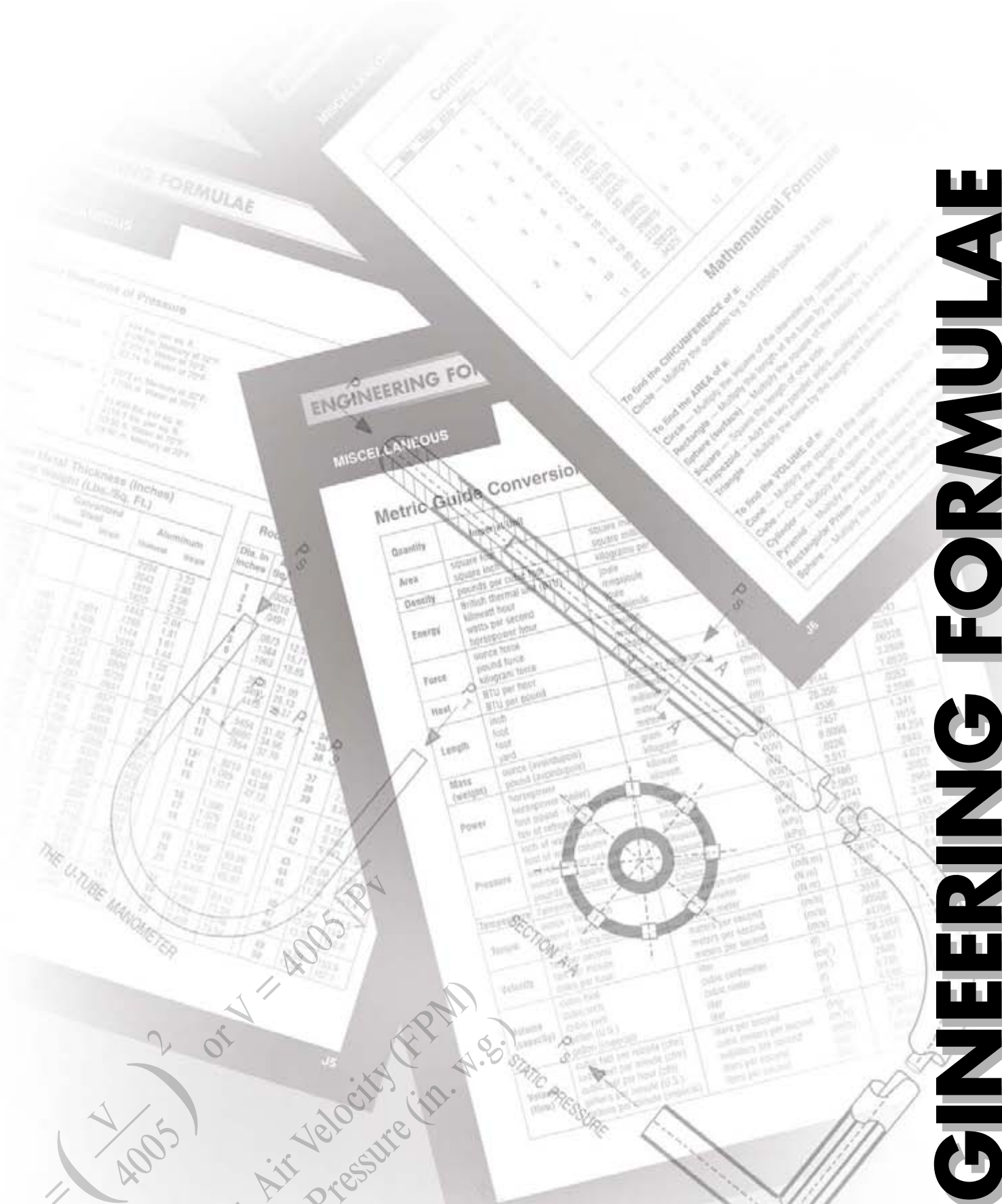


$$P_v = \left( \frac{V}{4005} \right)^2 \text{ or } V = 4005 \sqrt{P_v}$$

Where: V = Air Velocity (FPM)  
 P<sub>v</sub> = Velocity Pressure (in. w.g.)



**Nailor**  
 Industries Inc.

# ENGINEERING FORMULAE

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**J****ENGINEERING FORMULAE**

PRESSURE MEASUREMENT

Pressure Measurement

**Concepts of pressure.** Pressure is force per unit area. This may also be defined as energy per unit volume of fluid. There are three categories of pressure — Total Pressure, Static Pressure and Velocity Pressure that are associated with air handling. Unit of pressure is expressed in inches of water, designated **in. w.g.**

**Static Pressure** is the normal force per unit area at a small hole in the wall of a duct or other boundaries. It is a function of air density and degree of compression. It may be thought of as the pressure in a tire or in a tank; extends in all directions.

**Velocity Pressure** is the force per unit area capable of causing an equivalent velocity in moving air. Velocity pressure is a function of air density and velocity. At standard air density, the relationship between velocity pressure and velocity is expressed in the following formula:

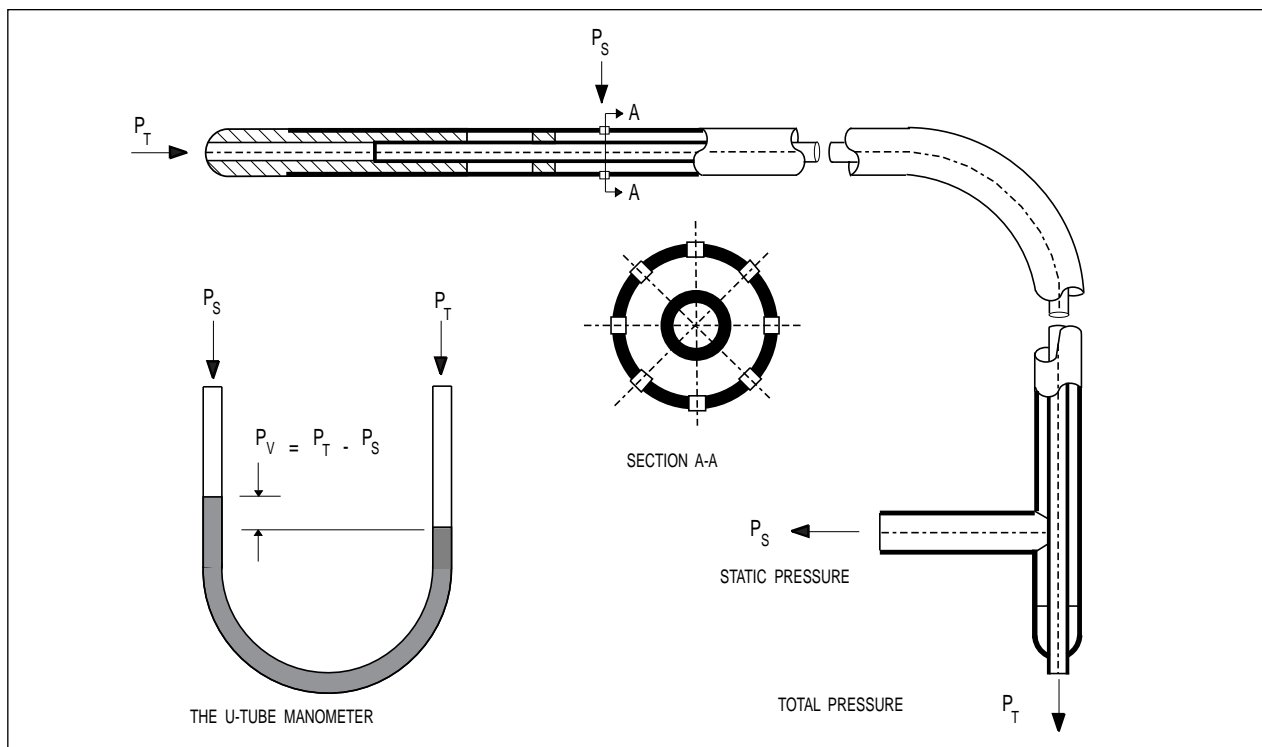
$$P_v = \left( \frac{V}{4005} \right)^2 \text{ or } V = 4005 \sqrt{P_v}$$

Where:  $V$  = Air Velocity (FPM)  
 $P_v$  = Velocity Pressure (in. w.g.)

**Total Pressure**, as its name implies, is the sum of static pressure and velocity pressure.

**The Pitot Static Tube** is an instrument used to measure pressure and velocities as illustrated below. It is constructed of two tubes. The inner, or impact, tube senses the total pressure as the impact opening faces upstream. The outer tube senses only the static pressure, which communicates with the airstream through small holes in its wall.

**The V-Tube Manometer** connects both parts of the Pitot static tube. The manometer functions as a subtracting device to give a reading of velocity pressure.





## MISCELLANEOUS

### Equivalent Measures of Pressure

1 lb. per square inch	=	<ul style="list-style-type: none"> <li>144 lbs. per sq. ft.</li> <li>2.036 in. Mercury at 32°F.</li> <li>2.311 ft. Water at 70°F.</li> <li>27.74 in. Water at 70°F.</li> </ul>	1 inch Water at 70°F	=	<ul style="list-style-type: none"> <li>.03609 lb. per sq. in.</li> <li>.5774 oz. per sq. in.</li> <li>5.196 lbs. per sq. ft.</li> </ul>
1 ounce per square inch	=	<ul style="list-style-type: none"> <li>1272 in. Mercury at 32°F.</li> <li>1.733 in. Water at 70°F.</li> </ul>	1 foot Water at 70°F	=	<ul style="list-style-type: none"> <li>.433 lbs. per sq. in.</li> <li>62.31 lbs. sq. ft.</li> </ul>
1 Atmosphere	=	<ul style="list-style-type: none"> <li>14.696 lbs. per sq. in.</li> <li>2116.3 lbs. per sq. ft.</li> <li>33.96 ft. Water at 70°F.</li> <li>29.92 in. Mercury at 32°F.</li> </ul>	1 inch Mercury at 32°F	=	<ul style="list-style-type: none"> <li>.491 lbs. per sq. in.</li> <li>7.86 oz. per sq. in.</li> <li>1.136 ft. Water at 70°F.</li> <li>13.63 in. Water at 70°F.</li> </ul>

### Sheet Metal Thickness (Inches) and Weight (Lbs./Sq. Ft.)

Gauge No.	Steel		Galvanized Steel		Aluminum	
	Thickness	Weight	Thickness	Weight	Thickness	Weight
3	.2391	10.000			.2294	3.23
4	.2242	9.375			.2043	2.88
5	.2092	8.750			.1819	2.56
6	.1943	8.125			.1620	2.29
7	.1793	7.500			.1443	2.04
8	.1644	6.875	.1681	7.031	.1285	1.81
9	.1495	6.250	.1532	6.406	.1144	1.61
10	.1345	5.625	.1382	5.781	.1019	1.44
11	.1196	5.000	.1233	5.156	.0907	1.28
12	.1046	4.375	.1084	4.531	.0808	1.14
13	.0897	3.750	.0934	3.906	.0720	1.02
14	.0747	3.125	.0785	3.281	.0641	.905
15	.0673	2.812	.0710	2.969	.0571	.806
16	.0598	2.500	.0635	2.656	.0508	.717
17	.0538	2.250	.0575	2.406	.0453	.639
18	.0478	2.000	.0516	2.156	.0403	.569
19	.0418	1.750	.0456	1.906	.0359	.507
20	.0359	1.500	.0396	1.656	.0320	.452
21	.0329	1.375	.0366	1.531	.0285	.402
22	.0299	1.250	.0336	1.406	.0254	.357
23	.0269	1.125	.0306	1.281	.0226	.319
24	.0239	1.000	.0276	1.156	.0201	.284
25	.0209	.875	.0247	1.031	.0179	.253
26	.0179	.750	.0217	.906	.0159	.224
27	.0164	.688	.0202	.844	.0142	.200
28	.0149	.625	.0187	.781	.0126	.178
29	.0135	.562	.0172	.719	.0113	.159
30	.0120	.500	.0157	.656	.0100	.141
31	.0105	.438	.0142	.594	.0089	.126
32	.0097	.406	.0134	.563	.0080	.113

### Round Duct Area and Circumference

Dia. In Inches	Area Sq. Ft.	Circum. Inches	Dia. In Inches	Area Sq. Ft.	Circum. Inches
1	.00545	3.142	26	3.687	81.68
2	.0218	6.283	27	3.976	84.82
3	.0491	9.425	28	4.276	87.96
4	.0873	12.57	29	4.587	91.11
5	.1364	15.71	30	4.909	94.25
6	.1963	18.85	31	5.241	97.39
7	.2673	21.99	32	5.585	100.5
8	.3491	25.13	33	5.940	103.7
9	.4418	28.27	34	6.305	106.8
10	.5454	31.42	35	6.681	110.0
11	.6600	34.56	36	7.069	113.1
12	.7854	37.70	37	7.467	116.2
13	.9218	40.84	38	7.876	119.4
14	1.069	43.98	39	8.296	122.5
15	1.227	47.12	40	8.727	125.7
16	1.396	50.27	41	9.168	128.8
17	1.576	53.41	42	9.621	131.9
18	1.767	56.55	43	10.08	135.1
19	1.969	59.69	44	10.56	138.2
20	2.182	62.83	45	11.04	141.4
21	2.405	65.97	46	11.54	144.5
22	2.640	69.12	47	12.05	147.7
23	2.885	72.26	48	12.57	150.8
24	3.142	75.40	49	13.09	153.9
25	3.409	78.54	50	13.64	157.1

† Steel – U.S. Standard (Revised)  
 Galvanized – Galvanized Gauge No.  
 Aluminum – American Gauge and Brown & Sharpe

## MISCELLANEOUS

### Common Fractions Reduced to Decimals

8ths	16ths	32ds	64ths		8ths	16ths	32ds	64ths		8ths	16ths	32ds	64ths	
		1	2	.015625				23	.359375				45	.703125
		1	3	.03125	3	6	12	24	.375			23	46	.71875
			3	.046875				25	.390625			24	47	.734375
	1	2	4	.0625			13	26	.40625	6	12	24	48	.75
			5	.078125				27	.421875			25	49	.765625
		3	6	.09375		7	14	28	.4375			27	50	.78125
			7	.109375				29	.453125			26	51	.796875
1	2	4	8	.125			15	30	.46875		13	26	52	.8125
			9	.140625				31	.484375			27	53	.828125
		5	10	.15625	4	8	16	32	.5			27	54	.84375
			11	.171875				33	.515625			28	55	.859375
	3	6	12	.1875			17	34	.53125	7	14	28	56	.875
			13	.203125				35	.546875			29	57	.890625
		7	14	.21875		9	18	36	.5625			29	58	.90625
			15	.234375				37	.578125			30	59	.921875
2	4	8	16	.25			19	38	.59375		15	30	60	.9375
			17	.265625				39	.609375			31	61	.953125
		9	18	.28125	5	10	20	40	.625			31	62	.96875
			19	.296875				41	.640625			32	63	.984375
	5	10	20	.3125			21	42	.65625	8	16	32	64	1.
			21	.328125				43	.671875					
		11	22	.34375		11	22	44	.6875					

### Mathematical Formulae

**To find the CIRCUMFERENCE of a:**

**Circle** — Multiply the diameter by 3.14159265 (usually 3.1416).

**To find the AREA of a:**

**Circle** — Multiply the square of the diameter by .785398 (usually .7854).

**Rectangle** — Multiply the length of the base by the height.

**Sphere (surface)** — Multiply the square of the radius by 3.1416 and multiply by 4.

**Square** — Square the length of one side.

**Trapezoid** — Add the two parallel sides, multiply by the height and divide by 2.

**Triangle** — Multiply the base by the height and divide by 2.

**To find the VOLUME of a:**

**Cone** — Multiply the square of the radius of the base by 3.1416, multiply by the height, and divide by 3.

**Cube** — Cube the length of one edge.

**Cylinder** — Multiply the square of the radius of the base by 3.1416 and multiply by the height.

**Pyramid** — Multiply the area of the base by the height and divide by 3.

**Rectangular Prism** — Multiply the length by the width by the height.

**Sphere** — Multiply the cube of the radius by 3.1416, multiply by 4 and divide by 3.

## MISCELLANEOUS

## Definitions and Formulae

CFM = Cubic Feet per Minute

FPM = Feet per Minute (Velocity)

Ak = Area Factor Expressed in Square Feet

TP = Total Pressure Expressed in Inches of Water

SP = Static Pressure Expressed in Inches of Water

VP = Velocity Pressure Expressed in Inches of Water

$VP = (FPM \div 4005)^2$

$\Delta P$  = Differential Pressure

$\Delta P_s$  = Static Differential Pressure

$\Delta P_T$  = Total Differential Pressure

$CFM = FPM \times Ak$

$FPM = CFM \div Ak$

$VP = TP - SP$

$TP = SP + VP$

$SP = TP - VP$

$\Delta P_T = TP_1 - TP_2$

$\Delta P_s = SP_1 - SP_2$

## Measures of Force and Pressure

**Dyne** = force necessary to accelerate a 1-gram mass 1 centimeter per second squared = 0.000072 poundal.

**Poundal** = force necessary to accelerate a 1-pound mass 1 foot per second squared = 13,825.5 dynes = 0.138255 newtons.

**Newton** = force needed to accelerate a 1-kilogram mass 1 meter per second squared.

**Pascal** (pressure) = 1 newton per square meter = 0.020885 pound per square foot.

**Atmosphere** (air pressure at sea level) = 2,116.102 pounds per square foot = 14.6952 pounds per square inch = 1.0332 kilograms per square centimeter = 101,323 newtons per square meter.

**METRIC CONVERSION**

**Metric Guide Conversion Factors**

Quantity	Imperial Unit	Metric Unit	From Imperial To Metric Multiply By:	From Metric To Imperial Multiply By:
<b>Area</b>	square foot	square meter (m <sup>2</sup> )	0.0929	10.764
	square inch	square millimeter (mm <sup>2</sup> )	645.16	.00155
<b>Density</b>	pounds per cubic foot	kilograms per cubic meter (kg/M <sup>3</sup> )	16.018	.0624
<b>Energy</b>	British thermal unit (BTU)	joule (J)	1055.056	.000948
	kilowatt hour	megajoule (MJ)	3.6	.2778
	watts per second	joule (J)	1.0	1.0
	horsepower hour	megajoule (MJ)	2.6845	.3725
<b>Force</b>	ounce force	newton (N)	.278	3.597
	pound force	newton (N)	4.4482	.2248
	kilogram force	newton (N)	9.8067	.102
<b>Heat</b>	BTU per hour	watt (W)	.2931	3.412
	BTU per pound	joules per kilogram (J/kg)	2326.0	.00043
<b>Length</b>	inch	millimeter (mm)	25.4	.0394
	foot	millimeter (mm)	304.8	.00328
	foot	meter (m)	.3048	3.2808
	yard	meter (m)	.9144	1.0936
<b>Mass (weight)</b>	ounce (avoirdupois)	gram (g)	28.350	.0353
	pound (avoirdupois)	kilogram (kg)	.4536	2.2046
<b>Power</b>	horsepower	kilowatt (kW)	.7457	1.341
	horsepower (boiler)	kilowatt (kW)	9.8095	.1019
	foot pound - force per minute	watt (W)	.0226	44.254
	ton of refrigeration	kilowatt (kW)	3.517	.2843
<b>Pressure</b>	inch of water column	kilopascal (kPa)	.2486	4.0219
	foot of water column	kilopascal (kPa)	2.9837	.3352
	inch of mercury column	kilopascal (kPa)	3.3741	.2964
	ounces per square inch	kilopascal (kPa)	.4309	2.3206
	pounds per square inch	kilopascal (kPa)	6.8948	.145
<b>Temperature</b>	Fahrenheit	Celsius (°C)	5/9(°F-32)	(9/5°C)+32
<b>Torque</b>	ounce - force inch	millinewton-meter (mN.m)	7.0616	.1416
	pound - force inch	newton-meter (N.m)	.1130	8.8495
	pound - force foot	newton-meter (N.m)	1.3558	.7376
<b>Velocity</b>	feet per second	meters per second (m/s)	.3048	3.2808
	feet per minute	meters per second (m/s)	.00508	196.85
	miles per hour	meters per second (m/s)	.44704	2.2369
<b>Volume (capacity)</b>	cubic foot	liter (l)	28.3168	.03531
	cubic inch	cubic centimeter (cm <sup>3</sup> )	16.3871	.06102
	cubic yard	cubic meter (m <sup>3</sup> )	.7646	1.308
	gallon (U.S.)	liter (l)	3.785	.2642
	gallon (imperial)	liter (l)	4.546	.2120
<b>Volume (flow)</b>	cubic feet per minute (cfm)	liters per second (l/s)	.4719	2.119
	cubic feet per minute (cfm)	cubic meters per second (m <sup>3</sup> /s)	.0004719	2119.0
	cubic feet per hour (cfh)	milliliters per second (ml/s)	7.8658	.127133
	gallons per minute (U.S.)	liters per second (l/s)	.06309	15.850
	gallons per minute (imperial)	liters per second (l/s)	0.7577	13.198



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