

# Fluid Power Design Data Sheet



## REVISED SHEET 21- EVOLUTION DESIGN DATA FILE

### U.S. CUSTOMARY UNITS COMPARED TO ISO INTERNATIONAL STANDARD UNITS

Preliminary work was started on an international system of units prior to 1954, and some European countries have adopted their own version of a metric system that could be used internationally. However, there are many duplicate metric units that could be used for the same function. At this writing, the basic units that we believe will be adopted are shown in the second column of the chart and will form the international standard (SI) set of units that will eventually be used all over the world. Some of the units (like the meter) are unhandy for fluid power use, and a variation (like the centimeter) may be used instead. These are shown in the third column of the chart. Correct abbreviations for each unit are shown in the table under the chart. There is controversy over the use of the "bar" for pressure.

Function	Basic SI Unit	Suggested Variation, Fluid Pwr.	Other Metric Equivalents	Conversion to/from U.S. Units
Length	m	cm	1m = 10dm = 100cm = 1000mm	1m = 39.37ins; or, 1 inch = 2.54cm
Area	m <sup>2</sup>	cm <sup>2</sup>	1m <sup>2</sup> = 100dm <sup>2</sup> = 10,000cm <sup>2</sup>	1m <sup>2</sup> = 1550ins <sup>2</sup> = 10.76ft <sup>2</sup>
Volume	m <sup>3</sup>	dm <sup>3</sup>	1m <sup>3</sup> = 1000dm <sup>3</sup> = 1000 liters	1m <sup>3</sup> = 61,023in <sup>3</sup> = 35.3ft <sup>3</sup>
Accel. of Gravity	m/s <sup>2</sup>	Same	Actual value = 9.806m/s <sup>2</sup>	Actual value = 32.17ft/s <sup>2</sup>
Mass	kg	Same	1kg = 9.807N (joules/meter)	1kg = 2.2046lbs (mass) = 70.92 poundals
Force (weight)	N	Same	1N = 0.102kg = 1 x 10 <sup>5</sup> dynes	1N = 0.225 lbs
Torque	Nm	Same	- - - -	1Nm = 8.85in.lb = 0.74ft.lb
Stress	N/m <sup>2</sup>	Same	1N/m <sup>2</sup> = 1 x 10 <sup>-5</sup> bar	1N/m <sup>2</sup> = 1.45 x 10 <sup>-4</sup> lbs/in <sup>2</sup> = 0.021lbs/ft <sup>2</sup>
Pressure (fluid)	N/m <sup>2</sup>	bar	1bar = 100,000 N/m <sup>2</sup>	1bar = 14.5 PSI; or, 1 PSI = 0.069 bar
Power	w	kw	1kw = 1000w	1kw = 1.34HP; or, 1HP = 746w = 0.746kw
Velocity	m/s	dm/min	1m/s = 600dm/min	1dm/min = 3.937in/min

cm = centimeter	in.lb = inch pound	min = minute
dm = decimeter	in/min = inches per minute	m/s = meters per second
dm/min = decimeters per minute	kg = kilogram	m/s <sup>2</sup> = meters per sec. per sec.
ft = foot	kw = kilowatt	N = newton
ft.lb = foot pound	lb = pound	Nm = newton meters
ft/s <sup>2</sup> = feet per second per second	lb/in <sup>2</sup> = pound per square inch	N/m <sup>2</sup> = newtons per square meter
g = gram	lb/ft <sup>2</sup> = pounds per square foot	PSI = pounds per square inch
HP = horsepower	m = meter	s = second
in = inch	mm = millimeter	w = watt

<i>Familiar Formula in Customary U.S. Units</i>	<i>Same Formula in the New SI Standard Units</i>
Torque, Power, and Speed Relations in Hydraulic Pumps & Motors	
<b>T = HP x 5252/RPM</b>	<b>T = kw x 9543/RPM</b>
<b>HP = T x RPM/5252</b>	<b>kw = T x RPM/9543</b>
<b>RPM = HP x 5252/T</b>	<b>RPM = kw x 9543/T</b>
T is torque in foot lbs.	T is torque in Nm (newton meters)
RPM is speed in revolutions per minute	RPM is speed in revolutions per minute
HP is horsepower (33,000 ft.lbs./min.)	kw is power in kilowatts
Hydraulic Power Flowing in the System	
<b>HP = PSI x GPM/1714</b>	<b>Kw = Bars x dm<sup>3</sup>/min / 600</b>
HP is horsepower (33,000 ft.lbs. per min.)	Kw is system power in kilowatts
PSI is gauge pressure, lbs. per square inch	Bars is system pressure
GPM is flow in gallons per minute	dm <sup>3</sup> /min is flow in cubic decimeters per minute

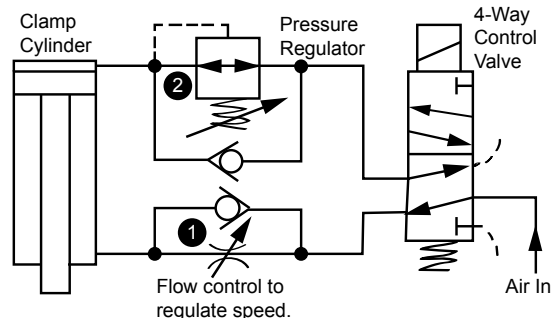
<b>Familiar Formula in Customary U.S. Units</b>	<b>Same Formula in the New SI Standard Units</b>
<b>Force Developed by Air or Hydraulic Cylinder</b>	
<b><math>T = A \times \text{PSI}</math></b>	<b><math>N = A \times \text{Bars} \times 10</math></b>
T is force or thrust, in pounds	N is cylinder force or thrust in newtons
A is piston area in square inches	A is piston area in square centimeters
PSI is gauge pressure, lbs. per sq.in.	Bars is gauge pressure
<b>Travel Speed of a Hydraulic Cylinder</b>	
<b><math>S = V / A</math></b>	<b><math>S = V / 6A</math></b>
S is travel speed in inches per minute	S is travel speed in meters per second
V is volume of oil into cylinder, cu.ins. per min.	V is oil flow in cubic decimeters per minute
A is piston area in square inches	A is piston area in square centimeters
<b>Barlow's Formula for Calculating Burst Pressure of Tubing and Pipe</b>	
<b><math>P = 2t \times S / O</math></b>	<b><math>P = 2t \times S / O</math></b>
P is burst pressure in PSI	P is burst pressure in bars
t is wall thickness of pipe in inches	t is wall thickness of pipe in millimeters
S is tensile strength of pipe material in PSI	S is tensile strength of pipe material in bars
O is outside diameter of pipe in inches	O is outside diameter of pipe in millimeters
<b>Velocity of Oil Flow in Hydraulic Lines</b>	
<b><math>V = \text{GPM} \times 0.3208 / A</math></b>	<b><math>V = \text{dm}^3/\text{min} / 6A</math></b>
V is velocity in feet per second	V is oil velocity in meters per second
GM is oil flow in gallons per minute	dm <sup>3</sup> /min is flow in cubic decimeters per second
A is inside area of pipe in square inches	A is inside area of pipe in square centimeters
<b>Recommended Maximum Oil Velocity in Hydraulic Line</b>	
Pump suction lines - 2 to 4 per sec.	Pump suction lines - 0.6 to 1.2 m/s (meters/sec)
Pressure lines up to 500 PSI - 10 to 15 ft/sec.	Pressure lines up to 35 bar - 3.0 to 4.5 m/s
Pressure lines 500 to 3000 PSI - 15 to 20 ft/sec.	Pressure lines 35 to 200 bar - 4.5 to 6.0 m/s
Pressure lines over 3000 PSI - 25 ft/sec.	Pressure lines over 200 bar - 7.5 m/s
Oil lines in air/oil system - 4 feet per sec.	Oil lines in air/oil system - 1.2 m/s

See Data Sheet 25 for many other conversions between U.S. customary and ISO units

## CLAMPING DELICATE PARTS

When an air cylinder is used for clamping delicate parts, the parts may be distorted, crushed, or suffer other damage for either or both of two possible reasons:

1. Too high a travel speed of the clamp cylinder may cause damage from impact, especially when the clamp is carrying a significant weight (mass) attached to its piston rod. This type of damage can be avoided by using a speed control and reducing travel speed. A flow control valve, 1, connected in a meter-out circuit will solve this problem.
  2. Even though speed is reduced, the part can be crushed from too much steady force after the clamp has closed. When the clamp stalls against the part to be clamped, it will, if given a second or so, come up to full force developed by system PSI working against full piston area. A speed control system, by itself, cannot prevent full force from being exerted against the clamped part. To reduce the force, a pressure regulator, 2, should be installed in the air line to the clamp and by-passed with a check valve so the clamp can be released fast and retracted under full pressure.
- To adjust this circuit, first set the pressure regulator to a pressure that will not damage the part when clamping force is constantly applied. Then adjust the speed control to a speed that will not produce a damaging impact.



*Both a speed and a pressure control may be required to avoid a damaging a delicate part which is being clamped.*