ALBERTA Instrumentation TECHNICAL HANDBOOK

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EDMONTON

	Municipal Airport	International Airport
Latitude	53° 34' N	53° 18' N
Longitude	113° 31' W	113° 35' W
Elevation	668m	715m
Barometric Pressure Annual average	93.44 kPa	92.91 kPa

CALGARY

	International Airport
Latitude	51° 7' N
Longitude	114° 1' W
Elevation	1077m
Barometric Pressure Annual average	88.92 kPa

Sea Level Barometric Pressure	101.325 kPa

PHYSICAL PROPERTIES OF SOLIDS

SOLID	DENSITY $\rho, \left[\frac{kg}{m^3}\right]$	LINEAR EXPANSION COEFFICIENT $\alpha \times 10^{-5}, \left[°C^{-1}\right]$	SPECIFIC HEAT $C_p, \left[\frac{J}{kg°C}\right]$
	[@20°C]	[@25°C]	[@25°C]
Ice	917 @0°C		2090 @0°C
Aluminum	2699	2.48	899
Copper	8960	1.66	385
Cast Iron	7874	1.2	452
Nickel	8902 @25°C	1.3	443
Brass	8470	1.89	384
Phosphor Bronze	8860	1.78	366
Carbon Steel	7830	1.21	448
Stainless Steel (316)	8030	1.51	500
K Monel	8470	1.33	544

NOTE: Values are at 101.325 kPa and 20°C or 25°C unless specified otherwise.

METRIC UNITS

Length	Area	Volume
1 km = 1000m	1 km^2 = 10^6 m^2	1 litre = 10^{-3} m^3
1 cm = 0.01 m	1 cm^2 = 10^{-4} m^2	1 cm^3 = 10^{-6} m^3
1mm = 0.001 m	1 mm^2 = 10^{-6} m^2	1 mm^3 = 10^{-6} m^3
1 micron = 10^{-6} m		
1 angstrom = 10^{-10} m		

GREEK ALPHABETS

A	α	alpha		I	ι	iota		P	ρ	rho
B	β	beta		K	κ	keppa		Σ	σ	sigma
Γ	γ	gamma		Λ	λ	lambda		T	τ	tau
Δ	δ	delta		M	μ	mu		Y	υ	upsilon
E	ε	epsilon		N	ν	nu		Φ	φ	phi
Z	ζ	zeta		Ξ	ξ	xi		X	χ	chi
H	η	eta		O	ο	omicron		Ψ	ψ	psi
Θ	θ	theta		Π	π	pi		Ω	ω	omega

Properties of various liquids
(15°C and 101.325 kPa)

Liquid	Density, ρ $\left[\frac{kg}{m^3}\right]$	Density temperature coefficient $\alpha \times 10^{-3}[°C^{-1}]$	Dynamic viscosity, $\mu \times 10^{-4}$ [Pa s]
Acetone	786	1.02	3.37
Benzene	884	1.19	7.05
Carbon Tetrachloride	1594	0.23	10.38
Ethyl Alcohol	791	1.07	13.33
Ethylene glycol	1105	0.38	251
Gasoline (natural)	680	1.12	3.2
Glycerine	1266	0.75	23300
n-Heptane	688	1.24	4.47
n-Hexane	663.8	1.35	3.76
Kerosene	830	1.31	20.8
Mercury	13558.5	0.18	1.59
Methyl Alcohol	796	1.17	6.32
n-Octane	706.7	1.12	5.74
Oil heavy crude	930	0.59	980
Oil heavy fuel	970	0.57	125000
Oil light crude	860	0.64	85
Oil SAE 10W motor	870	0.65	1020
Oil SAE 30 Motor	891	0.61	4300
n-Pentane	631	1.57	2.49
Sulfuric Acid	1834	0.85	328
Toluene	871.6	1.08	6.2
Turpentine	872	1.27	16.35

Properties of various liquids
(15°C and 101.325 kPa)

Liquid	Freezing Point [°C]	Boiling Point [°C]	Heat of fusion $\left[\frac{kJ}{kg}\right]$	Heat of vaporization $\left[\frac{kJ}{kg}\right]$	Specific Heat $\left[\frac{kJ}{kg°C}\right]$
Acetone	-95.5	56.2	98	551.7	2.15
Carbon Tetrachloride	-24	7.7	17.5	198	0.841
Ethylene glycol	-11.5	198	181	799.6	2.397
Glycerine	18.2	290	200.6	827	2.32
Mercury	-38.9	356.6	11.8	295.6	0.1394
Sulfuric Acid (98%)	3	338	190.5	511	1.419

PHYSICAL PROPERTIES OF WATER FROM 0 TO 100°C

Temperature [°C]	Density kg/m^3]	Vapor Pressure [kPa]	Viscosity [mPa.s]	Surface Tension [N/m]
0	999.84	0.611	1.792	0.0756
1	999.90	0.657	1.731	0.0755
2	999.94	0.706	1.673	0.0753
3	999.96	0.758	1.619	0.0752
4	999.97	0.813	1.567	0.0750
5	999.96	0.872	1.519	0.0749
6	999.94	0.935	1.473	0.0748
7	999.90	1.002	1.428	0.0746
8	999.85	1.072	1.386	0.0745
9	999.78	1.148	1.346	0.0743
10	999.70	1.228	1.308	0.0742
11	999.61	1.312	1.271	0.0741
12	999.50	1.402	1.236	0.0739
13	999.38	1.497	1.203	0.0738
14	999.24	1.598	1.171	0.0736
15	999.10	1.705	1.140	0.0735
16	998.94	1.818	1.111	0.0733
17	998.78	1.938	1.083	0.0732
18	998.60	2.064	1.056	0.0730
19	998.41	2.198	1.030	0.0729
20	998.20	2.339	1.005	0.0727
21	997.99	2.487	0.981	0.0726
22	997.77	2.645	0.958	0.0724
23	997.54	2.810	0.936	0.0723
24	997.30	2.985	0.914	0.0721
25	997.05	3.169	0.894	0.0720
26	996.78	3.363	0.874	0.0718
27	996.51	3.567	0.855	0.0717
28	996.23	3.782	0.836	0.0715
29	995.95	4.008	0.818	0.0713
30	995.65	4.246	0.801	0.0712

PHYSICAL PROPERTIES OF WATER FROM 0 TO 100°C

Temperature [°C]	Density kg/m^3]	Vapor Pressure [kPa]	Viscosity [mPa.s]	Surface Tension [N/m]
31	995.34	4.496	0.784	0.0710
32	995.03	4.759	0.768	0.0709
33	994.70	5.034	0.752	0.0707
34	994.37	5.324	0.737	0.0706
35	994.03	5.628	0.723	0.0704
36	993.68	5.947	0.709	0.0702
37	993.33	6.281	0.695	0.0701
38	992.97	6.632	0.681	0.0699
39	992.59	6.999	0.669	0.0697
40	992.22	7.384	0.656	0.0696
41	991.38	7.786	0.644	0.0694
42	991.44	8.208	0.632	0.0693
43	991.04	8.649	0.621	0.0691
44	990.63	9.111	0.610	0.0689
45	990.21	9.593	0.599	0.0688
46	989.79	10.10	0.588	0.0686
47	989.36	10.62	0.578	0.0684
48	988.93	11.18	0.568	0.0682
49	988.49	11.75	0.559	0.0681
50	988.04	12.35	0.549	0.0679
51	987.58	12.98	0.540	0.0677
52	987.12	13.63	0.532	0.0676
53	986.65	14.31	0.523	0.0674
54	986.18	15.02	0.515	0.0672
55	985.70	15.76	0.506	0.0671
56	985.22	16.53	0.499	0.0669
57	984.72	17.33	0.491	0.0667
58	984.22	18.17	0.483	0.0665
59	983.71	19.04	0.476	0.0664
60	983.20	19.94	0.469	0.0662
61	982.68	20.88	0.462	0.0660
62	982.16	21.86	0.455	0.0658
63	981.63	22.88	0.448	0.0657
64	981.10	23.93	0.442	0.0655
65	980.56	25.03	0.436	0.0653

PHYSICAL PROPERTIES OF WATER FROM 0 TO 100°C

Temperature [°C]	Density kg / m^3]	Vapor Pressure [kPa]	Viscosity [mPa.s]	Surface Tension [N/m]
66	980.01	26.17	0.429	0.0651
67	979.46	27.36	0.423	0.0649
68	978.90	28.59	0.417	0.0648
69	978.34	29.86	0.412	0.0646
70	977.77	31.19	0.406	0.0644
71	977.20	32.56	0.401	0.0642
72	976.62	33.99	0.395	0.0640
73	976.04	35.46	0.390	0.0639
74	975.45	36.99	0.385	0.0637
75	974.85	38.58	0.380	0.0635
76	974.25	40.22	0.375	0.0633
77	973.65	41.92	0.370	0.0631
78	973.03	43.68	0.366	0.0630
79	972.42	45.50	0.361	0.0628
80	971.80	47.39	0.357	0.0626
81	971.17	49.34	0.352	0.0624
82	970.54	51.36	0.348	0.0622
83	969.91	53.45	0.344	0.0620
84	969.27	55.60	0.340	0.0619
85	968.62	57.83	0.336	0.0617
86	967.97	60.14	0.332	0.0615
87	967.32	62.52	0.328	0.0613
88	966.66	64.98	0.324	0.0611
89	965.99	67.52	0.320	0.0609
90	965.32	70.14	0.317	0.0607
91	964.65	72.84	0.313	0.0606
92	963.97	75.64	0.310	0.0604
93	963.28	78.52	0.306	0.0602
94	962.60	81.49	0.303	0.0600
95	961.90	84.55	0.299	0.0598
96	961.20	87.71	0.296	0.0596
97	960.50	90.97	0.293	0.0595
98	959.79	94.33	0.290	0.0593
99	959.08	97.78	0.287	0.0591
100	958.37	101.33	0.284	0.0589

Viscosity of water and steam at various temperatures and pressures

Viscosity of Water and Steam - in centipoise (μ)

Temp.	Pressure Bar Absolute (1 bar = 100 kPa)														
°C	1	5	10	25	50	75	100	150	200	300	400	500	600	700	800
0	1.750	1.750	1.750	1.750	1.750	1.750	1.750	1.740	1.740	1.740	1.730	1.720	1.720	1.710	1.710
50	.544	.544	.544	.544	.545	.545	.545	.546	.546	.547	.548	.549	.550	.551	.552
100	.012	.279	.279	.280	.280	.280	.281	.282	.283	.285	.287	.289	.291	.293	.295
150	.014	.181	.181	.182	.182	.183	.183	.184	.186	.188	.190	.192	.194	.197	.199
200	.016	.016	.016	.134	.135	.135	.136	.137	.138	.140	.143	.145	.148	.150	.152
250	.018	.018	.018	.018	.107	.108	.108	.110	.111	.113	.116	.118	.121	.123	.126
300	.020	.020	.020	.020	.020	.020	.090	.092	.093	.095	.098	.101	.103	.106	.108
350	.022								.073	.078	.082	.085	.087	.089	.091
375	.023	.023	.023	.024	.024	.024	.025	.026	.029 ⊙	.066	.072	.076	.079	.082	.085
400	.024	.024	.024	.025	.025	.025	.026	.027	.029	.046	.063	.069	.074	.077	.080
425	.025	.025	.025	.026	.026	.026	.027	.028	.029	.034	.050	.061	.067	.071	.075
450	.026	.026	.026	.027	.027	.027	.028	.028	.030	.033	.041	.052	.060	.065	.069
475	.027	.027	.027	.028	.028	.028	.029	.029	.030	.033	.038	.046	.053	.060	.064
500	.028	.028	.028	.029	.029	.029	.029	.030	.031	.033	.037	.042	.048	.054	.060
550	.030	.030	.030	.031	.031	.031	.031	.032	.033	.035	.037	.040	.044	.048	.053
600	.032	.032	.033	.033	.033	.033	.033	.034	.034	.036	.038	.040	.043	.046	.049
650	.034	.034	.035	.035	.035	.035	.035	.036	.036	.038	.039	.041	.043	.045	.048
700	.036	.037	.037	.037	.037	.037	.037	.038	.038	.039	.041	.042	.044	.046	.048

Notes: (1) The entry shown for 0°C and 1 bar relates to a metastable liquid state. The stable state is here solid.

⊙ (2) Critical point, 374.15°C, 221.2 bar.

CONVERSION CONSTANTS

A. Dynamic viscosity (μ) defined as

$$\mu = \frac{\text{shear stress (force)}}{\text{shear rate}}$$

can be converted between different units using the following table of conversion factors

Units and conversion factors for dynamic viscosity, μ

To obtain the viscosity in the desired unit multiply the viscosity in the given unit by the listed conversion factor

→ Desired Unit ↓Given Unit	lb-s/ft^2	Pa.s*	Poise
lb-s/ft^2	1	47.88	478.8
Pa.s*	2.089×10^{-2}	1	10
poise**	2.089×10^{-3}	0.1	1
centipoise	2.089×10^{-5}	0.001	0.01

* Standard SI units
Equivalent unit: N.s/m^2
**dyne.s/cm^2
Equivalent unit: g/cm.s
Example: Given a viscosity of 200 centipoises, determine the viscosity in Pa.s

$$200 \text{ centipoises} \times \frac{0.001 \text{ Pa.s}}{\text{centipoise}} = 0.20 \text{ Pa.s}$$

B. Kinematic viscosity, ν, which is

$$\upsilon = \frac{\text{dynamic viscosity}}{\text{density}} = \frac{\mu}{\rho}$$

can be converted between different units using the following table of conversion factors

Units and conversion factors for kinematic viscosity, ν

To obtain the viscosity in the desired unit multiply the viscosity in the given unit by the listed conversion factor

→ Desired Unit ↓Given Unit	ft^2/s	SSU	m^2/s	Stoke
ft^2/s	1	4.29×10^5	9.290×10^{-2}	929.0
SSU*	2.33×10^{-6}	1	2.17×10^{-7}	2.17×10^{-3}
m^2/s**	10.764	4.61×10^6	1	10^4
stoke***	1.076×10^{-3}	4.61×10^2	10^{-4}	1
centistoke	1.076×10^{-5}	4.61	10^{-6}	0.01

* Saybolt Seconds, Universal (conversions approximate for SSU > 100)
For SSU < 100: $\nu = (0.226 \text{ SSU} - 195/\text{SSU})(10^{-6})\text{m}^2/\text{s}$
**Standard SI unit
***cm^2/s
Example: Given a viscosity of 200 centistokes, determine the viscosity in m^2/s

$$200 \text{ centistokes} \times \frac{10^{-6}\text{ m}^2/\text{s}}{\text{centistoke}} = 200 \times 10^{-6}\text{ m}^2/\text{s}$$

DIMENSIONS OF STEEL TUBING

Outside Diameter		Wall Thickness		Inside Diameter	Flow Area
(in)	(mm)	(in)	(mm)	(mm)	(m^2)
$\frac{1}{8}$	3.18	0.028	0.71	1.75	2.413×10^{-6}
		0.032	0.81	1.55	1.885×10^{-6}
		0.035	0.89	1.40	1.533×10^{-6}
$\frac{3}{16}$	4.76	0.032	0.81	3.14	7.729×10^{-6}
		0.035	0.89	2.98	6.996×10^{-6}
$\frac{1}{4}$	6.35	0.035	0.89	4.57	1.642×10^{-5}
		0.049	1.24	3.86	1.171×10^{-5}
		0.065	1.65	3.05	7.297×10^{-6}
$\frac{3}{16}$	7.94	0.035	0.89	6.16	2.979×10^{-5}
		0.049	1.24	5.45	2.331×10^{-5}
		0.065	1.65	4.64	1.688×10^{-5}
$\frac{3}{8}$	9.53	0.035	0.89	7.75	4.714×10^{-5}
		0.049	1.24	7.04	3.888×10^{-5}
		0.065	1.65	6.22	3.042×10^{-5}
$\frac{1}{2}$	12.70	0.035	0.89	10.92	9.365×10^{-5}
		0.049	1.24	10.21	8.189×10^{-5}
		0.065	1.65	9.40	6.937×10^{-5}
		0.083	2.11	8.48	5.652×10^{-5}
$\frac{5}{8}$	15.88	0.035	0.89	14.10	1.561×10^{-4}
		0.049	1.24	13.39	1.408×10^{-4}
		0.065	1.65	12.57	1.241×10^{-4}
		0.083	2.11	11.66	1.068×10^{-4}
$\frac{3}{4}$	19.05	0.049	1.24	16.56	2.154×10^{-4}
		0.065	1.65	15.75	1.948×10^{-4}
		0.083	2.11	14.83	1.728×10^{-4}
		0.109	2.77	13.51	1.434×10^{-4}
$\frac{7}{8}$	22.23	0.049	1.24	19.74	3.059×10^{-4}
		0.065	1.65	18.92	2.812×10^{-4}
		0.083	2.11	18.01	2.547×10^{-4}
		0.109	2.77	16.69	2.187×10^{-4}

VISCOSITY OF GASES (mPa.s) FROM 0 TO 400°C

SUBSTANCE	TEMPERATURE, °C								
	0	50	100	150	200	250	300	350	400
Air	0.0171	0.0195	0.0217	0.0238	0.0258	0.0278	0.0297	0.0317	0.0337
Oxygen	0.0189	0.0216	0.0242	0.0266	0.0289	0.0310	0.0330	0.0349	0.0369
Nitrogen	0.0166	0.0188	0.0208	0.0227	0.0245	0.0263	0.0280	0.0296	0.0309
Hydrogen	0.0084	0.0094	0.0103	0.0112	0.0121	0.0130	0.0138	0.0146	0.0153
Methane	0.0103	0.0118	0.0133	0.0147	0.0160	0.0172	0.0184	0.0195	0.0207
Ethane	0.0085	0.0100	0.0114	0.0128	0.0141	0.0154	0.0167	0.0180	0.0193
Propane	0.0074	0.0088	0.0101	0.0113	0.0125	0.0137	0.0149	0.0161	0.0173
Carbon Monoxide	0.0166	0.0189	0.0208	0.0226	0.0245	0.0265	0.0286	0.0306	0.0321
Carbon Dioxide	0.0139	0.0164	0.0187	0.0209	0.0229	0.0248	0.0267	0.0285	0.0302
Chlorine	0.0123	0.0147	0.0168	0.0189	0.0209	0.0230	0.0251	0.0272	0.0293
Hydrogen Sulphide	0.0117	0.0138	0.0159	0.0179	0.0200	0.0221	0.0243	0.0265	0.0287
Sulphur Dioxide	0.0116	0.0139	0.0161	0.0182	0.0204	0.0226	0.0248	0.0268	0.0285
Ammonia	0.0092	0.0109	0.0128	0.0146	0.0165	0.0181	0.0199	0.0216	0.0233

Conversions: Metric Values

The table below provides a fast and easy means of conversion from one metric notation to another. The value labeled "Unit" represents a basic unit of measurement, such as meter, gram, ohm, erg, etc. First, locate the original value in the left-hand column. Follow the row horizontally to the vertical column headed by the prefix of the desired value. The arrow and figure at this intersection represent the direction in which the decimal point should be moved and the number of places to move it.

Example: Convert 0.15 kilowatts to watts. Starting at the "Kilo-" box in the left-hand column, move horizontally to the column headed by "Unit" (since watt is a basic unit of measurement), and read 3→ . Thus 0.15 kilowatts is the equivalent of 150 watts.

Example: Convert 4,500 kilohertz to megahertz, read in the box horizontal to "Kilo-" and under "Mega-" the notation ← 3, which means a shift of the decimal point three places to the left. Thus, 4,500 kilohertz is the equivalent of 4.5 megahertz.

Original Value	Desired Value													
	Tera-	Giga-	Mega-	Myria-	Kilo-	Hecto-	Deka-	Unit	Deci-	Centi-	Milli-	Micro-	Nano-	Pico-
Tera-		3 →	6 →	8 →	9 →	10 →	11 →	12 →	13 →	14 →	15 →	18 →	21 →	24 →
Giga-	← 3		3 →	5 →	6 →	7 →	8 →	9 →	10 →	11 →	12 →	15 →	18 →	21 →
Mega-	← 6	← 3		2 →	3 →	4 →	5 →	6 →	7 →	8 →	9 →	12 →	15 →	18 →
Myria-	← 8	← 5	← 2		1 →	2 →	3 →	4 →	5 →	6 →	7 →	10 →	13 →	16 →
Kilo-	← 9	← 6	← 3	← 1		1 →	2 →	3 →	4 →	5 →	6 →	9 →	12 →	15 →
Hecto-	← 10	← 7	← 4	← 2	← 1		1 →	2 →	3 →	4 →	5 →	8 →	11 →	14 →
Deka-	← 11	← 8	← 5	← 3	← 2	← 1		1 →	2 →	3 →	4 →	7 →	10 →	13 →
Unit	← 12	← 9	← 6	← 4	← 3	← 2	← 1		1 →	2 →	3 →	6 →	9 →	12 →
Deci-	← 13	← 10	← 7	← 5	← 4	← 3	← 2	← 1		1 →	2 →	5 →	8 →	11 →
Centi-	← 14	← 11	← 8	← 6	← 5	← 4	← 3	← 2	← 1		1 →	4 →	7 →	10 →
Milli-	← 15	← 12	← 9	← 7	← 6	← 5	← 4	← 3	← 2	← 1		3 →	6 →	9 →
Micro-	← 18	← 15	← 12	← 10	← 9	← 8	← 7	← 6	← 5	← 4	← 3		3 →	6 →
Nano-	← 21	← 18	← 15	← 13	← 12	← 11	← 10	← 9	← 8	← 7	← 6	← 3		3 →
Pico-	← 24	← 21	← 18	← 16	← 15	← 14	← 13	← 12	← 11	← 10	← 9	← 6	← 3	

Conversions: Metric Prefixes

atto	a	one-quintillionth	0.000 000 000 000 000 001	10^{-18}
femto	f	one-quadrillionth	0.000 000 000 000 001	10^{-15}
pico	p	one-trillionth	0.000 000 000 001	10^{-12}
nano	n	one-billionth	0.000 000 001	10^{-9}
micro	μ	one-millionth	0.000 001	10^{-6}
milli	m	one-thousandth	0.001	10^{-3}
centi	c	one-hundredth	0.01	10^{-2}
deci	d	one-tenth	0.1	10^{-1}
uni		one	1.0	10^{0}
deka	da	ten	10.0	10^{1}
hecto	h	one hundred	100.0	10^{2}
kilo	k	one thousand	1 000.0	10^{3}
mega	M	one million	1 000 000.0	10^{6}
giga	G	one billion	1 000 000 000.0	10^{9}
tera	T	one trillion	1 000 000 000 000.0	10^{12}

Conversions: Temperature

Locate temperature in middle column. If in degrees Celsius, read Fahrenheit equivalent in right hand column; if in degrees Fahrenheit, read Celsius equivalent in left hand column.

–459.4° to 0°			1 to 60°			61° to 290°			300° to 890°			900° to 3000°		
C	C / F	F	C	C / F	F	C	C / F	F	C	C / F	F	C	C / F	F
–273.1	–459.7		–17.2	1	33.8	16.1	61	141.8	149	300	572	482	900	1652
–268	–450		–16.7	2	35.6	16.7	62	143.6	154	310	590	488	910	1670
–262	–440		–16.1	3	37.4	17.2	63	145.4	160	320	608	493	920	1688
–257	–430		–15.6	4	39.2	17.8	64	147.2	166	330	626	499	930	1706
–251	–420		–15.0	5	41.0	18.3	65	149.0	171	340	644	504	940	1724
–246	–410		–14.4	6	42.8	18.9	66	150.8	177	350	662	510	950	1742
–240	–400		–13.9	7	44.6	19.4	67	152.6	182	360	680	516	960	1760
–234	–390		–13.3	8	46.4	20.0	68	154.4	188	370	698	521	970	1778
–229	–380		–12.8	9	48.2	20.6	69	156.2	193	380	716	527	980	1796
–223	–370		–12.2	10	50.0	21.1	70	158.0	199	390	734	532	990	1814
–218	–360		–11.7	11	51.8	21.7	71	159.8	204	400	752	538	1000	1832
–212	–350		–11.1	12	53.6	22.2	72	161.6	210	410	770	549	1020	1868
–207	–340		–10.6	13	55.4	22.8	73	163.4	216	420	788	560	1040	1904
–201	–330		–10.0	14	57.2	23.3	74	165.2	221	430	806	571	1060	1940
–196	–320		– 9.4	15	59.0	23.9	75	167.0	227	440	824	582	1080	1976
–190	–310		– 8.9	16	60.8	24.4	76	168.8	232	450	842	593	1100	2012
–184	–300		– 8.3	17	62.6	25.0	77	170.6	238	460	860	604	1120	2048
–179	–290		– 7.8	18	64.4	25.6	78	172.4	243	470	878	616	1140	2084
–173	–280		– 7.2	19	66.2	26.1	79	174.2	249	480	896	627	1160	2120
–169	–273.1	–459.7	– 6.7	20	68.0	26.7	80	176.0	254	490	914	638	1180	2156
–168	–270	–454	– 6.1	21	69.8	27.2	81	177.8	260	500	932	649	1200	2192
–162	–260	–436	– 5.6	22	71.6	27.8	82	179.6	266	510	940	660	1220	2228
–157	–250	–418	– 5.0	23	73.4	28.3	83	181.4	271	520	968	671	1240	2264
–151	–240	–400	– 4.4	24	75.2	28.9	84	183.2	277	530	986	682	1260	2300
–146	–230	–382	– 3.9	25	77.0	29.4	85	185.0	282	540	1004	693	1280	2336
–140	–220	–364	– 3.3	26	78.8	30.0	86	186.8	288	550	1022	704	1300	2372
–134	–210	–346	– 2.8	27	80.6	30.6	87	188.6	293	560	1040	732	1350	2462
–129	–200	–328	– 2.2	28	82.4	31.1	88	190.4	299	570	1058	760	1400	2552
–123	–190	–310	– 1.7	29	84.2	31.7	89	192.2	304	580	1076	788	1450	2642
–118	–180	–292	– 1.1	30	86.0	32.2	90	194.0	310	590	1094	816	1500	2732
–112	–170	–274	– 0.6	31	87.8	32.8	91	195.8	316	600	1112	843	1550	2822
–107	–160	–256	0.0	32	89.6	33.3	92	197.6	321	610	1130	871	1600	2912
–101	–150	–238	0.6	33	91.4	33.9	93	199.4	327	620	1148	899	1650	3002
– 96	–140	–220	1.1	34	93.2	34.4	94	201.2	332	630	1166	927	1700	3092
– 90	–130	–202	1.7	35	95.0	35.0	95	203.0	338	640	1184	954	1750	3182
– 84	–120	–184	2.2	36	96.8	35.6	96	204.8	343	650	1202	982	1800	3272
– 79	–110	–166	2.8	37	98.6	36.1	97	206.6	349	660	1220	1010	1850	3362
– 73	–100	–148	3.3	38	100.4	36.7	98	208.4	354	670	1238	1038	1900	3452
– 68	– 90	–130	3.9	39	102.2	37.2	99	210.2	360	680	1256	1066	1950	3542
– 62	– 80	–112	4.4	40	104.0	37.8	100	212.0	366	690	1274	1093	2000	3632
– 57	– 70	– 94	5.0	41	105.8	43	110	230	371	700	1292	1121	2050	3722
– 51	– 60	– 76	5.6	42	107.6	49	120	248	377	710	1310	1149	2100	3812
– 46	– 50	– 58	6.1	43	109.4	54	130	266	382	720	1328	1177	2150	3902
– 40	– 40	– 40	6.7	44	111.2	60	140	284	388	730	1346	1204	2200	3992
– 34	– 30	– 22	7.2	45	113.0	66	150	302	393	740	1364	1232	2250	4082
– 29	– 20	– 4	7.8	46	114.8	71	160	320	399	750	1382	1260	2300	4172
– 23	– 10	14	8.3	47	116.6	77	170	338	404	760	1400	1288	2350	4262
– 17.8	0	32	8.9	48	118.4	82	180	356	410	770	1418	1316	2400	4352
			9.4	49	120.2	88	190	374	416	780	1436	1343	2450	4442
			10.0	50	122.0	92	200	392	421	790	1454	1371	2500	4532
			10.6	51	123.8	99	210	410	427	800	1472	1399	2550	4622
			11.1	62	125.6	100	212	413.6	432	810	1490	1427	2600	4712
			11.7	53	127.4	104	220	428	438	820	1508	1454	2650	4802
			12.2	54	129.2	110	230	446	443	830	1526	1482	2700	4892
			12.8	55	131.0	116	240	464	449	840	1544	1510	2750	4982
			13.3	56	132.8	121	250	482	454	850	1562	1538	2800	5072
			13.9	57	134.6	127	260	500	460	860	1580	1566	2850	5162
			14.4	58	136.4	132	270	518	466	870	1598	1593	2900	5252
			15.0	59	138.2	138	280	536	471	880	1616	1621	2950	5342
			15.6	60	140.0	143	290	554	477	890	1634	1649	3000	5432

Conversions: Flow Rate

Velocity in Feet per Second.
Find the volume flow rate (gallons per minute) in the left hand column, read the velocity flow rate (feet per second) for a specific line size in the right hand column. (Based on Schedule 40 pipe.)

GPM	Line Size 1”	Line Size 1 1/4”	Line Size 1 1/2”	Line Size 2”	Line Size 2 1/2”	Line Size 3”	Line Size 4”	Line Size 5”	Line Size 6”	Line Size 8”	Line Size 10”
0.03	0.011										
0.05	0.019	0.011	0.008								
0.10	0.037	0.021	0.016	0.010	0.007						
0.25	0.093	0.054	0.039	0.024	0.017	0.011					
0.50	0.186	0.107	0.079	0.048	0.034	0.022	0.013				
0.75	0.279	0.161	0.118	0.072	.0050	0.033	0.019	0.012			
1	0.371	0.214	0.158	0.095	0.067	0.043	0.025	0.016	0.011		
2	0.743	0.428	0.315	0.191	0.134	0.087	0.050	0.032	0.022	0.013	
3	1.114	0.643	0.473	0.286	0.201	0.130	0.076	0.048	0.033	0.019	0.012
4	1.485	0.857	0.630	0.382	0.268	0.174	0.101	0.064	0.044	0.026	0.016
5	1.857	1.071	0.788	0.477	0.335	0.217	0.126	0.080	0.056	0.032	0.020
6	2.228	1.285	0.945	0.573	0.402	0.261	0.151	0.096	0.067	0.038	0.024
8	2.971	1.714	1.261	0.764	0.537	0.347	0.202	0.128	0.089	0.051	0.033
10	3.713	2.142	1.576	0.955	0.671	0.434	0.252	0.160	0.111	0.064	0.041
15	5.570	3.213	2.364	1.432	1.006	0.651	0.378	0.240	0.167	0.096	0.061
20	7.427	4.285	3.151	1.910	1.341	0.869	0.504	0.321	0.222	0.128	0.081
25	9.283	5.356	3.939	2.387	1.677	1.086	0.630	0.401	0.278	0.160	0.102
30		6.427	4.727	2.865	2.012	1.303	0.756	0.481	0.333	0.192	.0122
35		7.498	5.515	3.342	2.347	1.520	0.882	0.561	0.389	0.224	0.142
40		8.569	6.303	3.820	2.683	1.737	1.008	0.641	0.444	0.257	0.163
45		9.640	7.091	4.297	3.018	1.954	1.134	0.721	0.500	0.289	0.183
50		10.712	7.878	4.775	3.353	2.172	1.260	0.801	0.555	0.321	0.203
60			9.454	5.730	4.024	2.606	1.512	0.962	0.666	0.385	0.244
70			11.030	6.685	4.695	3.040	1.764	1.122	0.777	0.449	0.285
80				7.640	5.365	3.474	2.016	1.282	0.889	0.513	0.326
100				9.550	6.707	4.343	2.520	1.603	1.111	0.641	0.407
125					8.384	5.429	3.150	2.004	1.388	0.802	0.509
150					10.060	6.515	3.781	2.404	1.666	0.962	0.610
175					11.737	7.600	4.411	2.805	1.944	1.122	0.712
200						8.686	5.041	3.206	2.221	1.283	0.814
225						9.772	5.671	3.606	2.499	1.443	0.916
250						10.858	6.301	4.007	2.777	1.603	1.017
275						11.944	6.931	4.408	3.054	1.764	1.119
300							7.561	4.809	3.332	1.924	1.221
325							8.191	5.209	3.610	2.084	1.323
350							8.821	5.610	3.887	2.245	1.424
375							9.451	6.011	4.165	2.405	1.526
400							10.081	6.412	4.443	2.565	1.628
425							10.712	6.812	4.720	2.726	1.730
450								7.213	4.998	2.886	1.831
475								7.614	5.276	3.046	1.933
500								8.014	5.553	3.207	2.035
550								8.816	6.109	3.527	2.238
600								9.617	6.664	3.848	2.442
650								10.419	7.219	4.169	2.645
700									7.775	4.489	2.849
750									8.330	4.810	3.052
800									8.885	5.131	3.256
850									9.441	5.451	3.459
900									9.996	5.772	3.662
950									10.551	6.093	3.866
1,000										6.413	4.069
1,100										7.055	4.476
1,200										7.696	4.883
1,300										8.337	5.290
1,400										8.979	5.697
1,500										9.620	6.104
1,600										10.261	6.511
1,800											7.325
2,000											8.139
2,500											10.174

Conversions: Flow Rate (cont.)

Velocity in Meters per Second

Find the volume flow rate (cubic meters per hour) in the left hand column, read the velocity flow rate (meters per second) for a specific line size in the right hand column. (Based on Schedule 40 pipe.)

m^3/hr	Line Size 1”	Line Size 1 1/4”	Line Size 1 1/2”	Line Size 2”	Line Size 2 1/2”	Line Size 3”	Line Size 4”	Line Size 5”	Line Size 6”	Line Size 8”	Line Size 10”
0.02	0.010										
0.05	0.025	0.014	0.011								
0.10	0.050	0.029	0.021	0.013	0.009						
0.15	0.075	0.043	0.032	0.019	0.014	0.009					
0.20	0.100	0.057	0.042	0.026	0.018	0.012	0.007				
0.25	0.125	0.072	0.053	0.032	0.023	0.015	0.008	0.005			
0.30	0.149	0.086	0.063	0.038	0.027	0.017	0.010	0.006	0.004		
0.35	0.174	0.101	0.074	0.045	0.032	0.020	0.012	0.008	0.005	0.003	
0.40	0.199	0.115	0.085	0.051	0.036	0.023	0.014	0.009	0.006	0.003	0.002
0.50	0.249	0.144	0.106	0.064	0.045	0.029	0.017	0.011	0.007	0.004	0.003
0.75	0.374	0.216	0.159	0.096	0.068	0.044	0.025	0.016	0.011	0.006	0.004
1.0	0.498	0.287	0.211	0.128	0.090	0.058	0.034	0.022	0.015	0.009	0.005
1.5	0.747	0.431	0.317	0.192	0.135	0.087	0.051	0.032	0.022	0.013	0.008
2.0	0.997	0.575	0.423	0.256	0.180	0.117	0.068	0.043	0.030	0.017	0.011
2.5	1.246	0.719	0.529	0.320	0.225	0.146	0.085	0.054	0.037	0.022	0.014
3.0	1.495	0.862	0.634	0.384	0.270	0.175	0.101	0.065	0.045	0.026	0.016
3.5	1.744	1.006	0.740	0.449	0.315	0.204	0.118	0.075	0.052	0.030	0.019
4.0	1.993	1.150	0.846	0.513	0.360	0.233	0.135	0.086	0.060	0.034	0.022
4.5	2.242	1.294	0.952	0.577	0.405	0.262	0.152	0.097	0.067	0.039	0.025
5.0	2.492	1.437	1.057	0.641	0.450	0.291	0.169	0.108	0.075	0.043	0.027
5.5	2.741	1.581	1.163	0.705	0.495	0.321	0.186	0.118	0.082	0.047	0.030
6.0		1.725	1.269	0.769	0.540	0.350	0.203	0.129	0.089	0.052	0.033
7.0		2.012	1.480	0.897	0.630	0.048	0.237	0.151	0.104	0.060	0.038
8.0		2.300	1.692	1.025	0.720	0.466	0.271	0.172	0.119	0.069	0.044
10		2.875	2.114	1.282	0.900	0.583	0.338	0.215	0.149	0.086	0.055
12			2.537	1.538	1.080	0.699	0.406	0.258	0.179	0.103	0.066
14				1.794	1.250	0.815	0.474	0.301	0.209	0.120	0.076
16				2.050	1.440	0.933	0.541	0.344	0.238	0.138	0.087
18				2.307	1.620	1.049	0.609	0.387	0.268	0.155	0.098
20				2.563	1.800	1.166	0.676	0.430	0.298	0.172	0.109
22				2.819	1.980	1.282	0.744	0.473	0.328	0.189	0.120
24					2.160	1.399	0.812	0.516	0.358	0.207	0.131
26					2.340	1.515	0.879	0.559	0.388	0.224	0.142
28					2.520	1.632	0.947	0.602	0.417	0.241	0.153
30					2.700	1.748	1.015	0.645	0.447	0.258	0.164
32					2.880	1.865	1.082	0.688	0.477	0.275	0.175
34					3.060	1.982	1.150	0.731	0.507	0.293	0.186
36						2.098	1.218	0.774	0.537	0.310	0.197
38						2.215	1.285	0.817	0.566	0.327	0.208
40						2.331	1.353	0.860	0.596	0.344	0.218
45						2.623	1.522	0.968	0.671	0.387	0.246
50						2.914	1.691	1.075	0.745	0.430	0.273
55						3.205	1.860	1.183	0.820	0.473	0.300
60							2.029	1.291	0.894	0.516	0.328
65							2.198	1.398	0.969	0.559	0.355
70							2.368	1.506	1.043	0.602	0.382
75							2.537	1.613	1.118	0.645	0.410
80							2.706	1.721	1.192	0.689	0.437
90							3.044	1.936	1.341	0.775	0.491
100								2.151	1.490	0.861	0.546
120								2.581	1.789	1.033	0.655
140								3.011	2.087	1.205	0.765
160									2.385	1.377	0.874
180									2.683	1.549	0.983
200										1.721	1.092
250										2.152	1.365
300										2.582	1.638
350										3.012	1.911
400											2.184
450											2.457
500											2.730

Conversions: Miscellaneous

TO CONVERT	INTO	MULTIPLY BY
A		
acres	sq. feet	43,560.0
"	sq. meters	4,047.0
"	sq. miles	1.562×10^{-3}
"	sq. yards	4,840.0
acre-feet	cu. feet	43,560.0
"	gallons	3.259×10^{5}
amperes/sq. cm.	amps./sq. in.	6.452
"	amps/sq. meter	10^{4}
amperes/sq. in.	amps/sq. cm.	0.1550
"	amps/sq. meter	1,550.0
amperes/sq. meter	amps/sq. cm.	10^{-4}
"	amps/sq. in.	6.452×10^{-4}
ampere-hours	coulombs	3,600.0
"	faradays	0.03731
ampere-turns	gilberts	1.257
ampere-turns/cm.	amp-turns/in.	2.540
"	amp-turns/meter	100.0
"	gilberts/cm.	1.257
ampere-turns/in.	amp-turns/cm.	0.3937
"	amp-turns/meter	39.37
"	gilberts/cm.	0.4950
ampere-turns/meter	amp-turns/cm.	0.01
"	amp-turns/in.	0.0254
"	gilberts/cm.	0.01257
ares	acres	0.02471
"	sq. meters	100.0
atmospheres	cms. of mercury	76.0
"	ft. of water (at 4°C)	33.90
"	in. of mercury (at 0°C)	29.92
"	kgs./sq. cm.	1.0333
"	kgs./sq. meter	10,332.0
"	pounds/sq. in.	14.70
"	tons/sq. ft.	1.058

TO CONVERT	INTO	MULTIPLY BY
B		
barrels (oil)	gallons (oil)	42.0
bars	atmospheres	0.9869
"	dynes/sq. cm.	1
"	kgs./sq. meter	1.020×10^{4}
"	pounds/sq. ft.	2,089.0
"	pounds/sq. in.	14.50
Btu	ergs	1.0550×10^{10}
"	foot-lbs.	778.3
"	gram-calories	252.0
"	horsepower-hrs.	3.931×10^{-4}
"	joules	1,054.8
"	kilogram-calories	0.2520
"	kilogram-meters	107.5
"	kilowatt-hrs.	2.928×10^{-4}
Btu/hr.	foot-pounds/sec.	0.2162
"	gram-cal./sec.	0.0700
"	horsepower-hrs.	3.929×10^{-4}
"	watts	0.2931
Btu/min.	foot-lbs./sec.	12.96
"	horsepower	0.02356
"	kilowatts	0.01757
"	watts	17.57
Btu/sq. ft./min.	watts/sq. in.	0.1221
bushels	cu. ft.	1.2445
"	cu. in.	2,150.4
"	cu. meters	0.03524
"	liters	35.24
"	pecks	4.0
"	pints (dry)	64.0
"	quarts (dry)	32.0

TO CONVERT	INTO	MULTIPLY BY
C		
centares (centiares)	sq. meters	1.0
Centigrade	Fahrenheit	(C° x 9/5) + 32
centigrams	grams	0.01
centiliters	liters	0.01
centimeters	feet	3.281×10^{-2}
"	inches	0.3937
"	kilometers	10^{-5}
"	meters	0.01
"	miles	6.214×10^{-6}
"	millimeters	10.0
"	mils	393.7
"	yards	1.094×10^{-2}
centimeter-dynes	cm.-grams	1.020×10^{-3}
"	meter-kgs.	1.020×10^{-8}
"	pound-feet	7.376×10^{-8}
centimeter-grams	cm.-dynes	980.7
"	meter-kgs.	10^{-5}
"	pound-feet	7.233×10^{-5}
centimeters of mercury	atmospheres	0.01310
"	feet of water	0.4401
"	kgs./sq. meter	136.0
"	pounds/sq. ft.	27.85
"	pounds/sq. in.	0.1934
centimeters/sec.	feet/min.	1.1969
"	feet/sec.	0.03281
"	kilometers/hr.	0.036
"	knots	0.1943
"	meters/min.	0.6
"	miles/hr.	0.02237
"	miles/min.	3.728×10^{-4}
centimeters/sec./sec.	feet/sec./sec.	0.03281
"	kms./hr./sec.	0.036
"	meters/sec./sec.	0.01
"	miles/hr./sec.	0.02237
circular mils	sq. cms.	5.067×10^{-6}
"	sq. mils	0.7854
"	sq. inches	7.854×10^{-7}
coulombs	faradays	1.036×10^{-5}
coulombs/sq. cm.	coulombs/sq. in.	64.52
"	coulombs/sq. meter	10^{4}
coulombs/sq. in.	coulombs/sq. cm.	0.1550
"	coulombs/sq. meter	1,550.0
coulombs/sq. meter	coulombs/sq. cm.	10^{-4}
"	coulombs/sq. in.	6.452×10^{-4}
cubic centimeters	cu. feet	3.531×10^{-5}
"	cu. inches	0.06102
"	cu. meters	10^{-6}
"	cu. yards	1.308×10^{-6}
"	gallons (U.S. liq.)	2.642×10^{-4}
"	liters	0.001
"	pints (U.S. liq.)	2.113×10^{-3}
"	quarts (U.S. liq.)	1.057×10^{-3}
cubic feet	bushels (dry)	0.8036
"	cu. cms.	28,320.0
"	cu. inches	1,728.0
"	cu. meters	0.02832
"	cu. yards	0.03704
"	gallons (U.S. liq.)	7.48052
"	liters	28.32
"	pints (U.S. liq.)	59.84
"	quarts (U.S. liq.)	29.92
cubic feet/min.	cu. cms./sec.	472.0
"	gallons/sec.	0.1247
"	liters/sec.	0.4720
"	pounds of water/min.	62.43

Conversions: Miscellaneous (cont.)

TO CONVERT	INTO	MULTIPLY BY
C (cont.)		
cubic feet/sec.	million gals./day	0.646317
"	gallons/min.	448.831
cubic inches	cu. cms.	16.39
"	cu. feet	5.787×10^{-4}
"	cu. meters	1.639×10^{-5}
"	cu. yards	2.143×10^{-5}
"	gallons (U.S. liq.)	4.329×10^{-3}
"	liters	0.01639
"	mil.-ft.	1.061×10^{5}
"	pints (U.S. liq.)	0.03463
"	quarts (U.S. liq.)	0.01732
cubic meters	bushels (dry)	28.38
"	cu. cms.	10^{6}
"	cu. feet	35.31
"	cu. inches	61,023.0
"	cu. yards	1.308
"	gallons (U.S. liq.)	264.2
"	liters	10^{3}
"	pints (U.S. liq.)	2,113.0
"	quarts (U.S. liq.)	1,057.0
cubic yards	cu. cms.	7.646×10^{5}
"	cu. feet	27.0
"	cu. inches	46,656.0
"	cu. meters	0.7646
"	gallons (U.S. liq.)	202.0
"	liters	764.6
"	pints (U.S. liq.)	1,615.9
"	quarts (U.S. liq.)	807.9
cubic yards/min.	cubic ft./sec.	0.45
"	gallons/sec.	3.367
"	liters/sec.	12.74
D		
days	hours	24.0
"	minutes	1,440.0
"	seconds	86,400.0
decigrams	grams	0.1
deciliters	liters	0.1
decimeters	meters	0.1
degrees (angle)	minutes	60.0
"	quadrants	0.01111
"	radians	0.01745
"	seconds	3,600.0
degrees/sec.	radians/sec.	0.01745
"	revolutions/min.	0.1667
"	revolutions/sec.	2.778×10^{-3}
dekagrams	grams	10.0
dekaliters	liters	10.0
dekameters	meters	10.0
drams	grams	1.7718
"	grains	27.3437
"	ounces	0.0625
dynes	grams	1.020×10^{-3}
"	joules/cm.	10^{7}
"	joules/meter (newtons)	10^{-5}
"	kilograms	1.020×10^{-6}
"	poundals	7.233×10^{-5}
"	pounds	2.248×10^{-6}
dynes/sq. cm.	bars	1
dynes/sq. meters	bars	10^{-4}
E		
ergs	Btu	9.480×10^{-11}
"	dyne-centimeters	1.0
"	foot-pounds	7.378×10^{-8}
"	gram-calories	2.389×10^{-8}

TO CONVERT	INTO	MULTIPLY BY
E (cont.)		
ergs (continued)	gram-cms.	1.020×10^{-3}
"	horsepower-hrs.	3.7250×10^{-14}
"	joules	10^{-7}
"	kg.-calories	2.389×10^{-11}
"	kg.-meters	1.020×10^{-8}
"	kilowatt-hrs.	0.2778×10^{-13}
"	watt-hours	0.2778×10^{-10}
ergs/sec.	Btu/min.	$5,688.0 \times 10^{-9}$
"	ft.-lbs./min.	4.427×10^{-6}
"	ft.-lbs./sec.	7.3756×10^{-8}
"	horsepower	1.341×10^{-10}
"	kg.-calories/min.	1.433×10^{-9}
"	kilowatts	10^{-10}
F		
farads	microfarads	10^{6}
faradays	ampere-hours	26.80
"	coulombs	9.649×10^{4}
fathoms	feet	6.0
feet	centimeters	30.48
"	kilometers	3.048×10^{-4}
"	meters	0.3048
"	miles (naut.)	1.645×10^{-4}
"	miles (stat.)	1.894×10^{-4}
"	millimeters	304.8
"	mils	1.2×10^{4}
feet of water	atmospheres	0.02950
"	in. of mercury	0.8826
"	kgs./sq. cm.	0.03048
"	kgs./sq. meter	304.8
"	pounds/sq. ft.	62.43
"	pounds/sq. in.	0.4335
feet/min.	cms./sec.	0.5080
"	feet/sec.	0.01667
"	kms./hr.	0.01829
"	meters/min.	0.3048
"	miles/hr.	0.01136
feet/sec.	cms./sec.	30.48
"	kms./hr.	1.097
"	knots	0.5921
"	meters/min.	18.29
"	miles/hr.	0.6818
"	miles/min.	0.01136
feet/sec./sec.	cms./sec./sec.	30.48
"	kms./hr./sec.	1.097
"	meters/sec./sec.	0.3048
"	miles/hr./sec.	0.6818
feet/100 feet	per cent grade	1.0
foot-pounds	Btu	1.286×10^{-3}
"	ergs	1.356×10^{7}
"	grams-calories	0.3238
"	hp-hrs.	5.050×10^{-7}
"	joules	1.356
"	kg.-calories	3.24×10^{-4}
"	kg.-meters	0.1383
"	kilowatt-hrs.	3.766×10^{-7}
foot-pounds/min.	Btu/min.	1.286×10^{-3}
"	foot-pounds/sec.	0.01667
"	horsepower	3.030×10^{-5}
"	kg.-calories/min.	3.24×10^{-4}
"	kilowatts	2.260×10^{-5}
foot-pounds/sec.	Btu/hr.	4.6263
"	Btu/min.	0.07717
"	horsepower	1.818×10^{-3}
"	kg.-calories/min.	0.01945
"	kilowatts	1.356×10^{-3}
furlongs	rods	40.0
"	feet	660.0

Conversions: Miscellaneous (cont.)

G

TO CONVERT	INTO	MULTIPLY BY
gallons	cu. cms.	3,785.0
"	cu. feet	0.1337
"	cu. inches	231.0
"	cu. meters	3.785×10^{-3}
"	cu. yards	4.951×10^{-3}
"	liters	3.785
"	pints	8.0
"	quarts	4.0
gallons (liq. Br. Imp.)	gallons (U.S. liq.)	1.20095
gallons (U.S.)	gallons (Imp.)	0.83267
gallons of water	pounds of water	8.3453
gallons/min.	cu. ft./sec.	2.228×10^{-3}
"	liters/sec.	0.06308
"	cu. ft./hr.	8.0208
gausses	lines/sq. in.	6.452
"	webers/sq. cm.	10^{-8}
"	webers/sq. in.	6.452×10^{-8}
"	webers/sq. meter	10^{-4}
gilberts	ampere-turns	0.7958
gilberts/cm.	amp-turns/cm.	0.7958
"	amp-turns/in.	2.021
"	amp-turns/meter	79.58
gils	liters	0.1183
"	pints (liq.)	0.25
grains (troy)	grains (avdp.)	1.0
"	grams	0.06480
"	ounces (avdp.)	2.0833×10^{-3}
"	pennyweight (troy)	0.04167
grains/U.S. gal.	parts/million	17.118
"	pounds/million gal.	142.86
grains/Imp. gal.	parts/million	14.286
grams	dynes	980.7
"	grains	15.43
"	joules/cm	9.807×10^{-5}
"	joules/meter (newtons)	9.807×10^{-3}
"	kilograms	10^{-3}
"	milligrams	10^{3}
"	ounces (avdp.)	0.03527
"	ounces (troy)	0.03215
"	poundals	0.07093
"	pounds	2.205×10^{-3}
grams/cm.	pounds/inch	5.600×10^{-3}
grams/cu. cm.	pounds/cu. ft.	62.43
"	pounds/cu. in.	0.03613
"	pounds/mil.-foot	3.405×10^{-7}
grams/liter	grains/gal.	58.417
"	pounds/1,000 gal.	8.345
"	pounds/cu. ft.	0.062427
"	parts/million	1,000.0
grams/sq. cm.	pounds/sq. ft.	2.0481
gram-calories	Btu	3.9683×10^{-3}
"	ergs	4.1868×10^{7}
"	foot-pounds	3.0880
"	horsepower-hrs.	1.5596×10^{-6}
"	kilowatt-hrs.	1.1630×10^{-6}
"	watt-hrs.	1.1630×10^{-3}
gram-calories/sec.	Btu/hr.	14.286
gram-centimeters	Btu	9.297×10^{-8}
"	ergs	980.7
"	joules	9.807×10^{-5}
"	kg.-cal.	2.343×10^{-8}
"	kg-meters	10^{-5}

H

TO CONVERT	INTO	MULTIPLY BY
hectares	acres	2.471
"	sq. foot	1.076×10^{5}
hectograms	grams	100.0
hectoliters	liters	100.0
hectometers	meters	100.0
hectowatts	watts	100.0
henries	millihenries	10^{3}
horsepower	Btu/min.	42.44
"	foot-lbs./min.	33,000.0
"	foot-lbs./sec.	550.0
horsepower (metric) (542.5 ft. lb./sec.)	horsepower (550 ft. lb./sec.)	0.9863
horsepower (550 ft. lb./sec.)	horsepower (metric) (542.5 ft. lb./sec.)	1.014
horsepower	kg.-calories/min.	10.68
"	kilowatts	0.7457
"	watts	745.7
horsepower (boiler)	Btu/hr.	33.479
"	kilowatts	9.803
horsepower-hrs.	Btu	2,547.0
"	ergs	2.6845×10^{13}
"	foot-lbs.	1.98×10^{6}
"	gram-calories	641,190.0
"	joules	2.694×10^{6}
"	kg.-calories	641.1
"	kg.-meters	2.737×10^{5}
"	kilowatt-hrs.	0.7457
hours	days	4.167×10^{-2}
"	minutes	60.0
"	seconds	3,600.0
"	weeks	5.952×10^{-3}

I

TO CONVERT	INTO	MULTIPLY BY
inches	centimeters	2.540
"	feet	8.333×10^{-2}
"	meters	2.540×10^{-2}
"	miles	1.578×10^{-5}
"	millimeters	25.40
"	mils	10^{3}
"	yards	2.778×10^{-2}
inches of mercury	atmospheres	0.03342
"	feet of water	1.133
"	kgs./sq. cm.	0.03453
"	kgs./sq. meter	345.3
"	pounds/sq. ft.	70.73
"	pounds/sq. in.	0.4912
inches of water (at 4°C)	atmospheres	2.458×10^{-3}
"	inches of mercury	0.07355
"	kgs./sq. cm.	2.540×10^{-3}
"	ounces/sq. in.	0.5781
"	pounds/sq. ft.	5.204
"	pounds/sq. in.	0.03613

J

TO CONVERT	INTO	MULTIPLY BY
joules	Btu	9.480×10^{-4}
"	ergs	10^{7}
"	foot-pounds	0.7376
"	kg.-calories	2.389×10^{-4}
"	kg.-meters	0.1020
"	watt-hrs.	2.778×10^{-4}
joules/cm.	grams	1.020×10^{-4}
"	dynes	10^{7}
"	joules/meter (newtons)	100.0
"	poundals	723.3
"	pounds	22.48

Conversions: Miscellaneous (cont.)

TO CONVERT	INTO	MULTIPLY BY
K		
kilograms	dynes	980,665.0
"	grams	10^3
"	joules/cm.	0.09807
"	joules/meter (newtons)	9.807
"	poundals	70.93
"	pounds	2.205
"	tons (long)	9.842×10^{-4}
"	tons (short)	1.102×10^{-3}
kilograms/cu. meter	grams/cu. cm.	0.001
"	pounds/cu. ft.	0.06243
"	pounds/cu. in.	3.613×10^{-5}
"	pounds/mil.-foot	3.405×10^{-10}
kilograms/meter	pounds/ft.	0.6720
kilograms/sq. cm.	atmospheres	0.9678
"	feet of water	32.81
"	inches of mercury	28.96
"	pounds/sq. ft.	2,048.0
"	pounds/sq. in.	14.22
kilograms/sq. meter	atmospheres	9.678×10^{-5}
"	bars	98.07×10^{-6}
"	feet of water	32.81×10^{-3}
"	inches of mercury	2.896×10^{-3}
"	pounds/sq. ft.	0.2048
"	pounds/sq. in.	1.422×10^{-3}
kilograms/sq. mm.	kgs./sq. meter	10^6
kilogram-calories	Btu	3.968
"	foot-pounds	3,088.0
"	hp-hrs.	1.560×10^{-7}
"	joules	4,186.0
"	kg.-meters	426.9
"	kilojoules	4.186
"	kilowatt-hrs.	1.163×10^{-3}
kilogram meters	Btu	9.294×10^{-3}
"	ergs	9.804×10^7
"	foot-pounds	7.233
"	joules	9.804
"	kg.-calories	2.342×10^{-3}
"	kilowatt-hrs.	2.723×10^{-6}
kilolines	maxwells	10^3
kiloliters	liters	10^3
kilometers	centimeters	10^5
"	feet	3,281.0
"	inches	3.937×10^4
"	meters	10^3
"	miles	0.6214
"	millimeters	10^6
"	yards	1,094.0
kilometers/hr.	cms./sec.	27.78
"	feet/min.	54.68
"	feet/sec.	0.9113
"	knots	0.5396
"	meters/min.	16.67
"	miles/hr.	0.6214
kilometers/hrs./sec.	cms./sec./sec.	27.78
"	ft./sec./sec.	0.9113
"	meters/sec./sec.	0.2778
"	miles/hr./sec.	0.6214
kilopascals	atmospheres	9.87×10^{-3}
"	feet of water	0.335
"	inches of Hg	0.296
"	kgs/sq. meter	1.02×10^2
"	pounds/sq. ft.	20.9
"	pounds/sq. in.	0.145
"	torr	7.5
kilowatts	Btu/min.	56.92
"	foot-lbs./min.	4.426×10^4
"	foot-lbs./sec.	737.6

TO CONVERT	INTO	MULTIPLY BY
K (cont.)		
kilowatts (cont.)	horsepower	1.341
"	kg.-calories/min.	14.34
"	watts	10^3
kilowatt-hrs.	Btu	3,413.0
"	ergs	3.600×10^{13}
"	foot-lbs.	2.655×10^6
"	gram-calories	859,850.0
"	horsepower-hrs.	1.341
"	joules	3.6×10^6
"	kg.-calories	860.5
"	kg.-meters	3.671×10^5
"	pounds of water evaporated from and at 212°F	3.53
"	pounds of water raised from 62° to 212°F	22.75
knots	feet/hr.	6,080.0
"	kilometers/hr.	1.8532
"	nautical miles/hr.	1.0
"	statute miles/hr.	1.151
"	yards/hr.	2,027.0
"	feet/sec.	1.689
L		
league	miles (approx.)	3.0
lines/sq. cm.	gausses	1.0
lines/sq. in.	gausses	0.1550
"	webers/sq. cm.	1.550×10^{-9}
"	webers/sq. in.	10^{-8}
"	webers/sq. meter	1.550×10^{-5}
links (engineer's)	inches	12.0
links (surveyor's)	inches	7.92
liters	bushels (U.S. dry)	0.02838
"	cu. cm.	10^3
"	cu. feet	0.03531
"	cu. inches	61.02
"	cu. meters	0.001
"	cu. yards	1.308×10^{-3}
"	gallons (U.S. liq.)	0.2642
"	pints (U.S. liq.)	2.113
"	quarts (U.S. liq.)	1.057
liters/min.	cu. ft./sec.	5.886×10^{-4}
"	gals./sec.	4.403×10^{-3}
lumens/sq. ft.	foot-candles	1.0
lux	foot-candles	0.0929
M		
maxwells	kilolines	10^{-3}
"	webers	10^{-8}
megalines	maxwells	10^6
megohms	microhms	10^{12}
"	ohms	10^6
meters	centimeters	10^2
"	feet	3.281
"	inches	39.37
"	kilometers	0.001
"	miles (naut.)	5.396×10^{-4}
"	miles (stat.)	6.214×10^{-4}
"	millimeters	10^3
"	yards	1.094
"	varas	1.179
meters/min.	cms./sec.	1.667
"	feet/min.	3.281
"	feet/sec.	0.5468
"	kms./hr.	0.06
"	knots	0.03238

Conversions: Miscellaneous (cont.)

TO CONVERT	INTO	MULTIPLY BY
M (cont.)		
meters/min. (cont.)	miles/hr.	0.03728
meters/sec.	feet/min.	196.8
"	feet/sec.	3.281
"	kilometers/hr.	3.6
"	miles/hr.	2.237
"	miles/min.	0.03728
meters/sec./sec.	cms./sec./sec.	10^{2}
"	ft./sec./sec.	3.281
"	kms./hr./sec.	3.6
"	miles/hr./sec.	2.237
meter-kilograms	cm.-dynes	9.807×10^{7}
"	cm.-grams	10^{5}
"	pound-feet	7.233
microfarad	farads	10^{-6}
micrograms	grams	10^{-6}
microhms	megohms	10^{-12}
"	ohms	10^{-6}
microliters	liters	10^{-6}
microns	meters	10^{-6}
miles (naut.)	feet	6,080.27
"	kilometers	1.853
"	meters	1,853.00
"	miles (statute)	1.1516
"	yards	2,027.0
miles (statute)	centimeters	1.609×10^{5}
"	feet	5,280.0
"	inches	6.336×10^{4}
"	kilometers	1.609
"	meters	1,609.0
"	miles (naut.)	0.8684
"	yards	1,760.0
miles/hr.	cm./sec.	44.70
"	feet/min.	88.0
"	feet/sec.	1.467
"	kms./hr.	1.609
"	kms./min.	0.02682
"	knots	0.8684
"	meters/min.	26.82
"	miles/min.	0.01667
miles/hr./sec.	cms./sec./sec.	44.70
"	feet/sec./sec.	1.467
"	kms./hr./sec.	1.609
"	meters/sec./sec.	0.4470
miles/min.	cms./sec.	2,682.0
"	feet/sec.	88.0
"	kms./min.	1.609
"	miles (naut.)/min.	0.8684
"	miles/hr.	60.0
mil-feet	cu. inches	9.425×10^{-6}
milliers	kilograms	10^{3}
milligrams	grams	10^{-3}
milligrams/liter	parts/million	1.0
millihenries	henries	10^{-3}
milliliters	liters	10^{-3}
millimeters	centimeters	0.1
"	feet	3.281×10^{-3}
"	inches	0.03937
"	meters	0.001
"	miles	6.214×10^{-7}
"	mils	39.37
"	yards	1.094×10^{-3}
million gals./day	cu. ft./sec.	1.54723
mils	centimeters	2.540×10^{-3}
"	feet	8.333×10^{-5}
"	inches	0.001
"	kilometers	2.540×10^{-8}

TO CONVERT	INTO	MULTIPLY BY
M (cont.)		
mils (cont.)	yards	2.778×10^{-5}
miner's inches	cu. ft./min.	1.5
minutes (angles)	degrees	0.01667
"	quadrants	1.852×10^{-4}
"	radians	2.909×10^{-4}
"	seconds	60.0 myriagrams
	kilograms	10.0
myriameters	kilometers	10.0
myriawatts	kilowatts	10.0
N		
nepers	decibels	8.686
O		
ohms	megohms	10^{-6}
ohms	microhms	10^{6}
ounces	drams	16.0
"	grains	437.5
"	grams	28.349527
"	pounds	0.0625
"	ounces (troy)	0.9115
"	tons (long)	2.790×10^{-5}
"	tons (metric)	2.834×10^{-5}
ounces (fluid)	cu. inches	1.805
"	liters	0.2957
ounces (troy)	grains	480.0
"	grams	31.103481
"	ounces (avdp.)	1.09714
"	pennyweights (troy)	20.0
"	pounds (troy)	0.08333
ounces/sq. in.	pounds/sq. in.	0.0625
P		
parts/million	grains/U.S. gal.	0.0584
"	grains/Imp. gal.	0.07016
"	pounds/million gal.	8.345
pascals	millibar	10^{-2}
"	pounds/sq. ft.	2.09×10^{-2}
"	pounds/sq. in.	1.45×10^{-4}
"	torr	7.5×10^{-3}
"	in.Hg	2.96×10^{-4}
pennyweights (troy)	grains	24.0
"	ounces (troy)	0.05
"	grams	1.55517
"	pounds (troy)	4.1667×10^{-3}
pints (dry)	cu. inches	33.60
pints (liq.)	cu. cms.	473.2
"	cu. feet	0.01671
"	cu. inches	28.87
"	cu. meters	4.732×10^{-4}
"	cu. yards	6.189×10^{-4}
"	gallons	0.125
"	liters	0.4732
"	quarts (liq.)	0.5
poundals	dynes	13,826.0
"	grams	14.10
"	joules/cm.	1.383×10^{-3}
"	joules/meter (newtons)	0.1383
"	kilograms	0.01410
"	pounds	0.03108
pounds	drams	256.0
"	dynes	44.4823×10^{4}
"	grains	7,000.0
"	grams	453.5924
"	joules/cm.	0.04448
"	joules/meter (newton)	4.448

Conversions: Miscellaneous (cont.)

TO CONVERT	INTO	MULTIPLY BY
P (cont.)		
pounds (cont.)	kilograms	0.4536
"	ounces	16.0
"	ounces (troy)	14.5833
"	poundals	32.17
"	pounds (troy)	1.21528
"	tons (short)	0.0005
pounds (troy)	grains	5,760.0
"	grams	373.24177
"	ounces (avdp.)	13.1657
"	ounces (troy)	12.0 pounds (troy)
"	pennyweights (troy)	240.0
"	pounds (avdp.)	0.822857
"	tons (long)	3.6735×10^{-4}
"	tons (metric)	3.7324×10^{-4}
"	tons (short)	4.1143×10^{-4}
pounds of water	cu. feet	0.01602
"	cu. inches	27.68
"	gallons	0.1198
pounds of water/min.	cu. ft./sec.	2.670×10^{-4}
pounds-feet	cm.-dynes	1.356×10^{7}
"	cm.-grams	13,825.0
"	meter-kgs.	0.1383
pounds/cu. ft.	grams/cu. cm.	0.01602
"	kgs./cu. meter	16.02
"	pounds/cu. in.	5.787×10^{-4}
"	pounds/mil.-ft.	5.456×10^{-9}
pounds/cu. in.	gms./cu. cm.	27.68
"	kgs./cu. meter	2.768×10^{4}
"	pounds/cu. ft.	1,728.0
"	pounds/mil.-foot	9.425×10^{-6}
pounds/ft.	kgs./meter	1.488
pounds/in.	gms./cm.	178.6
pounds/mil.-foot	gms./cu. cm.	2.306×10^{6}
pounds/sq. ft.	atmospheres	4.725×10^{-4}
"	feet of water	0.01602
"	inches of mercury	0.01414
"	kgs./sq. meter	4.882
"	pounds/sq. in.	6.944×10^{-3}
pounds/sq. in.	atmospheres	0.06804
"	feet of water	2.307
"	inches of mercury	2.036
"	kgs./sq. meter	703.1
"	pounds/sq. ft.	144.0
"	kilopascal	6.8948
Q		
quadrants (angle)	degrees	90.0
"	minutes	5,400.0
"	radians	1.571
"	seconds	3.24×10^{5}
quarts (dry)	cu. inches	67.20
quarts (liq.)	cu. cms.	946.4
"	cu. feet	0.03342
"	cu. inches	57.75
"	cu. meters	9.464×10^{-4}
"	cu. yards	1.238×10^{-3}
"	gallons	0.25
"	liters	0.9463
R		
radians	degrees	57.30
"	minutes	3,438.0
"	quadrants	0.6366
"	seconds	2.063×10^{5}
radians/sec.	degrees sec.	57.30
"	revolutions/min.	9.549

TO CONVERT	INTO	MULTIPLY BY
R (cont.)		
radians/sec. (cont.)	revolutions/sec.	0.1592
radians/sec./sec.	revs./min./min.	573.0
"	revs./min./sec.	9.549
"	revs./sec./sec.	0.1592
revolutions	degrees	360.0
"	quadrants	4.00
"	radians	6.283
revolutions/min.	degrees/sec.	6.0
"	radians/sec.	0.1047
"	revs./sec.	0.01667
revolutions/min./min.	radians/sec./sec.	1.745×10^{-3}
"	revs./min./sec.	0.01667
"	revs./sec./sec.	2.778×10^{-4}
revolutions/sec.	degrees/sec.	360.0
"	radians/sec.	6.283
"	revs./min.	60.0
revolutions/sec./sec.	radians/sec./sec.	6.283
"	revs./min./min.	3,600.0
"	revs./min./sec.	60.0
rods	feet	16.5
S		
seconds (angle)	degrees	2.778×10^{-4}
"	minutes	0.01667
"	quadrants	3.087×10^{-6}
"	radians	4.848×10^{-6}
square centimeters	circular mils	1.973×10^{5}
"	sq. feet	1.076×10^{-3}
"	sq. inches	0.1550
"	sq. meters	0.0001
"	sq. miles	3.861×10^{-11}
"	sq. millimeters	100.0
"	sq. yards	1.196×10^{-4}
square feet	acre	2.296×10^{-5}
"	circular mils	1.833×10^{8}
"	sq. cms.	929.0
"	sq. inches	144.0
"	sq. meters	0.09290
"	sq. miles	3.587×10^{-8}
"	sq. millimeters	9.290×10^{4}
"	sq. yards	0.1111
square inches	circular mils	1.273×10^{6}
"	sq. cms.	6.452
"	sq. feet	6.944×10^{-3}
"	sq. millimeters	645.2
"	sq. mils	10^{6}
"	sq. yards	7.716×10^{-4}
square kilometers	acres	247.1
"	sq. cms.	10^{10}
"	sq. ft.	10.76×10^{6}
"	sq. inches	1.550×10^{9}
"	sq. meters	10^{6}
"	sq. miles	0.3861
"	sq.yards	1.196×10^{6}
square meters	acres	2.471×10^{-4}
"	sq. cms.	10^{4}
"	sq. feet	10.76
"	sq. inches	1,550.0
"	sq. miles	3.861×10^{-7}
"	sq. millimeters	10^{6}
"	sq. yards	1.196
square miles	acres	640.0
"	sq. feet	27.88×10^{6}
"	sq. kms.	2.590
"	sq. meters	2.590×10^{6}
"	sq. yards	3.098×10^{6}

Conversions: Miscellaneous (cont.)

S (cont.)

TO CONVERT	INTO	MULTIPLY BY
square millimeters	circular mils	1,973.0
"	sq. cms.	0.01
"	sq. feet	1.076×10^{-5}
"	sq. inches	1.550 x 10-C
square mils	circular mils	1.273
"	sq. cms.	6.452×10^{-6}
"	sq. inches	10^{-6}
square yards	acres	2.066×10^{-4}
"	sq. cms.	8,361.0
"	sq. ft.	9.0
"	sq. inches	1,296.0
"	sq. meters	0.8361
"	sq. miles	3.228×10^{-7}
"	sq. millimeters	8.361×10^{5}

T

TO CONVERT	INTO	MULTIPLY BY
temperature (°C) + 273	absolute temperature (°C)	1.0
temperature (°C) + 17.78	temperature (°F)	1.8
temperature (°F) + 460	absolute temperature (°F)	1.0
temperature (°F) - 32	temperature (°C)	0.555
tons (long)	kilograms	1,016.0
"	pounds	2,240.0
"	tons (short)	1.120
tons (metric)	kilograms	1,000.0
"	pounds	2,205.0
tons (short)	kilograms	907.1848
"	ounces	32,000.0
"	ounces (troy)	29,166.66
"	pounds	2,000.0
"	pounds (troy)	2,430.56
"	tons (long)	0.89287
"	tons (metric)	0.9078
tons (short)/sq. ft.	kgs./sq. meter	9,765.0
"	pounds/sq. in.	2,000.0
tons of water/24 hrs.	pounds of water/hr.	83.333
"	gallons/min.	0.16643
"	cu. ft./hr.	1.3349

W

TO CONVERT	INTO	MULTIPLY BY
watts	Btu/hr.	3.4192
"	Btu/min.	0.05688
"	ergs/sec.	107.0
"	foot-lbs./min.	44.27
"	foot-lbs./sec.	0.7378
"	horsepower	1.341×10^{-3}
"	horsepower (metric)	1.360×10^{-3}
"	kg.-calories/min.	0.01433
"	kilowatts	0.001
watt-hours	Btu	3.413
"	ergs	3.60×10^{10}
"	foot-pounds	2,656.0
"	gram-calories	859.85
"	horsepower-hrs.	1.341×10^{-3}
"	kilogram-calories	0.8605
"	kilogram-meters	367.2
"	kilowatt-hrs.	0.001
webers	maxwells	10^{8}
"	kilolines	10^{5}
webers/sq. in.	gausses	1.550×10^{7}
"	lines/sq. in.	10^{8}
"	webers/sq. cm.	0.1550
"	webers/sq. meter	1,550.0
webers/sq. meter	gausses	10^{4}
"	lines/sq. in.	6.452×10^{4}
"	webers/sq. cm.	10^{-4}
"	webers/sq. in.	6.452×10^{-4}

Y

TO CONVERT	INTO	MULTIPLY BY
yards	centimeters	91.44
"	feet	3.0
"	inches	36.0
"	kilometers	9.144×10^{-4}
"	meters	0.9144
"	miles (naut.)	4.934×10^{-4}
"	miles (stat.)	5.682×10^{-4}
"	millimeters	914.4

Equivalents: Liquid Measures and Weights

TO OBTAIN / MULTIPLY BY	U.S. Gallon	Imperial Gallon	U.S. Pint	U.S. Pound Water*	U.S. Cubic Foot	U.S. Cubic Inch	Liter	Cubic Meter
U.S. Gallon	1	0.833	8.0	8.337	0.13368	231.0	3.78533	0.003785
Imperial Gallon	1.2009	1	9.60762	10.0	0.16054	277.42	4.54596	0.004546
U.S. Pint	0.125	0.1041	1	1.042	0.01671	28.875	0.473166	0.000473
U.S. Pound Water*	0.11995	0.1	0.9596	1	0.016035	27.708	0.45405	0.000454
U.S. Cubic Foot	7.48052	6.22888	59.8442	62.365	1	1728.0	28.31702	0.028317
U.S. Cubic Inch	0.004329	0.00361	0.034632	0.03609	0.0005787	1	0.016387	0.0000164
Liter	0.2641779	0.2199756	2.113423	2.202	0.0353154	61.02509	1	0.001000
Cubic Meter	264.170	219.969	2113.34	2202.0	35.31446	61023.38	999.972	1

*Water at 60°F (15.6°C)
1 Barrel = 42 gallons (petroleum measure)

EXAMPLE:
(8 Imperial gallons) (4.54596) = 36.36768 liters

Equivalents: Kinematic Viscosity

To convert kinematic viscosity from one set of units to another, locate the given set of units in the left hand column and multiply the numerical value by the factor shown horizontally to the right, under the set of units desired.

As an example, suppose a given kinematic viscosity of 0.5 square foot/second is to be converted to centistokes. By referring to the table, we find the conversion factor to be 92,900. Then, 0.5 (sq ft/sec) times 92,900 = 46,450 centistokes.

Kinematic Viscosity		centistokes (ν)	stokes $\frac{cm^2}{sec}$ (100 ν)	$\frac{ft^2}{sec}$ (ν')
centistokes	(ν)	1	0.01	$1.076\ (10^{-5})$
stokes $\frac{cm^2}{sec}$	(100 ν)	100	1	$1.076\ (10^{-3})$
$\frac{ft^2}{sec}$	(ν')	92,900	929	1

Equivalents: Absolute Viscosity

To convert absolute or dynamic viscosity from one set of units to another, locate the given set of units in the left hand column and multiply the numerical value by the factor shown horizontally to the right under the set of units desired.

As an example, suppose a given absolute viscosity of 2 poise is to be converted to slugs/foot second. By referring to the table, we find the conversion factor to be 2.09 (10^{-3}). Then, 2 (poise) times 2.09 (10^{-3}) = 4.18 (10^{-3}) = 0.00418 slugs/foot second.

Absolute or Dynamic Viscosity		**centipoise** **(μ)**	**poise** $\frac{\text{gram}}{\text{cm sec}}$ $\frac{\text{dyne sec}}{\text{cm}^2}$ **(100 μ)**	$\frac{\text{slugs}}{\text{ft sec}}$ $\frac{\text{pounds}_f}{\text{ft}^2}$ **(μ' $_e$)**	$\frac{\dagger\text{pounds}_m}{\text{ft sec}}$ $\frac{\text{poundal sec}}{\text{ft}^2}$ **(μ $_e$)**
centipoise	(μ)	1	0.01	2.09 (10^{-5})	6.72 (10^{-4})
poise $\frac{\text{gram}}{\text{cm sec}}$ $\frac{\text{dyne sec}}{\text{cm}^2}$	(100 μ)	100	1	2.09 (10^{-3})	0.0672
$\frac{\text{slugs}}{\text{ft. sec}}$ $\frac{*\text{pounds}_f \text{ sec}}{\text{ft}^2}$	(μ'_e)	47,900	479	1	g or 32.2
$\frac{\dagger\text{pounds}_m}{\text{ft. sec}}$ $\frac{\text{poundal sec}}{\text{ft}^2}$	(μ_e)	1,487	14.87	$\frac{1}{g}$ or .0311	1

*Pound$_f$ = Pound of Force †Pound$_m$ = Pound of Mass

Equivalents: Electrical Units

	Practical Unit	**Cgs Electromagnetic Unit**	**Cgs Electrostatic Unit**
Emf	volt = 10^8 abvolts volt = 3.3 x 10^{-3} statvolt	abvolt = 10^{-8} volt abvolt = 3.3 x 10^{-11} statvolt	statvolt = 300 volts (approx.) statvolt = 3 x 10^{10} abvolts
Resistance	ohm = 10^9 abohms ohm = 1.1 x 10^{-12} statohm	abohm = 10^{-9} ohm abohm = 1.1 x 10^{-21} statohm	statohm = 9 x 10^{11} ohms statohm = 9 x 10^{20} abohms
Current	ampere = 10^{-1} abampere ampere = 3 x 10^9 statamperes	abampere = 10 amperes abampere = 3 x 10^{10} statamperes	statampere = 3.3 x 10^{-10} ampere statampere = 3.3 x 10^{-11} abampere
Quantity	coulomb = 10^{-1} abcoulomb coulomb = 3 x 10^9 statcoulombs	abcoulomb = 10 coulombs abcoulomb = 3 x 10^{10} statcoulombs	statcoulomb = 3.3 x 10^{-10} coulomb statcoulomb = 3.3 x 10^{-11} abcoulombs
Capacitance	farad = 10^{-9} abfarads farad = 9 x 10^{11} statfarads	abfarad = 10^9 farads abfarad = 9 x 10^{20} statfarads	statfarad = 1.1 x 10^{-12} farads statfarad = 1.1 x 10^{-21} abfarads
Inductance	henry = 10^9 abhenries henry = 1.1 x 10^{-12} stathenry	abhenry = 10^{-9} henry abhenry = 1.1 x 10^{-21} stathenries	stathenry = 9 x 10^{11} henries stathenry = 9 x 10^{20} abhenries
Energy	joule = 10^7 ergs	erg = 10^{-7} joule	erg = 10^{-7} joule
Power	watt = 10^7 $\frac{\text{ergs}}{\text{sec}}$	$\frac{\text{erg}}{\text{sec}}$ = 10^{-7} watt	$\frac{\text{erg}}{\text{sec}}$ = 10^{-7} watt

Equivalents: Degrees API and Degrees Baumé

Degrees on API or Baumé Scale	Values for API Scale Oil			Values for Baumé Scale					
				Liquids Lighter Than Water			Liquids Heavier Than Water		
	Specific Gravity *S*	Weight Density Lb/Ft³ *p*	Pounds per Gallon	Specific Gravity *S*	Weight Density Lb/Ft³ *p*	Pounds per Gallon	Specific Gravity *S*	Weight Density Lb/Ft³ *p*	Pounds per Gallon
0	–	–	–	–	–	–	1.0000	62.36	8.337
2	–	–	–	–	–	–	1.0140	63.24	8.454
4	–	–	–	–	–	–	1.0284	64.14	8.574
6	–	–	–	–	–	–	1.0432	65.06	8.697
8	–	–	–	–	–	–	1.0584	66.01	8.824
10	1.0000	62.36	8.337	1.0000	62.36	8.337	1.0741	66.99	8.955
12	0.9861	61.50	8.221	0.9859	61.49	8.219	1.0902	67.99	9.089
14	0.9724	60.65	8.108	0.9722	60.63	8.105	1.1069	69.03	9.228
16	0.9593	59.53	7.998	0.9589	59.80	7.994	1.1240	70.10	9.371
18	0.9465	59.03	7.891	0.9459	58.99	7.886	1.1417	71.20	9.518
20	0.9340	58.25	7.787	0.9333	58.20	7.781	1.1600	72.34	9.671
22	0.9218	57.87	7.736	0.9211	57.44	7.679	1.1789	73.52	9.828
24	0.9100	56.75	7.587	0.9091	56.70	7.579	1.1983	74.73	9.990
26	0.8984	56.03	7.490	0.8974	55.97	7.482	1.2185	75.99	10.159
28	0.8871	55.32	7.396	0.8861	55.26	7.387	1.2393	77.29	10.332
30	0.8762	54.64	7.305	0.8750	54.57	7.295	1.2609	78.64	10.512
32	0.8654	53.97	7.215	0.8642	53.90	7.205	1.2832	80.03	10.698
34	0.8550	53.32	7.128	0.8537	53.24	7.117	1.3063	81.47	10.891
36	0.8448	52.69	7.043	0.8434	52.60	7.031	1.3303	82.96	11.091
38	0.8348	52.06	6.960	0.8333	51.97	6.947	1.3551	84.51	11.297
40	0.8251	51.46	6.879	0.8235	51.36	6.865	1.3810	86.13	11.513
42	0.8155	50.86	6.799	0.8140	50.76	6.786	1.4078	87.80	11.737
44	0.8063	50.28	6.722	0.8046	50.18	6.708	1.4356	89.53	11.969
46	0.7972	49.72	6.646	0.7955	49.61	6.632	1.4646	91.34	12.210
48	0.7883	49.16	6.572	0.7865	49.05	6.557	1.4948	93.22	12.462
50	0.7796	48.62	6.499	0.7778	48.51	6.484	1.5263	95.19	12.725
52	0.7711	48.09	6.429	0.7692	47.97	6.413	1.5591	97.23	12.998
54	0.7628	47.57	6.359	0.7609	47.45	6.344	1.5934	99.37	13.284
56	0.7547	47.07	6.292	0.7527	46.94	6.275	1.6292	101.60	13.583
58	0.7467	46.57	6.225	0.7447	46.44	6.209	1.6667	103.94	13.895
60	0.7389	46.08	6.160	0.7368	45.95	6.143	1.7059	106.39	14.222
62	0.7313	45.61	6.097	0.7292	45.48	6.079	1.7470	108.95	14.565
64	0.7238	45.14	6.034	0.7216	45.00	6.016	1.7901	111.64	14.924
66	0.7165	44.68	5.973	0.7143	44.55	5.955	1.8354	114.46	15.302
68	0.7093	44.23	5.913	0.7071	44.10	5.895	1.8831	117.44	15.699
70	0.7022	43.79	5.854	0.7000	43.66	5.836	1.9333	120.57	16.118
72	0.6953	43.36	5.797	0.6931	43.22	5.788	–	–	–
74	0.6886	42.94	5.741	0.6863	42.80	5.722	–	–	–
76	0.6819	42.53	5.685	0.6796	42.38	5.666	–	–	–
78	0.6754	42.12	5.631	0.6731	41.98	5.612	–	–	–
80	0.6690	41.72	5.577	0.6667	41.58	5.558	–	–	–
82	0.6628	41.33	5.526	0.6604	41.19	5.506	–	–	–
84	0.6566	40.95	5.474	0.6542	40.80	5.454	–	–	–
86	0.6506	40.57	5.424	0.6482	40.42	5.404	–	–	–
88	0.6446	40.20	5.374	0.6422	40.05	5.354	–	–	–
90	0.6388	39.84	5.326	0.6364	39.69	5.306	–	–	–
92	0.6331	39.48	5.278	0.6306	39.33	5.257	–	–	–
94	0.6275	39.13	5.231	0.6250	38.98	5.211	–	–	–
96	0.6220	38.79	5.186	0.6195	38.63	5.165	–	–	–
98	0.6166	38.45	5.141	0.6140	38.29	5.119	–	–	–
100	0.6112	38.12	5.096	0.6087	37.96	5.075	–	–	–

Equivalents: Kinematic and Saybolt Viscosity

Equivalents of Kinematic and Saybolt Furol Viscosity

Kinematic Viscosity, Centistokes v	Equivalent Saybolt Furol Viscosity, Sec	
	At 122°F (50°C) Basic Values	At 210°F (99°C)
48	25.3	
50	26.1	25.2
60	30.6	29.8
70	35.1	34.4
80	39.6	39.0
90	44.1	43.7
100	48.6	48.3
125	60.1	60.1
150	71.7	71.8
175	83.8	83.7
200	95.0	95.6
225	106.7	107.5
250	118.4	119.4
275	130.1	131.4
300	141.8	143.5
325	153.6	155.5
350	165.3	167.6
375	177.0	179.7
400	188.8	191.8
425	200.6	204.0
450	212.4	216.1
475	224.1	228.3
500	235.9	240.5
525	247.7	252.8
550	259.5	265.0
575	271.3	277.2
600	283.1	289.5
625	294.9	301.8
650	306.7	314.1
675	318.4	326.4
700	330.2	338.7
725	342.0	351.0
750	353.8	363.4
775	365.5	375.7
800	377.4	388.1
825	389.2	400.5
850	400.9	412.9
875	412.7	425.3
900	424.5	437.7
925	436.3	450.1
950	448.1	462.5
975	459.9	474.9
1000	471.7	487.4
1024	483.5	499.8
1050	495.2	512.3
1075	507.0	524.8
1100	518.8	537.2
1125	530.6	549.7
1150	542.4	562.2
1175	554.2	574.7
1200	566.0	587.2
1225	577.8	599.7
1250	589.9	612.2
1275	601.3	624.8
1300	613.1	637.3
Over 1300	Saybolt Furol Seconds = Centistokes x 0.4717	Log (Saybolt Furol Seconds - 2.87) = 1.0276 [Log (Centistokes)] - 0.3975

Equivalents of Kinematic and Saybolt Universal Viscosity

Kinematic Viscosity, Centistokes v	Equivalent Saybolt Universal Viscosity, Sec	
	At 100°F (37.8°C) Basic Values	At 210°F (99°C)
1.83	32.01	32.23
2.0	32.62	32.85
4.0	39.14	39.41
6.0	45.56	45.88
8.0	52.09	52.45
10.0	58.91	59.32
15.0	77.39	77.93
20.0	97.77	98.45
25.0	119.3	120.1
30.0	141.3	142.3
35.0	163.7	164.9
40.0	186.3	187.6
45.0	209.1	210.5
50.0	232.1	233.8
55.0	255.2	257.0
60.0	278.3	280.2
65.0	301.4	303.5
70.0	324.4	326.7
75.0	347.6	350.0
80.0	370.8	373.4
85.0	393.9	396.7
90.0	417.1	420.0
95.0	440.3	443.4
100.0	463.5	466.7
120.0	556.2	560.1
140.0	648.9	653.4
160.0	741.6	
180.0	834.2	
200.0	926.9	
220.0	1019.6	
240.0	1112.3	
250.0	1205.0	
280.0	1297.7	
300.0	1390.4	
320.0	1483.1	
340.0	1575.8	
360.0	1668.5	Saybolt Seconds = Centistokes x 4.6673
380.0	1761.2	
400.0	1853.9	
420.0	1946.6	
440.0	2039.3	
460.0	2132.0	
480.0	2224.7	
500.0	2317.4	
Over 500	Saybolt Seconds = Centistokes x 4.6347	

Note: To obtain the Saybolt Universal viscosity equivalent to a kinematic viscosity determined at t, multiply the equivalent Saybolt Universal viscosity at 100°F (37.8°C) by $1+(t - 100)\ 0.000\ 064$.

For example, 10 v at 210°F (99°C) are equivalent to 58.91 multiplied by 1.0070 or 59.32 sec Saybolt Universal at 210°F (99°C).

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To convert from one set of units to another, locate the given unit in the left hand column, and multiply the numerical value by the factor shown horizontally to the right, under the set of units desired.

TO OBTAIN / MULTIPLY BY	lb/in²	lb/ft²	Atmospheres	kg/cm²	kg/m²	in. water (68°F)*	ft. water (68°F)*	in. mercury (32°F)†	mm mercury (32°F)†	Bars ‡	Mega-Pascals (MPa)‡	kPa	mm water (68°F)
lb/in.²	1	144.0	0.068046	0.070307	703.070	27.7300	2.3108	2.03602	51.7149	0.068948	0.0068948	6.8948	704.342
lb/ft.²	0.0069444	1	0.000473	0.000488	4.88243	0.019257	0.016048	0.014139	0.35913	0.0004788	0.0000479	0.04788	4.89127
Atmospheres	14.696	2116.22	1	1.0332	10332.0	407.520	33.9600	29.921	760.00	1.01325	0.101325	101.325	10351.0
kg/cm²	14.2233	2048.16	0.96784	1	10000.0	394.41	32.868	28.959	735.558	0.98066	0.098066	98.066	10018.1
kg/m²	0.001422	0.204816	0.0000968	0.0001	1	0.03944	0.003287	0.002896	0.073556	0.000098	0.0000098	0.0098	1.00181
in./water*	0.036062	5.1929	0.002454	0.00253	25.354	1	0.08333	0.073423	1.8649	0.002486	0.000249	0.24864	25.4
ft./water*	0.432744	62.315	0.029446	0.030425	304.249	12.0	1	0.88108	22.3793	0.29837	0.0029837	2.9837	304.800
in. mercury†	0.491154	70.7262	0.033420	0.03453	345.319	13.6197	1.1350	1	25.4	0.033864	0.0033864	3.3864	345.94
mm mercury†	0.0193368	2.78450	0.0013158	0.0013595	13.595	0.53621	0.044684	0.03937	1	0.001333	0.0001333	0.13332	13.6197
Bars‡	14.5038	2088.54	0.98692	1.01972	10197.2	402.190	33.5158	29.5300	750.061	1	0.10	100.0	10215.6
MPa‡	145.038	20885.4	9.8692	10.1972	101972.0	4021.90	335.158	295.300	7500.61	10.0	1	1000.0	102156.0
kPa	0.145038	20.8854	0.0098692	0.0101972	101.972	4.02190	0.33516	0.2953	7.50061	0.01	0.001	1	102.156
mm water column	.0014198	.20445	.0000966	.0000998	.99819	.039370	.003281	.002891	.073423	.0000979	.0000098	.0097889	1

*Water at 68°F (20°C) †mercury at 32°F (0°C) ‡MPa (MegaPascal) = 10 Bars = 1,000,000 N/m² (Newtons/meter²)

EXAMPLE:

(5 kg/cm²) (2048.16) = 10,240.8 lb./ft.²

Properties: Density and Specific Gravity of Selected Liquids

Liquid	Temperature		Density①	Specific②
	°F	°C	lb/ft³	Gravity
Acetaldehyde	64	17.8	38.9	0.8
Acetone	60	15.6	49.4	0.8
Acetic Anhydride	68	20.0	67.5	1.1
Acid, Acetic Conc.	68	20.0	65.5	1.1
Acid, Benzoic	59	15.0	79.0	1.3
Acid, Butyric, Conc.	68	20.0	60.2	1.0
Acid, Hydrochloric, 42.5%	64	17.8	92.3	1.4
Acid, Hydrocyanic	64	17.8	43.5	0.8
Acid, Nitric, Conc. Boil.	64	17.8	93.7	1.5
Acid, Ortho-phosphoric	65	18.3	114.4	1.8
Ammonia, Saturated	10	-12.2	40.9	0.7
Aniline	68	20.0	63.8	1.0
Argon	60	15.6	102.9	1.7
Asphalt	75	23.9	61.1	1.0
Beer	60	15.6	63.0	1.0
Benzene	32	0.0	56.1	0.9
Brine, 10% CaCl	32	0.0	68.1	1.1
Brine, 10% NaCl	32	0.0	67.2	1.1
Bromine	60	15.6	182.7	3.0
Bunkers C Fuel Max	60	15.6	63.3	1.0
Butane-n	60	15.6	36.4	0.6
Carbon Disulphide	32	0.0	80.6	1.3
Carbon Monoxide	60	15.6	49.9	0.8
Carbon Tetrachloride	68	20.0	99.6	1.6
China Wood Oil	60	15.6	58.8	1.0
Chloride	77	25.0	97.3	1.6
Chlorobenzene	68	20.0	69.1	1.1
Chloroform	68	20.0	92.9	1.5
Chromic Acid	60	15.6	75.5	1.2
Citric Acid	60	15.6	96.1	1.5
Cocoanut Oil	60	15.6	57.9	0.9
Corn syrup 86.4 Brix	60	15.6	91.1	1.5
Corn syrup 78.4 Brix	60	15.6	87.9	1.4
Creosote	60	15.6	66.7	1.1
Cresol, Meta	68	20.0	64.5	1.0
Decane-n	60	15.6	45.5	0.7
Diesel Fuel grade 1-D	60	15.6	51.5	0.8
Diesel Fuel grade 2-D	60	15.6	54.0	0.9
Diesel Fuel grade 4-D	60	15.6	57.3	0.9
Diphenyl	163	72.8	61.9	1.0
Distallate	60	15.6	63.0	0.9
Dowtherm A	700	371.1	45.5	0.7
Ethanol	77	25.0	48.6	0.8
Ether	77	25.0	44.7	0.7
Ethyl Acetate	68	20.0	56.1	0.9
Ethyl Alcohol	77	25.0	49.1	0.8
Ethylamine	61	16.1	42.6	0.7
Ethyl Benzene	68	20.0	53.6	0.9
Ethyl Chloride	68	20.0	78.0	1.3
Ethyl Oxide	30	-1.1	54.9	0.9
Ethylene Glycol	60	15.6	70.5	1.1
Fluorine	60	15.6	69.7	1.1
Formaldehyde	113	45.0	50.8	0.8
Formic Acid	100	37.8	56.1	0.9
Fuell 3 Max	60	15.6	56.0	0.9
Fuel 5 Min	60	15.6	60.2	1.0
Fuel 5 Max	60	15.6	61.9	1.0
Fuel 6 Min	60	15.6	61.9	1.0
Fuel Oil (Bunker C)	59	15.6	62.3	1.0
Furfural	68	20.0	72.3	1.2
Gasoline	60	15.6	46.8	0.8
Gasoline, Natural	60	15.6	42.4	0.7
Glucose	60	15.6	87.3	1.4
Glycerol (Glycerine)	122	50.0	78.6	1.3
Glycol	68	20.0	69.2	1.1
Helium	60	15.6	8.7	0.1
Heptane	68	20.0	42.7	0.7
Heptane-n	60	15.6	42.9	0.7
Hexane-n	60	15.6	41.4	0.7
Hexanol	77	25.0	50.7	0.8
Hydrofluoric Acid	60	15.6	57.4	0.9
Hydrogen Chloride	60	15.6	53.6	0.9
Hydrogen Sulfide	60	15.6	49.3	0.8
Ink, printers	60	15.6	74.8	1.2
Ionene	77	25.0	58.3	0.9
Isobutyl Alcohol	68	20.0	50.5	0.8
Isopropyl Alcohol	68	20.0	49.9	0.8
Jet Fuel, grade JP-4	60	15.6	53.0	0.7
Kerosene	60	15.6	50.8	0.8
Lard	60	15.6	59.9	1.0
Lard Oil	60	15.6	57.4	0.9
Linolenic Acid	77	25.0	56.3	0.9
Linseed Oil	60	15.6	58.0	0.9
M. C. Residuum	60	15.6	58.3	0.9
Mercury	20	-6.7	849.7	13.6
Mercury	40	4.4	848.0	13.6
Mercury	60	15.6	846.3	13.6
Mercury	80	26.7	844.6	13.5
Mercury	100	37.8	842.9	13.5
Methane	-2.66	-16.3	29.1	0.5
Methyl Alcohol	77	25.0	49.2	0.8
Methylene Chloride	68	20.0	83.4	1.3
Methyl Ethyl Ketone	72	22.2	49.9	0.8
Methyl Propyl	58	14.4	50.5	0.8
Milk	60	15.6	64.8	1.0
Mineral Oil	80	26.7	56.1	0.9
Naphtha, Petroleum	59	15.0	41.6	0.7
Naphtha, Wood	77	25.0	43.7	0.7
Naphthalene	77	25.0	60.1	1.0
Nonane-n	60	15.6	64.8	1.0
Nonanol	77	25.0	51.3	0.8
Ocimene	77	25.0	49.9	0.8
Octane-n	60	15.6	44.1	0.7
Oil, Olive	69	15.0	57.3	0.9
Palmitic Acid	77	25.0	53.2	0.9
Pentane	59	15.0	38.9	0.6
Petroleum Ether	60	15.6	39.9	0.6
Phenol	77	25.0	66.8	1.1
Phosgene	32	0	86.1	1.4
Phosphorus	93	33.9	108.5	1.7
Propane	0	-17.7	30.1	0.5
Propanol	77	25.0	50.3	0.8
Propyl Alcohol	77	25.0	50.0	0.8
Propylene	77	25.0	32.2	0.5
Propylene Glycol	77	25.0	60.4	1.0
Pyridine	68	20.0	61.3	1.0
Resorcinol	77	25.0	79.3	1.3
Rosin Oil	60	15.6	61.1	1.0
Sabiname	77	25.0	50.8	0.8
SAE 10 Lube	60	15.6	54.6	0.9
SAE 30 Lube	60	15.6	56.0	0.9
SAE 70 Lube	60	15.6	57.1	0.9
Salt Creek Crude	60	15.6	53.8	0.9
Silane	77	25.0	44.8	0.7
Sorbaldehyde	77	25.0	56.0	0.9
Sperm Oil	60	15.6	86.7	1.4
Starch	60	15.6	93.6	1.5
Stearic Acid	77	25.0	58.7	0.9
Styrene	77	25.0	56.5	0.9
Sucrose 60 Brix	60	15.6	80.5	1.3
Sucrose 76 Brix	60	15.6	86.7	1.4
Sulphur Dioxide	32	0.0	89.2	1.4
Sulphuric Acid	68	20.0	116.0	1.9
Sulphuric Acid	60	15.6	114.1	1.8
Sulphur Trioxide	70	21.1	119.8	1.9
32.6° API Crude	60	15.6	53.8	0.9
35.6° API Crude	60	15.6	52.8	0.8
40° API Crude	60	15.6	51.4	0.8
48° API Crude	60	15.6	49.2	0.8
Tar, Road RT-4	60	15.6	67.4	1.1
Tar, Road RT-8	60	15.6	70.5	1.1
Tar, Road RT-12	60	15.6	71.7	1.2
Terpinene	212	100.0	53.0	0.9
Toluene (Toluol)	68	20.0	54.1	0.9
Transmission Oil	80	26.7	58.6	0.9
Trichloroethylene	68	20.0	91.5	1.5
Turpentine	60	15.6	53.9	0.9
Varnish, spar	60	15.6	56.1	0.9
Vegetable Oil	60	15.6	56.8	0.9
Water	60	15.6	62.4	1.0
Water	100	37.8	61.9	1.0
Water, Distilled	70	21.1	61.7	1.0
Water, sea	60	15.6	64.2	1.0
Whale Oil	60	15.6	57.7	0.9
Xylol (Xylene)	68	20.0	55.0	0.9

① Density is shown for the temperature listed.

② Specific gravity uses water at 60°F as base conditions.

Properties: Density and Specific Gravity of Selected Gases

Gas	Chemical Formula	Molecular Weight	Density① lb/ft³	Density② kg/m³	Specific② Gravity
Acetylene	C_2H_2	26.04	.0673	1.1459	0.899
Air	–	28.96	.0748	1.2740	1.000
Ammonia	NH_3	17.03	.0440	0.7491	0.588
Argon	Ar	39.95	.1032	1.7572	1.379
Bio Gas (65% Methane, 35% CO_2)	–	25.83	.0668	1.1363	0.892
Butane-N	C_4H_{10}	58.12	.1502	2.5567	2.007
Butylene	C_4H_8	56.11	.1450	2.4681	1.937
Carbon Dioxide	CO_2	44.11	.1137	1.9359	1.520
Carbon Monoxide	CO	28.01	.0724	1.2321	0.967
Chlorine	Cl_2	70.91	.1833	3.1205	2.499
Ethane	C_2H_6	30.07	.0777	1.3227	1.038
Ethylene	C_2H_4	28.05	.0725	1.2340	0.969
Helium	He	4.00	.0103	0.1761	0.138
Hextane, Average	C_6H_{14}	86.18	.2227	3.7908	2.976
Hydrogen	H_2	2.02	.0052	0.0887	0.070
Hydrogen Sulfide	H_2S	34.08	.0881	1.4997	2.125
Methane	CH_4	16.04	.0415	0.7057	0.554
Nitric Oxide	NO	30.00	.0776	1.3202	1.071
Nitrogen	N_2	28.01	.0724	1.2323	0.967
Nitrous Oxide	N_2O	44.01	.1138	1.9367	1.376
Oxygen	O_2	32.00	.0827	1.4076	1.105
Pentane	C_5H_{12}	72.15	.1865	3.1738	2.491
Propane	C_3H_8	44.10	.1140	1.9397	1.523
Propylene	C_3H_6	42.08	.1088	1.8510	1.453
Sulphur Dioxide	SO_2	64.06	.1656	2.8191	2.213

① Density is given for gas at 14.7 psia @ +70° F.

② Density is given for gas at 1 bar @ +0° C.

Properties: Density and Specific Gravity of Saturated Water

Temperature		Pressure	Density	S.G.	Dielectric Constant Of Liquid	Dielectric Constant Of Vapor	Error in Distance, %
°F	°C	PSI	lbs/ft³				
32	0	0.09	62.42	1.00	—	—	—
35	2	0.10	62.42	1.00	—	—	—
40	4	0.12	62.42	1.00	—	—	—
45	7	0.15	62.42	1.00	—	—	—
50	10	0.18	62.42	1.00	—	—	—
52	11	0.19	62.38	1.00	—	—	—
54	12	0.21	62.38	1.00	—	—	—
56	13	0.22	62.38	1.00	—	—	—
58	14	0.24	62.38	1.00	—	—	—
60	16	0.26	62.34	1.00	—	—	—
62	17	0.28	62.34	1.00	—	—	—
64	18	0.30	62.34	1.00	—	—	—
66	19	0.32	62.34	1.00	—	—	—
68	20	0.34	62.31	1.00	—	—	—
70	21	0.36	62.31	1.00	—	—	—
72	22	0.39	62.27	1.00	—	—	—
74	23	0.42	62.27	1.00	—	—	—
76	24	0.45	62.27	1.00	—	—	—
78	26	0.48	62.23	1.00	—	—	—
80	27	0.51	62.23	1.00	—	—	—
82	28	0.54	62.19	1.00	—	—	—
84	29	0.58	62.19	1.00	—	—	—
86	30	0.62	62.15	1.00	—	—	—
88	31	0.66	62.15	1.00	—	—	—
90	32	0.70	62.11	1.00	—	—	—
92	33	0.74	62.07	0.99	—	—	—
94	34	0.79	62.07	0.99	—	—	—
96	36	0.84	62.03	0.99	—	—	—
98	37	0.89	62.03	0.99	—	—	—
100	38	0.95	62.00	0.99	73.95	1.001	0.0
110	43	1.28	61.84	0.99	72.09	1.001	0.0
120	49	1.70	61.69	0.99	70.27	1.001	0.0
130	54	2.23	61.54	0.99	68.50	1.001	0.0
140	61	2.89	61.39	0.98	66.77	1.001	0.0
150	66	3.72	61.20	0.98	65.09	1.002	0.1
160	71	4.74	60.98	0.98	63.44	1.002	0.1
170	77	6.00	60.79	0.97	61.84	1.003	0.1
180	82	7.52	60.57	0.97	60.28	1.003	0.1
190	88	9.34	60.35	0.97	58.75	1.004	0.2
200	92	11.53	60.13	0.96	57.26	1.005	0.2

Temperature		Pressure	Density	S.G.	Dielectric Constant Of Liquid	Dielectric Constant Of Vapor	Error in Distance, %
°F	°C	PSI	lbs/ft³				
210	99	14.13	59.88	0.96	55.81	1.006	0.3
212	100	14.70	59.81	0.96	—	—	—
220	104	17.19	59.63	0.96	54.40	1.007	0.3
230	110	20.78	59.35	0.95	53.02	1.008	0.4
240	116	24.97	59.10	0.95	51.67	1.009	0.4
250	121	29.82	58.82	0.94	50.36	1.011	0.5
260	127	65.42	58.55	0.94	49.08	1.013	0.6
270	132	41.83	58.24	0.93	47.83	1.015	0.7
280	138	49.18	57.94	0.93	46.61	1.017	0.8
290	143	57.53	57.64	0.92	45.42	1.019	0.9
300	149	66.98	57.31	0.92	44.26	1.022	1.1
310	154	77.64	56.98	0.91	43.13	1.025	1.2
320	160	89.60	56.66	0.91	42.02	1.028	1.4
330	166	103.00	56.34	0.90	40.94	1.032	1.6
340	171	117.93	55.96	0.90	39.88	1.036	1.8
350	177	134.53	55.59	0.89	38.84	1.040	2.0
360	182	152.92	55.22	0.88	37.83	1.045	2.2
370	188	173.23	54.85	0.88	36.84	1.050	2.5
380	193	195.60	54.47	0.87	35.88	1.056	2.8
390	199	220.20	54.05	0.87	34.93	1.062	3.1
400	204	247.10	53.65	0.86	34.00	1.069	3.4
410	210	276.50	53.25	0.85	33.09	1.076	3.7
420	216	308.50	52.80	0.85	32.20	1.085	4.2
430	221	343.30	52.38	0.84	31.32	1.093	4.5
440	227	381.20	51.92	0.83	30.46	1.103	5.0
450	232	422.10	51.47	0.82	29.62	1.113	5.5
460	238	466.30	50.99	0.82	28.78	1.124	6.0
470	243	514.10	50.51	0.81	27.97	1.137	6.6
480	249	565.50	50.00	0.80	27.16	1.150	7.2
490	254	620.70	49.48	0.79	26.36	1.164	7.9
500	260	680.00	48.95	0.78	25.58	1.180	8.6
520	271	811.40	47.82	0.77	24.04	1.216	10.3
540	282	961.50	46.62	0.75	22.52	1.260	12.2
560	293	1131.80	45.31	0.73	21.03	1.313	14.6
580	304	1324.30	43.90	0.70	19.54	1.378	17.4
600	316	1541.00	42.32	0.68	18.04	1.461	20.9
620	327	1784.40	40.57	0.65	16.52	1.570	25.3
640	338	2057.10	38.57	0.62	14.93	1.719	31.1
660	349	2362.00	36.14	0.58	13.23	1.938	39.2
680	360	2705.00	32.98	0.53	11.23	2.310	52.0
700	371	3090.00	27.28	0.44	8.29	3.295	81.5
705	374	3204.00	19.79	0.32	—	—	—

Properties: Density of Superheated Steam and Compressed Water

Temperature		Superheated Steam and Compressed Water Density lbm/ft³										
°F	°C	1 PSIA	2 PSIA	5 PSIA	10 PSIA	20 PSIA	50 PSIA	100 PSIA	200 PSIA	500 PSIA	750 PSIA	1000 PSIA
32	0	62.42	62.42	62.42	62.42	62.42	62.42	62.42	62.46	62.54	62.58	62.62
40	4	62.42	62.42	62.42	62.42	62.42	62.42	62.42	62.46	62.54	62.58	62.62
60	16	62.37	62.37	62.37	62.37	62.37	62.37	62.37	62.42	62.46	62.50	62.58
80	27	62.23	62.23	62.23	62.23	62.23	62.23	62.23	62.27	62.31	62.38	62.42
100	38	62.00	62.00	62.00	62.00	62.00	62.00	62.00	62.04	62.07	62.15	62.19
120	49	.002901	61.73	61.73	61.73	61.73	61.73	61.73	61.77	61.81	61.84	61.88
140	60	.002804	.005619	61.39	61.39	61.39	61.39	61.39	61.43	61.46	61.50	61.58
160	71	.002713	.005435	60.98	60.98	61.01	61.01	61.01	61.01	61.09	61.13	61.20
180	82	.002628	.005263	.01321	60.55	60.57	60.57	60.57	60.61	60.68	60.72	60.75
200	93	.002548	.005101	.01280	.02575	60.10	60.13	60.13	60.13	60.21	60.24	60.31
220	104	.002472	.004950	.01241	.02495	59.59	59.60	59.60	59.67	59.70	59.77	59.81
240	116	.002402	.004807	.01205	.02420	.04885	59.10	59.10	59.10	59.17	59.24	59.28
260	127	.002334	.004672	.01171	.02351	.04738	58.51	58.55	58.55	58.62	58.69	58.72
280	138	.002271	.004545	.01139	.02285	.04602	57.94	57.94	57.97	58.04	58.07	58.14
300	149	.002211	.004425	.01108	.02223	.04473	.1140	57.31	57.34	57.41	57.57	57.54
320	160	.002154	.004311	.01079	.02165	.04352	.1107	56.63	56.66	56.75	56.82	56.88
340	171	.002100	.004203	.01052	.02109	.04239	.1076	.2213	55.96	56.05	56.12	56.18
360	182	.002049	.004100	.01026	.02057	.04131	.1047	.2146	55.22	55.31	55.40	55.46
380	193	.002000	.004002	.01002	.02007	.04029	.1019	.2084	54.47	54.56	54.65	54.71
400	204	.001954	.003908	.009781	.01960	.03933	.09938	.2026	.4238	53.74	53.82	53.91
420	216	.001909	.003819	.009557	.01914	.03841	.09696	.1973	.4104	52.88	52.97	53.08
440	227	.001866	.003734	.009343	.01871	.03753	09466	.1923	.3982	51.98	52.08	52.17
460	238	.001826	.003653	.009139	.01830	.03670	.09249	.1876	.3870	50.99	51.13	51.23
480	249	.001787	.003575	.008944	.01791	.03590	.09042	.1832	.3766	1.049	50.08	50.20
500	260	.001750	.003500	.008756	.01753	.03514	.08845	.1790	.3670	1.008	48.97	49.12
520	271	.001714	.003429	.008576	.01717	03441	.08657	.1750	.3580	.9728	1.603	47.94
540	282	.001680	.003360	.008405	.01682	.03371	.08477	.1712	.3496	.9413	1.530	46.64
560	293	.001647	.003294	.008239	.01649	.03304	.08305	.1676	.3416	.9128	1.468	2.142
580	304	.001615	.003230	.008080	.01617	.03240	.08140	.1642	.3341	.8870	1.415	2.035
600	316	.001585	.003169	.007927	.01587	.03178	.07982	.1609	.3270	.8633	1.367	1.947
620	327	.001555	.003111	.007780	.01557	.03119	.07830	.1577	.3202	.8413	1.325	1.871
640	338	.001527	.003054	.007638	.01529	.03061	.07683	.1547	.3137	.8209	1.287	1.804
660	349	.001499	.002999	.007501	.01501	.03006	.07543	.1518	.3076	.8019	1.252	1.746
680	360	.001473	.002947	.007369	.01475	.02953	.07408	.1490	.3017	.7840	1.219	1.693
700	371	.001448	.002896	.007242	.01449	.02902	.07278	.1464	.2960	.7671	1.189	1.645
720	382	.001423	.002847	.007119	.01425	.02852	.07152	.1438	.2906	.7510	1.161	1.601
740	393	.001400	.002799	.007000	.01401	.02804	.07030	.1413	.2854	.7359	1.135	1.560
760	404	.001376	.002753	.006885	.01378	.02758	.06913	.1389	.2804	.7215	1.111	1.523
780	416	.001354	.002709	.006774	.01355	.02713	.06800	.1366	.2755	.7077	1.087	1.488
800	427	.001333	.002666	.006666	.01334	.02670	.06690	.1344	.2709	.6946	1.065	1.455
820	438	.001312	.002624	.006562	.01313	.02628	.06584	.1322	.2664	.6820	1.045	1.424
840	449	.001292	002584	.006461	.01293	.02587	.06482	.1301	.2621	.6700	1.025	1.394
860	460	.001272	.002545	.006363	.01273	.02548	.06382	.1281	.2579	.6584	1.006	1.367
880	471	.001253	.002507	.006268	.01254	.02509	.06286	.1261	.2539	.6473	.9877	1.340
900	482	.001235	.002470	.006175	.01235	.02472	.06192	.1242	.2500	.6366	.9703	1.315
920	493	.001217	.002434	.006086	.01217	.02436	.06101	.1224	.2462	.6263	.9537	1.291
940	504	.001199	.002399	.005998	.01200	.02401	.06013	.1206	.2425	.6163	.9377	1.269
960	516	.001182	.002365	.005914	.01183	.02367	.05928	.1187	.2389	.6068	.9223	1.247
980	527	.001166	.002332	.005832	.01167	.02334	.05845	.1172	.2355	.5976	.9075	1.226
1000	538	.001150	.002300	.005752	.01151	.02302	.05764	.1155	.2321	.5885	.8933	1.206
Saturated Steam		.002998	.005755	.01360	.02603	.04978	.1175	.2257	.4372	1.078	1.641	2.242
Saturated Water		61.96	61.61	60.94	60.28	59.42	57.90	56.37	54.38	50.63	48.33	46.32
Tsat °F		101.74	126.07	162.24	193.21	227.96	281.02	327.82	381.80	467.01	510.84	544.58

Properties: Specific Gravity of Petroleum Products

Temperature Relationship for Petroleum Oils

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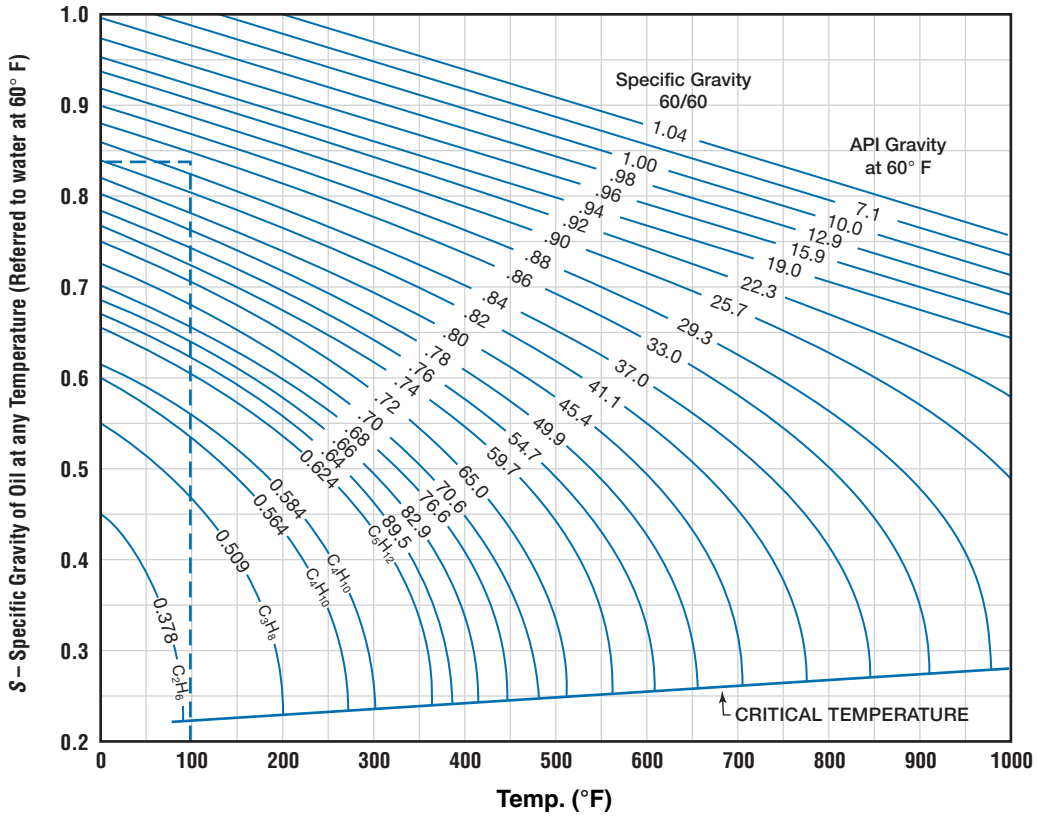


C_2H_6 = Ethane
C_3H_8 = Propane
C_4H_{10} = Butane
iC_4H_{10} = Isobutane
iC_5H_{12} = Isopentane

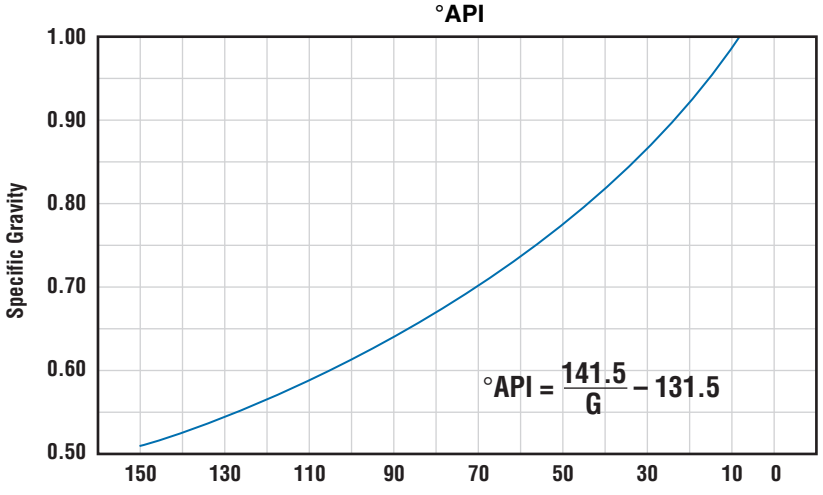
Example: The specific gravity of an oil at 60°F is 0.85. The specific gravity at 100°F = 0.83.

To find the weight density of a petroleum oil at its flowing temperature when the specific gravity at 60°F is known, multiply the specific gravity of the oil at flowing temperature (see chart above) by 62.4, the density of water at 60°F.

*Reprinted from Crane Company's Technical Paper 410.

Specific Gravity versus API Gravity

(for hydrocarbon based products and water gravity °A.P.I.)



Properties: Density of Air

Temperature		Air Density lbm/ft³											
°F	°C	14.73 PSIA	100 PSIA	200 PSIA	300 PSIA	400 PSIA	500 PSIA	600 PSIA	700 PSIA	800 PSIA	900 PSIA	1000 PSIA	1100 PSIA
–40	–40	0.0949	0.6488	1.3087	1.9796	2.661	3.3525	4.0533	4.7628	5.4768	6.2031	6.9315	7.6632
–20	–29	0.0905	0.6182	1.245	1.8799	2.5227	3.1728	3.8295	4.492	5.1594	5.8308	6.5051	7.1811
0	–18	0.0866	0.5905	1.1875	1.7906	2.3995	3.0135	3.6321	4.2547	4.8805	5.5086	6.1382	6.7684
20	– 7	0.0830	0.5652	1.1353	1.71	2.2887	2.8711	3.4567	4.0447	4.6347	5.2258	5.8175	6.409
40	4	0.0797	0.5421	1.0878	1.6368	2.1886	2.7429	3.2992	3.857	4.4157	4.9748	5.5338	6.092
60	16	0.0765	0.5208	1.0442	1.5699	2.0974	2.6266	3.1569	3.6879	4.2191	4.7502	5.2805	5.8098
80	27	0.0737	0.5012	1.0041	1.5085	2.0141	2.5205	3.0275	3.5347	4.0416	4.5478	5.0529	5.5567
100	38	0.0711	0.4829	0.9670	1.4519	1.9375	2.4234	2.9093	3.3949	3.8798	4.3637	4.8464	5.3274
120	49	0.0687	0.4660	0.9327	1.3997	1.8668	2.3339	2.8006	3.2666	3.7316	4.1954	4.6577	5.1184
140	60	0.0664	0.4503	0.9007	1.3511	1.8013	2.2511	2.7001	3.1482	3.5951	4.0406	4.4845	4.9265
160	71	0.0641	0.4356	0.871	1.3061	1.7406	2.1744	2.6073	3.0391	3.4695	3.8985	4.3257	4.7509
180	82	0.0621	0.4218	0.8432	1.264	1.684	2.103	2.521	2.938	3.3529	3.7665	4.1783	4.5882
200	93	0.0602	0.4089	0.8171	1.2246	1.6311	2.0364	2.4405	2.8432	3.2444	3.6439	4.0417	4.4375
220	104	0.0585	0.3967	0.7927	1.1877	1.5815	1.9741	2.3654	2.7551	3.1432	3.5296	3.9144	4.2972
240	116	0.0568	0.3853	0.7697	1.1529	1.5349	1.9156	2.2948	2.6725	3.0485	3.4228	3.7953	4.1658
260	127	0.0552	0.3745	0.7480	1.1202	1.4911	1.8606	2.2288	2.5956	2.9608	3.3239	3.6846	4.0424
280	138	0.0537	0.3644	0.7275	1.0893	1.4497	1.8088	2.1666	2.5231	2.8779	3.2306	3.4803	3.9264
300	149	0.0523	0.3547	0.7081	1.0601	1.4107	1.7599	2.1078	2.4546	2.7997	3.1424	3.4819	3.8174
320	160	0.0510	0.3456	0.6898	1.0325	1.3737	1.7136	1.9997	2.3897	2.7256	3.059	3.389	3.7147
340	171	0.0497	0.3369	0.6724	1.0063	1.3388	1.6698	2.0523	2.6553	2.6553	2.98	3.3013	3.6184

Properties: Speed of Sound

Gases	m/sec	ft/sec
air, dry	331	1086
ammonia	415	1362
argon	308	1010
carbon dioxide	259	850
carbon monoxide	338	1109
chlorine	206	676
deuterium	890	2920
ethane	308	1010
ethylene	317	1040
helium	965	3166
hydrogen	1284	4213
hydrogen bromide	200	656
hydrogen chloride	206	676
hydrogen iodide	157	515
hydrogen sulfide	289	948
illuminating (coal gas)	453	1486
methane	430	1411
neon	435	1427
nitric oxide	324	1063
nitrogen	334	1096
nitrous oxide	263	863
oxygen	316	1037
sulfur dioxide	213	699

Vapors	m/sec	ft/sec
acetone	230	755
benzene	202	663
carbon tetrachloride	145	476
chloroform	171	561
ethanol	269	883
ethyl ether	206	676
methanol	335	1099
water	494	1621

Note: the speed of sound in gases is measured at 32°F (0°C) except ethane and nitric oxide which is measured at 50°F (10°C). The speed of sound in vapors is measured at 206°F (97°C) except water which is measured at 270°F (134°C).

Properties: Dielectric Constants of Liquids

This listing contains dielectric values for the most commonly used materials. This information can be used to help select a probe, establish how much capacitance information your particular application will develop, or determine the effect of a coating on the probe.

Non-conductive materials are those with dielectric values less than 10. Conductive materials are those with dielectric values greater than 10.

Liquids	Temperature		Dielectric Constant
	°F	°C	
Acenaphthene	70	21	3.0
Acetal	70	21	3.6
Acetaldehyde	50	10	22.2
Acetaldoxime	70	21	3.4
Acetamide	68	20	4.0
Acetanilide	71	22	2.9
Acetic Acid	65	18	6.1
Acetic Anhydride	70	21	22.0
Acetone	75	24	20.7
Acetone	80	27	20.7
Acetone	130	54	17.7
Acetonitrile	70	21	37.5
Acetophenone	75	24	17.3
Acetoxime	75	24	3.0
Acetylacetone	68	20	23.1
Acetylbromide	68	20	16.5
Acetylchloride	68	20	15.8
Acetylmethyl Hexyl Ketone	66	19	27.9
Acrylic Resin	70	20	3.0
Aliphatic Amine	195	90	7.2
Allyl Alcohol	70	21	21.0
Allyl Bromide	66	19	7.0
Allyl Chloride	68	20	8.2
Allyl Iodide	66	19	6.1
Allyl Isothiocyanate	64	18	17.5
Alluminum Bromide	212	100	3.4
Alluminum Oleate	68	20	2.4
Alox 600	130	54	4.1
Aminox	275	135	2.4
Ammonia	-30	-34	22.4
Ammonia	-104	-75	25.0
Ammonia	75	24	16.9
Ammonia, Aqueous	70	21	16.8
Amyl Acetate	68	20	5.0
Amyl Alcohol	-180	-118	35.5
Amyl Alcohol	68	20	15.8
Amyl Alcohol	140	60	11.2
Amylamine	72	22	4.6
Amyl Benzoate	68	20	5.1
Amyl Bromide	50	10	6.3
Amyl Chloride	52	11	6.6
Amylene	70	21	2.0
Amylene Bromide	58	14	5.6
Amyl Ether	60	16	3.1
Amyl Formate	66	19	5.7
Amyl Iodide	62	17	6.9
Amylmercapton	68	20	4.7
Amyl Nitrate	62	17	9.1
Amyl Thiocyanate	68	20	17.4
Aniline	32	0	7.8
Aniline	68	20	7.3
Aniline	212	100	5.5
Anisaldehyde	68	20	15.8
Anisoldoxine	145	63	9.2
Anisole	68	20	4.3
Antimony Pentachloride	68	20	3.2
Antimony Tribromide	212	100	20.9
Antimony Trichloride	166	74	33.0
Antimony Tricodide	347	175	13.9
Arsenic Tribromide	98	37	9.0

Liquids	Temperature		Dielectric Constant
	°F	°C	
Arsenic Trichloride	70	21	12.4
Arsenic Triiodide	302	150	7.0
Arsine	-58	-50	2.7
Asphalt	75	24	2.7
Azoxyanisole	122	50	2.3
Azoxybenzene	104	40	5.1
BPA	68	20	5.0
Beef Talo	70	21	2.8
Benzal Chloride	68	20	6.9
Benzaldehyde	68	20	17.0
Benzaldoxime	68	20	3.8
Benzene	68	20	2.3
Benzil	202	95	13.0
Benzonitrile	68	20	26.0
Benzonitrile	160	71	22.0
Benzophenone	68	20	13.0
Benzophenone	122	50	11.4
Benzotrichloride	68	20	7.4
Benzoylacetone	68	20	3.8
Benzoyl Chloride	158	70	22.1
Benzoyl Chloride	75	24	19.0
Benzyl Acetate	70	21	5.0
Benzyl Alcohol	68	20	13.0
Benzylamine	68	20	4.6
Benzyl Benzoate	68	20	4.8
Benzyl Chloride	68	20	6.4
Benzyl Cyanide	68	20	18.3
Benzyl Ethylamine	68	20	4.3
Benzyl Methylamine	67	19	4.4
Benzyl Salicylate	68	20	4.1
Bornyl Acetate	70	21	4.6
Boron Bromide	32	0	2.6
Boronyl Chloride	202	95	5.2
Bromal	70	21	7.6
Bromocotyl Bromide	68	20	12.6
Bromohexadecane	76	24	3.7
Bromine	68	20	3.1
Bromo-2-Ethoxyheptane	68	20	5.5
Bromoaniline	66	19	13.0
Bromoanisole	86	30	7.1
Bromobenzene	68	20	5.4
Bromobutylene	68	20	5.8
Bromobutyric Acid	68	20	7.2
Bromodecane	76	24	4.4
Bromodocosane	130	54	3.1
Bromododocane	76	24	4.1
Bromo-2-Othoxypentane	76	24	6.5
Bromoform	68	20	4.4
Bromoheptane	76	24	5.3
Bromohexane	76	24	5.8
Bromolsovoleric Acid	68	20	6.5
Bromonaphtholene	66	19	5.1
Bromooctodecane	86	30	3.5
Bromopentaeocane	68	20	3.9
Bromoproplonic Acid	68	20	11.0
Bromotoluene	68	20	5.1
Bromotridecone	50	10	4.2
Bromoundecone	15	–9	4.7
Butadiene	77	25	2.4
Butane	30	–1	1.4
N-Butylacetate	66	19	5.1

Properties: Dielectric Constants of Liquids (cont.)

Liquids	Temperature		Dielectric Constant
	°F	°C	
Iso-Butylacetate	68	20	5.6
Iso-Butylamine	70	21	4.5
N-Butyl Alcohol	66	19	7.8
Iso-Butyl Alcohol	112	45	31.7
Iso-Butyl Alochol	32	0	20.5
Iso-Butyl Alcohol	68	20	18.7
Butylomine	70	21	5.4
N-Butyl Bromide	68	20	6.6
Butyl Chlorol	64	18	10.0
Butyl Chloride	68	20	9.6
N-Butyl Formate	317	158	2.4
N-Butyl Iodide	77	25	6.1
Iso-Butyl Iodide	68	20	5.8
Iso-Butyl Nitrate	66	19	11.9
Butyric Anhydride	68	20	12.0
Butyroldehyda	79	26	13.4
Butyric Acid	68	20	2.8
N-Butyricacid	68	20	2.9
Iso-Butyric Acid	68	20	2.7
Butyric Anhydride	68	20	12.9
Butyronitrile	70	21	20.7
Iso-Butyronitrile	75	24	20.8
Cable Oil	75	24	2.2
Camphanedione	398	203	16.0
Camphene	68	20	2.7
Camphorpinacane	68	20	3.6
Caproic Acid	160	71	2.6
Caprolactum	180	82	13.1
Caprylic Acid	65	18	3.2
Carbon Dioxide	32	0	1.6
Carbon Dioxide	-110	-80	2.1
Carbon Disulfide	68	20	2.6
Carbon Tetrachloride	68	20	2.2
Carvenone	68	20	18.4
Carveol	64	18	11.2
Carvone	71	22	11.0
Castor Oil	58	14	4.8
Castor Oil	75	24	2.6
Camphene	104	40	2.3
Camphoric Imide	480	249	5.5
Cetyl Iodide	68	20	3.3
Chloral Hydrate	59	15	5.5
Chlorocetic Acid	140	60	12.3
Chlorine	32	0	2.0
Chloroocelle Acid	68	20	21.0
Chloroacetone	68	20	29.8
Chlorobenzene	68	20	5.9
Chlorobenzene	212	100	4.7
Chlorocyclohexane	76	24	7.6
Chloroheptane	71	22	5.5
Chloroform	32	0	5.5
Chlorohexanone oxime	192	89	3.0
Chlorohydrate	68	20	3.3
Chloronophtholene	76	24	5.0
O-Chlorophenol	66	19	8.2
3-Chloro-1, Dihydroxprone	68	20	31.0
Chlorooctane	76	24	5.1
Chlorotoluene	68	20	4.7
Cholestrol	80	27	2.9
Chorine	170	77	1.7
Chromyl Chloride	68	20	2.6
Cis-3-Hexene	76	24	2.1
Cinnamaldehyde	75	24	16.9
Citranconic Anhydride	68	20	40.3
Cocaine	68	20	3.1
Copper Oleate	68	20	2.8
Creosol	62	17	10.6
O-Cresol	75	24	5.8
M-Cresol	75	24	5.0
P-Cresol	75	24	5.6

Liquids	Temperature		Dielectric Constant
	°F	°C	
Cresol	75	24	5.0
Crisco Oil	130	54	2.2
Crotonic Nitrice	68	20	28.0
Cumaldehyde	59	15	11.0
Cumene	68	20	2.4
Cumicaldehyde	58	14	10.7
Cupric Oxide	60	16	18.1
Cyanoacetic Acid	40	4	33.0
Cyanoethyl Acetate	68	20	19.3
Cyanogen	73	23	2.6
Cyclohedane	68	20	2.0
Cyclohexane	68	20	2.0
Cyclohexanecarboxylic Acid	88	31	2.6
Cyclohexanone oxime	192	89	3.0
Cyclohexanemethanol	140	60	9.7
Cyclohexanone	68	20	18.2
Cyclohexylomine	–5	–21	5.3
Cyclohexylphenol	130	54	4.0
Cyclohexyltrifluoromethane	-120	-84	11.0
Cyclohexanol	77	25	15.0
Cyclopentane	68	20	2.2
P-Cymene	63	17	2.3
Cymene	62	17	2.3
Decahydronaphthalene	68	20	2.2
Decamethylcyclopentasiloxane	68	20	2.5
Decamethyltetrasiloxane	68	20	2.4
Decane	68	20	2.0
Decane	340	171	1.8
Decylene	62	17	2.7
Decyne	68	20	2.2
Decanol	68	20	8.1
Deuterium	68	20	1.3
Deuterium Oxide	76	24	78.3
Diacetoxybutane	76	24	6.6
Diallyl Sufide	68	20	4.9
Dibenzyl Sebacate	68	20	4.6
Dibroheptane	24	-4	5.1
Dibromobenzene	68	20	8.8
P-Dibromobenzene	190	88	4.5
Dibromobutane	68	20	5.7
Dibromoethylene	32	0	7.7
Dibromomethane	50	10	7.8
Dibromoheptane	76	24	5.1
Dibromohexane	76	24	5.0
Dibromopropane	68	20	4.3
Dibromopropyl Alcohol	70	21	9.1
Dibenzylomine	68	20	3.6
Dibutyl phtolote	86	30	6.4
Dibutyl tartrote	109	43	9.4
Dichlorocetic Acid	68	20	10.7
Dibutyl sebacote	86	30	4.5
Dichlorocotone	68	20	14.0
O-Dichlorobenzone	77	25	7.5
P-Dichlorobenzone	68	20	2.9
O-Dichlorobenzene	68	20	7.5
Dichlorobenzene	127	53	2.8
1, 2-Dichloroethane	77	25	10.7
Dichloroethane	68	20	16.7
Dichlorostyrene	76	24	2.6
Dichlorotoluene	68	20	6.9
Dicyclohexyladipate	95	35	4.8
1-Diethoxyethane	76	24	3.8
Diethyloniline	66	19	5.5
Diethyl Benzalmalamate	32	0	8.0
Diethyl Di-malmate	64	18	10.2
Diethyl Disulfide	64	18	15.9
Diethyl Glutarate	86	30	6.7
Diethyl Ketone	58	14	17.3
Diethyl-L-malate	68	20	9.5
Diethyl Malanate	70	21	7.9

Properties: Dielectric Constants of Liquids (cont.)

Liquids	Temperature		Dielectric Constant
	°F	°C	
Diethylamine	68	20	3.7
Diethyl Oxalate	70	21	8.2
Diethyl Oxalacetate	66	19	6.1
Diethyl Racemote	68	20	4.5
Diethyl Sebacate	86	30	5.0
Diethyl Succinate	86	30	6.6
Diethyl Succinosuccinate	66	19	2.5
Diethyl Sulfide	68	20	7.2
Diethyl Sulfite	68	20	15.9
Diethyl Tortrate	68	20	4.5
Diethyl Disulfide	66	19	15.9
Dihydrocoroane	66	19	8.7
Dihydrocorvane	66	19	8.5
Diimylamine	64	18	2.5
Diioomylene	62	17	2.4
Diiodoethylene	180	82	4.0
Diiodomethane	76	24	5.3
Diisoomyl	62	17	2.0
Diisobutylomine	71	22	2.7
Dimethoxybenzene	73	23	4.5
Dimethylbromoethylene	68	20	6.7
Dimethyldichloro Silane	68	20	12.3
Dimethyleyclohexyomine	180	82	4.4
Dimethyloniline	68	20	4.4
Dimethyl Ethyl	68	20	11.7
Dimethyl Ethyl Carbinol	68	20	11.7
Dimethylheptane	68	20	1.9
Dimethyl-2-hexane	68	20	2.4
Dimethyl-1-Hydroxybenzene	62	17	4.8
Dimethyl Malanate	68	20	10.4
Dimethyl Oxalate	68	20	3.0
Dimethylpentane	68	20	1.9
Dimethylquinoxaline	76	24	2.3
Dimethyl Sulfide	68	20	6.3
Dimethyl Sulfate	68	20	55.0
D imethyltoluidine	68	20	3.3
M-Dinitro Benzene	68	20	2.8
Dinitrogen Oxide	32	0	1.6
Dinitrogen Tetroxide	58	14	2.5
Dioctyl phthalate	76	24	5.1
Dioxane 1,4	77	25	2.2
Dipolmitin	161	72	3.5
Dipentene	68	20.	2.3
Diphenyl	166	74	2.5
Diphenylomine	125	52	3.3
Diphenylethane	230	110	2.4
Diphenyl Ether	82	28	3.9
Diphenylmethane	62	17	2.6
Diproppylomine	70	21	2.9
Dipropyl Ketone	62	17	12.6
Distearin	172	78	3.3
Docosane	122	50	2.0
Dodeanol	76	24	6.5
Dodecamethylcyclohexisolox	68	20	2.6
Dodecamethylpentasiloxane	68	20	2.5
Dodecyne	76	24	2.2
Dowtherm	70	21	3.4
Epichlorohydrin	68	20	22.9
Epon Resin	75	24	13.3
Ethonediomine	68	20	14.2
Ethanethiol	58	14	6.9
Ethanethiolic Acid	68	20	13.0
Ethanol	77	25	24.3
Ether	75	25	4.3
Ethoxybenzene	68	20	4.2
Ethoxyethyl Acetate	86	30	7.6
Ethoxypentane	73	23	3.6
Ethoxy-3-metylbutane	68	20	4.0
Ethoxytoluene	68	20	3.9
Ethoxynaphthalene	66	19	3.3

Liquids	Temperature		Dielectric Constant
	°F	°C	
Ethyl Acetate	68	20	6.4
Ethyl Acetoacetate	71	22	15.9
Ethyl Acetoneoxalate	66	19	16.1
Ethyl Acetophenoneoxalate	66	19	3.3
Ethyl Alcohol	77	25	24.3
Ethyl Acrylate	257	125	11.7
Ethylamine	70	21	6.3
Ethyl Amyl Ether	68	20	4.0
Ethyloniline	68	20	5.9
Ethyl Benzene	68	0	5.5
Ethyl Benzoate	68	20	6.0
Ethyl Benzoylacetate	68	20	12.8
Ethyl Benzoylacetoacetate	70	21	8.6
Ethyl Benzyl Ether	68	20	3.8
Ethyl 1-Brombutyrate	68	20	8.0
Ethyl Bromide	64	18	4.9
Ethyl Bromoisobutyrate	68	20	7.9
Ethyl Bromoproprionate	68	20	9.4
Ethyl Butyrate	68	20	5.1
Ethyl Carbonate	68	20	3.1
Ethyl Chloracetate	68	20	11.6
Ethyl Chloroformate	68	20	11.3
Ethyl Chloropropionate	68	20	10.1
Ethyl Cinnamate	66	19	5.3
Ethyl Cyanoacetate	68	20	27.0
Ethyl Cyclobutane	68	20	2.0
Ethyl Dodeconoate	68	20	3.4
Ethylene	68	20	1.6
Ethylene Chloride	68	20	10.5
Ethylene Chlorohydrin	75	24	25.0
Ethylene Cyanide	136	58	58.3
Ethylenediamine	64	18	16.0
Ethylene Glycol	68	20	37.0
Ethylene Oxide	30	–1	13.9
Ethyl Ether	–148	–100	8.1
Ethyl Ether	–40	–40	5.7
Ethyl Ether	68	20	4.3
Ethyl Ethoxybenzoate	70	21	7.1
Ethyl Formate	66	19	8.4
Ethyl Formylphenylacetate	68	20	3.0
Ethyl Fumorate	73	23	6.5
Ethyl Iodide	68	20	7.4
Ethyl 2-Iodoproprionate	68	20	8.8
Ethyl Iso-Thioconate	68	20	19.7
Ethyl Isothiocyanate	68	20	19.7
Ethyl Levulinate	70	21	12.1
Ethyl Maleate	73	23	8.5
Ethyl Mercoptan	68	20	8.0
Ethyl Nitrate	68	20	19.7
Ethyl Oleate	80	27	3.2
Ethyl Polmitate	68	20	3.2
Ethyl Pentane	68	20	1.9
Ethyl Phenylacetate	70	21	5.4
Ethyl Propionate	68	20	5.7
Ethyl Solicylate	70	21	8.6
Ethyl Silicate	68	20	4.1
Ethyl Stearate	104	40	3.0
Ethyl Toluene	76	24	2.2
Ethyl Trichloroacetate	68	20	7.8
Ethyl Thiocyanate	68	20	29.6
Ethyl Undeconoate	68	20	3.6
Ethyl Volerate	68	20	4.7
Ethyl Benzene	76	24	3.0
Etibine	–58	–50	2.5
Eugenol	64	18	6.1
Fenchone	68	20	12.0
Ferric Oleate	68	20	2.6
Ferrous Oxide	60	16	14.2
Ferrous Sulfate	58	14	14.2
Flexol	75	24	5.3

Properties: Dielectric Constants of Liquids (cont.)

Liquids	Temperature		Dielectric Constant
	°F	°C	
Flourine	-332	-20	1.5
Fluorotoluene	86	30	4.2
Formamide	68	20	84.0
Formic Acid	60	16	58.5
Freon 12	70	21	2.4
Freon 11	70	21	3.1
Freon 113	70	21	2.6
Furan	76	24	2.9
Furfuraldehyde	68	20	41.9
Furmanium Tetrachloride	76	24	2.4
Furfural	70	21	42.0
Gasoline	70	21	2.0
Germanium Tetrachloride	77	25	2.4
Grapeseed Oil	60	16	2.9
Glycerine	68	20	47.0
Glycerol	68	20	43.0
Glycerol	32	0	47.2
Glycerol Triacetate	70	21	6.0
Glycol	68	20	42.2
Glycol	122	50	35.6
Glycolic Nitrile	68	20	27.0
Guaiacol	0	–18	11.0
Glucohepititol	248	120	27.0
Hagemannic Ester	68	20	10.6
Helium-3	58	14	1.1
Heptadecconome	140	60	5.3
Heptane	68	20	1.9
Heptanone	68	20	11.9
Heptanoic Acid	160	71	2.6
Heptyl Alcohol	70	21	6.7
Hexamethylene	75	24	14.1
Hexamethylene Diamine	150	66	6.0
Hexomethyldisiloxane	68	20	2.2
Hexane	68	20	1.9
Hexanol	76	24	13.3
Hexanone	59	15	14.6
Hexdecamethylcyloheptasiloxane	68	20	2.7
Hexyl Iodide	68	20	6.6
Hexylene	62	17	2.0
Hydrocyanic Acid	70	21	2.3
Hydrofluoric Acid	32	0	83.6
Hydrogen	-423	-253	1.2
Hydrogen Bromide	76	24	3.8
Hydrogen Chloride	82	28	4.6
Hydrogen Cyanide	70	21	95.4
Hydrogen Fluoride	32	0	84.0
Hydrogen Iodide	72	22	2.9
Hydrogen Peroxide	32	0	84.2
Hydrogen Sulfide	–120	–84	9.3
Hydrogen Sulfide	48	9	5.8
Hydroxy-4-Methyl-2-Pentanone	76	24	18.2
Hydroxymethylene Camphor	86	30	5.2
Hydroxymethylenebenzyl Cyanide	68	20	6
Hydrazine	68	20	52.9
Indanol	140	60	7.8
Ido-Iedohexodecane	68	20	3.5
Iodine	284	140	11.0
Iodohexane	68	20	5.4
Iodoheptane	71	22	4.9
Iodomethane	68	20	7.0
Iodotoluene	68	20	6.1
Isoamyl Alcohol	74	23	15.3
Iodooctane	76	24	4.6
Isoamyl Bromide	76	24	6.1
Isoamyl Butyrate	68	20	3.9
Isoamyl Chlorocetate	68	20	7.8
Isoamyl Chloride	64	18	6.4
Isoamyl Chloroformate	68	20	7.8
Isoamyl Iodide	65	18	5.6
Isoamyl Propionate	68	20	4.2

Liquids	Temperature		Dielectric Constant
	°F	°C	
Isoamyl Solicylate	68	20	5.4
Isoamyl Volerate	66	20	3.6
Isobutyl Acetate	68	20	5.6
Isobutyl Alcohol	68	20	18.7
Isobutylamine	70	21	4.5
Isobutyl Benzene	62	17	2.3
Isobutyl Benzoate	68	20	5.9
Isobutyl Bromide	68	20	6.6
Isobutyl Bulyrate	68	20	4.0
Isobutyl Chloride	68	20	7.1
Isobutyl Cyanide	74	23	13.3
Isobutyl Chloroformate	68	20	9.2
Isobutyl Formate	66	18	6.5
Isobutylene Bromide	68	20	4.0
Isobutyl Iodide	68	20	5.8
Isobutyl Nitrate	66	19	11.9
Isobutyl Rininoleate	70	21	4.7
Isobutyl Volerate	66	19	3.8
Isobutryic Acid	68	20	2.6
Isobutryic Anhydride	68	20	13.9
Isobutyronitrila	75	24	20.8
Isocopronitrilo	68	20	15.7
Isopropyl Alcohol (IPA)	68	20	18.3
Isopropylamine	68	20	5.5
Isopropyl Benzene	68	20	2.4
Isopropylether	77	25	3.9
Isopropyl Nitrate	66	19	11.5
Isoquinoline	76	24	10.7
Isonofrol	70	21	3.4
IsoValeric Acid	68	20	2.7
Jet Fuel (Military—JP4)	70	21	1.7
Kerosene	70	21	1.8
Lactic Acid	66	19	19.4
Lactonitrilla	68	20	38.4
Lead Carbonate	60	16	18.1
Lead Nomoxide	60	16	25.9
Lead Oleate	64	18	3.2
Lead Tetrachloride	68	20	2.8
Lecithin	120	49	3.5
Lemon Oil	70	21	2.3
Limonene	68	20	2.3
Linseed Oil	55	13	3.4
Linoleic Acid	32	0	2.9
Lonone	65	18	10.0
Malonic Nitrate	97	36	47.0
Maleic Anhydride	140	60	51.0
Mannitol	71	22	3.0
Mandelic Nitrile	73	23	18.1
Mandenitrile	73	23	17.0
Menthol	107	42	4.0
Menthenol	110	43	2.1
Methallmine	77	25	9.4
Methoxyethyl Stearate	140	60	3.4
Mercury Diethyl	68	20	2.3
Mesitylene	68	20	2.4
Mesitylene	68	20	3.4
Mesityl Oxide	68	20	15.4
Methal Cyanacetate	69	21	29.4
Methane	32	0	1.6
Methane	-280	-173	1.7
Methanol	77	25	33.6
Methoxybenzene	76	24	4.3
Methoxytoluene	68	20	3.5
Methoxy-4-Methylphenol	60	16	11.0
Methyl Acetate	68	20	7.3
Methyl Acetopheononoaxalate	64	18	2.8
Methylal	68	20	2.7
Methyl Alcohol	–112	–80	56.6
Methyl Alcohol	32	0	37.5
Methyl Alcohol	68	20	33.1

Properties: Dielectric Constants of Liquids (cont.)

Liquids	Temperature		Dielectric Constant
	°F	°C	
Methylamine	70	21	10.5
Methyl Benzoate	68	20	6.6
Methyl Benzylamine	65	18	4.4
Methyl Butane	68	20	1.8
Methyl Butyl Ketone	62	17	12.4
Methyl Butyrate	68	20	5.6
Methyl Chloracetate	68	20	12.9
Methyl Chloride	77	25	12.9
Methyl Cyclohexonal	68	20	13.0
Methyl Cyclohexanone	192	89	18.0
Methyl Cyclopentane	68	20	2.0
Methyl-1-Cyclopentanol	95	35	6.9
Methylene Chloride	70	20	9.3
Methylene Iodide	70	21	5.1
Methyl Ether	78	26	5.0
Methyl Ethyl Ketone	72	22	18.4
Methyl Ethyl Ketoxime	68	20	3.4
Methyl Heptanol	68	20	5.3
Methyl Hexane	68	20	1.9
Methyl Kezyl Ketone	62	17	10.7
Methyl Iodide	68	20	7.1
Methyl-5 Ketocyclohexylene	68	20	24.0
Methyl Nitrobenzoate	80	27	27.0
Methyl Octane	69	21	30.0
Methoxyphenol	82	28	11.0
Methyl O-Methoxybenzoate	70	21	7.8
Methyl-2, 4-Pentonddiol	86	30	24.4
Methyl-2-Pentoene	68	21	13.1
Methylphenyl Hydrazin	66	19	7.3
Methyl Propionate	66	19	5.4
Methyl Propyl Ketone	58	14	16.8
Methyl p-toluate	91	33	4.3
Methyl Salicylate	68	20	9.0
Methyl Thiocyanate	68	20	35.9
Methyl Trichloro Silane	68	20	6.8
Methyl Tertiary-butyl Ether (MTBE)	68	20	2.6
Methyl Volorate	66	19	4.3
Metilox	160	71	4.5
Mineral Oil	80	27	2.1
Misella	68	20	1.9
Monomyristin	158	70	6.1
Monopalmitin	152	67	5.3
Monostearin	170	77	4.9
Nanene	50	10	2.0
Naptha	68	20	2.0
Napthalene	185	85	2.3
Napthalene	68	20	2.5
Napthonitrile	70	21	6.4
Napthtyl Ethyl Ether	67	19	3.2
Nitric Acid	57	14	40.0
Nitroenisole	68	20	24.0
Nitrobenzol Doxime	248	120	48.1
Nitrobenzene	68	20	36.1
Nitrobenzene	77	25	34.9
Nitrobenzene	176	80	26.3
Nitrobenzyl Alcohol	68	20	22.0
Nitroethane	68	20	19.7
Nitrogen	-203	-130	1.5
Nitromethane	68	20	39.4
Nitroglycerin	68	20	19.0
Nitrosodimethylamine	68	20	54.0
Nitrosyl Bromide	4	-16	13.4
Nitrosyl Chloride	10	-12	18.2
Nitrotoluene	68	20	25.0
Nitrous Oxide	32	0	1.6
Nonane	68	20	2.0
O-Chlorophenol	66	19	8.2
Octadecanol	136	58	3.4
Octamethyltrisiloxane	68	20	2.3
Octanone	68	20	10.3

Liquids	Temperature		Dielectric Constant
	°F	°C	
Octane	68	20	2.0
Octane	76	24	2.1
Octyl Alcohol	64	18	3.4
Octylene	65	18	4.1
Octyl Iodide	68	20	4.9
Octic Acid	68	20	2.5
Oil, Almond	68	20	2.8
Oil, Cottonseed	57	14	3.1
Oil, Grapeseed	61	16	2.9
Oil, Lemon	70	21	2.3
Oil, Linseed	55	13	3.4
Oil, Olive	68	20	3.1
Oil, Paraffin	68	20	2.2–4.7
Oil, Peanut	52	11	3.0
Oil, Petroleum	68	20	2.1
Oil, Pyranol	68	20	5.3
Oil, Sesame	55	13	3.0
Oil, Sperm	68	20	3.2
Oil, Terpentine	68	20	2.2
Oil, Transformer	68	20	2.2
Oleic Acid	68	20	2.5
Palmitic Acid	160	71	2.3
Paraffin	68	20	2.2
Paraldehyde	68	20	14.5
Peanut Oil	110	43	3.5
Pentochloroethane	60	16	3.7
Pentane	68	20	1.8
Phenethiene	68	20	2.8
Phenenthrene	230	110	2.7
Phenetidine	70	21	7.3
Phenetole	70	21	4.5
Phenol	130	54	8.8
Phenol Ether	85	29	9.8
Phenol Isobuthyl	85	29	14.9
Phenoxyacetylene	76	24	4.8
Phenylacetaldehyde	68	20.	4.8
Phenylacetanitrile	80	27	18.0
Phenylacetate	68	20	6.9
Phenylacetic	68	20	3.0
Phenylethanol	68	20	13.0
Phenylethyl Acetate	58	14	4.5
Phenylisocyanate	68	20	8.9
Phenyliso-Thiocyanate	68	20	10.7
Phosgene	32	0	4.7
Phenyl-1-Iropane	68	20	2.7
Phosphine	–76	–60	2.5
Phosphorus	93	34	4.1
Phenylsolicylate	122	50	6.3
Phtholide	166	75	36.0
Pinocolin	62	17	12.8
Pinocone	75	24	7.4
Pinane	68	20	2.7
Piperidine	68	20	5.9
Propane	32	0	1.6
Propionoldehyde	62	17	18.9
Propionic Acid	66	19	3.1
Propionic Anhydride	60	16	18.0
Propionitrile	68	20	27.7
Propyl Acetate	68	20	6.3
Propyl Alcohol	68	20	21.8
Propyl Benzene	68	20	2.4
Propyl Bromide	68	20	7.2
Propyl Butyrate	68	20	4.3
Propyl Cholorformate	68	20	11.2
Propyl Ether	78	26	3.4
Propyl Formate	66	19	7.9
Propyl Nitrate	64	18	14.2
Propyl Propionate	68	20	4.7
Propyl Volerate	65	18	4.0
Prnopylene	77	25	1.9

Properties: Dielectric Constants of Liquids (cont.)

Liquids	Temperature		Dielectric Constant
	°F	°C	
Pseudocumene	60	16	2.4
Pulegone	68	20	9.5
Pulezone	66	19	9.7
Pyridine	68	20	12.5
Pyroanol Oil	68	20	5.3
Quinoline	77	25	9.0
Quinoline	460	238	5.1
Safrol	70	21	3.1
Salicyladehyde	68	20	13.9
Santowax	70	21	2.3
Sealtherm 800	750	400	2.2
Sealtherm XLT	750	400	2.3
Selenium	482	250	5.4
Sesame Oil	55	13	3.0
Silicon Tetrachloride	60	16	2.4
Sodium Hydroxide	70	20	80.0
Sodium Oleate	68	20	2.7
Sorbitol	176	80	33.5
Stannic Chloride	72	22	3.2
Stearic Acid	71	160	2.3
Styrene (phenylethene)	77	25	2.4
Succinamide	72	22	2.9
Succinic Acid	78	26	2.4
Sulfur Dioxide	-4	-20	17.6
Sulfurous Oxychloride	72	22	9.1
Sulfur Monochloride	58	14	4.8
Sulfur Trioxide	64	18	3.1
Sulfuryl Chloride	72	22	10.0
Sulfur	752	400	3.4
Sulfur	245	118	3.5
Sulfur Dioxide	32	0	15.6
Sulfuric Acid	68	20	84.0
Sulfuric Oxychloride	72	22	9.2
Sulfur Trioxide	70	21	3.6
Tallow (Beef)	68	20	2.8
Tallowamine	108	42	2.6
Tartaric Acid	68	20	6.0
Tartaric Acid	58	14	35.9
Terpinene	70	21	2.7
Terpineol	68	20	2.8
Tetrobromiethone	68	20	7.1
Tetrachloroethylene	70	21	2.5
Tetradecamethylcycloheptas	68	20	2.7
Tetraethyl Silicate	68	20	4.1
Tetradecanal	100	38	4.7
Tetraethyl Amylenetetrarar	66	189	4.4
Tetraethyl Propane Tetracarboxylate	66	19	5.2
Tetraethyl Propylene Tetracarboxylate	66	19	5.2
Tetrahydro-B-Naphthol	68	20	11.0
Tetratriocontadiene	70	21	2.8
Tetronitrimethane	68	20	2.2
Thioacetic Acid	68	20	13.0
Thionyl Bromide	68	20	9.1
Thionyl Chloride	68	20	9.3
Thiophene	68	20	2.8
Thiophosphoryl Chloride	70	21	5.8
Tin Tetrochloride	68	20	2.9
Titanium Tetrochloride	68	20	2.8
Thujone	32	0	10.0
Toluene	68	20	2.4
Toluidine	68	20	6.0
Tolunitrile	73	23	18.8
Totane	111	44	5.5
Tolyl Methyl Ether	68	20	3.5
Trans-3-Hexane	76	24	2.0
Transformer Oil	68	20	2.2
Transmission Oil	80	27	2.2
Trichloroethane	68	20	7.5
Triethylamine	75	24	2.4
Triethylamine	39	4	2.9

Liquids	Temperature		Dielectric Constant
	°F	°C	
Trifluoroacetic Acid	68	20	39.0
Trinitrotoluene	68	20	22.0
Triethyl Ethanetricarbox	66	19	6.5
Trimethyl-3-Heptane	68	20	2.2
Tribomopropane	68	20	6.4
Tributylphosphate	86	30	8.0
Trichloroacetic Acid	141	61	4.5
Trichlorotoluene	70	21	6.9
Trichloroethylene	61	16	3.4
Trichloropropane	76	24	2.4
Tricosanane	176	80	4.0
Tricosyl Phosphate	104	40	6.9
Triethyl Aconitate	68	20	6.4
Triethylamine	70	21	3.2
Triethyl Aluminum	68	20	2.9
Triethyl Isoaconitate	68	20	7.2
Trifluoroactic Acid	68	20	39.0
Trifluorotoluene	86	30	9.2
Triethylomine	39	4	2.9
Trimethylbenzene	68	20	2.3
Trimethylborate	68	20	8.2
Trimethylbutane	68	20	1.9
Trimethylpentane	68	20	2.0
Trimethylsulfanilic Acid	64	18	89.0
Trinitrobenzene	68	20	2.2
Trinitrotoluene	69	21	22.0
Tripolmitin	140	60	2.9
Triphenylmethane	212	100	2.5
Tistearin	158	70	2.8
Triolein	76	24	3.2
Turpentine	68	20	2.2
Undecane	68	20	2.0
Undecanone	58	14	8.4
Urea	71	22	3.5
Urethane	74	23	3.2
Valaraldehyde	58	14	11.8
Valeric Acid	62	17	2.6
Valeronitrile	70	21	17.7
Vanadium Oxybromide	78	26	3.6
Vanadium Oxychloride	78	26	3.4
Vanadium Tetrachloride	78	26	3.0
Vegetable Oil	100	38	4.0
Vegetable Oil	230	110	3.3
Veratrol	73	23	4.5
Vinyl Ether	68	20	3.9
Water	32	0	88.0
Water	68	20	80.0
Water	212	100	48.0
Water (Ultra-Clean, DI)	68	20	12–15
Wax	100	38	7.5
Xylene	68	20	2.4
Xylenol	62	17	3.9
Xylidine	68	20	5.0

Properties: Dielectric Constants of Solids

Material	Dielectric Constant
Acetamide	41.0
Acetanilide	2.8
Acetic Acid	4.1
Aluminum Phosphate	6.0
Ammonium Bromide	7.2
Ammonium Chloride	7.0
Antimony Trichloride	5.3
Asbestos	4.8
Asphalt	2.7
Bakelite	5.0
Barium Chloride	11.0
Barium Chloride	9.4
Barium Nitrate	5.8
Barium Sulfate	11.4
Calcium Carbonate	9.1
Calcium Fluoride	7.4
Calcium Sulfate	5.6
Cellulose	4.0
Cellulose Acetate	3.6–7.5
Cement	1.5–2.1
Cereals	3.0–5.0
Charcoal	1.2–1.8
Cupric Oleafe	2.8
Cupric Oxide	18.1
Cupric Sulfate	10.3
Diamond	10.0
Diphenylethane	2.7
Dolomite	8.0
Ferrous Oxide	14.2
Fly Ash	1.9–2.6
Glass	3.7–4.2
Iodine	4.0
Lead Acetate	2.5
Lead Carbonate	18.1
Lead Chloride	4.2
Lead Nomoxide	25.9
Lead Nitrate	37.7
Lead Oleate	3.3
Lead Oxide	25.9
Lead Sulfate	14.3
Magnesium Oxide	9.7
Malachite	7.2
Mercuric Chloride	3.2
Mercurous Chloride	9.4
Mica	7.0
Napthalane	2.5

Material	Dielectric Constant
Nylon	3.7
Paper	2.0
Paraffin	2.2
Phenonthrene	2.8
Phenol	4.3
Phosphorus, Red	4.1
Phosphorus, Yellow	3.6
Polyethylene	4.0–5.0
Polypropylene	1.5
Porcelain	5.0–7.0
Potassium Aluminum Sulphate	3.8
Potassium Carbonate	5.6
Potassium Chlorate	5.1
Potassium Chloride	5.0
Potassium Chloronate	7.3
Potassium Iodide	5.6
Potassium Nitrate	5.0
Potassium Sulfate	5.9
Quartz	4.4
Resorcinol	3.2
Rice	3.5
Rubber	3.0
Sand	3.0–5.0
Selinium	11.0
Shellac	3.5
Silver Bromide	12.2
Silver Chloride	11.2
Silver Cyanide	5.6
Slate	7.0
Sodium Carbonate	8.4
Sodium Carbonate	5.3
Sodium Chloride	6.1
Sodium Nitrate	5.2
Sodium Oleate	2.8
Sodium Perchlorate	5.4
Sulfur	3.4
Sugar	3.0
Sucrose	3.3
Tantalum Oxide	11.6
Thallium Chloride	46.9
Thorium Oxide	10.6
P-Toluidine	3.0
Urea	3.5
Zinc Sulfide	8.2
Zirconium Oxide	12.5
Teflon	2.0

Properties: Viscosity of Gases and Vapors

The curves for hydrocarbon vapors and natural gases in the chart at the upper right are taken from Maxwell; the curves for all other gases (except helium) in the chart are based upon Sutherland's formula, as follows:

$$\mu = \mu_o \left(\frac{0.555\ T_o + C}{0.555\ T + C}\right)\left(\frac{T}{T_o}\right)^{3/2}$$

where:

μ = viscosity, in centipoise at temperature T.

μ_o = viscosity, in centipoise at temperature T_o.

T = absolute temperature, in degrees Rankine (460 + deg. F) for which viscosity is desired.

T_o = absolute temperature, in degrees Rankine, for which viscosity is known.

C = Sutherland's constant.

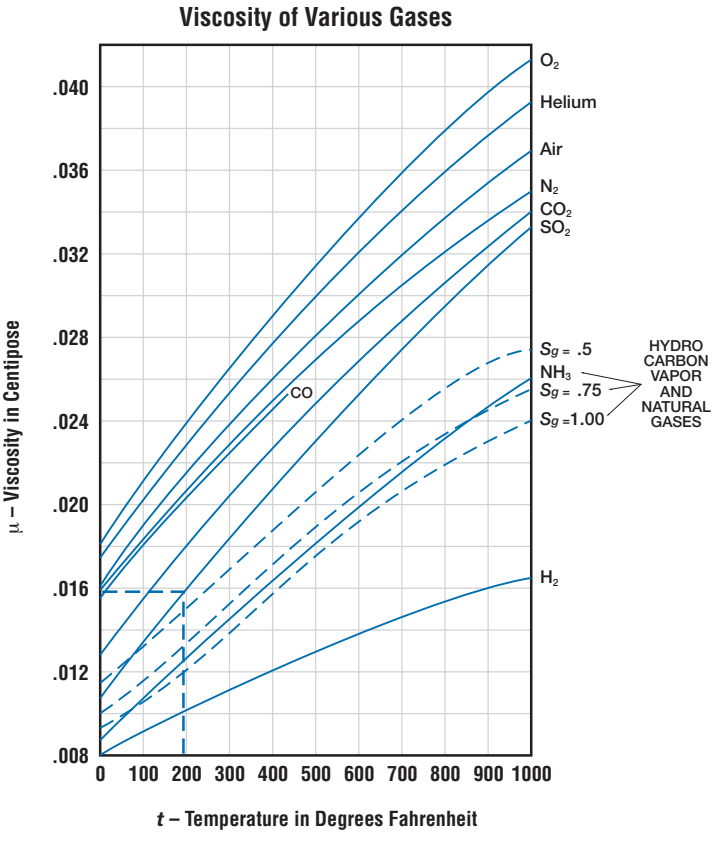
Note: The variation of viscosity with pressure is small for most gases. For gases given on this page, the correction of viscosity for pressure is less than 10% for pressures up to 500 pounds per square inch.

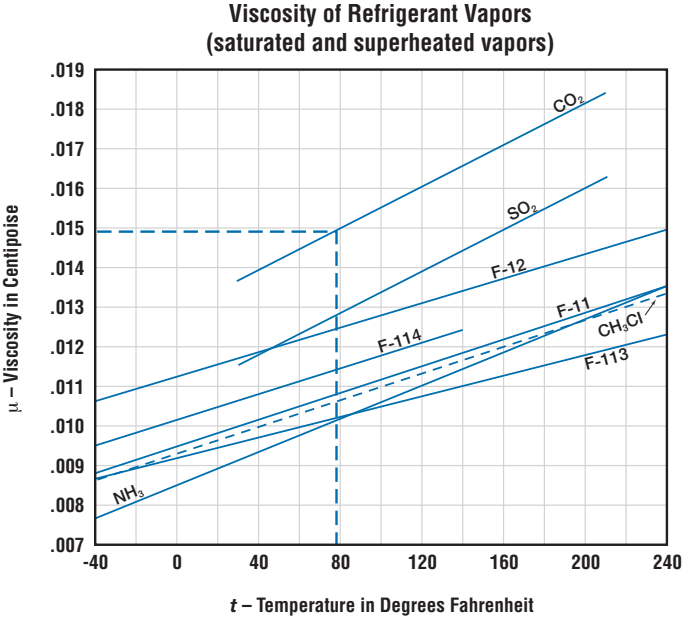
Fluid	Approximate Values of "C"
O_2	127
Air	120
N_2	111
CO_2	240
CO	118
SO_2	416
NH_3	370
H_2	72

Upper chart example: The viscosity of sulphur dioxide gas (SO_2) at 200°F (93°C) is 0.016 centipoise.

Lower chart example: The viscosity of carbon dioxide gas (CO_2) at about 80°F (26.7°) is 0.015 centipoise.

Viscosity of various gases





Properties: Viscosity of Water and Steam

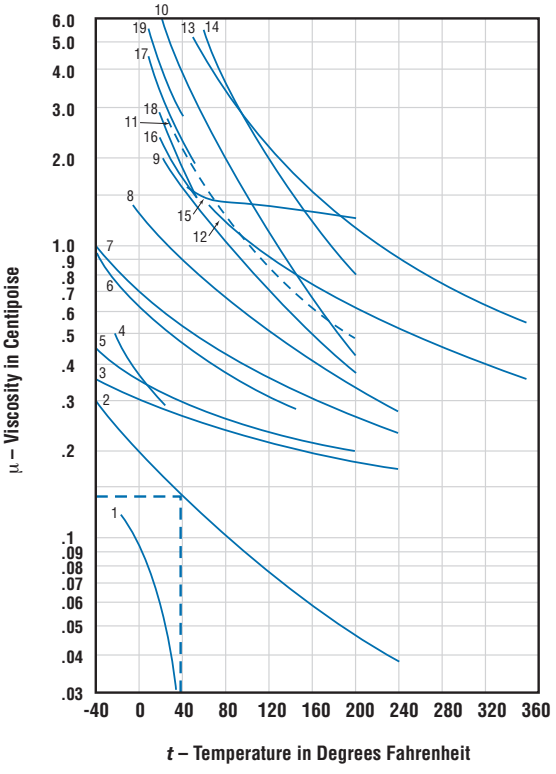
Temperature °F (°C)	Viscosity of Water and Steam – in Centipoise (μ)									
	1 PSIA	2 PSIA	5 PSIA	10 PSIA	20 PSIA	50 PSIA	100 PSIA	200 PSIA	500 PSIA	1000 PSIA
Saturated Water	.667	.524	.388	.313	.255	.197	.164	.138	.111	.094
Saturated Steam	.010	.010	.011	.012	.012	.013	.014	.015	.017	.019
1000 (538)	.030	.030	.030	.030	.030	.030	.030	.030	.030	.031
950 (510)	.029	.029	.029	.029	.029	.029	.029	.029	.029	.030
900 (482)	.028	.028	.028	.028	.028	.028	.028	.028	.028	.028
850 (454)	.026	.026	.026	.026	.026	.026	.027	.027	.027	.027
800 (427)	.025	.025	.025	.025	.025	.025	.025	.025	.026	.026
750 (399)	.024	.024	.024	.024	.024	.024	.024	.024	.025	.025
700 (371)	.023	.023	.023	.023	.023	.023	.023	.023	.023	.024
650 (343)	.022	.022	.022	.022	.022	.022	.022	.022	.023	.023
600 (316)	.021	.021	.021	.021	.021	.021	.021	.021	.021	.021
550 (288)	.020	.020	.020	.020	.020	.020	.020	.020	.020	.019
500 (260)	.019	.019	.019	.019	.019	.019	.019	.018	.018	.103
450 (232)	.018	.018	.018	.018	.017	.017	.017	.017	.115	.116
400 (204)	.016	.016	.016	.016	.016	.016	.016	.016	.131	.132
350 (177)	.015	.015	.015	.015	.015	.015	.015	.152	.153	.154
300 (149)	.014	.014	.014	.014	.014	.014	.182	.183	.183	.184
250 (121)	.013	.013	.013	.013	.013	.228	.228	.228	.228	.229
200 (93)	.012	.012	.012	.012	.300	.300	.300	.300	.300	.301
150 (66)	.011	.011	.427	.427	.427	.427	.427	.427	.427	.428
100 (37.8)	.680	.680	.680	.680	.680	.680	.680	.680	.680	.680
50 (10)	1.299	1.299	1.299	1.299	1.299	.1299	1.299	1.299	1.299	1.298
32 (0)	1.753	1.763	1.753	1.753	1.753	1.753	1.753	1.752	1.751	1.749

Values below the line are for water.

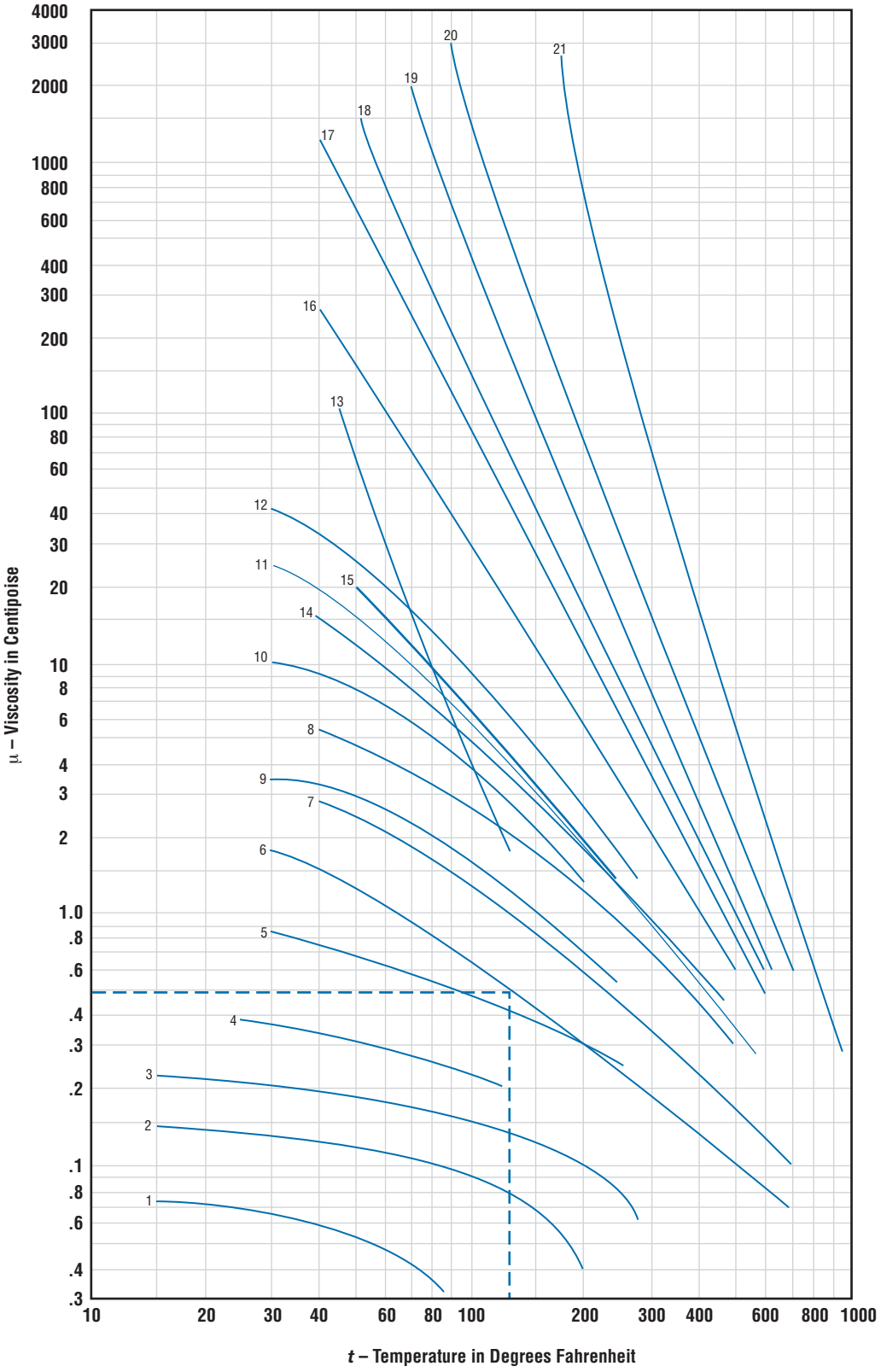
Properties: Viscosity of Various Liquids

1. Carbon Dioxide.....CO_2
2. Ammonia.....NH_3
3. Methyl Chloride.....CH_3Cl
4. Sulphur Dioxide.....SO_2
5. Freon 12.....F-12
6. Freon 114.....F-114
7. Freon 11.....F-11
8. Freon 113.....F-113
9. Ethyl Alcohol.....C_2H_5OH
10. Isopropyl Alcohol.....$(CH_3)_2\ CH_20$
11. 20% Sulphuric Acid.....20% H_2SO_4
12. Dowtherm E
13. Dowtherm A
14. 20% Sodium Hydroxide.....20% NaOH
15. Mercury.....Hg
16. 10% Sodium Chloride Brine.....10% NaCl
17. 20% Sodium Chloride Brine.....20% NaCl
18. 10% Calcium Chloride Brine.....10% $CaCl_2$
19. 20% Calcium Chloride Brine.....20% $CaCl_2$

Example: The viscosity of ammonia at 40°F is 0.14 centipoise.



Properties: Viscosity of Liquid Petroleum Products

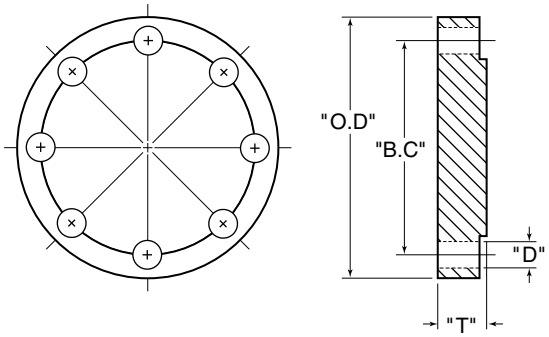


1. Ethane (C_2H_6)
2. Propane (C_3H_8)
3. Butane (C_4H_{10})
4. Natural Gasoline
5. Gasoline
6. Water
7. Kerosene
8. Distillate
9. 48 Deg. API Crude
10. 40 Deg. API Crude
11. 35.6 Deg. API Crude
12. 32.6 Deg. API Crude
13. Salt Creek Crude
14. Fuel 3 (Max.)
15. Fuel 5 (Min.)
16. SAE 10 Lube (100 V.I.)
17. SAE 30 Lube (100 V.I.)
18. Fuel 5 (Max.) or Fuel 6 (Min.)
19. SAE 70 Lube (100 V.I.)
20. Bunker C Fuel (Max.) and M.C. Residuum
21. Asphalt

Example: The viscosity of water at 125°F is 0.52 centipoise (Curve No. 6).

Note: Consult factory whenever viscosity of fluid exceeds 300 centipoise.

Pipe Data: Dimensions of Blind Flanges



NOTE: Pressure ratings shown for forged steel flanges apply to all ASA/ANSI standard flanges.

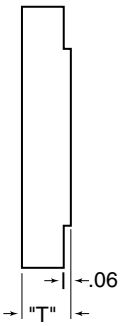
Cast Iron–125#					
Nominal Pipe Size	Outside Dia. of Flange "O.D"	Thickness "T"	Dia. of Bolt Circle "BC"	No. of Holes	Dia. of Bolt Holes "D"
1"	4¼"	7/16"	3⅛"	4	⅝"
1½"	5"	9/16"	3⅞"	4	⅝"
2"	6"	⅝"	4¾"	4	¾"
2½"	7"	11/16"	5½"	4	¾"
3"	7½"	¾"	6"	4	¾"
3½"	8½"	13/16"	7"	8	¾"
4"	9"	15/16"	7½"	8	¾"
5"	10"	15/16"	8½"	8	⅞"
6"	11"	1"	9½"	8	⅞"
8"	13½"	1⅛"	11¾"	8	⅞"

Cast Iron–250#					
Nominal Pipe Size	Outside Dia. of Flange "O.D"	Thickness "T"	Dia. of Bolt Circle "BC"	No. of Holes	Dia. of Bolt Holes "D"
1"	4⅞"	11/16"	3½"	4	¾"
1½"	6⅛"	13/16"	4½"	4	⅞"
2"	6½"	⅞"	5"	8	¾"
2½"	7½"	1"	5⅞"	8	⅞"
3"	8¼"	1⅛"	6⅝"	8	⅞"
3½"	9"	1 3/16"	7¼"	8	⅞"
4"	10"	1¼"	7⅞"	8	⅞"
5"	11"	1⅜"	9¼"	8	⅞"
6"	12½"	1 7/16"	10⅝"	12	⅞"
8"	15"	1⅝"	13"	12	1"

Forged Steel – 150#					
Nominal Pipe Size	Outside Dia. of Flange "O.D."	Thickness "T"	Dia. of Bolt Circle "BC"	No. of Holes	Dia. of Bolt Holes "D"
½"	3½"	7/16"	2⅜"	4	⅝"
¾"	3⅞"	½"	2¾"	4	⅝"
1"	4¼"	9/16"	3⅛"	4	⅝"
1½"	5"	11/16"	3⅞"	4	⅝"
2"	6"	¾"	4¾"	4	¾"
2½"	7"	⅞"	5½"	4	¾"
3"	7½"	15/16"	6"	4	¾"
3½"	8½"	15/16"	7"	8	¾"
4"	9"	15/16"	7½"	8	¾"
5"	10"	15/16"	8½"	8	⅞"
6"	11"	1"	9½"	8	⅞"
8"	13½"	1⅛"	11¾"	8	⅞"

Forged Steel – 300#					
Nominal Pipe Size	Outside Dia. of Flange "O.D."	Thickness "T"	Dia. of Bolt Circle "BC"	No. of Holes	Dia. of Bolt Holes "D"
½"	3¾"	9/16"	2⅝"	4	⅝"
¾"	4⅝"	⅝"	3¼"	4	¾"
1"	4⅞"	11/16"	3½"	4	¾"
1½"	6⅛"	13/16"	4½"	4	⅞"
2"	6½"	⅞"	5"	8	¾"
2½"	7½"	1"	5⅞"	8	⅞"
3"	8¼"	1⅛"	6⅝"	8	⅞"
3½"	9"	1 3/16"	7¼"	8	⅞"
4"	10"	1¼"	7⅞"	8	⅞"
5"	11"	1⅜"	9¼"	8	⅞"
6"	12½"	1 7/16"	10⅝"	12	⅞"
8"	15"	1⅝"	13"	12	1"

Forged Steel – 600#					
Nominal Pipe Size	Outside Dia. of Flange "O.D."	Thickness "T"	Dia. of Bolt Circle "BC"	No. of Holes	Dia. of Bolt Holes "D"
½"	3¾"	9/16"	2⅝"	4	⅝"
¾"	4⅝"	⅝"	3¼"	4	¾"
1"	4⅞"	11/16"	3½"	4	¾"
1½"	6⅛"	⅞"	4½"	4	⅞"
2"	6½"	1"	5"	8	¾"
2½"	7½"	1⅛"	5⅞"	8	⅞"
3"	8¼"	1¼"	6⅝"	8	⅞"
3½"	9"	1 3/16"	7¼"	8	1"
4"	10¾"	1½"	8½"	8	1"
5"	13"	1¾"	10½"	8	1⅛"
6"	14"	1⅞"	11½"	12	1⅛"



150# & 300#

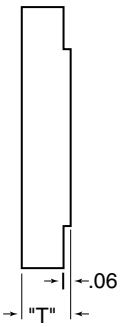
600# & above

Pipe Data: Dimensions of Blind Flanges

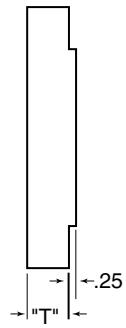
Forged Steel – 900#					
Nominal Pipe Size	Outside Dia. of Flange "O.D."	Thickness "T"	Dia. of Bolt Circle "BC"	No. of Holes	Dia. of Bolt Holes "D"
½"	4¾"	⅞"	3¼"	4	⅞"
¾"	5⅛"	1"	3½"	4	⅞"
1"	5⅞"	1⅛"	4"	4	1"
1½"	7"	1¼"	4⅞"	4	1⅛"
2"	8½"	1½"	6½"	8	1"
2½"	9⅝"	1⅝"	7½"	8	1⅛"
3"	9½"	1½"	7½"	8	1"
4"	11½"	1¾"	9¼"	8	1¼"
5"	13¾"	2"	11"	8	1⅜"
6"	15"	2 3/16"	12½"	12	1¼"
8"	18½"	2½"	15½"	12	1½"

Forged Steel – 1500#					
Nominal Pipe Size	Outside Dia. of Flange "O.D."	Thickness "T"	Dia. of Bolt Circle "BC"	No. of Holes	Dia. of Bolt Holes "D"
½"	4¾"	⅞"	3¼"	4	⅞"
¾"	5⅛"	1"	3½"	4	⅞"
1"	5⅞"	1⅛"	4"	4	1"
1½"	7"	1¼"	4⅞"	4	1⅛"
2"	8½"	1½"	6½"	8	1"
2½"	9⅝"	1⅝"	7½"	8	1⅛"
3"	10½"	1⅞"	8"	8	1¼"
4"	12¼"	2⅛"	9½"	8	1⅜"
5"	14¾"	2⅞"	11½"	8	1⅝"
6"	15½"	3¼"	12½"	12	1½"
8"	19"	3⅝"	15½"	12	1¾"

Forged Steel – 2500#					
Nominal Pipe Size	Outside Dia. of Flange "O.D."	Thickness "T"	Dia. of Bolt Circle "BC"	No. of Holes	Dia. of Bolt Holes "D"
½"	5¼"	1 3/16"	3½"	4	⅞"
¾"	5½"	1¼"	3¾"	4	⅞"
1"	6¼"	1⅜"	4¼"	4	1"
1½"	8"	1¾"	5¾"	4	1¼"
2"	9¼"	2"	6¾"	8	1⅛"
2½"	10½"	2¼"	7¾"	8	1¼"
3"	12"	2⅝"	9"	8	1⅜"
4"	14"	3"	10¾"	8	1⅝"
5"	16½"	3⅝"	12¾"	8	1⅞"
6"	19"	4¼"	14½"	8	2⅛"
8"	21¾"	5"	17¼"	12	2⅛"



150# & 300#



600# & above

Pipe Data: Flange Ratings

Flanges DIN versus ANSI

Pressure Rating		Sizes	
ANSI	DIN	ANSI	DIN
125 lbs.	PN 6 / PN 10	1"	DN 25
150 lbs.	PN 16	1½"	DN 40
300 lbs.	PN 25 / PN 40	2"	DN 50
400 lbs.	PN 64	2½"	DN 65
600 lbs.	PN 100	3"	DN 80
900 lbs.	PN 150	4"	DN 100
1500 lbs.	PN 250	5"	DN 125
2500 lbs.	PN 320 / PN 400	6"	DN 150

Type

Flat Face = Form B flange
Raised Face = Form C flange (Form E is smoother facing finish)
Ring Joint Flange = Only for ANSI flanges

A DIN flange is never identical to an ANSI flange; the table at left is a guideline to find the most equivalent ANSI/DIN flange. DIN increments differ from country to country, the table refers to the German DIN standard.

Class 150 pressure-temperature ratings (pressure-PSIG)

Temp. °F	Materials																		Temp. °F.
	304 SS	304L or 316L SS	316 SS	316SS 316/ 316L SS Dual Grade	321 SS	347/ 348 SS	A105 Carbon Steel	Carp. 20SS	Grade F1 C-½ Mo	Grade F11 1¼ Cr-½ Mo	Grade F22 2¼ Cr-1 Mo	Grade F91 9 Cr-1 Mo-V	Hast. B2	Hast. C & Inconel 625 & Incoloy 825	Incoloy 800	Inconel 600	Monel 400 & 405	Nickel 200	
-20 to 100	275	230	260	275	275	275	285	290	265	290	290	290	290	290	275	290	230	140	-20 to 100
200	230	195	235	235	245	255	260	260	260	260	260	260	260	260	255	260	200	140	200
300	205	175	220	215	230	230	230	230	230	230	230	230	230	230	230	230	190	140	300
400	190	160	200	195	200	200	200	200	200	200	200	200	200	200	200	200	185	140	400
500	170	145	170	170	170	170	170	170	170	170	170	170	170	170	170	170	170	140	500
600	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	140	600
650	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125	125	-	650
700	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	110	-	700
750	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	95	-	750
800	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	80	-	800
850	65	65	65	65	65	65	65	-	65	65	65	65	-	65	65	65	65	-	850
900	50	-	50	50	50	50	50	-	50	50	50	50	-	50	50	50	50	-	900
950	35	-	35	35	35	35	35	-	35	35	35	35	-	35	35	35	-	-	950
1000	20	-	20	20	20	20	20	-	20	20	20	20	-	20	20	20	-	-	1000

Pipe Data: Flange Ratings (cont.)

Class 300 pressure-temperature ratings (pressure-PSIG)

Temp. °F	Materials																		Temp. °F.
	304 SS	304L or 316L SS	310 SS	316SS 316/ 316L SS Dual Grade	321 SS	347/ 348 SS	A105 Carbon Steel	Carp. 20SS	Grade F1 C-½ Mo	Grade F11 1¼ Cr-½ Mo	Grade F22 2¼ Cr-1 Mo	Grade F91 9 Cr-1 Mo-V	Hast. B2	Hast. C & Inconel 625 & Incoloy 825	Incoloy 800	Inconel 600	Monel 400 & 405	Nickel 200	
-20 to 100	720	600	670	720	720	720	740	750	695	750	750	750	750	750	720	750	600	360	-20 to 100
200	600	505	605	620	645	660	675	720	680	750	750	750	750	750	660	750	530	360	200
300	540	455	570	560	595	615	655	715	655	720	730	730	730	730	625	730	495	360	300
400	495	415	535	515	550	575	635	675	640	695	705	705	705	705	600	705	480	360	400
500	465	380	505	480	515	540	600	655	620	665	665	665	665	665	580	665	475	360	500
600	435	360	480	450	485	515	550	605	605	605	605	605	605	605	575	605	475	360	600
650	430	350	470	445	480	505	535	590	590	590	590	590	590	590	570	590	475	-	650
700	425	345	455	430	465	495	535	570	570	570	570	570	570	570	565	570	475	-	700
750	415	335	450	425	460	490	505	530	530	530	530	530	530	530	530	530	470	-	750
800	405	330	435	420	450	485	410	510	510	510	510	510	510	510	505	510	460	-	800
850	395	320	425	420	445	485	270	-	485	485	485	485	-	485	485	485	340	-	850
900	390	-	420	415	440	450	170	-	450	450	450	450	-	450	450	450	245	-	900
950	380	-	385	385	385	385	105	-	280	320	375	385	-	385	385	325	-	-	950
1000	320	-	345	350	355	365	50	-	165	215	260	365	-	365	365	215	-	-	1000
1050	310	-	335	345	315	360	-	-	-	145	175	360	-	360	360	140	-	-	1050
1100	255	-	260	305	270	325	-	-	-	95	110	300	-	325	325	95	-	-	1100
1150	200	-	190	235	235	275	-	-	-	60	70	225	-	275	275	70	-	-	1150
1200	155	-	135	185	186	170	-	-	-	40	40	145	-	186	205	60	-	-	1200
1250	115	-	105	145	140	125	-	-	-	-	-	-	-	146	130	-	-	-	1250
1300	85	-	75	115	110	95	-	-	-	-	-	-	-	110	60	-	-	-	1300
1350	60	-	60	95	85	70	-	-	-	-	-	-	-	-	50	-	-	-	1350
1400	50	-	45	75	65	66	-	-	-	-	-	-	-	-	35	-	-	-	1400
1450	35	-	35	60	50	40	-	-	-	-	-	-	-	-	30	-	-	-	1450
1500	25	-	25	40	40	35	-	-	-	-	-	-	-	-	25	-	-	-	1500

Class 600 pressure-temperature ratings (pressure-PSIG)

Temp. °F	Materials																		Temp. °F.
	304 SS	304L or 316L SS	310 SS	316SS 316/ 316L SS Dual Grade	321 SS	347/ 348 SS	A105 Carbon Steel	Carp. 20SS	Grade F1 C-½ Mo	Grade F11 1¼ Cr-½ Mo	Grade F22 2¼ Cr-1 Mo	Grade F91 9 Cr-1 Mo-V	Hast. B2	Hast. C & Inconel 625 & Incoloy 825	Incoloy 800	Inconel 600	Monel 400 & 405	Nickel 200	
-20 to 100	1440	1200	1345	1440	1440	1440	1480	1500	1390	1500	1500	1500	1500	1500	1440	1500	1200	720	-20 to 100
200	1200	1015	1215	1240	1290	1320	1350	1440	1360	1500	1500	1500	1500	1500	1325	1500	1055	720	200
300	1080	910	1140	1120	1190	1230	1315	1425	1305	1445	1455	1455	1455	1455	1250	1455	990	720	300
400	995	825	1070	1025	1105	1145	1270	1345	1280	1385	1410	1410	1410	1410	1200	1410	955	720	400
500	930	765	1015	955	1030	1080	1200	1310	1245	1330	1330	1330	1330	1330	1155	1330	950	720	500
600	875	720	960	900	975	1025	1095	1210	1210	1210	1210	1210	1210	1210	1145	1210	950	720	600
650	860	700	935	890	955	1010	1075	1175	1175	1175	1175	1175	1175	1175	1140	1175	950	-	650
700	850	685	910	870	930	990	1065	1135	1135	1135	1135	1135	1135	1135	1130	1135	950	-	700
750	830	670	900	855	915	985	1010	1065	1065	1065	1065	1065	1065	1065	1065	1065	935	-	750
800	805	660	875	845	900	975	825	1015	1015	1015	1015	1015	1015	1015	1015	1015	915	-	800
850	790	645	855	835	895	970	535	-	975	975	975	975	-	975	975	975	680	-	850
900	780	-	835	830	885	900	345	-	900	900	900	900	-	900	900	900	495	-	900
950	765	-	775	775	775	775	205	-	560	640	755	775	-	775	775	655	-	-	950
1000	640	-	685	700	715	725	105	-	330	430	520	725	-	725	725	430	-	-	1000
1050	615	-	670	685	625	720	-	-	-	290	350	720	-	720	720	280	-	-	1050
1100	515	-	520	610	545	645	-	-	-	190	220	605	-	645	645	185	-	-	1100
1150	400	-	375	475	475	550	-	-	-	125	135	445	-	550	550	135	-	-	1150
1200	310	-	275	370	320	345	-	-	-	75	80	290	-	370	405	125	-	-	1200
1250	225	-	205	295	280	245	-	-	-	-	-	-	-	295	260	-	-	-	1250
1300	170	-	150	235	220	185	-	-	-	-	-	-	-	215	125	-	-	-	1300
1350	125	-	115	190	170	135	-	-	-	-	-	-	-	-	100	-	-	-	1350
1400	90	-	90	150	130	110	-	-	-	-	-	-	-	-	70	-	-	-	1400
1450	70	-	65	115	105	80	-	-	-	-	-	-	-	-	60	-	-	-	1450
1500	55	-	50	85	75	70	-	-	-	-	-	-	-	-	50	-	-	-	1500

Pipe Data: Flange Ratings (cont.)

Class 900 pressure-temperature ratings (pressure-PSIG)

Temp. °F	Materials																		Temp. °F.
	304 SS	304L or 316L SS	310 SS	316SS 316/ 316L SS Dual Grade	321 SS	347/ 348 SS	A105 Carbon Steel	Carp. 20SS	Grade F1 C-½ Mo	Grade F11 1¼ Cr-½ Mo	Grade F22 2¼ Cr-1 Mo	Grade F91 9 Cr-1 Mo-V	Hast. B2	Hast. C & Inconel 625 & Incoloy 825	Incoloy 800	Inconel 600	Monel 400 & 405	Nickel 200	
-20 to 100	2160	1800	2015	2160	2160	2160	2220	2250	2085	2250	2250	2250	2250	2250	2160	2250	1800	1080	-20 to 100
200	1800	1520	1820	1860	1935	1980	2025	2160	2035	2250	2250	2250	2250	2250	1990	2250	1585	1080	200
300	1620	1360	1705	1680	1785	1845	1970	2140	1955	2165	2185	2185	2185	2185	1870	2185	1485	1080	300
400	1490	1240	1605	1540	1655	1720	1900	2020	1920	2080	2115	2115	2115	2115	1800	2115	1435	1080	400
500	1395	1145	1520	1435	1545	1620	1795	1965	1865	1995	1995	1995	1995	1995	1735	1995	1435	1080	500
600	1310	1080	1440	1355	1460	1540	1640	1815	1815	1815	1815	1815	1815	1815	1720	1815	1435	1080	600
650	1290	1050	1405	1330	1435	1510	1610	1765	1765	1765	1765	1765	1765	1765	1705	1765	1435	-	650
700	1275	1030	1370	1305	1395	1485	1600	1705	1705	1705	1705	1705	1705	1705	1690	1705	1435	-	700
750	1245	1010	1345	1280	1375	1475	1510	1595	1595	1595	1595	1595	1595	1595	1595	1595	1405	-	750
800	1210	985	1310	1265	1355	1460	1235	1525	1525	1525	1525	1525	1520	1520	1520	1520	1375	-	800
850	1190	985	1280	1255	1340	1455	805	-	1460	1460	1460	1460	-	1460	1460	1460	1020	-	850
900	1165	-	1255	1245	1325	1350	515	-	1350	1350	1350	1350	-	1350	1350	1350	740	-	900
950	1145	-	1160	1160	1160	1160	310	-	845	955	1130	1160	-	1160	1160	980	-	-	950
1000	965	-	1030	1050	1070	1090	155	-	495	650	780	1090	-	1090	1090	965	-	-	1000
1050	925	-	-	1010	1030	940	1080	-	-	430	525	1080	-	1080	1080	415	-	-	1050
1100	770	-	780	915	815	985	-	-	-	290	330	905	-	965	965	280	-	-	1100
1150	595	-	565	710	710	825	-	-	-	185	205	670	-	825	825	205	-	-	1150
1200	465	-	410	555	555	515	-	-	-	115	125	430	-	555	610	185	-	-	1200
1250	340	-	310	440	420	370	-	-	-	-	-	-	-	440	390	-	-	-	1250
1300	255	-	225	350	330	280	-	-	-	-	-	-	-	325	185	-	-	-	1300
1350	185	-	175	290	255	205	-	-	-	-	-	-	-	-	150	-	-	-	1350
1400	145	-	135	225	195	165	-	-	-	-	-	-	-	-	100	-	-	-	1400
1450	105	-	100	175	155	125	-	-	-	-	-	-	-	-	95	-	-	-	1450
1500	80	-	75	125	115	105	-	-	-	-	-	-	-	-	75	-	-	-	1500

Class 1500 pressure-temperature ratings (pressure-PSIG)

Temp. °F	Materials																		Temp. °F.
	304 SS	304L or 316L SS	310 SS	316SS 316/ 316L SS Dual Grade	321 SS	347/ 348 SS	A105 Carbon Steel	Carp. 20SS	Grade F1 C-½ Mo	Grade F11 1¼ Cr-½ Mo	Grade F22 2¼ Cr-1 Mo	Grade F91 9 Cr-1 Mo-V	Hast. B2	Hast. C & Inconel 625 & Incoloy 825	Incoloy 800	Inconel 600	Monel 400 & 405	Nickel 200	
-20 to 100	3600	3000	3360	3600	3600	3600	3705	3750	3470	3750	3750	3750	3750	3750	3600	3750	3000	1800	-20 to 200
200	3000	2530	3035	3095	3230	3300	3375	3600	3395	3750	3750	3750	3750	3750	3310	3750	2640	1800	200
300	2700	2270	2845	2795	2975	3070	3280	3565	3260	3610	3640	3640	3640	3640	3120	3640	2740	1800	300
400	2485	2065	2675	2570	2760	2870	3170	3365	3200	3465	3530	3530	3530	3530	3000	3530	2390	1800	400
500	2330	1910	2530	2390	2570	2570	2700	3275	3105	3325	3325	3325	3325	3325	2890	3325	2375	1800	500
600	2185	1800	2400	2255	2435	2570	2735	3025	3025	3025	3025	3025	3025	3025	2870	3025	2375	1800	600
650	2150	1750	2340	2220	2390	2520	2685	2940	2940	2940	2940	2940	2940	2940	2845	2940	2375	-	650
700	2125	1715	2280	2170	2330	2470	2665	2840	2840	2840	2840	2840	2840	2840	2840	2840	2375	-	700
750	2075	1680	2245	2135	2290	2460	2520	2660	2660	3660	2660	2660	2660	2660	2650	2660	2340	-	750
800	2015	1645	2185	2110	2255	2435	2060	2540	2540	2540	2540	2540	2540	2540	2535	2540	2290	-	800
850	1980	1810	2135	2090	2230	2425	1340	-	2435	2435	2435	2435	-	2435	2435	2435	1695	-	850
900	1945	-	2090	2075	2210	2245	860	-	2245	2245	2245	2245	-	2245	2245	2245	1235	-	900
950	1910	-	1930	1930	1930	1930	515	-	1405	1595	1885	1930	-	1930	1930	1635	-	-	950
1000	1605	-	1720	1740	1785	1820	260	-	825	1080	1305	1820	-	1820	1820	1080	-	-	1000
1050	1545	-	1680	1720	1580	1800	-	-	-	720	875	1800	-	1800	1800	695	-	-	1050
1100	1285	-	1305	1525	1360	1610	-	-	-	480	550	1510	-	1610	1610	465	-	-	1100
1150	995	-	934	1185	1185	1370	-	-	-	310	345	1115	-	1370	1370	340	-	-	1150
1200	770	-	685	925	925	855	-	-	-	190	205	720	-	925	1020	310	-	-	1200
1250	565	-	515	735	705	615	-	-	-	-	-	-	-	735	650	-	-	-	1250
1300	430	-	375	585	660	465	-	-	-	-	-	-	-	640	310	-	-	-	1300
1350	310	-	290	480	430	345	-	-	-	-	-	-	-	-	245	-	-	-	1350
1400	240	-	225	380	325	275	-	-	-	-	-	-	-	-	170	-	-	-	1400
1450	170	-	165	290	255	205	-	-	-	-	-	-	-	-	155	-	-	-	1450
1500	135	-	130	205	190	170	-	-	-	-	-	-	-	-	125	-	-	-	1500

Pipe Data: Flange Ratings (cont.)

Class 2500 pressure-temperature ratings (pressure-PSIG)

Temp. °F	Materials																		Temp. °F.
	304 SS	304L or 316L SS	310 SS	316SS 316/ 316L SS Dual Grade	321 SS	347/ 348 SS	A105 Carbon Steel	Carp. 20SS	Grade F1 C-½ Mo	Grade F11 1¼ Cr-½ Mo	Grade F22 2¼ Cr-1 Mo	Grade F91 9 Cr-1 Mo-V	Hast. B2	Hast. C & Inconel 625 & Incoloy 825	Incoloy 800	Inconel 600	Monel 400 & 405	Nickel 200	
-20 to 100	6000	5000	5600	6000	6000	6000	6170	6250	5785	6250	6250	6250	6250	6250	6000	6250	5000	3000	-20 to 100
200	5000	4220	5060	5160	5380	5500	5625	6000	5660	6250	6250	6250	6250	6250	5520	6250	4400	3000	200
300	4500	3780	4740	4660	4960	5120	5470	5940	5435	6015	6070	6070	6070	6070	5200	6070	4120	3000	300
400	4140	3440	4460	4280	4600	4780	5280	5610	5330	5775	5880	5880	5880	5880	5000	5880	3980	3000	400
500	3880	3180	4220	3980	4285	4500	4990	5460	5180	5540	5540	5540	5540	5540	4820	5540	3960	3000	500
600	3640	3000	4000	3760	4060	4280	4560	5040	5040	5040	5040	5040	5040	5040	4780	5040	3960	3000	600
650	3580	2920	3900	3700	3980	4200	4475	4905	4905	4905	4905	4905	4905	4905	4740	4905	3960	-	650
700	3540	2860	3800	3620	3880	4120	4440	4730	4730	4730	4730	4730	4730	4730	4700	4730	3960	-	700
750	3460	2800	3740	3560	3820	4100	4200	4430	4430	4430	4430	4430	4430	4430	4430	4430	3900	-	750
800	3360	2740	3640	3520	3760	4060	3430	4230	4230	4230	4230	4230	4230	4230	4230	4230	3820	-	800
850	3300	2680	3560	3480	3720	4040	2230	-	4060	4060	4060	4060	-	4060	4060	4060	2830	-	850
900	3240	-	3480	3460	3680	3745	1430	-	3745	3745	3745	3745	-	3745	3745	3745	2055	-	900
950	3180	-	3220	3220	3220	3220	860	-	2345	2655	3145	3220	-	3220	3220	2725	-	-	950
1000	2675	-	2865	2915	2970	3030	430	-	1370	1800	2170	3030	-	3030	3030	1800	-	-	1000
1050	2570	-	2800	2865	2605	3000	-	-	-	1200	1455	3000	-	3000	3000	1155	-	-	1050
1100	2145	-	2170	2545	2255	2685	-	-	-	800	915	2515	-	2685	2685	770	-	-	1100
1150	1655	-	1570	1970	1970	2285	-	-	-	515	570	1855	-	2285	2285	565	-	-	1150
1200	1285	-	1145	1545	1545	1430	-	-	-	315	345	1200	-	1545	1695	515	-	-	1200
1250	945	-	855	1230	1170	1030	-	-	-	-	-	-	-	1220	1080	-	-	-	1250
1300	715	-	630	970	915	710	-	-	-	-	-	-	-	900	515	-	-	-	1300
1350	515	-	485	800	715	570	-	-	-	-	-	-	-	-	410	-	-	-	1350
1400	400	-	370	630	545	455	-	-	-	-	-	-	-	-	285	-	-	-	1400
1450	285	-	275	485	430	345	-	-	-	-	-	-	-	-	255	-	-	-	1450
1500	230	-	215	345	315	285	-	-	-	-	-	-	-	-	205	-	-	-	1500

ANSI Flange Bolting Dimensions for Stud Bolts (inches)

Nominal Pipe Size	Flange Face	ANSI Pressure Class											
		150#		300#		600#		900#		1500#		2500#	
		Diam.	Length	Diam	Length	Diam	Length	Diam	Length	Diam	Length	Diam	Length
½"	RF	½"	2.25	½"	2.50	½"	3.00	¾"	4.25	¾"	4.25	¾"	4.75
	RTJ		——		3.00		3.00		4.25		4.25		4.75
¾"	RF	½"	2.50	⅝"	3.00	⅝"	3.50	¾"	4.50	¾"	4.50	¾"	5.00
	RTJ		——		3.50		3.50		4.50		4.50		5.00
1"	RF	½"	2.50	⅝"	3.00	⅝"	3.50	⅞"	5.00	⅞"	5.00	⅞"	5.50
	RTJ		3.00		3.50		3.50		5.00		5.00		5.50
1¼"	RF	½"	2.75	⅝"	3.25	⅝"	3.75	⅞"	5.00	⅞"	5.00	1	6.00
	RTJ		3.25		3.75		3.75		5.00		5.00		6.00
1½"	RF	½"	2.75	¾"	3.50	¾"	4.25	1	5.50	1	5.50	1⅛"	6.75
	RTJ		3.25		4.00		4.25		5.50		5.50		6.75
2"	RF	⅝"	3.25	⅝"	3.50	⅝"	4.25	⅞"	5.75	⅞"	5.75	1	7.00
	RTJ		3.75		4.00		4.25		5.75		5.75		7.00
2½"	RF	⅝"	3.50	¾"	4.00	¾"	4.75	1	6.25	1	6.25	1⅛"	7.75
	RTJ		4.00		4.50		4.75		6.25		6.25		8.00
3	RF	⅝"	3.50	¾"	4.25	¾"	5.00	⅞"	5.75	1⅛"	7.00	1¼"	8.75
	RTJ		4.00		4.75		5.00		5.75		7.00		9.00
3½"	RF	⅝"	3.50	¾"	4.25	⅞"	5.50	——	——	——	——	——	——
	RTJ		4.00		5.00		5.50		——		——		——
4"	RF	⅝"	3.50	¾"	4.50	⅞"	5.75	1⅛"	6.75	1¼"	7.75	1½"	10.00
	RTJ		4.00		5.00		5.75		6.75		7.75		10.25
5"	RF	¾"	3.75	¾"	4.75	1	6.50	1¼"	7.50	1½"	9.75	1¾"	11.75
	RTJ		4.25		5.25		6.50		7.50		9.75		12.25
6"	RF	¾"	4.00	¾"	4.75	1	6.75	1⅛"	7.50	1⅜"	10.25	2	16.50
	RTJ		4.50		5.50		6.75		7.75		10.50		14.00
8"	RF	¾"	4.25	⅞"	5.50	1⅛"	7.25	1⅜"	8.75	1⅝"	11.50	2	15.00
	RTJ		4.75		6.00		7.75		8.75		12.75		15.50

*3MHP Type torqued to 20 ft. ib. with Buna-N gasket

Service Ratings of Tri-Clamp Connections

	Pressure Rating (PSI)					
TEMP (°F)	1"/1.5"	2"	2.5"	3"	4"	5"
70	1500	1000	1000	1000	1000	300
250	1200	800	800	800	800	200
400	950	725	N/A	N/A	450	N/A

Pipe Data: Plastic Flange Ratings

Temperature (°F)	Material					
	PVC	CPVC	PVDF (Kynar®)	PTFE (Teflon®)	Fiberglass (1" to 3")	Fiberglass (4")
73	150	150	150	15	450	225
100	93	127	150	13	450	225
120	60	97	150	11	450	225
140	33	75	150	10	450	225
160	—	60	133	8	450	225
180	—	37	115	—	450	225
200	—	30	97	—	450	225
220	—	—	80	—	450	225
240	—	—	60	—	—	—
260	—	—	43	—	—	—
280	—	—	25	—	—	—
300	—	—	—	—	—	—
400	—	—	—	—	—	—

Pipe Data: Cast Iron Pipe

Cast Iron Pipe–ASA Standard

Pipe Size	Pipe O.D.	Class 50 50 PSIG		Class 100 100 PSIG		Class 150 150 PSIG		Class 200 200 PSIG		Class 250 250 PSIG		Class 300 300 PSIG		Class 350 350 PSIG	
		WALL	I.D.	WALL	I.D.	WALL	I.D.	WALL	I.D.	WALL	I.D.	WALL	I.D.	WALL	I.D.
3	3.96	0.32	3.32	0.32	3.32	0.32	3.32	0.32	3.32	0.32	3.32	0.32	3.32	0.32	3.32
4	4.80	0.35	4.10	0.35	4.10	0.35	4.10	0.35	4.10	0.35	4.10	0.35	4.10	0.35	4.10
6	6.90	0.38	6.14	0.38	6.14	0.38	6.14	0.38	6.14	0.38	6.14	0.38	6.14	0.38	6.14
8	9.05	0.41	8.23	0.41	8.23	0.41	8.23	0.41	8.23	0.41	8.23	0.41	8.23	0.41	8.23
10	11.10	0.44	10.22	0.44	10.22	0.44	10.22	0.44	10.22	0.44	10.22	0.48	10.14	0.52	10.06
12	13.20	0.48	12.24	0.48	12.24	0.48	12.24	0.48	12.24	0.52	12.16	0.51	12.16	0.56	12.08
14	15.30	0.48	14.34	0.51	14.28	0.51	14.28	0.55	14.20	0.59	14.12	0.59	14.12	0.64	14.02
16	17.40	0.54	16.32	0.54	16.32	0.54	16.32	0.58	16.24	0.63	16.14	0.68	16.04	0.68	16.04
18	19.50	0.54	18.42	0.58	18.34	0.58	18.34	0.63	18.24	0.68	18.14	0.73	18.04	0.79	17.92
20	21.60	0.57	20.46	0.62	20.36	0.62	20.36	0.67	20.26	0.72	20.16	0.78	20.04	0.84	19.92
24	25.80	0.63	24.54	0.68	24.44	0.73	24.34	0.79	24.22	0.79	24.22	0.85	24.10	0.92	23.96

Cast Iron Pipe–AWWA Standard

Pipe Size	Class A 100 Ft. 43 PSIG			Class B 200 Ft. 86 PSIG			Class C 300 Ft. 130 PSIG			Class D 400 Ft. 173 PSIG		
	O.D.	WALL	I.D.	O.D.	WALL	I.D.	O.D.	WALL	I.D.	O.D.	WALL	I.D.
3	3.80	0.39	3.02	3.96	0.42	3.12	3.96	0.45	3.06	3.96	0.48	3.00
4	4.80	0.42	3.96	5.00	0.45	4.10	5.00	0.48	4.04	5.00	0.52	3.96
6	6.90	0.44	6.02	7.10	0.48	6.14	7.10	0.51	6.08	7.10	0.55	6.00
8	9.05	0.46	8.13	9.05	0.51	8.03	9.30	0.56	8.18	9.30	0.60	8.10
10	11.10	0.50	10.10	11.10	0.57	9.96	11.40	0.62	10.16	11.40	0.68	10.04
12	13.20	0.54	12.12	13.20	0.62	11.96	13.50	0.68	12.14	13.50	0.75	12.00
14	15.30	0.57	14.16	15.30	0.66	13.98	15.65	0.74	14.17	15.65	0.82	14.01
16	17.40	0.60	16.20	17.40	0.70	16.00	17.80	0.80	16.20	17.80	0.89	16.02
18	19.50	0.64	18.22	19.50	0.75	18.00	19.92	0.87	18.18	19.92	0.96	18.00
20	21.60	0.67	20.26	21.60	0.80	20.00	22.06	0.92	20.22	22.06	1.03	20.00
24	25.80	0.76	24.28	25.80	0.89	24.02	26.32	1.04	24.22	26.32	1.16	24.00
30	31.74	0.88	29.98	32.00	1.03	29.94	32.40	1.20	30.00	32.74	1.37	30.00
36	37.96	0.99	35.98	38.30	1.15	36.00	38.70	1.36	39.98	39.16	1.58	36.00
42	44.20	1.10	42.00	44.50	1.28	41.94	45.10	1.54	42.02	45.58	1.78	42.02
48	50.50	1.26	47.98	50.80	1.42	47.96	51.40	1.71	47.98	51.98	1.96	48.06
54	56.66	1.35	53.96	57.10	1.55	54.00	57.80	1.90	54.00	58.40	2.23	53.94
60	62.80	1.39	60.02	63.40	1.67	60.06	64.20	2.00	60.20	64.82	2.38	60.06
72	75.34	1.62	72.10	75.00	1.95	72.10	76.88	2.39	72.10	–	–	–
84	87.54	1.72	84.10	88.54	2.22	84.10	–	–	–	–	–	–

Pipe Size	Class E 500 Ft. 217 PSIG			Class F 600 Ft. 260 PSIG			Class G 700 Ft. 304 PSIG			Class H 800 Ft. 347 PSIG		
	O.D.	WALL	I.D.	O.D.	WALL	I.D.	O.D.	WALL	I.D.	O.D.	WALL	I.D.
6	7.22	0.58	6.06	7.22	0.61	6.00	7.38	0.65	6.08	7.38	0.69	6.00
8	9.42	0.66	8.10	9.42	0.71	8.00	9.60	0.75	8.10	9.60	0.80	8.00
10	11.60	0.74	10.12	11.60	0.80	10.00	11.84	0.86	10.12	11.84	0.92	10.00
12	13.78	0.82	12.14	13.78	0.89	12.00	14.08	0.97	12.14	14.08	1.04	12.00
14	15.98	0.90	14.18	15.98	0.99	14.00	16.32	1.07	14.18	16.32	1.16	14.00
16	18.16	0.98	16.20	18.16	1.08	16.00	18.54	1.18	16.18	18.54	1.27	16.00
18	20.34	1.07	18.20	20.34	1.17	18.00	20.78	1.28	18.22	20.78	1.39	18.00
20	22.54	1.15	20.24	22.54	1.27	20.00	23.02	1.39	20.24	23.02	1.51	20.00
24	26.90	1.31	24.28	26.90	1.45	24.00	27.76	1.75	24.26	27.76	1.88	24.00
30	33.10	1.55	30.00	33.46	1.73	30.00	–	–	–	–	–	–

Pipe Data: Steel Pipe

Nominal Pipe Size, in.	Outside Diameter, in.	Schedule No.	Wall Thickness, in.	Inside Diameter, in.	Cross-sectional Area		Circumference, ft., or surface, ft²/ft of length		Capacity at 1-ft/s velocity		Weight of plain-end pipe, lb/ft
					Metal, in²	Flow, ft²	Outside	Inside	U.S. gal/min	lb/h water	
⅛	0.405	10S	.049	.307	.055	.00051	.106	.0804	.231	115.5	.19
		40ST, 40S	.068	.269	.072	.00040	.106	.0705	.179	89.5	.24
		80XS, 80S	.095	.215	.093	.00025	.106	.0563	.113	56.5	.31
¼	0.540	10S	.065	.410	.097	.00092	.141	.107	.412	206.5	.33
		40ST, 40S	.088	.364	.125	.00072	.141	.095	.323	161.5	.42
		80XS, 80S	.119	.302	.157	.00050	.141	.079	.224	112.0	.54
⅜	0.675	10S	.065	.545	.125	.00162	.177	.143	.727	363.5	.42
		40ST, 40S	.091	.493	.167	.00133	.177	.129	.596	298.0	.57
		80XS, 80S	.126	.423	.217	.00098	.177	.111	.440	220.0	.74
½	0.840	5S	.065	.710	.158	.00275	.220	.186	1.234	617.0	.54
		10S	.083	.674	.197	.00248	.220	.176	1.112	556.0	.67
		40ST, 40S	.109	.622	.250	.00211	.220	.163	0.945	472.0	.85
		80XS, 80S	.147	.546	.320	.00163	.220	.143	0.730	365.0	1.09
		160	.188	.464	.385	.00117	.220	.122	0.527	263.5	1.31
		XX	.294	.252	.504	.00035	.220	.066	0.155	77.5	1.71
¾	1.050	5S	.065	.920	.201	.00461	.275	.241	2.072	1036.0	0.69
		10S	.083	.884	.252	.00426	.275	.231	1.903	951.5	0.86
		40ST, 40S	.113	.824	.333	.00371	.275	.216	1.665	832.5	1.13
		80XS, 80S	.154	.742	.433	.00300	.275	.194	1.345	672.5	1.47
		160	.219	.612	.572	.00204	.275	.160	0.917	458.5	1.94
		XX	.308	.434	.718	.00103	.275	.114	0.461	230.5	2.44
1	1.315	5S	.065	1.185	.255	.00768	.344	.310	3.449	1725	0.87
		10S	.109	1.097	.413	.00656	.344	.287	2.946	1473	1.40
		40ST, 40S	.133	1.049	.494	.00600	.344	.275	2.690	1345	1.68
		80XS, 80S	.179	0.957	.639	.00499	.344	.250	2.240	1120	2.17
		160	.250	0.815	.836	.00362	.344	.213	1.625	812.5	2.84
		XX	.358	0.599	1.076	.00196	.344	.157	0.878	439.0	3.66
1¼	1.660	5S	.065	1.530	0.326	.01277	.435	.401	5.73	2865	1.11
		10S	.109	1.442	0.531	.01134	.435	.378	5.09	2545	1.81
		40ST, 40S	.140	1.380	0.668	.01040	.435	.361	4.57	2285	2.27
		80XS, 80S	.191	1.278	0.881	.00891	.435	.335	3.99	1995	3.00
		160	.250	1.160	1.107	.00734	.435	.304	3.29	1645	3.76
		XX	.382	0.896	1.534	.00438	.435	.235	1.97	985	5.21
1½	1.900	5S	.065	1.770	0.375	.01709	.497	.463	7.67	3835	1.28
		10S	.109	1.682	0.614	.01543	.497	.440	6.94	3465	2.09
		40ST, 40S	.145	1.610	0.800	.01414	.497	.421	6.34	3170	2.72
		80XS, 80S	.200	1.500	1.069	.01225	.497	.393	5.49	2745	3.63
		160	.281	1.338	1.429	.00976	.497	.350	4.38	2190	4.86
		XX	.400	1.100	1.885	.00660	.497	.288	2.96	1480	6.41
2	2.375	5S	.065	2.245	0.472	.02749	.622	.588	12.34	6170	1.61
		10S	.109	2.157	0.776	.02538	.622	.565	11.39	5695	2.64
		40ST, 40S	.154	2.067	1.075	.02330	.622	.541	10.45	5225	3.65
		80ST, 80S	.218	1.939	1.477	.02050	.622	.508	9.20	4600	5.02
		160	.344	1.687	2.195	.01552	.622	.436	6.97	3485	7.46
		XX	.436	1.503	2.656	.01232	.622	.393	5.53	2765	9.03
2½	2.875	5S	.083	2.709	0.728	.04003	.753	.709	17.97	8985	2.48
		10S	.120	2.635	1.039	.03787	.753	.690	17.00	8500	3.53
		40ST, 40S	.203	2.469	1.704	.03322	.753	.647	14.92	7460	5.79
		80XS, 80S	.276	2.323	2.254	.02942	.753	.608	13.20	6600	7.66
		160	.375	2.125	2.945	.02463	.753	.556	11.07	5535	10.01
		XX	.552	1.771	4.028	.01711	.753	.464	7.68	3840	13.69
3	3.500	5S	.083	3.334	0.891	.06063	.916	.873	27.21	13,605	3.03
		10S	.120	3.260	1.274	.05796	.916	.853	26.02	13,010	4.33
		40ST, 40S	.216	3.068	2.228	.05130	.916	.803	23.00	11,500	7.58
		80XS, 80S	.300	2.900	3.016	.04587	.916	.759	20.55	10,275	10.25
		160	.438	2.624	4.213	.03755	.916	.687	16.86	8430	14.32
		XX	.600	2.300	5.466	.02885	.916	.602	12.95	6475	18.58
3½	4.0	5S	.083	3.834	1.021	.08017	1.047	1.004	35.98	17,990	3.48
		10S	.120	3.760	1.463	.07711	1.047	0.984	34.61	17,305	4.97
		40ST, 40S	.226	3.548	2.680	.06870	1.047	0.929	30.80	15,400	9.11
		80XS, 80S	.318	3.364	3.678	.06170	1.047	0.881	27.70	13,850	12.50
4	4.5	5S	.083	4.334	1.152	.10245	1.178	1.135	46.0	23,000	3.92
		10S	.120	4.260	1.651	.09898	1.178	1.115	44.4	22,200	5.61
		40ST, 40S	.237	4.026	3.17	.08840	1.178	1.054	39.6	19,800	10.79
		80XS, 80S	.337	3.826	4.41	.07986	1.178	1.002	35.8	17,900	14.98
		120	.438	3.624	5.58	.07170	1.178	0.949	32.2	16,100	19.00
		160	.531	3.438	6.62	.06647	1.178	0.900	28.9	14,450	22.51
		XX	.674	3.152	8.10	.05419	1.178	0.825	24.3	12,150	27.54

Pipe Data: Steel Pipe (cont.)

Nominal Pipe Size, in.	Outside Diameter, in.	Schedule No.	Wall Thickness, in.	Inside Diameter, in.	Cross-sectional Area		Circumference, ft., or surface, ft²/ft of length		Capacity at 1-ft/s velocity		Weight of plain-end pipe, lb/ft
					Metal, in²	Flow, ft²	Outside	Inside	U.S. gal/min	lb/h water	
5	5.563	5S	.109	5.345	1.87	.1558	1.456	1.399	69.9	34,950	6.36
		10S	.134	5.295	2.29	.1529	1.456	1.386	68.6	34,300	7.77
		40ST, 40S	.258	5.047	4.30	.1390	1.456	1.321	62.3	31,150	14.62
		80SX, 80S	.375	4.813	6.11	.1263	1.456	1.260	57.7	28,850	20.78
		120	.500	4.563	7.95	.1136	1.456	1.195	51.0	25,500	27.04
		160	.625	4.313	9.70	.1015	1.456	1.129	45.5	22,750	32.96
		XX	.750	4.063	11.34	.0900	1.456	1.064	40.4	20,200	38.55
6	6.625	5S	.109	6.407	2.23	.2239	1.734	1.677	100.5	50,250	7.60
		10S	.134	6.357	2.73	.2204	1.734	1.664	98.9	49,450	9.29
		40ST, 40S	.280	6.065	5.58	.2006	1.734	1.588	90.0	45,000	18.97
		80XS, 80S	.432	5.761	8.40	.1810	1.734	1.508	81.1	40,550	28.57
		120	.562	5.501	10.70	.1650	1.734	1.440	73.9	36,950	36.39
		160	.719	5.187	13.34	.1467	1.734	1.358	65.9	32,950	45.34
		XX	.864	4.897	15.64	.1308	1.734	1.282	58.7	29,350	53.16
8	8.625	5S	.109	8.407	2.915	.3855	2.258	2.201	173.0	86,500	9.93
		10S	.148	8.329	3.941	.3784	2.258	2.180	169.8	84,900	13.40
		20	.250	8.125	6.578	.3601	2.258	2.217	161.5	80,750	22.36
		30	.277	8.071	7.265	.3553	2.258	2.113	159.4	79,700	24.70
		40ST, 40S	.322	7.981	8.399	.3474	2.258	2.089	155.7	77,850	28.55
		60	.406	7.813	10.48	.3329	2.258	2.045	149.4	74,700	35.64
		80XS, 80S	.500	7.625	12.76	.3171	2.258	1.996	142.3	71,150	43.39
		100	.594	7.437	14.99	.3017	2.258	1.947	135.4	67,700	50.95
		120	.719	7.187	17.86	.2817	2.258	1.882	126.4	63,200	60.71
		140	.812	7.001	19.93	.2673	2.258	1.833	120.0	60,000	67.76
		XX	.875	6.875	21.30	.2578	2.258	1.800	115.7	57,850	72.42
		160	.906	6.813	21.97	.2532	2.258	1.784	113.5	56,750	74.69
10	10.75	5S	.134	10.482	4.47	.5993	2.814	2.744	269.0	134,500	15.19
		10S	.165	10.420	5.49	.5922	2.814	2.728	265.8	132,900	18.65
		20	.250	10.250	8.25	.5731	2.814	2.685	257.0	128,500	28.04
		30	.307	10.136	10.07	.5603	2.814	2.655	252.0	126,000	34.24
		40ST, 40S	.365	10.020	11.91	.5475	2.814	2.620	246.0	123,000	40.48
		80S, 60XS	.500	9.750	16.10	.5185	2.814	2.550	233.0	116,500	54.74
		80	.594	9.562	18.95	.4987	2.814	2.503	223.4	111,700	64.43
		100	.719	9.312	22.66	.4729	2.814	2.438	212.3	106,150	77.03
		120	.844	9.062	26.27	.4479	2.814	2.372	201.0	100,500	89.29
		140, XX	1.000	8.750	30.63	.4176	2.814	2.291	188.0	94,000	104.13
		160	1.125	8.500	34.02	.3941	2.814	2.225	177.0	88,500	115.64
12	12.75	5S	0.156	12.438	6.17	.8438	3.338	3.26	378.7	189,350	20.98
		10S	0.180	12.390	7.11	.8373	3.338	3.24	375.8	187,900	24.17
		20	0.250	12.250	9.82	.8185	3.338	3.21	367.0	183,500	33.38
		30	0.330	12.090	12.88	.7972	3.338	3.17	358.0	179,000	43.77
		ST, 40S	0.375	12.000	14.58	.7854	3.338	3.14	352.5	176,250	49.56
		40	0.406	11.938	15.74	.7773	3.338	3.13	349.0	174,500	53.52
		XS, 80S	0.500	11.750	19.24	.7530	3.338	3.08	338.0	169,000	65.42
		60	0.562	11.626	21.52	.7372	3.338	3.04	331.0	165,500	73.15
		80	0.688	11.374	26.07	.7056	3.338	2.98	316.7	158,350	88.63
		100	0.844	11.062	31.57	.6674	3.338	2.90	299.6	149,800	107.32
		120, XX	1.000	10.750	36.91	.6303	3.338	2.81	283.0	141,500	125.49
		140	1.125	10.500	41.09	.6013	3.338	2.75	270.0	135,000	139.67
		160	1.312	10.126	47.14	.5592	3.338	2.65	251.0	125,500	160.27
14	14	5S	0.156	13.688	6.78	1.0219	3.665	3.58	459	229,500	23.07
		10S	0.188	13.624	8.16	1.0125	3.665	3.57	454	227,000	27.73
		10	0.250	13.500	10.80	0.9940	3.665	3.53	446	223,000	36.71
		20	0.312	13.376	13.42	0.9750	3.665	3.50	438	219,000	45.61
		30, ST	0.375	13.250	16.05	0.9575	3.665	3.47	430	215,000	54.57
		40	0.438	13.124	18.66	0.9397	3.665	3.44	422	211,000	63.44
		XS	0.500	13.000	21.21	0.9218	3.665	3.40	414	207,000	72.09
		60	0.594	12.812	25.02	0.8957	3.665	3.35	402	201,000	85.05
		80	0.750	12.500	31.22	0.8522	3.665	3.27	382	191,000	106.13
		100	0.938	12.124	38.49	0.8017	3.665	3.17	360	180,000	130.85
		120	1.094	11.812	44.36	0.7610	3.665	3.09	342	171,000	150.79
		140	1.250	11.500	50.07	0.7213	3.665	3.01	324	162,000	170.21
		160	1.406	11.188	55.63	0.6827	3.665	2.93	306	153,000	189.11
16	16	5S	0.165	15.670	8.21	1.3393	4.189	4.10	601	300,500	27.90
		10S	0.188	15.624	9.34	1.3314	4.189	4.09	598	299,000	31.75
		10	0.250	15.500	12.37	1.3104	4.189	4.06	587	293,500	42.05
		20	0.312	15.376	15.38	1.2985	4.189	4.03	578	289,000	52.27
		30, ST	0.375	15.250	18.41	1.2680	4.189	3.99	568	284,000	62.58
		40, XS	0.500	15.000	24.35	1.2272	4.189	3.93	550	275,000	82.77
		60	0.656	14.688	31.62	1.1766	4.189	3.85	528	264,000	107.50

Pipe Data: Steel Pipe (cont.)

Nominal Pipe Size, in.	Outside Diameter, in.	Schedule No.	Wall Thickness, in.	Inside Diameter, in.	Cross-sectional Area		Circumference, ft., or surface, ft²/ft of length		Capacity at 1-ft/s velocity		Weight of plain-end pipe, lb/ft
					Metal, in²	Flow, ft²	Outside	Inside	U.S. gal/min	lb/h water	
		80	0.844	14.312	40.19	1.1171	4.189	3.75	501	250,500	136.61
		100	1.031	13.938	48.48	1.0596	4.189	3.65	474	237,000	164.82
		120	1.219	13.562	56.61	1.0032	4.189	3.55	450	225,000	192.43
		140	1.438	13.124	65.79	0.9394	4.189	3.44	422	211,000	223.64
		160	1.594	12.812	72.14	0.8953	4.189	3.35	402	201,000	245.25
18	18	5S	0.165	17.670	9.25	1.7029	4.712	4.63	764	382,000	31.43
		10S	0.188	17.624	10.52	1.6941	4.712	4.51	760	379,400	35.76
		10	0.250	17.500	13.94	1.6703	4.712	4.58	750	375,000	47.39
		20	0.312	17.376	17.34	1.6468	4.712	4.55	739	369,500	58.94
		ST	0.375	17.250	20.76	1.6230	4.712	4.52	728	364,000	70.59
		30	0.438	17.124	24.16	1.5993	4.712	4.48	718	359,000	82.15
		XS	0.500	17.000	27.49	1.5763	4.712	4.45	707	353,500	93.45
		40	0.562	16.876	30.79	1.5533	4.712	4.42	697	348,500	104.67
		60	0.750	16.500	40.64	1.4849	4.712	4.32	666	333,000	138.17
		80	0.938	16.124	50.28	1.4180	4.712	4.22	636	318,000	170.92
		100	1.156	15.688	61.17	1.3423	4.712	4.11	602	301,000	207.96
		120	1.375	15.250	71.82	1.2684	4.712	3.99	569	284,500	244.14
		140	1.562	14.876	80.66	1.2070	4.712	3.89	540	270,000	274.22
		160	1.781	14.438	90.75	1.1370	4.712	3.78	510	255,000	308.50
20	20	5S	0.188	19.624	11.70	2.1004	5.236	5.14	943	471,500	39.78
		10S	0.218	19.564	13.55	2.0878	5.236	5.12	937	467,500	46.06
		10	0.250	19.500	15.51	2.0740	5.236	5.11	930	465,000	52.73
		20, ST	0.375	19.250	23.12	2.0211	5.236	5.04	902	451,000	78.60
		30, XS	0.500	19.000	30.63	1.9689	5.236	4.97	883	441,500	104.13
		40	0.594	18.812	36.21	1.9302	5.236	4.92	866	433,000	123.11
		60	0.812	18.376	48.95	1.8417	5.236	4.81	826	413,000	166.40
		80	1.031	17.938	61.44	1.7550	5.236	4.70	787	393,500	208.87
		100	1.281	17.438	75.33	1.6585	5.236	4.57	744	372,000	256.10
		120	1.500	17.000	87.18	1.5763	5.236	4.45	707	353,500	296.37
		140	1.750	16.500	100.3	1.4849	5.236	4.32	665	332,500	341.09
		160	1.969	16.062	111.5	1.4071	5.236	4.21	632	316,000	397.17
24	24	5S	0.218	23.564	16.29	3.0285	6.283	6.17	1359	679,500	55.37
		10, 10S	0.250	23.500	18.65	3.012	6.283	6.15	1350	675,000	63.41
		20, ST	0.375	23.250	27.83	2.948	6.283	6.09	1325	662,500	94.62
		XS	0.500	23.000	36.90	2.885	6.283	6.02	1295	642,500	125.49
		30	0.562	22.876	41.39	2.854	6.283	5.99	1281	640,500	140.68
		40	0.688	22.624	50.39	2.792	6.283	5.92	1253	626,500	171.29
		60	0.969	22.062	70.11	2.655	6.283	5.78	1192	596,000	238.35
		80	1.219	21.562	87.24	2.536	6.283	5.64	1138	569,000	296.58
		100	1.531	20.938	108.1	2.391	6.283	5.48	1073	536,500	367.39
		120	1.812	20.376	126.3	2.264	6.283	5.33	1016	508,000	429.39
		140	2.062	19.876	142.1	2.155	6.283	5.20	965	482,500	483.12
		160	2.344	19.312	159.5	2.034	6.283	5.06	913	456,500	542.13
30	30	5S	0.250	29.500	23.37	4.746	7.854	7.72	2130	1,065,000	79.43
		10, 10S	0.312	29.376	29.10	4.707	7.854	7.69	2110	1,055,000	98.93
		ST	0.375	29.259	34.90	4.666	7.854	7.66	2094	1,048,000	118.65
		20, XS	0.500	29.000	46.34	4.587	7.854	7.59	2055	1,027,500	157.53
		30	0.625	28.750	57.68	4.508	7.854	7.53	2020	1,010,000	196.08

5S, 10S, and 40S are extracted from Stainless Steel Pipe, ANSI B36.19–1976, the American Society of Mechanical Engineers, New York. ST = standard wall, XS = extra strong wall, XX = double extra strong wall, and Schedules 10 through 160 are extracted from Wrought-Steel and Wrought-Iron Pipe, ANSI B36.10–1975. Decimal thicknesses for respective pipe sizes represent their nominal or average wall dimensions. Mill tolerances as high as ± 12½ percent are permitted.

International Electrotechnical Committee (IEC)

The IEC was founded in 1906 and is presently comprised of approximately 52 countries. The IEC represents the electrotechnical interests, of manufacturing, research and development, scientific, academic and consumer bodies in each country. Membership includes the world's major trading nations and an increasing number of industrializing countries.

The IEC has assigned a technical committee, TC31, to develop international standards for equipment, testing procedures, area classification and installations for areas where there is a hazard due to the possible presence of ignitable gas, vapours, liquid particles or dust in the atmosphere.

The results of the work carried out by TC31 are contained in IEC publication 79 Entitled "Electrical Apparatus For Explosive Gas Atmospheres" and IEC 1241 entitled "Electrical Apparatus For Use In The Presence Of Combustible Dust". In addition to area classification, each of these standards consists of several parts covering various apparatus and installation procedures. The IEC has introduced the IECEx Scheme for certification of electrical equipment to these standards.

Canada and the United States, which have differed from the IEC in the past, are in the process of adapting these standards in some form.

CENELEC
(The European Committee for Electrotechnical Standardization)

CENELEC standards contribute to the European economy by securing the safety of the users of electrical products and services, and the breaking down of trade barriers between member nations. They are one of the success factors in Europe's economic freedom.

In most cases CENELEC standards are based on, or related to, those of the IEC and their adoption is generally realized through Parallel Voting. Whenever CENELEC starts work on an a European Standard, all national work on the same subject subsides. It is mandatory for EU members to adopt any published CENELEC standard, which is not the case those of the IEC.

The Standards published by CENELC are called Euronorms (EN). Third party certification agencies exist in member country which approve products to EN standards for use throughout Europe.

IEC PUBLICATION	NATIONAL STANDARD OF CANADA	CONTENT	METHODS OF PROTECTION	EURONORM
79-0	CAN/CSA-E79-0-95	General Requirements		EN50014
79-1	CAN/CSA-E79-1-95	Construction and Test of Flameproof Enclosures of Electrical Apparatus	Flameproof "d"	EN50018
79-2	CAN/CSA-E79-2-95	Pressurized Enclosures	Pressurization "p"	EN50016
79-3	CAN/CSA-E79-3-95	Spark Test Apparatus for Intrinsically Safe Circuits	Intrinsic Safety "i"	EN50020
79-4		Method of Test for Ignition Temperature		
79-5	CAN/CSA-E79-5-95	Sand Filled Apparatus	Sand Filled "q"	EN50017
79-6	CAN/CSA-E79-6-95	Oil Immersed Apparatus	Oil Immersion "o"	EN50015
79-7	CAN/CSA-E79-7-95	Construction and Test of Electrical Apparatus "Increased Safety"	Increased Safety "e"	EN50019
79-8		Classification of Maximum Surface Temperatures		
79-9		Product Marking		
79-10		Classification of Hazardous Areas		
79-11	CAN/CSA-E79-11-95	Intrinsic Safety	Intrinsic Safety "i"	EN50020
79-15	CAN/CSA-E79-15-95	Non-Sparking	Non-Sparking "n"	
79-18	CAN/CSA-E79-18-95	Encapsulation	Encapsulation "m"	EN50028
1241-1-1	CAN/CSA-E1241-1-1	Electrical Apparatus For Use in the Presence of Combustible Dust		

CLASSIFICATION OF HAZARDOUS AREAS

IEC Publication 79-10 and 1241 define the guidelines for classifying hazardous areas. North America has used Classes and Divisions in the past whereas the IEC uses the term Zone as explained below.

Explosive Gas Atmospheres

Zone 0 - is an area in which ignitable explosive gas-air mixtures are present continuously or for long periods of time. Zone 0 locations comprise only a small percentage of all hazardous areas and industrial users tend to limit the use of electrical equipment in these locations. Only Intrinsic Safety (ia) devices may be used in a Zone 0 location.

Zone 1 - is an area in which explosive gas atmospheres are likely to occur during normal operation. Most IEC equipment is designed for Zone 1 areas.

Zone 2 - is an area where an explosive gas atmosphere is not likely to occur in normal operation and if they do occur they will exist for short periods of time only.

Combustible Dust Atmospheres
(These have not been adopted in North America at time of writing)

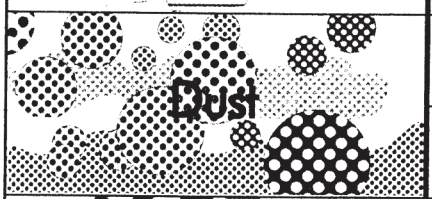
Zone 20 - is an area in which an combustible dust, as a cloud, is present continuously or frequently during normal operations in sufficient quantities to produce an explosive mixture.

Zone 21 - is an area in which an combustible dust, as a cloud, is likely to occur during normal operations in sufficient quantities to produce an explosive mixture.

Zone 22 - is an area in which combustible dust clouds may occur infrequently and persist for only short periods or in which accumulations or layers may be present under abnormal conditions.

Note: Class III locations dealing with fibers and flyings are not defined in the IEC at this time.

CLASSIFICATION COMPARISION

HAZARDOUS MATERIAL	CEC CANADIAN STANDARDS[1]	IEC & CEC (1998)[2] EURONORM STANDARDS
	CLASS I, DIVISION 1	ZONE 0 and ZONE 1
	CLASSI, DIVISION 2	ZONE 2
	CLASS II, DIVISION 1	ZONE 20 and ZONE 21
	CLASS II, DIVISION 2	ZONE 22
	CLASS III, DIVISION 1	
	CLASS III, DIVISION 2	

[1] Standard definitions in North America prior to 1996.
[2] In June 1996 CSA approved changing of the 1998 CEC section 18 definitions to zones 1996 NEC article 505 identifies zones in parallel to divisions.

CLASSIFYING GASES AND VAPORS - EUROPE VS NORTH AMERICA

The grouping of hazardous gases and vapors is based on the explosive characteristics of the material. It is important to refer to specific publications[3] of the appropriate authorities for group designations. The following table will provide a simplified view of how the CEC and IEC systems designate gases and vapors.

GAS	EXPLOSIVE GROUP (CEC)[4]	EXPLOSIVE GROUP (IEC) CEC (1998)[5]
ACETYLENE	A	II C ACETYLENE & HYDROGEN
HYDROGEN	B	
ETHYLENE	C	II B ETHYLENE
PROPANE	D	II A PROPANE

NORTH AMERICAN DIRECTION

Canada and the United States are in the process of accommodating the IEC classification system in their respective codes and standards.

The 1998 Canadian Electrical Code (CEC) includes the definitions for area classification of the IEC for explosive gas atmospheres in Section 18 along with recognizing the various methods of protection. The CEC moved the rules which existed for hazardous locations prior to 1998 to Annex J.

The Canadian Standards Association (CSA) adopted a number of IEC product standards with minor deviations as National Standards of Canada. All products used in Canada must bear the mark of a third party testing agency accredited by the Standards Council of Canada.

The National Electrical Code (NEC) has added Article 505 which identifies the IEC system. While not specific enough for general use, it does provide a framework on which to build. Third party certification agencies working to introduce standards similar to those of the IEC which include requirements specific to the US.

For Further information on this subject contact Killark for a Code Digest or Code update.

METHODS OF PROTECTION

Areas classified as hazardous can be treated with a number of different types of equipment. Most of these methods are used and approved under Canadian standards. The IEC methods are as follows:

1. Flameproof "d" - CEC term (explosion-proof) - Sources of ignition within enclosures which can withstand an internal explosion without igniting the surrounding atmosphere. Zone 1 and 2 applicability.
2. Increased Safety "e" - Apparatus in which additional measures are taken to prevent excessive heat, arcs or sparks from occurring in equipment, where this does not normally occur, i.e. terminals. Zone 1 and Zone 2 applicability.
3. Pressurized "p" - Explosive gases or vapors are prevented from entering the enclosure by maintaining air, or non-flammable gas within the enclosure at pressure above the external atmosphere. Zone 1 and Zone 2 applicability.
4. Oil Immersed "o" - Sources of arcs are immersed in oil to a sufficient depth that it cannot ignite a hazardous gas mixture above the surface of the oil. Zone 1 and 2 applicability.
5. Sand Filled "q" - Live parts are embedded in a powdery or granular material such that arcs occurring cannot ignite an explosive mixture above the material. Zone 1 and 2 applicability.
6. Intrinsic Safety "i, ia & ib" - Circuits which are incapable of releasing sufficient energy to ignite an explosive gas atmosphere when operating normally or under fault conditions. Equipment rated "ib" is only suitable for Zones 1 and 2. Only equipment rated "i" or "ia" is permitted in Zone 0 and may also be used in Zones 1 and 2.
7. Non-Sparking "n" - Electrical apparatus such that, in normal operation, it is not capable of igniting a surrounding explosive gas atmosphere and a fault capable of causing ignition is not likely to occur. Zone 2 applicability.
8. Encapsulation "m" - Protection in which could ignite an explosive atmosphere by either sparking or heating are enclosed in a compound in such a way that this explosive atmosphere cannot be ignited. Zone 1 and 2 applicability.

[3] Examples of Publications include NFPA 325M and British Standard Code of practice BS5345 Part 1.

[4] The NEC is similar to but not identical to the CEC.

[5] IEC definitions are used in the 1998 CEC.

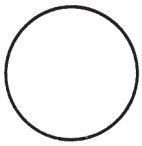
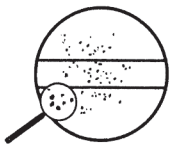
IEC 529 · THE DEGREE OF PROTECTION OF ENCLOSURES

IP

The IP classification system designates, by means of a number, the degree of protection provided by an enclosure against impact or dust or water ingress. Please note that the IP classification should not be construed as indicating corrosion resistance.

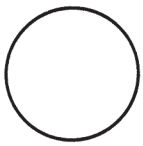
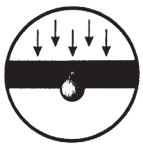
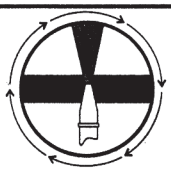
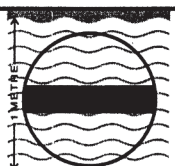
FIRST NUMBER

Degree of protection against solid objects

0		Non-protected
1		Protected against a solid object greater than 50mm such as a hand.
2		Protected against a solid object greater than 12mm, such as a finger.
3		Protected against a solid object greater than 2.5mm, such as wire or a tool.
4		Protected against a solid object greater than 1.0 mm, such as wire or thin strips.
5		Dust-protected. Prevents ingress of dust sufficient to cause harm
6		Dust tight. No dust ingress

SECOND NUMBER

Degree of protection against water

0		Non-protected
1		Protected against water dripping vertically, such as condensation
2		Protected against dripping water when tilted up to 15°
3		Protected against water spraying at an angle of up to 60°
4		Protected against water splashing from any direction
5		Protected against jets of water from any direction
6		Protected against heavy seas or powerful jets of water. Prevents ingress sufficient to cause harm.
7		Protected against harmful ingress of water when immersed between a depth of 150mm to 1 metre
8		Protected against submersion. Suitable for continuous immersion in water.

CLASSIFICATION OF MAXIMUM SURFACE TEMPERATURE

Similar to Canadian standards, the IEC has a system of "T-Codes" which are used to designate the maximum operating temperatures on the surface of apparatus used in hazardous locations. The IEC "T-Code" designations are identical to those found in the Canadian Electrical Code, however, the CEC has many intermediate codes for applications where more precise information is desired.

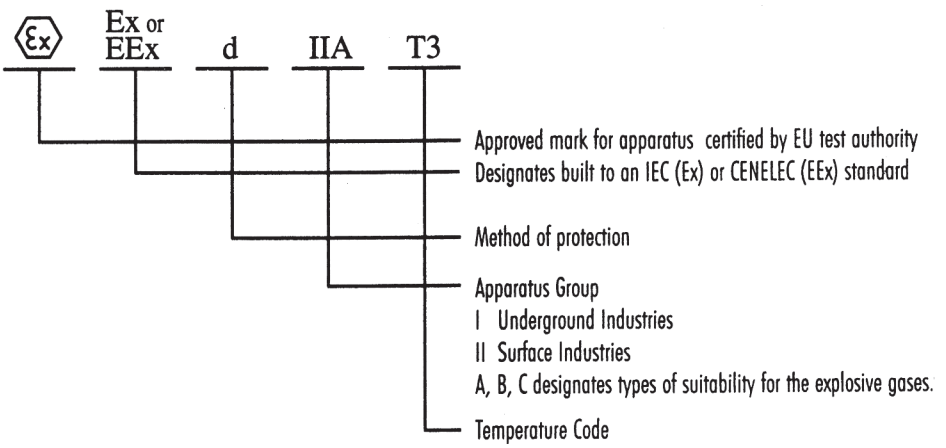
MAXIMUM SURFACE TEMPERATURE CODES

MAXIMUM TEMPERATURE (DEGREES C)	CEC T-CODE	IEC T-CODE
450	T1	T1
300	T2	T2
280	T2A	--
260	T2B	--
230	T2C	--
215	T2D	--
200	T3	T3
180	T3A	--
165	T3B	--
160	T3C	--
135	T4	T4
120	T4A	--
100	T5	T5
85	T6	T6

PRODUCT MARKING

In addition to the manufacturers data, equipment requires marking concerning its suitibility in various hazardous locations. The marking system used on equipment certified to IEC or CENELEC standards is basically the CAN/CSA E79 series of standards.

MARKING SYSTEM



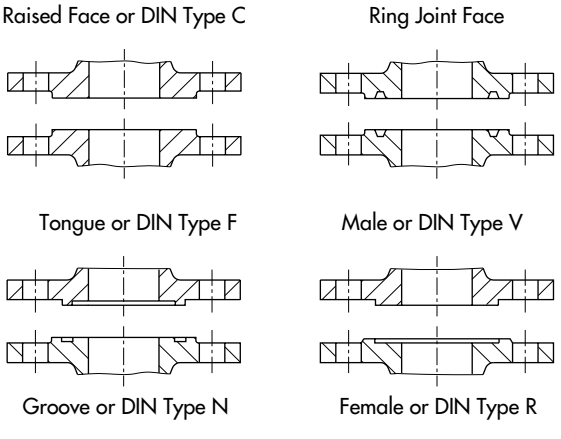
Types of Piping Connections

In industrial plants, flange connections are the preferred solution. The reasons are easy assembling and disassembling of the valves as well as high reliability and tightness of the milled sealing surfaces.

The US standard for flanges is ANSI/ASME B 16.1 for Class 125, and for higher nominal pressure ratings ANSI/ASME B 16.5. The standard version for valves of Class 125 made of cast iron is manufactured without sealing face (FF-flat face). Valves of Class 300 have a sealing face RF 0.06 (raised face with 0.06" height), with higher nominal pressure ratings the valves have a sealing face RF 0.25. Flange face finish for RF is standard R_a 125 ...250 µinch (3.2...6.3 µm).

A survey of DIN flanges is provided in DIN 2500. Whereas the connecting dimensions are specified in DIN 2501, and the types of the possible sealing faces in DIN 2526.

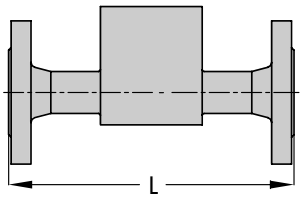
For control valves according to DIN standards, the weld-on fittings are designed according to DIN 3239 T1 with edge forms according to DIN 2559 T1. For control valves according to US standards, the weld-on fittings are specified in ASME/ANSI B 16.25.



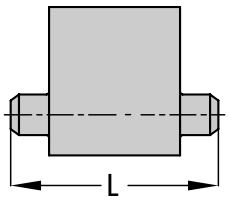
Flange types

Face-to-face and End-to-end Dimensions

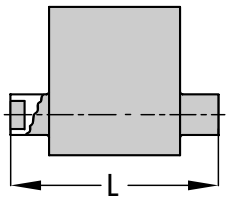
For control valves according to US standards, the face-to-face dimensions of are specified in ANSI/ISA-S75.03, .04, .08, .12, .15, .16, and .22. For other valve types, the ASME/ANSI B16.10 applies.The face-to-face dimensions of metric globe valves and face-to-center dimensions of angle valves are specified in DIN 3202. Part 1 includes the dimensions for the flange connections (row F 1 for PN 10 to 40, row F 2 for PN 63 to 160 and row F 3 for PN 250 and 320).



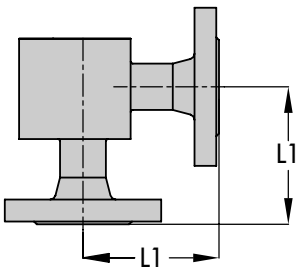
Raised Face or DIN Type C



Butt welding end



Socket welding end



Raised Face – Angle pattern

Face-to-face and end-to-end dimensions for globe control valves according to ISA and IEC · Dimensions in inches

ISA dimension "L" inches		Flanged [1]		Short Pattern Class 150, 300, 600 (Grp 1 PN 20,50,100)	
Nominal valve size		Class 150 (PN 20), Class 125	Class 300 (PN 50), Class 250	Socket weld [2]	Butt weld [3]
inches	mm				
½	15	7.25	7.50	6.69	7.38
¾	20	7.25	7.62	6.69	7.38
1	25	7.25	7.75	7.75	7.38
1½	40	8.75	9.25	9.25	8.75
2	50	10.00	10.50	10.50	10.00
2½	65	10.88	11.50	11.50	11.50
3	80	11.75	12.50	12.50	12.50
4	100	13.88	14.50	14.50	14.50
6	150	17.75	18.62	–	17.75
8	200	21.38	22.38	–	21.38
10	250	26.50	27.88	–	26.50
12	300	29.00	30.50	–	29.00
14	350	35.00	36.50	–	33.50
16	400	40.00	41.62	–	40.00

FF–Flat Face RF–Raised Face SWE–Socket welding ends BWE–Butt welding ends

1) ISA-S75.03 and IEC 60534-3-1, Table I
2) ISA-S75.12
3) ISA-S75.15 and IEC 60534-3-3

Face-to-face and end-to-end dimensions for globe control valves according to ISA and IEC · Dimensions in inches

ISA dimension "L" inches		Flanged [1]	Long Pattern Class 150, 300, 600 (Group 2 PN 20, 50, 100)	
Nominal valve size		Class 600 (PN 100)	Socket weld [2]	Butt weld [3]
inches	mm			
½	15	8.00	8.12	8.00
¾	20	8.12	8.25	8.25
1	25	8.25	8.25	8.25
1½	40	9.88	9.88	9.88
2	50	11.25	11.25	11.25
2½	65	12.25	12.25	12.25
3	80	13.25	13.25	13.25
4	100	15.50	15.50	15.50
6	150	20.00	–	20.00
8	200	24.00	–	24.00
10	250	29.62	–	29.62
12	300	32.25	–	32.35
14	350	38.25	–	40.50
16	400	43.62	–	43.62

RF–Raised Face SWE–Socket welding ends BWE–Butt welding ends

1) ISA-S75.03 and IEC 60534-3-1, Table I
2) ISA-S75.12
3) ISA-S75.15 and IEC 60534-3-3

Face-to-centerline dimensions for flanged globe-style angle control valves · Dimension "L_1" in inches

Nominal valve size		Class 150 (ISO PN 20)	Class 300 (ISO PN 50)	Class 600 (ISO PN 100)
inches	mm			
½	15	–	–	–
¾	20	–	–	–
1	25	3.62	3.88	4.12
1½	40	4.37	4.62	4.94
2	50	5.00	5.25	5.62
2½	65	–	–	–
3	80	5.88	6.25	6.62
4	100	6.94	7.25	7.75
6	150	8.88	9.31	10.00
8	200	10.69	11.19	12.00

According to ISA-S75.22

End-to-end dimensions for globe control valves with ring joint facings · Dimensions in inches

Nominal valve size		Class 150 (ISO PN 20)	Class 300 (ISO PN 50)	Class 600 (ISO PN 100)
inches	mm			
½	15	7.25 + 0.50	7.50 + 0.44	8.00 – 0.06
¾	20	7.25 + 0.50	7.62 + 0.50	8.12 + 0.00
1	25	7.25 + 0.50	7.75 + 0.50	8.25 + 0.00
1½	40	8.75 + 0.50	9.25 + 0.50	9.88 + 0.00
2	50	10.00 + 0.50	10.50 + 0.62	11.25 + 0.12
2½	65	10.88 + 0.50	11.50 + 0.62	12.25 + 0.12
3	80	11.75 + 0.50	12.50 + 0.62	13.25 + 0.12
4	100	13.88 + 0.50	14.50 + 0.62	15.50 + 0.12
6	150	17.75 + 0.50	18.62 + 0.62	20.00 + 0.12
8	200	21.38 + 0.50	22.38 + 0.62	24.00 + 0.12
10	250	26.50 + 0.50	27.88 + 0.62	29.62 + 0.12
12	300	29.00 + 0.50	30.50 + 0.62	32.25 + 0.12
14	350	35.00 + 0.50	36.50 + 0.62	38.25 + 0.12
16	400	40.00 + 0.50	41.62 + 0.62	43.62 + 0.12

According to ISA-S75.03 and ASME B16.10

Face-to-face and end-to-end dimensions for globe control valves according to ISA and IEC · Dimensions in mm

ISA dimension "L" mm		Flanged [1]		Short Pattern Class 150, 300, 600 (Grp 1 PN 20,50,100)	
Nominal valve size		Class 150 (PN 20), Class 125	Class 300 (PN 50), Class 250	Socket weld [2]	Butt weld [3]
inches	mm				
½	15	184	190	170	187
¾	20	184	194	170	187
1	25	184	197	197	187
1½	40	222	235	235	222
2	50	254	267	267	254
2½	65	276	292	292	292
3	80	298	318	318	318
4	100	352	368	368	368
6	150	451	473	–	451
8	200	543	568	–	543
10	250	673	708	–	673
12	300	737	775	–	737
14	350	889	927	–	851
16	400	1016	1057	–	1016

FF–Flat Face RF–Raised Face SWE–Socket welding ends BWE–Butt welding ends

1) ISA-S75.03 and IEC 60534-3-1, Table I
2) ISA-S75.12
3) ISA-S75.15 and IEC 60534-3-3

Face-to-face and end-to-end dimensions for globe control valves according to ISA and IEC · Dimensions in mm

ISA dimension "L" mm		Flanged [1]	Long Pattern Class 150, 300, 600 (Group 2 PN 20, 50, 100)	
Nominal valve size		Class 600 (PN 100)	Socket weld [2]	Butt weld [3]
inches	mm			
½	15	203	206	203
¾	20	206	210	206
1	25	210	210	210
1½	40	251	251	251
2	50	286	286	286
2½	65	311	311	311
3	80	337	337	337
4	100	394	394	394
6	150	508	–	508
8	200	610	–	610
10	250	752	–	752
12	300	819	–	819
14	350	972	–	1029
16	400	1108	–	1108

RF–Raised Face SWE–Socket welding ends BWE–Butt welding ends

1) ISA-S75.03 and IEC 60534-3-1, Table I
2) ISA-S75.12
3) ISA-S75.15 and IEC 60534-3-3

Face-to-centerline dimensions for flanged globe-style angle control valves · Dimension "L_1" in mm

Nominal valve size		Class 150 (ISO PN 20)	Class 300 (ISO PN 50)	Class 600 (ISO PN 100)
inches	mm			
½	15	–	–	–
¾	20	–	–	–
1	25	92	99	105
1½	40	111	117	125
2	50	127	133	143
2½	65	–	–	–
3	80	149	159	168
4	100	176	184	197
6	150	226	236	254
8	200	272	284	305

According to ISA-S75.22

End-to-end dimensions for globe control valves with ring joint facings · Dimensions in millimeters

Nominal valve size		Class 150 (ISO PN 20)	Class 300 (ISO PN 50)	Class 600 (ISO PN 100)
inches	mm			
½	15	184+13=197	190+11=201	203-1.5=201
¾	20	184+13=197	194+13=207	206+0=206
1	25	184+13=197	197+13=210	210+0=210
1½	40	222+13=235	235+13=248	251+0=251
2	50	254+13=267	267+16=283	286+3=289
2½	65	276+13=289	292+16=308	311+3=314
3	80	298+13=311	318+16=333	337+3=340
4	100	352+13=365	368+16=384	394+3=397
6	150	451+13=464	473+16=489	508+3=511
8	200	543+13=556	568+16=584	610+3=613
10	250	673+13=686	708+16=724	752+3=755
12	300	737+13=750	775+16=791	819+3=822
14	350	889+13=902	927+16=943	972+3=975
16	400	1016+13=1029	1057+16=1074	1108+3=1111

According to ISA-S75.03 and ASME B16.10

Valve-specific Parameters

Flow coefficients

C_V value

The necessary C_V value is calculated according to ISA-S75.01 or EN 60534 using the specified operating data.

The valve C_{V100} value corresponds to the C_V value for the nominal travel height H_{100}. In order to increase control accuracy and with regard to the manufacturing tolerances, the C_V or value chosen is to be higher than the C_V value calculated.

K_V value

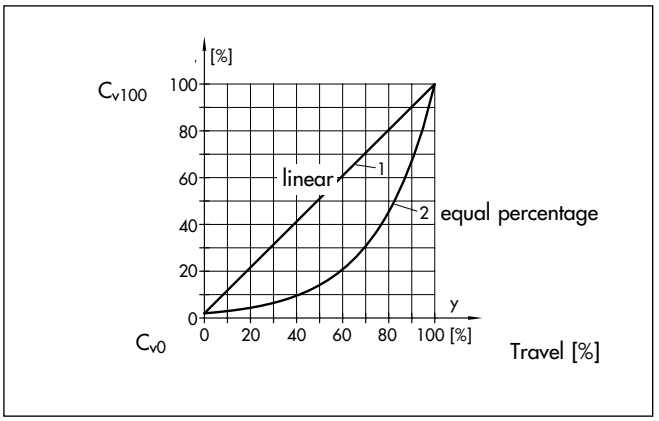
The K_V value is the alternative flow coefficient as defined by EN 60534. The conversion is $C_V \approx 1.17 \cdot K_V$.

Inherent characteristic

The characteristic represents the C_V value's dependence on the travel height (H). Control valves are provided either with an equal percentage (2) or with a linear (1) characteristic.The equal percentage characteristic means that equal changes in travel result in equal percentage changes of the C_V value in question. The linear characteristic means that equal changes in travel are followed by equal changes of the C_V value.

Rangeability

The rangeability is C_V multiplied by $C_{V\,calc}$. For this calculation, the $C_{V\,calc}$ value represents the smallest C_V value with which the characteristic lies still within the permissible gradient tolerance of the characteristic (ISA-S75.11 and EN 60 534 Part 2-4).



Cavitation parameters

With liquids, the lowest pressure level within the control valve occurs at a location just downstream of the throttling area, called the vena contracta. If the absolute pressure at the vena contracta p_{vc}, is reduced during the throttling process to a level at or below the vapor pressure of the process medium p_v, a portion of the fluid starts to vaporize, forming bubbles within the flow stream. Downstream of the vena contracta, the pressure level recovers back to a level above the vapor pressure, and the vapor bubbles collapse (implode) back to a liquid state, with a rapid transformation of energy which causes shock waves. The presence of cavitation can be detected by a sharp increase in the sound level due to the shock waves caused by the implosion of the vapor bubbles.

Incipient cavitation

The pressure drop can be expressed in the form of a ratio, X_F, which is defined as:

$$X_F = \frac{p_1 - p_2}{p_1 - p_V}.$$

The pressure drop at which cavitation begins (z or X_{FZ}), is similarly defined:

$$z = X_{FZ} = \frac{p_1 - p_{2Z}}{p_1 - p_V}.$$

Z is dependent on the trim size and the relative opening, y, and is often expressed as z_y.

If the pressure drop is greater than or equal to the pressure drop at which cavitation begins, i.e.

$$\text{If } X_F \geq z$$

Incipient cavitation

$$\text{If } X_F < z$$

No cavitation

Incipient cavitation is considered to be insufficient to cause significant erosion of the valve internals.

Cavitation Index

The cavitation index K_c, defined by the NRC (U.S. Nuclear Regulatory Commission) standard CR-6031. It is the point at which it is possible to measure a deviation of the actual flow rate from the theoretical linearly increasing in flow rate predicted by the C_V equation, with increasing pressure drop $\sqrt{\Delta p}$. This deviation is caused by the increasing presence of vapor bubbles, which reduces the overall flow rate. From experimental measurements with SAMSON globe valves:

$$K_C \approx F_L^{\,3}$$

F_L and K_C values for Series 3240 are provided in Table 8.

$$\text{If } X_F \geq K_C,$$

Significant cavitation

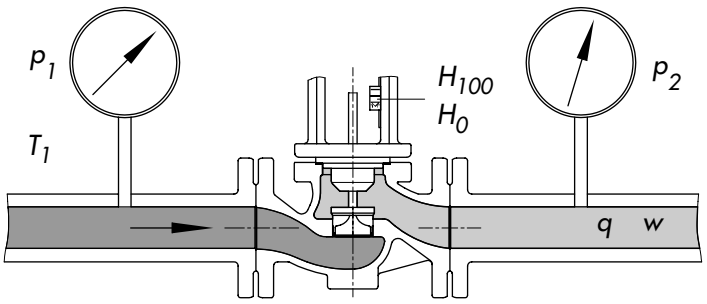
For water, with low pressure drops (less than 150 psig / 10 barg), standard trim materials are normally acceptable.

With moderate pressures drops (above 150 psi or 10 bar) hardened trim with Stellite or with very significant drops, special hard chrome steels are recommended.

Valve Sizing

Calculation of the C_v value

The C_v value is calculated according to ISA-S75.01 and DIN IEC EN 60 534. The Technical Data Sheets provide the necessary device-specific data. A simplified manual calculation may be made with the help of the equations given below. They do not take into account the influence of the connecting fittings or the effects under non-turbulent (laminar or transitional) flow conditions.



p_1	Upstream pressure in psi(a), bar(a)
p_2	Downstream pressure in psi(a), bar(a)
H	Travel (height) in inches, mm
q	Volumetric flow rate in gpm or m^3/h
w	Mass flow rate in lb/h or kg/h
G_f	Specific gravity (liquid)
G_g	Specific gravity (gas, vapor)
ρ_1	Upstream density in lb_m/ft^3 or kg/m^3
T_1	Upstream temperature in °R or K

Incompressible fluids (liquids)

Pressure drop	Equations for p_{vc} determination	Flow coefficient equation, with given units... gpm, psi(a)	lb/h, psi(a), lb_m/ft^3	m^3/h, bar(a)	kg/h, bar(a), kg/m^3
Subcritical $\Delta p < F_L^2(p_1 - p_{vc})$	$p_{vc} = F_F p_v$	$C_V = q\sqrt{\frac{G_f}{p_1 - p_2}}$	$C_V = \frac{w}{63.3\sqrt{(p_1 - p_2)\rho_1}}$	$C_V = \frac{q}{0.865}\sqrt{\frac{G_f}{p_1 - p_2}}$	$C_V = \frac{w}{27.3\sqrt{(p_1 - p_2)\rho_1}}$
Critical (choked) $\Delta p \geq F_L^2(p_1 - p_{vc})$	$F_F = 0.96 - 0.28\left(\frac{p_v}{p_c}\right)^{\frac{1}{2}}$	$C_V = \frac{q_{max}}{F_L}\sqrt{\frac{G_f}{p_1 - p_{vc}}}$	$C_V = \frac{w_{max}}{63.3F_L\sqrt{(p_1 - p_{vc})\rho_1}}$	$C_V = \frac{q_{max}}{0.865F_L}\sqrt{\frac{G_f}{p_1 - p_{vc}}}$	$C_V = \frac{w_{max}}{27.3F_L\sqrt{(p_1 - p_{vc})\rho_1}}$

Compressible fluids (gases, vapors)

Pressure drop	Equations for x, F_k, Y, determination	Flow coefficient equation, with given units... Std ft^3/h (scfh), psi(a), °R	lb/h, psi(a), lb_m/ft^3	m^3/h, bar(a), K	kg/h, bar(a), kg/m^3
Subcritical $x < F_\kappa \cdot x_T$	$x = \frac{\Delta p}{p_1}$ $F_\kappa = \frac{\kappa}{1.4}$ $Y = 1 - \frac{x}{3F_\kappa x_T}$	$C_V = \frac{q}{1360p_1Y}\sqrt{\frac{G_g T_1 Z}{x}}$	$C_V = \frac{w}{63.3Y\sqrt{xp_1\rho_1}}$	$C_V = \frac{q}{417p_1Y}\sqrt{\frac{G_g T_1 Z}{x}}$	$C_V = \frac{w}{27.3Y\sqrt{xp_1\rho_1}}$
Critical (choked) $x \geq F_\kappa \cdot x_T$		$C_V = \frac{q_{max}}{907p_1}\sqrt{\frac{G_g T_1 Z}{F_k x_T}}$	$C_V = \frac{w_{max}}{42.2\sqrt{F_k x_T p_1 \rho_1}}$	$C_V = \frac{q_{max}}{278p_1}\sqrt{\frac{G_g T_1 Z}{F_k x_T}}$	$C_V = \frac{w_{max}}{18.2\sqrt{F_k x_T p_1 \rho_1}}$

Notes regarding the above equations:

For exact results with valves with attached fittings (pipe reductions, elbows, etc.), the Piping geometry factor (F_P) may be applied ($C_V = C_V / F_P$).
For non-turbulent flow (laminar and transitional), the Reynolds number factor (F_R) may be applied ($C_V = C_V / F_R$).
Refer to the ISA standard for determination and application of these two factors.

Symbols used:

p_1	(psi, bar)	Absolute pressure p_{abs} (inlet)
p_2	(psi, bar)	Absolute pressure p_{abs} (outlet)
Δp	(psi, bar)	Differential pressure ($p_1 - p_2$)
T_1	(°R, K)	Absolute temperature (inlet) °R=°F+459.69, K=°C+273.16
q	(gpm, m^3/h)	Volumetric flow rate (liquids)
q	(scfh, nm^3/h)	Volumetric flow rate (gases) at 14.73 psi(a) and 60°F or 1.013 bar(a) and 15 °C
G_f		Specific gravity (liquids) (ρ/ρ_{H_2O}) at 60°F, 15.6 °C
G_g		Specific gravity (gases) (ρ/ρ_{air}) at 60°F, 15.6 °C
ρ_1	(lb_m/ft^3, kg/m^3)	Density (liquids)
ρ_1	(lb_m/ft^3, kg/m^3)	Density (gases) 14.73 psi(a), 60°F, 15 °C, 1.013 bar(a)
p_v	(psia, bara)	Absolute vapor pressure of liquid (inlet temperature)
p_c	(psia, bara)	Absolute critical pressure
p_{vc}	(psia, bara)	Absolute pressure at the vena contracta
κ	(kappa)	Ratio of specific heats, dimensionless
Z		Compressibility factor, dimensionless

Materials according to ASTM and DIN

The body materials mainly used and their temperature limits are listed in the following Table.

The application limits of selected materials are included in the associated pressure-temperature table.

Materials

Material	Casting			Forging			Temperature range	
	Identification	Standard	Grade	Identification	Standard	Grade	[°F]	[°C]
Materials according to ASTM								
Gray iron	Cast iron	ASTM A 126	Class B	–	–	–	–20 ... 450	–29 ... 232
Ductile iron	Ductile iron	ASTM A 395	–	–	–	–	–20 ... 650	–29 ... 343
Aluminum Bronze	UNS C95200	ASTM B 148	9A	–	–	–	–20 ... 430	–29 ... 220
Carbon steel	WCB	ASTM A 216	WCB	–	ASTM A 105	–	–20 ... 800	–29 ... 427
Carbon steel, low temp.	LCB	ASTM A 352	LCB	–	ASTM A 350	LF 2	–50 ... 650	–46 ... 343
Carbon steel, low temp.	3½ Ni	ASTM A 352	LC3	–	ASTM A 350	LF 3	–150 ... 650	–100 ... 343
Carbon steel, high temp	Chrome Moly	ASTM A 217	WC6	UNS K11564	ASTM A 182	F 12	–20 ... 1100	–29 ... 593
Carbon steel, high temp	Chrome Moly	ASTM A 217	WC9	UNS K21590	ASTM A 182	F 22	–20 ... 1100	–29 ... 593
Stainless steel 18Cr-8Ni	Type 304	ASTM A 351	CF8	UNS S30400	ASTM A 182	F 304	–425 ... 1000	–254 ... 537
Stainless steel	Type 316	ASTM A 351	CF8M	UNS S31600	ASTM A 182	F 316	–425 ... 1000	–254 ... 537
Stainless steel	Type 316 L	ASTM A 351	CF3M	UNS S31603	ASTM A 182	F 316 L	–425 ... 850	–254 ... 454
Alloy 400	Ni-Cu	ASTM A 494	M35-1	UNS N04400	ASTM A 564	400	–20 ... 500	–29 ... 260
Alloy C-4	Ni-Mo-Cr	ASTM A 494	CW2M	UNS N06455	ASTM A 574	C-4	–20 ... 800	–29 ... 427
Comparable materials according to DIN								
Gray cast iron	GG-25	DIN 1691	0.6025	–	–	–	14 ... 572	–10 ... 300
Spheroidal graphite iron	GGG-40.3	DIN 1693	0.7043	–	–	–	14 ... 662	–10 ... 350
Cast steel	GS-C25	DIN 17 245	1.0619	C 22.8	DIN 17 243	1.0460	14 ... 752	–10 ... 400
Cast steel, low temp.	GS-21 Mn 5	SEW 685	1.1138	TStE 355	SEW 081	1.0566	–58 ... 572	–50 ... 300
Cast steel, high temp.	GS-17CrMo 5 5	DIN 17 245	1.7357	13CrMo 44	–	1.7335	14 ... 932	–10 ... 500
Cast steel, high temp.	GS-17CrMo V 5 11	DIN 17 245	1.7706				14 ... 1022	–10 ... 550
Stainless steel	G-X6CrNi 18 9	DIN 17 445	1.4308	X5CrNi 18 9	–	1.4301	–328 ... 572	–200 ... 300
Stainless steel (cast)	G-X5CrNiMoNb18 10	DIN 17 445	1.4581	–	–	–	14 ... 842	–10 ... 450
Stainless steel (forged)	–	–	–	X6 CrNiMoTi 17 12 2	DIN 17 440	1.4571	–454 ... 842	–270 ... 450
Stainless steel (forged)	–	–	–	X2 CrNiMo 17 12 2	DIN 17 440	1.4404	–454 ... 842	–270 ... 450
Alloy 400	NiCu30Fe	DIN 17743	2.4360	–	–	2.4360	–	–
Alloy C4-C	NiMo16Cr16Ti	DIN 17744	2.4610	–	–	2.4610	14 ... 752	–10 ... 400

Permissible pressure dependent upon the temperature · Iron and Bronze acc. to ANSI B16.1, B16.4, B16.15, B16.24

Body material	Class	Temperature (°F) and perm. operating pressure (psi)																
		–20	100	150	175	200	225	250	275	300	325	350	353	375	400	406	425	450
Threaded (NPT)																		
A 126 Cl.B (NPT)	125	175	(175)	175	(170)	165	(158)	150	(145)	140	(133)	125	125	–	–	–	–	
B16.4 –20...406 °F	250	400	(400)	400	(385)	370	(355)	340	(325)	310	(305)	300	(297)	(275)	250	250		
B 62 Bronze (NPT)	125	200	(200)	200	(195)	190	(185)	180	(173)	165	(158)	150	(149)	(138)	125	–		
B16.15 –20...400 °F	250	400	(400)	400	(393)	385	(375)	365	(350)	335	(318)	300	(297)	(275)	250			
Flat face flanged (FF)																		
A 126 Cl.B (FF)	125	200	(200)	200	(195)	190	180	175	170	165	155	(150)	150	145	(141)	140	130	125
B16.1 –20...450 °F	250	500	(500)	500	(480)	460	440	415	395	375	355	(337)	335	315	(295)	290	270	250
B 62 Bronze (FF)	150	225	(225)	225	220	210	205	195	190	180	(173	165	(164)	(158)	(152)	150	135	–
B16.24 –20...430 °F	300	500	(500)	500	480	465	445	425	410	390	(390)	350	(348)	(333)	(315)	(311)	(298)	280

Permissible pressure dependent upon the temperature · Steels according to ANSI B16.34 · Standard Class

Body material	Class	Temperature (°F) and perm. operating pressure (psi)																
		–20	100	200	300	400	500	600	650	700	750	800	850	900	950	1000	1050	1100
A 216 WCB –20 ... +800 °F	150	285	285	260	230	200	170	140	125	110	95	80	–					
	300	740	740	675	655	635	600	550	535	535	505	410						
	600	1480	1480	1350	1315	1270	1200	1095	1075	1065	1010	825						
	900	2220	2220	2025	1970	1900	1795	1640	1610	1600	1510	1235						
	1500	3705	3705	3375	3280	3170	2995	2735	2685	2665	2520	2060						
	2500	6170	6170	5625	5470	5280	4990	4560	4475	4440	4200	3430						
A 105 forged –20 ... +800 °F	300	740	740	675	655	635	600	550	535	535	505	410	–					
A 352 LCB –50 ... +650 °F	150	265	265	250	230	200	170	140	125	–								
	300	695	695	655	640	620	858	535	525									
A 217 WC6 –20 ... +1100 °F	300	750	750	710	675	660	640	605	590	570	530	510	485	450	380	225	140	95
	600	1500	1500	1425	1345	1315	1285	1210	1175	1135	1065	1015	975	900	755	445	275	190
	900	2250	2250	2135	2020	1975	1925	1815	1765	1705	1595	1525	1460	1350	1130	670	410	290
	1500	3750	3750	3560	3365	3290	3210	3025	2940	2840	2660	2540	2435	2245	1885	1115	684	480
	2500	6250	6250	5930	5605	5485	5350	5040	4905	4730	4430	4230	4060	3745	3145	1860	1145	800
A 217 WC9 –20 ... +1100 °F	300	750	750	715	675	650	640	605	590	570	530	510	485	450	380	270	200	115
	600	1500	1500	1430	1355	1295	1280	1210	1175	1135	1065	1015	975	900	755	535	400	225
	900	2250	2250	2150	2030	1945	1920	1815	1765	1705	1595	1525	1460	1350	1130	805	595	340
	1500	3750	3750	3580	3385	3240	3200	3025	2940	2840	2660	2540	2435	2245	1885	1340	995	565
	2500	6250	6250	5965	5640	5400	5330	5040	4905	4730	4430	4230	4060	3745	3145	2230	1660	945
A 351 CF8 –425 ... +1500 °F [2]	150	275	275	235	205	180	170	140	125	110	95	80	65	50	35	20	–	
	300	720	720	600	530	470	435	415	410	405	400	395	390	385	375	325		
	600	1440	1440	1200	1055	940	875	830	815	805	795	790	780	770	750	645		
	900	2160	2160	1800	1585	1410	1310	1245	1225	1210	1195	1180	1165	1150	1125	965		
A 351 CF8M –425 ... +1500 °F [2] A 351 CF3M –425 ... +850 °F	150	275	275	240	215	195	170	140	125	110	95	80	65	50	35	20	–	
	300	720	720	620	560	515	480	450	445	430	425	415	405	395	385	365		
	600	1440	1440	1240	1120	1030	955	905	890	865	845	830	810	790	775	725		
	900	2160	2160	1860	1680	1540	1435	1355	1330	1295	1270	1245	1215	1180	1160	1090		
	1500	3600	3600	3095	2795	2570	2390	2255	2220	2160	2110	2075	2030	1970	1930	1820		
	2500	6000	6000	5160	4660	4280	3980	3760	3700	3600	3520	3460	3380	3280	3220	3030		
A 182 F 316 forged –425 ... +1500 °F [2]	300	720	720	620	560	515	480	450	445	430	425	415	405	395	385	365	–	

Values in parentheses are interpolated values.
Some valve types may have lower limits based on the design. Consult the manufacturer for the respective model.

[1] For welding end valves only. Flanged end valves terminate at 1000 °F.

[2] For temperatures above 1000 °F, use only when carbon is 0.04% or higher. For temperature values above 1100 °F, consult the ANSI standard.

Specification Form for Controls Valves
According to ISA Form S20.50, Rev. 1

Project		Data Sheet	of
Unit		Date	
P.O.		Spec	
Item		Tag	
Contract		Dwg	
Mfr Serial*		Service	

1 Fluid _____ Crit Press Pc _____

SERVICE CONDITIONS

	Units	Max Flow	Norm Flow	Min Flow	Shut-Off	
2 Flow Rate					–	
3 Inlet Pressure						
4 Outlet Pressure						
5 Inlet Temperature						
6 Density/Spec Grav/Mol Wt					–	
7 Viscosity/Spec Heat Ratio					–	
8 Vapor Pressure Pv					–	
9 * Required Cv					–	
10 * Travel	%				0	
11 Allowable/*Predicted SPL	dB(A)				–	
12						

LINE

13 Pipe Line Size In _____
14 & Schedule Out _____
15 Pipeline Insulation

VALVE BODY / BONNET

16 * Type _____
17 * Size _____ ANSI Class _____
18 Max Press/Temp _____
19 * Mfr & Model _____
20 * Body/Bonnet Matl _____
21 * Liner Matl/ID _____
22 End In _____
23 Connection Out _____
24 Flg Face Finish _____
25 End Ext/Matl _____
26 * Flow Direction _____
27 * Type of Bonnet _____
28 Lub & Iso Valve _____ Lube _____
29 * Packing Material _____
30 * Packing Type _____
31

TRIM

32 * Type _____
33 * Size _____ Rated Travel _____
34 * Characteristic _____
35 * Balanced/Unbalanced _____
36 * Rated Cv _____ FL _____ XT _____
37 * Plug/Ball/Disk Material _____
38 * Seat Material _____
39 * Cage/Guide Material _____
40 * Stem Material _____
41
42

SPECIALS / ACCESSORIES

43 NEC Class _____ Group _____ Div. _____
44
45
46
47
48
49
50
51
52

ACTUATOR

53 * Type _____
54 * Mfr & Model _____
55 * Size _____ Eff Area _____
56 On/Off _____ Modulating _____
57 Spring Action Open/Close _____
58 * Max Allowable Pressure _____
59 * Min Required Pressure _____
60 Available Instr. Air Max _____
61 Supply Pressure Min _____
62 * Bench Range _____
63 Act Orientation _____
64 Handwheel Type _____
65 Air Fails Valve _____ Set at _____
66
67 Input signal

POSITIONER

68 * Type _____
69 * Mfr & Model _____
70 * On Increasing Signal Output Incr/Decr _____
71 Gauges _____ Bypass _____
72 * Cam Characteristic _____
73

SWITCHES

74 Type _____ Quantity _____
75 * Mfr & Model _____
76 Contacts/Rating _____
77 Actuation Points _____
78

AIRSET

79 * Mfr & Model _____
80 * Set Pressure _____
81 Filter _____ Gauges _____
82

TESTS

83 * Hydrostatic Pressure _____
84 ANSI/FCI Leakage Class _____
85
86

Rev	Date	Revision	Orig	App

* Information supplied by manufacturer unless already specified.