{\text{in}}{\text{ft}}\right)^2 = 2116.22\ \frac{\text{lbs}}{\text{ft}^2} \tag{15}$$

$$1\,\text{Atm} = 760\,\text{torr} \doteq 760\,\text{mm of Hg}\ @\ 0\,°C \Big/ \left(25.4\ \frac{\text{mm}}{\text{in}}\right) = 29.92126\ \ \text{in of Hg}\ @\ 0\,°C \tag{16}$$

$$1\,\text{Atm} = 101325\ \frac{\text{N}}{\text{m}^2} \Big/ \left(\frac{\text{gee}}{1000}\ \frac{\text{N}}{\text{gram-force}}\right) \Big/ \left(100\ \frac{\text{cm}}{\text{m}}\right)^2 =$$
$$1033.23\ \frac{\text{gram-force}}{\text{cm}^2} \doteq 1033.23\ \ \text{cm of}\ H_2O\ @\ 3.98\,°C \Big/ \left(2.54\ \frac{\text{cm}}{\text{in}}\right) = 406.782\ \ \text{in of}\ H_2O\ @\ 3.98\,°C \tag{17}$$

■ **Pascal**

$$1\,\text{Pa} = 1\,\text{N}\big/\text{m}^2 = 1\,\frac{\text{kg m}}{\text{s}^2}\Big/\text{m}^2 = \frac{1000\,\text{g}}{100\,\text{cm s}^2} = 10\,\text{dyne}\big/\text{cm}^2 \tag{18}$$

$$1\,\text{Pa}\Big/\left(101325\,\frac{\text{Pa}}{\text{Atm}}\right) = 9.86923\times10^{-6}\,\text{Atm} \tag{19}$$

$$1\,\text{Pa} = 9.86923\times10^{-6}\,\text{Atm}\times760\,\frac{\text{torr}}{\text{Atm}} = 7.50062\times10^{-3}\,\text{torr} \tag{20}$$

$$1\,\text{Pa} = 7.50062\times10^{-3}\,\text{torr} \doteq 7.50062\times10^{-3}\,\text{mm of Hg @ 0 °C}\Big/\left(25.4\,\frac{\text{mm}}{\text{in}}\right) = 2.953\times10^{-4}\ \text{in of Hg @ 0 °C} \tag{21}$$

$$1\,\text{Pa} = 1\,\frac{\text{N}}{\text{m}^2}\Big/\left(9.80665\times10^{-3}\,\frac{\text{N}}{\text{gram-force}}\right)\Big/\left(100\,\frac{\text{cm}}{\text{m}}\right)^2 \doteq 1.01972\times10^{-2}\,\frac{\text{gram-force}}{\text{cm}^2} = 1.01972\times10^{-2}\ \text{cm of}\ H_2O\ @\ 3.98\,°\text{C} \tag{22}$$

$$1.01972\times10^{-2}\ \text{cm of}\ H_2O\ @\ 3.98\,°\text{C}\Big/\left(2.54\,\frac{\text{cm}}{\text{in}}\right) = 4.01463\times10^{-3}\ \text{cm of}\ H_2O\ @\ 3.98\,°\text{C} \tag{23}$$

$$1\,\text{Pa} = 1\,\frac{\text{N}}{\text{m}^2}\Big/\left(4.44822\,\frac{\text{N}}{\text{lbf}}\right)\left(2.54\,\frac{\text{cm}}{\text{in}}\times\frac{1}{100}\,\frac{\text{m}}{\text{cm}}\right)^2 = 1.45038\times10^{-4}\,\frac{\text{lbf}}{\text{in}^2} = 1.45038\times10^{-4}\,\text{psi} \tag{24}$$

$$1\,\text{Pa} = 1.45038\times10^{-4}\,\text{psi}\times\left(12\,\frac{\text{in}}{\text{ft}}\right)^2 = 2.08854\times10^{-2}\,\text{lbs}\big/\text{ft}^2 \tag{25}$$

$$1\,\text{Pa} = 1\,\frac{\text{N}}{\text{m}^2}\Big/\left(9.80665\,\frac{\text{N}}{\text{kgf}}\right) = 0.101972\,\frac{\text{kgf}}{\text{m}^2} \tag{26}$$

- **Mercury Units**

$$1\ \text{torr} = \frac{1}{760}\ \text{Atm}\left(101325\ \frac{\text{Pa}}{\text{Atm}}\right) = 133.322\ \ \text{Pa}\Big/\left(9.80665\ \frac{\text{N}}{\text{kgf}}\right) = \frac{\text{kgf}}{\text{m}^2} \tag{27}$$

$$1\ \text{torr} = 133.322\ \ \text{Pa} \times 1.45038 \times 10^{-4}\ \frac{\text{psi}}{\text{Pa}} = 1.93368 \times 10^{-2}\ \text{psi} \times \left(12\ \frac{\text{in}}{\text{ft}}\right)^2 = 2.7845\ \frac{\text{lbs}}{\text{ft}^2} \tag{28}$$

$$1\ \text{torr} \doteq 1\ \text{mm of Hg @ 0 °C}\Big/\left(25.4\ \frac{\text{mm}}{\text{in}}\right) = 3.93701 \times 10^{-2}\ \ \text{in of Hg @ 0 °C} \tag{29}$$

$$1\ \text{torr} = 133.3221\ \text{Pa} = 133.322\ \frac{\text{N}}{\text{m}^2}\Big/\left(9.80665 \times 10^{-3}\ \frac{\text{N}}{\text{gram-force}}\right)\Big/\left(100\ \frac{\text{cm}}{\text{m}}\right)^2 \doteq 1.35951\ \frac{\text{gram-force}}{\text{cm}^2} = 1.35951\ \text{cm of}\ H_2\ O\ @\ 3.98\ °\text{C} \tag{30}$$

$$1\ \text{torr} = 1.35951\ \text{cm of}\ H_2\ O\ @\ 3.98\ °\text{C}\Big/\left(2.54\ \frac{\text{cm}}{\text{in}}\right) = 0.53524\ \text{in of}\ H_2\ O\ @\ 3.98\ °\text{C} \tag{31}$$

- **Water Units**

$$1\ \text{cm of}\ H_2\ O\ @\ 3.98\ °\text{C} \doteq 1\ \frac{\text{gram-force}}{\text{cm}^2} \times \left(9.80665 \times 10^{-3}\ \frac{\text{N}}{\text{gram-force}}\right) \times \left(100\ \frac{\text{cm}}{\text{m}}\right)^2 = 98.0665\ \frac{\text{N}}{\text{m}^2}\Big/\left(101325\ \frac{\text{Pa}}{\text{Atm}}\right) = 9.67841 \times 10^{-4}\ \text{Atm} \tag{32}$$