

# General Engineering Data

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This section, General Engineering Data, covers four main areas. The first includes information on sizing of steam, water, natural gas, and fuel oil piping. It also provides information on stacks.

Thermodynamic Properties contains information on fuel oils, water, and steam, including viscosities, thermal properties of water, and properties of saturated steam.

Unit Conversion includes an extensive conversion table for commonly used units of measurement.

Finally, a list is provided of associations responsible for publishing standards relevant to the boiler industry and boiler room practices.

## STEAM PIPING

Figure 1 allows pressure drop to be calculated given saturated steam pressure, flow rate and pipe diameter. Although the example covers calculating pressure drop, it is possible to work backwards to calculate pipe size, given pressure drop.

### Example for Steam Pipe Chart, Pounds per Minute to Pressure Drop

A 500 hp boiler at 125 psig has a capacity of 17210 lbs/hr. Pressure drop will be found through 100 feet of 5" inside diameter pipe.

First, convert pounds/hr to pounds/min by dividing by 60:

$$17210 \div 60 = 285$$

Next, convert psig to absolute pressure by adding 14.7:

$$125 + 14.7 = 139.7$$

Now, plot 140 (the pressure) on its corresponding axis. This gives point A. Draw a line from A through B, which is the pipe diameter. Continue this line to the axis, X. This gives point C.

A new line is plotted from point C, through the pounds of steam per minute axis (point D). This line ends at the pressure drop axis, for a drop of slightly more than 2.5 psi per 100 feet of pipe.

### Example for Steam Pipe Chart, Pounds per Minute to Feet per Minute

The same specifications will be used from the previous example.

For this chart, begin with pounds/min. This gives point A. Draw the line through the proper point (in this case, point B) on the diameter axis to the X axis (point C). Next, plot from the X axis through the appropriate pressure (point D) to get steam velocity. In this example, that corresponds to 3200 feet per minute.

$$500 \text{ hp} \times 33475 \frac{\text{Btu}}{\text{hr} \times \text{hp}} \times \frac{1}{20^\circ\text{F}} \times \frac{\text{lb} \times ^\circ\text{F}}{1 \text{ Btu}} \times \frac{1 \text{ hr}}{60 \text{ min}} \times \frac{\text{gallon}}{8.3 \text{ lb}} = 1680 \frac{\text{gallons}}{\text{m in}}$$

## WATER PIPING

Figure 2 allows pressure drop in psi or ft. of water to be calculated for a given flow and pipe size. Like Figure 1, working backwards will allow pipe size to be calculated for a target pressure drop. This figure will work with either water flow in a hot water system boiler or feedwater to a steam boiler. This assumes a constant viscosity and density for water over this range of temperatures, but should not cause significant error.

### Hot Water Boiler Example

In this example, pressure drop will be calculated for a 500 hp hot water boiler with a 20 °F temperature differential. This corresponds to approximately 1700 gpm.

The system will use 10" nominal size schedule 40 pipe. These two figures are plotted on their respective axis, giving points A and B. A line is drawn through these two points and the remaining two axis, giving a pressure drop of .57 psig (1.3 ft. of water) and a 6.4 feet per second velocity.

### *Feedwater Example*

Now consider a 500 hp steam boiler. This requires approximately 40 gallons per minute of feedwater. A 2" nominal schedule 40 pipe will be used. Plotting these figure yields points C and D. Drawing a line through the points as before gives us a pressure drop of 2 psig, or 4.6 feet of water.

## NATURAL GAS PIPING

Table 1 shows capacity of a natural gas line for a given initial pressure with a 5% pressure drop. For example, consider a 500 hp boiler, which requires 20,925 cu.-ft. / hr. A 5 psi initial pressure is available for 100 ft. of pipe. To find the correct pipe size, go to the line for initial gas pressure reading 5 pounds. Now move to the right, until a number larger than 20,925 appears. In this case, the first greater number is 30,500. The number at the top of that column shows the appropriate pipe size, in this case 4". Table 1 assumes gas at 60 °F, 1000 Btu/cu.-ft., and a specific gravity of 0.619.

## FUEL OIL PIPING

Table 2 through Table 6 show pressure drop for liquids with specific gravities and viscosities in the ranges found for numbers 2 through 6 fuel oils.

To use these tables, select the table with the appropriate viscosity for the oil that is being used. (An oil viscosity chart is provided later in this section in Figure 6.) Select the line corresponding to the required flow, and the column corresponding to the nominal pipe size. The intersection will give the pressure drop in psi per 100 feet of equivalent pipe length.

For example, a typical No. 2 fuel oil has a viscosity 40 SSU. A 500 hp boiler requires up to 115 gallons per hour of No. 2 oil. Using Table 2, and specifying a 1-inch nominal pipe size, gives 0.1 psi pressure drop at 100 gph, and 0.2 at 150 gph. Linear interpolation gives 0.13 psi pressure drop per 100 equivalent feet of pipe. Note that heavy oils require a return line, which increases total flow requirements.

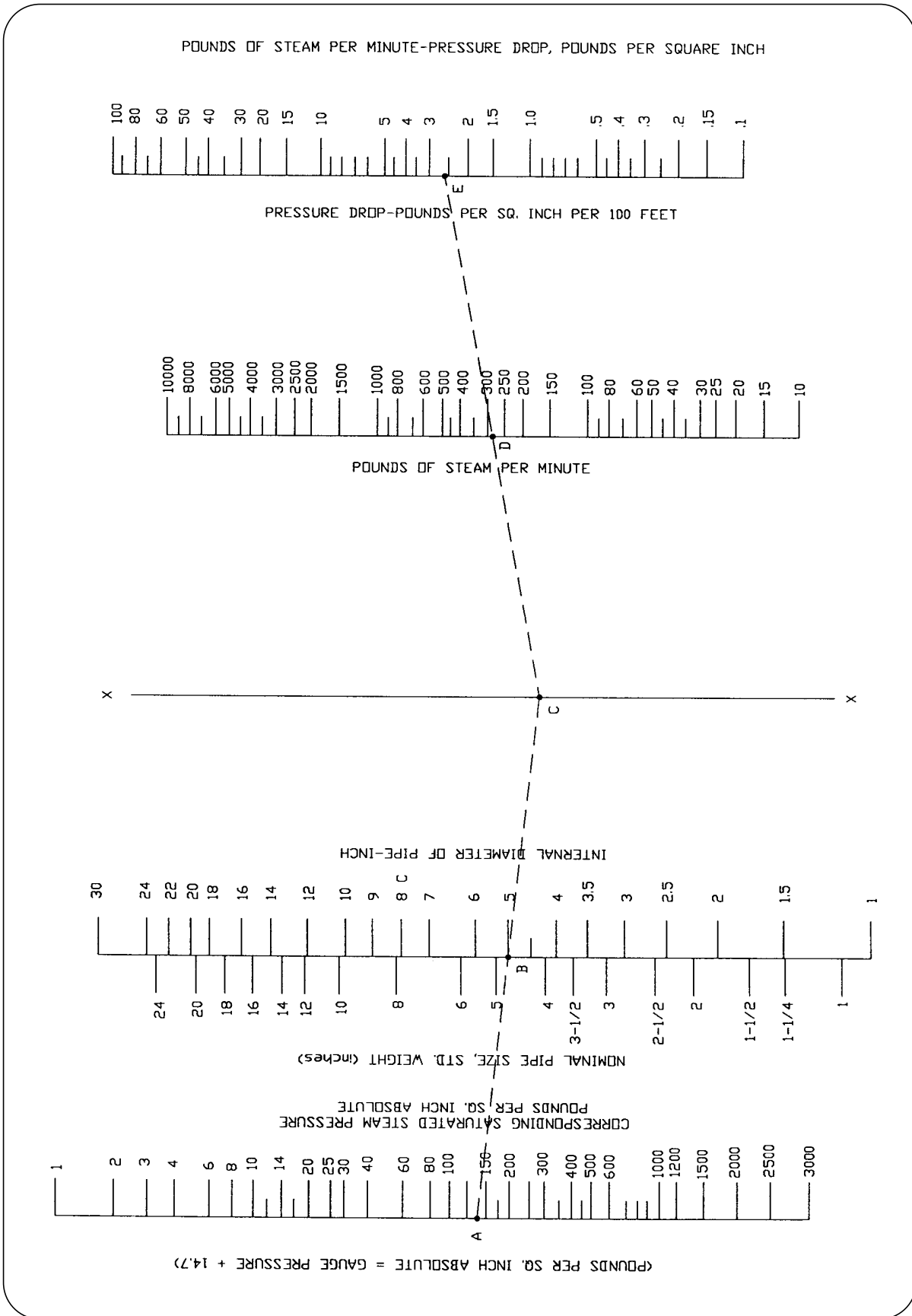


Figure 1. Steam Pipe Chart - Pressure Drop

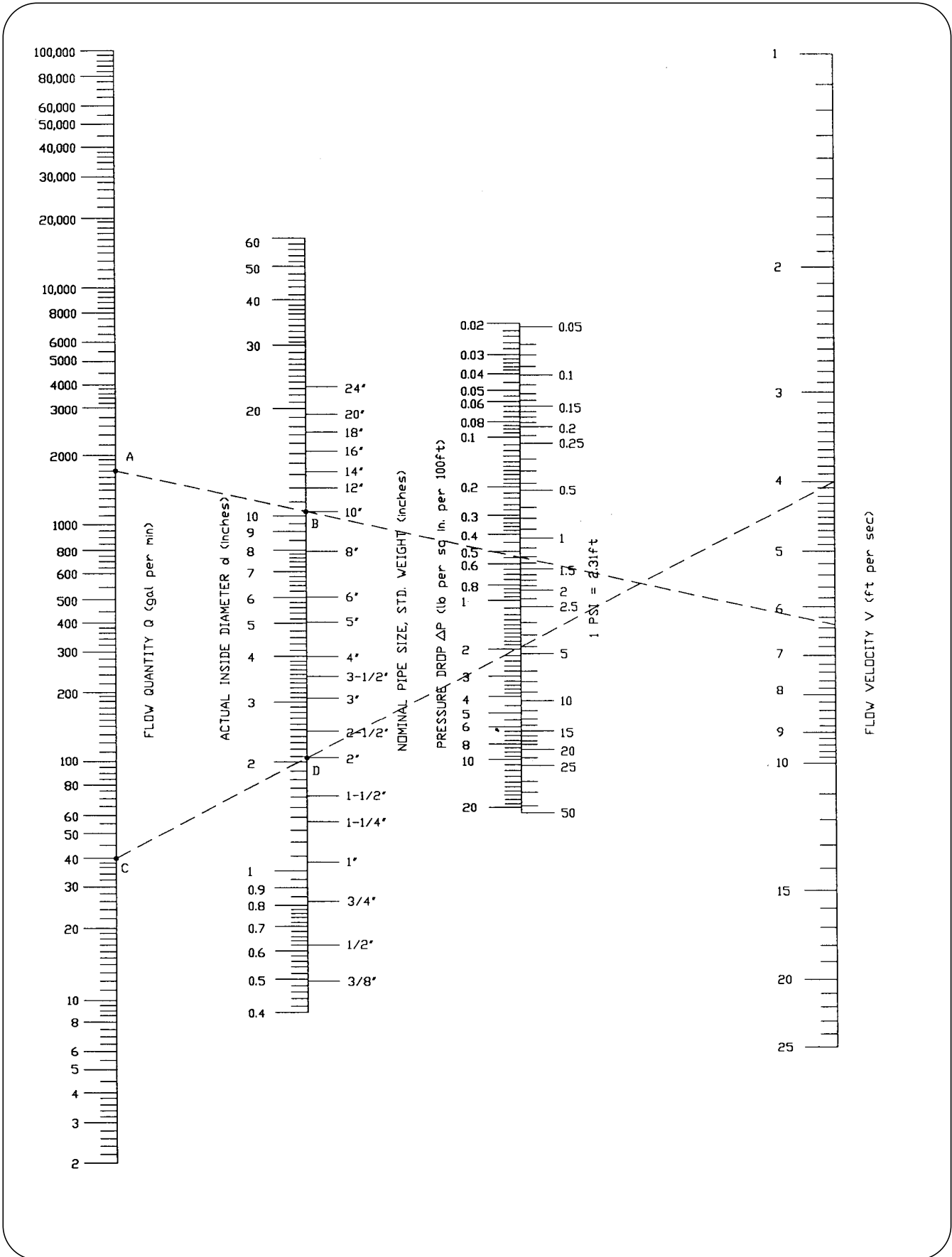


Figure 2. Pressure Drop for Water

**Table 1. Gas Line Capacities**

INITIAL GAS PRESSURE	TOTAL PRESS DROP	GAS LINE CAPACITIES (CU-FT/HR THROUGH 100 FT LENGTH)											
		DIAMETER OF PIPE IN INCHES											
		1/2	3/4	1	1-1/4	1-1/2	2	2-1/2	3	4	5	6	8
4" water	0.2"	23	52	104	230	358	724	1180	2150	4510	8210	13400	27300
5" water	0.25"	26	58	117	257	400	811	1320	2410	5050	9190	14900	30600
6" water	0.30"	28	64	128	282	439	889	1450	2640	5540	10100	16400	33500
7" water	0.35"	31	69	139	305	475	962	1570	2860	5990	10900	17700	36300
8" water	0.40"	33	74	148	327	508	1030	1680	3060	6410	11700	19000	38800
9" water	0.45"	35	79	158	347	540	1090	1780	3250	6810	12400	20200	41200
10" water	0.50"	37	83	166	366	569	1150	1880	3430	7180	13100	21300	43500
11" water	0.55"	38	87	175	385	598	1210	1980	3600	7550	13700	22300	45700
12" water	0.6"	40	91	183	402	625	1280	2060	3760	7890	14300	23300	47700
1/2 psi	.025 psi	43	98	197	433	673	1360	2220	4050	8590	15400	25100	51400
3/4 psi	.038 psi	53	121	243	534	831	1680	2750	5000	10500	19100	31100	63500
1 psi	.050 psi	62	141	282	622	967	1960	3190	5820	12200	22200	36100	73800
1-1/4 psi	.062 psi	70	159	319	702	1090	2210	3600	6570	13800	25000	40800	83300
1-1/2 psi	.075 psi	77	175	351	773	1200	2440	3970	7240	15200	27600	44900	91800
1-3/4 psi	.088 psi	84	191	382	842	1310	2650	4320	7870	16500	30000	48900	99900
2 psi	.100 psi	91	205	412	906	1410	2850	4660	8480	17800	32300	52600	108000
2-1/2 psi	.125 psi	103	233	467	1030	1600	3240	5280	9620	20200	36700	59000	122000
3 psi	.150 psi	114	259	519	1140	1780	3600	5870	10700	22400	40800	66300	136000
3-1/2 psi	.175 psi	125	283	568	1250	1940	3940	6420	11700	24500	44600	72600	148000
4 psi	.200 psi	135	307	615	1350	2110	4270	6960	12700	26600	48300	78700	161000
4-1/2 psi	.225 psi	146	330	661	1460	2260	4580	7480	13600	28500	51900	84500	173000
5 psi	.250 psi	155	352	706	1550	2420	4890	7980	14500	30500	55400	90200	184000
6 psi	.300 psi	174	395	792	1740	2710	5490	8960	16300	34200	62200	101000	207000
8 psi	.400 psi	211	477	957	2110	3280	6640	10800	19700	41300	75200	122000	250000
10 psi	.500 psi	246	556	1120	2460	3820	7730	12600	23000	48200	87600	143000	292000
For total lengths other than 100 ft, multiply the capacity shown in the table by the factor corresponding to the desired length as follows:													
Length of pipe in ft		10	15	25	50	100	150	200	250	300	350	400	500
Multiplier		3.16	2.58	2.00	1.41	1.00	.817	.707	.632	.577	.535	.500	.447
For pressures and diameters not shown, consult you local Cleaver-Brooks authorized representative.													

This table shows gas flow capacities of pipes from 1/2" to 8" diameter, based upon a pressure drop of 5% of the initial gas pressure for 100-ft. length of pipe. Turbulent flow is assumed, hence the non-linear ratio of length to capacity.

**Table 2. Oil Piping Pressure Drop (Viscosity = 40 SSU and Specific Gravity = 0.9)**

FUEL OIL FLOW RATE (GPH)	NOMINAL PIPE SIZE (INCHES)							
	0.5	0.75	1	1.5	2	2.5	3	4
25	0.3	0.1	0.0*	0.01	0.00*	0.001	0.000*	0.000*
50	0.6	0.2	0.1	0.01	0.00	0.002	0.001	0.000*
75	0.9	0.3	0.1	0.02	0.01	0.003	0.001	0.000*
100	1.1	0.4	0.1	0.03	0.01	0.005	0.002	0.001
150	3.6	0.9	0.2	0.04	0.01	0.007	0.003	0.001
200	6.0	1.6	0.5	0.05	0.02	0.009	0.004	0.001
250	8.9	2.3	0.7	0.06	0.02	0.011	0.005	0.002
300	12.3	3.2	1.0	0.13	0.03	0.014	0.006	0.002
400	20.3	5.3	1.7	0.22	0.07	0.018	0.008	0.003
500	30.5	7.9	2.5	0.32	0.10	0.042	0.010	0.003
600	42.2	11.0	3.5	0.45	0.13	0.058	0.020	0.004
700	55.6	14.5	4.6	0.59	0.18	0.076	0.027	0.007

NOTE: Pressure Drop (psig) per 100 equivalent ft of pipe for a fuel oil viscosity of 40 SSU, specific gravity of 0.9  
 \* Negligible pressure drop.

**Table 3. Oil Piping Pressure Drop (Viscosity = 100 SSU and Specific Gravity = 0.94)**

FUEL OIL FLOW RATE (GPH)	NOMINAL PIPE SIZE (INCHES)							
	0.5	0.75	1	1.5	2	2.5	3	4
25	3.9	1.3	0.5	0.1	0.03	0.02	0.007	0.002
50	7.8	2.5	1.0	0.2	0.06	0.03	0.013	0.004
75	11.6	3.8	1.4	0.3	0.10	0.05	0.020	0.007
100	15.5	5.0	1.9	0.3	0.13	0.06	0.026	0.009
150	23.3	7.6	2.9	0.5	0.19	0.09	0.039	0.013
200	31.1	10.1	3.8	0.7	0.25	0.13	0.052	0.018
250	38.8	12.6	4.8	0.9	0.32	0.16	0.066	0.022
300	46.6	15.1	5.8	1.0	0.38	0.19	0.079	0.027
400	62.1	20.2	7.7	1.4	0.51	0.25	0.10	0.035
500	77.6	25.2	9.6	1.7	0.64	0.31	0.13	0.044
600	93.2	30.2	11.5	2.1	0.76	0.38	0.16	0.053
700	108.7	35.3	13.4	2.4	0.89	0.44	0.18	0.062

NOTE: Pressure Drop (psig) per 100 equivalent ft of pipe for a fuel oil viscosity of 100 SSU, specific gravity of 0.94

**Table 4. Oil Piping Pressure Drop (Viscosity = 500 SSU and Specific Gravity = 0.94)**

FUEL OIL FLOW RATE (GPH)	NOMINAL PIPE SIZE (INCHES)							
	0.5	0.75	1	1.5	2	2.5	3	4
25	7.8	2.5	1.0	0.2	0.06	0.03	0.013	0.004
50	15.6	5.1	1.9	0.3	0.13	0.06	0.026	0.009
75	23.5	7.6	2.9	0.5	0.19	0.09	0.039	0.013
100	31.3	10.2	3.9	0.7	0.26	0.13	0.052	0.018
150	46.9	15.2	5.8	1.0	0.38	0.19	0.079	0.027
200	62.6	20.3	7.7	1.4	0.51	0.25	0.106	0.036
250	78.2	25.4	9.7	1.7	0.64	0.32	0.132	0.045
300	93.9	30.5	11.6	2.1	0.77	0.38	0.159	0.053
400	125.1	40.6	15.5	2.8	1.03	0.50	0.21	0.071
500	156.4	50.8	19.3	3.5	1.28	0.63	0.26	0.089
600	187.7	69.9	23.2	4.2	1.54	0.76	0.32	0.107
700	219.0	71.1	27.1	4.9	1.80	0.88	0.37	0.125

NOTE: Pressure Drop (psig) per 100 equivalent ft of pipe for a fuel oil viscosity of 500 SSU, specific gravity of 0.94



**Table 5. Oil Piping Pressure Drop (Viscosity = 1000 SSU and Specific Gravity = 0.96)**

FUEL OIL FLOW RATE (GPH)	NOMINAL PIPE SIZE (INCHES)							
	0.5	0.75	1	1.5	2	2.5	3	4
25	16.0	5.2	2.0	0.4	0.13	0.06	0.027	0.009
50	32.0	10.4	4.0	0.7	0.26	0.13	0.054	0.018
75	48.0	15.6	5.9	1.1	0.39	0.19	0.081	0.027
100	64.0	20.8	7.9	1.4	0.52	0.26	0.108	0.036
150	96.0	31.2	11.9	2.1	0.79	0.39	0.162	0.055
200	128.0	41.6	15.8	2.9	1.05	.052	0.216	0.073
250	160.1	52.0	19.8	3.6	1.31	0.64	0.270	0.091
300	192.1	62.4	23.7	4.3	1.57	0.77	0.324	0.109
400	256.1	83.1	31.7	5.7	2.10	1.03	0.43	0.146
500	320.1	103.9	39.6	7.1	2.62	1.29	0.54	0.182
600	384.1	124.7	47.5	8.6	3.15	1.55	0.65	0.219
700	448.1	145.5	55.4	10.0	3.67	1.81	0.76	0.255

NOTE: Pressure Drop (psig) per 100 equivalent ft of pipe for a fuel oil viscosity of 1000 SSU, specific gravity of 0.96

**Table 6. Oil Piping Pressure Drop (Viscosity = 5000 SSU and Specific Gravity = 0.96)**

FUEL OIL FLOW RATE (GPH)	NOMINAL PIPE SIZE (INCHES)							
	0.5	0.75	1	1.5	2	2.5	3	4
25	80	26	10	2	1	0.3	0.1	0.05
50	160	52	20	4	1	0.6	0.3	0.09
75	240	78	30	5	2	1.0	0.4	0.14
100	320	104	40	7	3	1.3	0.5	0.18
150	480	156	59	11	4	1.9	0.8	0.27
200	641	208	79	14	5	2.6	1.1	0.36
250	801	260	99	18	7	3.2	1.4	0.46
300	961	312	119	21	8	3.9	1.6	0.55
400	1281	416	158	29	11	5.2	2.2	0.73
500	1601	520	198	36	13	6.5	2.7	0.91
600	1922	624	238	43	16	7.7	3.2	1.09
700	2242	728	277	50	18	9.0	3.8	1.28

NOTE: Pressure Drop (psig) per 100 equivalent ft of pipe for a fuel oil viscosity of 5000 SSU, specific gravity of 0.96

**EQUIVALENT LENGTHS**

Table 7 shows equivalent lengths of pipe for various plumbing fittings. Find the nominal pipe size being used in the leftmost column. For each fitting, read the value under the appropriate heading and add this to the length of piping. This allows total system pressure drop to be calculated. (This is valid for any fluid.)

**STACKS**

**Notice**

**For boilers over 800 hp, consult your local Cleaver-Brooks authorized representative.**

**Why Used**

The only purpose of a vent stack on Cleaver-Brooks boilers is to conduct the products of combustion to a point of safe discharge (atmosphere). Forced draft design eliminates the need for a stack designed to create a draft.

**Stack Draft on CB Boilers**

Depending on the boiler model, draft variations of as much as 1/2 inch W.C. at the boiler vent outlet will have no appreciable effect on the Model CB burner operation. This is due to the high pressure drops which are taken from the burner inlet to the boiler vent outlet. See individual boiler sections for specific limitations on stack/breeching size criteria. Other typical pressure drops for the Model CB Boilers are as follows:

- A. A 4 inch to 12 inch WC drop is taken across the burner in order to provide high turbulence, good mixing of fuel and air, and high CO<sub>2</sub> readings for most efficient combustion,
- B. A 2 inch to 6 inch WC drop is taken through the four (4) gas passes of the boiler in order to maintain high flue gas velocities and thus increase heat transfer.

For other boiler types, the draft variation could be similar. Consult you local Cleaver-Brooks authorized representative.

**Table 7. Equivalent Length of Pipe**

PIPE SIZE	EQUIVALENT LENGTH OF STRAIGHT PIPE (FEET)				
	STANDARD ELBOW	STANDARD TEE	GATE VALVE FULL OPEN	GLOBE VALVE FULL OPEN	ANGLE VALVE FULL OPEN
1-1/2	4	9	0.9	41	21
2	5	11	1.2	54	27
2-1/2	6	13	1.4	64	32
3	8	16	1.6	80	40
3-1/2	9	18	2.0	91	45
4	11	21	2.2	110	55
5	13	26	2.8	140	70
6	16	32	3.4	155	81
8	20	42	4.5	210	110
10	25	55	5.5	270	140
12	30	65	6.5	320	160
14	35	75	8.0	370	190

This table contains the number of feet of straight pipe usually allowed for standard fittings and valves.

If the stack height is over 150 feet or if an extremely large breeching and stack combination cause excessive draft, a simple barometric damper can be located in the breeching close to the stack or chimney. This damper should only be considered after burner adjustment problems have been experienced and are serious enough to warrant corrective action.

Automatic or special draft controls are not required and are not recommended for use with Cleaver-Brooks boilers.

### ***Stack Location***

An off-set type stack connection to the stub vent on the boiler is preferred and recommended. A direct vertical connection can also be made, if required. A typical stack location diagram is shown in Figure 3.

### ***Stack Condensation***

The amount of condensation in the stack will vary with the type of fuel and with the stack gas temperature. Normally, the temperature of the flue gas leaving the boiler is higher than the temperature of the steam or the water in the boiler.

Stack condensation is most likely to occur on heating boiler installations where light loads and intermittent firing cause a cool stack condition, which results in condensation of the water vapor in the flue gas. This condensed water accelerates corrosion of steel stacks or breechings.

The following items should be considered when planning to keep stack condensation to a minimum:

- A. The boiler should be sized as close as possible to the true heat load. Oversized boilers should be avoided.
- B. Masonry stacks have better heat holding characteristics than steel stacks.
- C. When steel stacks are used, stack insulation will help prevent heat loss.
- D. An off-set stack (recommended) with bottom clean-out and drain connection will prevent any condensed water from draining back into the boiler.

### ***Stack Weight***

Boiler vent outlets will withstand a maximum direct vertical load of 2,000 pounds. This loading must include the effect of wind and guy wires.

### ***Stack Construction***

The stack can be terminated several feet above the top of the roof. (State and local codes may govern the stack height above the roof.) If down drafts are unavoidable, the stack outlet can be provided with a ventilator such as the Breidert Air-X-Hauster or equivalent. See Figure 4 for typical stack construction details.

### ***Stack Material***

Minimum 12 gauge steel is recommended for stack sections. If the stack will be inaccessible, the use of a non-corrosive material (e.g. glass lining) should be considered.

A rain cap or hood should be used at the top of the stack to minimize the entrance of rain or snow. See Figure 5 for typical rain cap details.

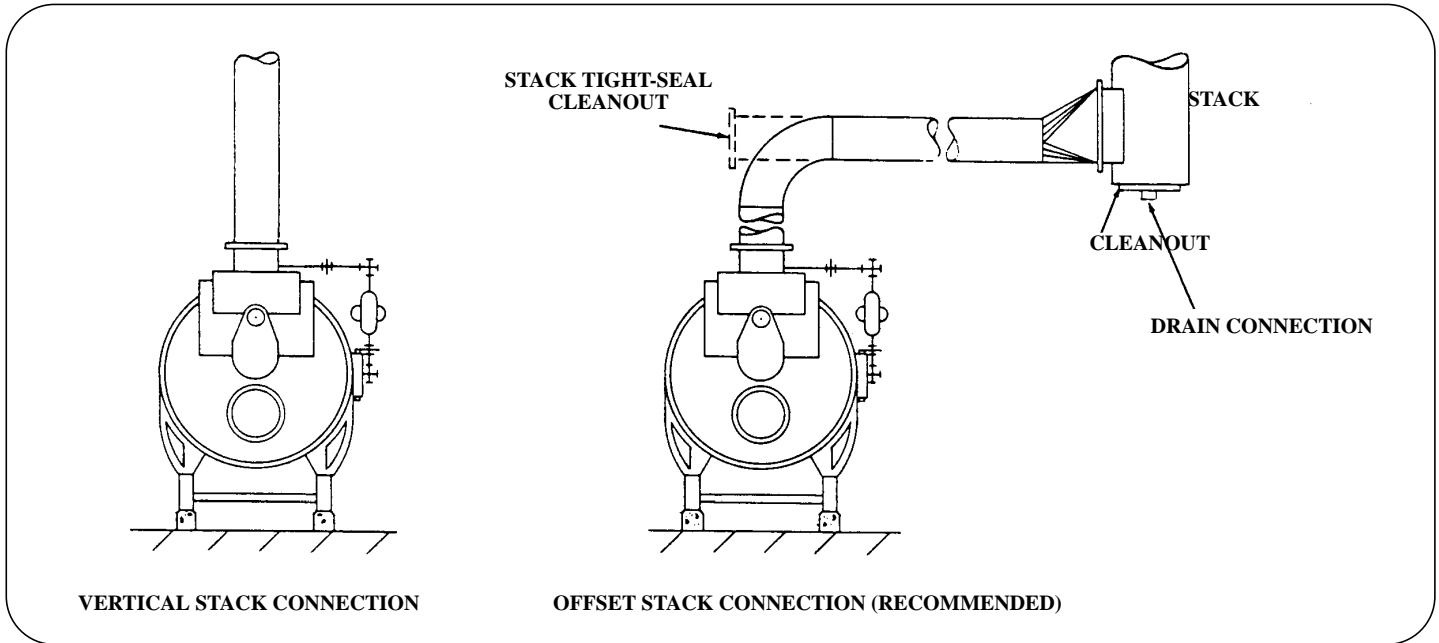


Figure 3. Typical Stack Locations

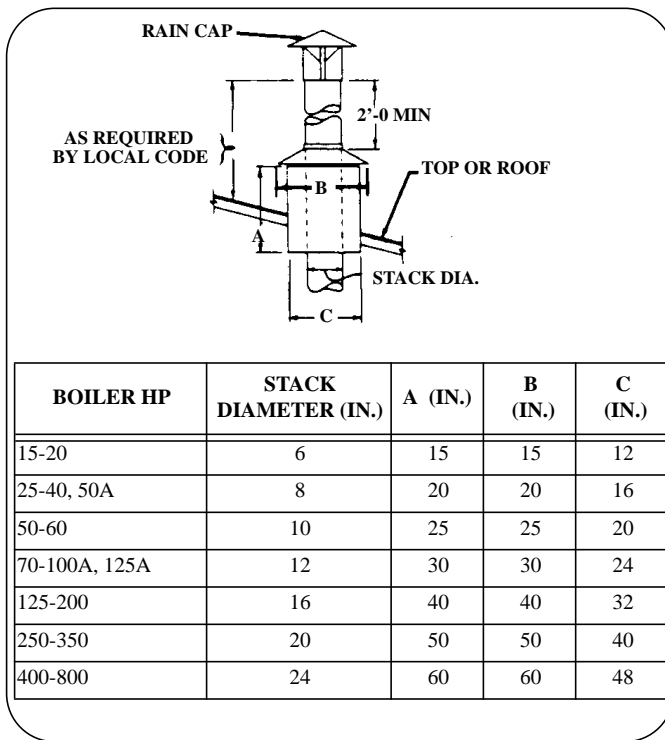


Figure 4. Typical Stack Construction

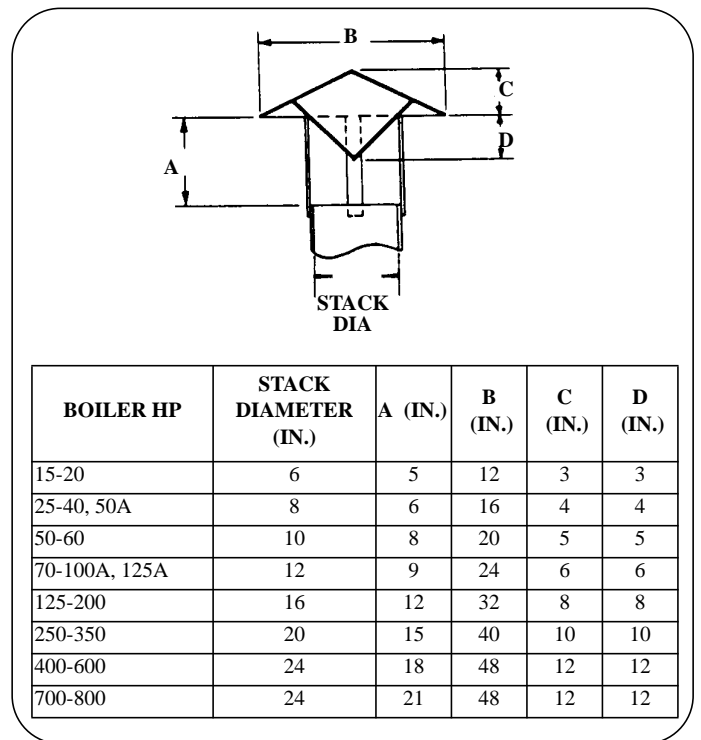


Figure 5. Rain Cap Details

**Stack/Breeching Size Criteria**

The design of the stack and breeching system must provide a draft at the boiler outlet(s) which is within the required limits. Consideration must be given to operation variations (including number of boilers), purge cycles, outside wind and air conditions, and the impact of other variables that may impact draft conditions. Safe and reliable burner performance requires good stack design. See Table 8 and further detail in the individual boiler sections.

Stack and breeching sizes should always be provided by a reputable stack supplier who will design the stack and breeching system based on the required system layout. Your local Cleaver-Brooks authorized representative is capable of assisting in your evaluation of the stack/breeching design.

**FACTORS OF EVAPORATION**

The factor of evaporation is used to adjust rated boiler output (from and at 212 °F) to actual job or operating conditions. Available feedwater temperature and expected boiler operating pressure (psig) affect the boiler output ratings which are based on “from and at 212 °F.”

Example: A boiler is to have an output of 3060 pounds of steam per hour when operating at 10 psig with feedwater at 100 °F. What should the boiler rating be on the basis of “from and at 212 °F.”

Referring to Table 10, at 100 °F and 10 psig, the following factors can be obtained: 30.6 pounds of steam per boiler horsepower. This factor is used to convert the “from and at 212 °F” rating basis:

$$3060 \div 30.6 = 100 \text{ hp rated boiler should be selected.}$$

**Table 8. Single Boiler Vent or Stack Diameter**

BOILER HP	STACK DIAMETER Same as Boiler Vent Outlet Size (Inches OD)
15-20	6
25-40, 50A	8
50-60	10
70-100, 100A, 125A	12
125-200	16
250-350	20
400-800	24

**Table 9. Multiple Boilers - Common Breeching and Stack**

BOILER HP	MINIMUM RECOMMENDED STACK DIAMETER <sup>A</sup>					
	NUMBER OF BOILERS					
	2		3		4	
	100 FT	200 FT	100 FT	200 FT	100 FT	200 FT
15-20	9"	10"	10"	12"	11"	12"
25-40	11"	12"	13"	14"	14"	16"
50A, 50-60	13"	14"	15"	16"	17"	18"
70-100, 100A	16"	17"	19"	20"	21"	23"
125-200	21"	22"	24"	26"	28"	30"
250-350	26"	28"	32"	34"	34"	40"
400-600	32"	34"	38"	40"	42"	46"
700-800	38"	42"	44"	48"	48"	52"

Notes:

A. No barometric damper required.

*THERMODYNAMIC PROPERTIES*

**Fuel Oils**

The purpose of this section is to provide technical information on the various grades of fuel oils commonly used in the generation of steam and hot water. The American Society for Testing and Materials (ASTM) has established numerous tests to identify fuel oil properties and specifications that allow the fuel to be identified by a grade, which can be No. 1, 2, 4, 5, or 6.

Grades No. 1 and No. 2 are considered distillate oil, while grades No. 4 through No. 6 are considered residual oils. Distillate oils have a low viscosity and are relatively easy to burn. Residual oils have a high viscosity and often require heating to pump and atomize. Residual oils will also have much higher emission levels, and their use is frequently regulated because of this.

The viscosity ranges of fuel oils are shown in Figure 6.

**Table 10. Factor of Evaporation**

Feed-Water Temp.	Gauge Pressure — psig																		
	0	2	10	15	20	40	50	60	80	100	120	140	150	160	180	200	220	240	
30	29.0	29.0	28.8	28.7	28.6	28.4	28.3	28.2	28.2	28.1	28.0	28.0	27.9	27.9	27.9	27.9	27.9	27.9	27.8
40	29.3	29.2	29.1	29.0	28.9	28.7	28.6	28.5	28.4	28.3	28.2	28.2	28.2	28.2	28.2	28.1	28.1	28.1	28.1
50	29.6	29.5	29.3	29.2	29.1	28.9	28.8	28.8	28.7	28.6	28.5	28.5	28.4	28.4	28.4	28.3	28.3	28.3	28.3
60	29.8	29.8	29.6	29.5	29.4	29.2	29.1	29.0	28.9	28.8	28.8	28.7	28.7	28.6	28.6	28.6	28.6	28.6	28.5
70	30.1	30.0	29.9	29.8	29.7	29.5	29.4	29.3	29.2	29.1	29.0	29.0	28.9	28.9	28.9	28.8	28.8	28.8	28.8
80	30.4	30.3	30.1	30.0	30.0	29.8	29.6	29.6	29.5	29.3	29.2	29.2	29.2	29.2	29.1	29.1	29.1	29.1	29.0
90	30.6	30.6	30.4	30.3	30.2	30.0	29.9	29.8	29.7	29.6	29.5	29.5	29.4	29.4	29.4	29.3	29.3	29.3	29.3
100	30.9	30.8	30.6	30.6	30.5	30.3	30.2	30.1	30.0	29.8	29.8	29.8	29.7	29.7	29.7	29.6	29.6	29.6	29.6
110	31.2	31.2	30.9	30.8	30.8	30.6	30.4	30.3	30.2	30.0	30.0	30.0	30.0	30.0	29.9	29.9	29.8	29.8	29.8
120	31.5	31.4	31.2	31.2	31.1	30.8	30.7	30.6	30.5	30.4	30.3	30.3	30.2	30.2	30.2	30.1	30.1	30.1	30.1
130	31.8	31.7	31.5	31.4	31.4	31.1	31.0	30.9	30.8	30.7	30.6	30.6	30.5	30.5	30.4	30.4	30.4	30.4	30.4
140	32.1	32.0	31.8	31.7	31.6	31.4	31.3	31.2	31.1	31.0	30.9	30.8	30.8	30.8	30.8	30.7	30.7	30.7	30.6
150	32.4	32.4	32.1	32.0	31.9	31.7	31.6	31.5	31.4	31.2	31.2	31.2	31.1	31.1	31.0	31.0	30.9	30.9	30.9
160	32.7	32.7	32.4	32.4	32.3	32.0	31.9	31.8	31.7	31.5	31.4	31.4	31.4	31.4	31.3	31.3	31.2	31.2	31.2
170	33.0	33.0	32.7	32.6	32.6	32.3	32.2	32.1	32.0	31.8	31.7	31.7	31.7	31.6	31.6	31.6	31.5	31.5	31.5
180	33.4	33.3	33.0	33.0	32.9	32.6	32.5	32.4	32.3	32.2	32.1	32.0	32.0	32.0	31.9	31.9	31.8	31.8	31.8
190	33.8	33.7	33.4	33.3	33.2	32.9	32.8	32.7	32.6	32.5	32.4	32.4	32.3	32.3	32.2	32.2	32.1	32.1	32.1
200	34.1	34.0	33.7	33.6	33.5	33.2	33.1	33.0	32.9	32.8	32.7	32.6	32.6	32.6	32.6	32.5	32.4	32.4	32.4
212	34.5	34.4	34.2	34.1	33.8	33.6	33.5	33.4	33.3	33.2	33.1	33.0	33.0	33.0	32.9	32.9	32.8	32.8	32.8
220	34.8	34.7	34.4	34.3	34.2	33.9	33.8	33.7	33.5	33.4	33.3	33.3	33.2	33.2	33.1	33.1	33.1	33.1	33.0
227	35.0	34.9	34.7	34.5	34.4	34.1	34.0	33.9	33.8	33.7	33.6	33.5	33.5	33.4	33.4	33.3	33.3	33.3	33.3
230	35.2	35.0	34.8	34.7	34.5	34.2	34.1	34.0	33.9	33.8	33.7	33.6	33.5	33.5	33.4	33.4	33.4	33.4	33.4

**Fuel Oil Specifications**

The limits on fuel oil properties are shown in Table 11, Table 12, and Table 13. Definitions of these properties are discussed next.

**Ultimate Analysis** - Ultimate analysis is a statement of the quantities of the various elements of which a substance is composed. For fuel oils, this will likely state higher heating values and specific gravity in addition to the percentages by weight of each element.

**Flash Point** - The flash point of a fuel oil is an indication of the maximum temperature at which it can be stored and handled without serious fire hazard. The minimum permissible flash point is usually regulated by federal, state or municipal laws and is based on accepted practice in handling and use.

**Pour Point** - The pour point is an indication of the lowest temperature at which a fuel oil can be stored and still be capable of flowing under very low forces. The pour point is prescribed in accordance with the conditions of storage and use. Higher pour point fuels are permissible where heated storage and adequate piping facilities are provided. An increase in pour point can occur when residual fuel oils are subjected to cyclic temperature variations that can occur in the course of storage or when the fuel is preheated and returned to storage tanks. To predict these properties, Test Method D 3245 may be required.

**Water and Sediment** - Appreciable amounts of water and sediments in a fuel oil tend to cause fouling of facilities for handling it, and cause trouble in burner mechanisms. Sediment may accumulate in storage tanks and on filter screens or burner parts, resulting in obstructions to flow of oil from the tank to the burner. Water in distillate fuels can cause corrosion of tanks and equipment, and can cause emulsions in residual fuels.

**Carbon Residue** - The carbon residue of a fuel is a measure of the carbonaceous material left after all the volatile components are vaporized in the absence of air. It is a rough approximation of the tendency of a fuel to form deposits in vaporizing burners, such as pot-type and sleeve burners, where the fuel is vaporized in an air-deficient atmosphere.

To obtain measurable values of carbon residue in the lighter distillate fuel oils, it is necessary to distill the oil to remove 90% of it in accordance with Section 9 of Test Method D 524, and determine the carbon residue concentrated in the remaining 10% bottoms.

**Ash** - The amount of ash is the quantity of noncombustible material in an oil. Excessive amounts can indicate the presence of materials that cause high wear of burner pumps and valves, and contribute to deposits on boiler heating surfaces.

**Table 11. Typical Units for Fuels**

ITEM	GROSS HEATING VALUES
No. 2 Oil	140,000 Btu/gal.
No 5 Oil	148,000 Btu/gal.
No. 6 Oil	150,000 Btu/gal.
1 Therm	100,000 Btu
1 kW	3,413 Btu

**Table 12. Detailed Requirements for Fuel Oils - Properties of Fuel Oil**

PROPERTY	ASTM TEST METHOD <sup>B</sup>	FUEL OIL GRADE						
		No. 1	No. 2	No. 4 (Light)	No. 4	No 5 (Light)	No. 5 (Heavy)	No. 6
Flash Point °C min	D 93	38	38	38	55	55	55	60
Water and sediment,% vol max	D 1796	0.05	0.05	(0.50) <sup>C</sup>	(0.50) <sup>C</sup>	(1.00) <sup>C</sup>	(1.00) <sup>C</sup>	(2.00) <sup>C</sup>
Distillation temperature °C	D 85	–	–	–	–	–	–	–
10% vol recovered, max	–	215	–	–	–	–	–	–
90% vol recovered, min	–	–	282	–	–	–	–	–
max	–	288	338	–	–	–	–	–
Kinematic viscosity at 40 °C mm <sup>2</sup> /s	D 445	–	–	–	–	–	–	–
Minimum viscosity	–	1.3	1.9	1.9	>5.5	–	–	–
Maximum viscosity	–	2.1	3.4	5.5	24.0 <sup>D</sup>	–	–	–
Kinematic viscosity at 100 °C mm <sup>2</sup> /s								
Minimum viscosity	–	–	–	–	–	5.0	9.0	15.0
Maximum viscosity	–	–	–	–	–	8.9 <sup>D</sup>	14.9 <sup>D</sup>	50.0 <sup>D</sup>
Ramsbottom carbon residue on 10% distillation residue% mass, max	D 524	0.15	0.35	–	–	–	–	–
Ash,% mass, max	D 482	–	–	0.05	0.15	0.10	0.15	–
Sulfur,% mass, max <sup>E</sup>	D 129	0.50	0.50	–	–	–	–	–
Copper, strip corrosion rating, max, 3h at 50 °C	D 130	No. 3	No. 3	–	–	–	–	–
Density at 15 °C, kg/m <sup>3</sup>	D 1298	–	–	–	–	–	–	–
Minimum density	–	–	–	>876 <sup>F</sup>	–	–	–	–
Maximum density	–	850	876	–	–	–	–	–
Pour Point °C, ma <sup>G</sup>	D 97	-18	-6	-6	-6	–	–	H

<sup>A</sup> It is the intent of these classifications that failure to meet any requirement of a given grade does not automatically place an oil in the next lower grade unless in fact it meets all requirements of the lower grade. However, to meet special operating conditions modification of individual limiting requirements may be agreed upon among purchaser, seller, and manufacturer.

<sup>B</sup> The test methods indicated are the approved referee methods.

<sup>C</sup> The amount of water by distillation by Test Method D 95 plus the sediment by extraction by Test Method D 473 shall not exceed the value shown in the table. For Grade No.6 fuel oil, the amount of sediment by extraction shall not exceed 0.50 mass%, and a deduction in quantity shall be made for all water and sediment in excess of 1.0 mass%.

<sup>D</sup> Where low sulfur fuel oil is required, fuel oil falling in the viscosity range of a lower numbered grade down to and including No. 4 can be supplied by agreement between the purchaser and supplier. The viscosity range of the initial shipment shall be identified and advance notice shall be required when changing from one viscosity range and another. This notice shall be in sufficient time to permit the user to make the necessary adjustments.

<sup>E</sup> Other sulfur limits may apply in selected areas in the United States and in other countries.

<sup>F</sup> This limit assures a minimum heating value and also prevents misrepresentation and misapplication of this product as Grade No. 2.

<sup>G</sup> Lower or higher pour points can be specified whenever required by conditions of storage or use. When a pour point less than -18 °C is specified, the minimum viscosity at 40 °C for grade No. 2 shall be 1.7 MM.<sup>2</sup>/S. and the minimum 90% recovered temperature shall be waived.

<sup>H</sup> Where low sulfur fuel oil is required, Grade No. 6 fuel oil will be classified as Low Pour (+15 °C max) or High Pour (no max). Low Pour fuel oil should be used unless tanks and lines are heated.



**Table 13. Detailed Requirements for Fuel Oil – Grade of Fuel Oil**

GRADE OF FUEL OIL	FLASH POINT °F MIN	POUR POINT °F MAX	WATER & SEDIMENT % MAX	CARBON RESIDUE ON 10% RESIDUUM % MAX	ASH% MAX	DISTILLATION TEMPERATURES, °F		
						10% POINT MAX	90% POINT MAX	END POINT MAX
1. Distillate oil intended for vaporizing pot-type burners and other burners requiring this grade.	100 or legal	0	trace	0.15	–	420	–	625
2. A distillate oil for general purpose domestic heating for use in burners not requiring No. 1.	100 or legal	20	0.10	0.35	–	–	675	–
4. An oil for burner installations not equipped with preheating facilities.	130 or legal	20	0.50	–	0.10	–	–	–
5. A residual type oil for burner installations equipped with preheating facilities.	130 or legal	–	1.00	–	0.10	–	–	–
6. An oil for use in burners equipped with preheaters permitting a high viscosity fuel,	130 or legal	–	2.00	–	–	–	–	–

**Distillation** - The distillation test shows the volatility of a fuel and the ease with which it can be vaporized. The test is of greater significance for oils that are to be burned in vaporizing type burners than for the atomizing type. For example, the maximum 10% and 90% distilled temperatures are specified for grade No. 1 fuel. The limiting 10% value assures easy starting in vaporizing type burner and the 90% limit excludes heavier fractions that would be difficult to vaporize.

The limits specified for grade No. 2 heating oil define a product that is acceptable for burners of the atomizing type in household heating installations. Distillation limits are not specified for fuel oils of grades No. 4, 5, and 6.

**Viscosity Limits for Grades Nos 1 and 2** - The viscosity of an oil is a measure of its resistance to flow. In fuel oil it is highly significant since it indicates both the relative ease with which the oil will flow or can be pumped and the ease of atomization.

Viscosity limits for No. 1 and No. 2 grades are specified to help maintain uniform fuel flow in appliances with gravity flow, and to provide satisfactory atomization and constant flow rate through the small nozzles of household burners. For the heavier grades of industrial and bunker fuel oils, viscosity is of major importance, so that adequate preheating facilities can be provided to permit them to be pumped to the burner and to provide good atomization. However, it is equally important that the maximum viscosity under the existing conditions be such that the oil can be pumped satisfactorily from the storage tank to the preheater.

**Density** - Density alone is of little significance as an indication of the burning characteristics of fuel oil. However, when used in conjunction with other properties,

it is of value in mass-volume relationships and in calculating the specific energy (heating value) of an oil.

**Corrosion** - The corrosion test serves to indicate the presence or absence of materials that could corrode copper, brass, and bronze components of the fuel system. This property is specified only for Nos. 1 and 2 distillate fuel oils.

Limited sulfur content of fuel oil can be required to meet federal, state, or local legislation or regulations.

**Nitrogen** - Nitrogen oxide emission regulations have been imposed on certain combustion facilities as a function of fuel nitrogen content. For purposes of these regulations, distillate fuels, low nitrogen residual fuels, and high nitrogen residual fuels have been defined by their nitrogen content. Installations are required to meet different emission standards according to the classification of the fuel being used. When regulations require such a distinction to be made, fuel nitrogen specifications can be needed in the contractual agreement between the purchaser and the supplier.

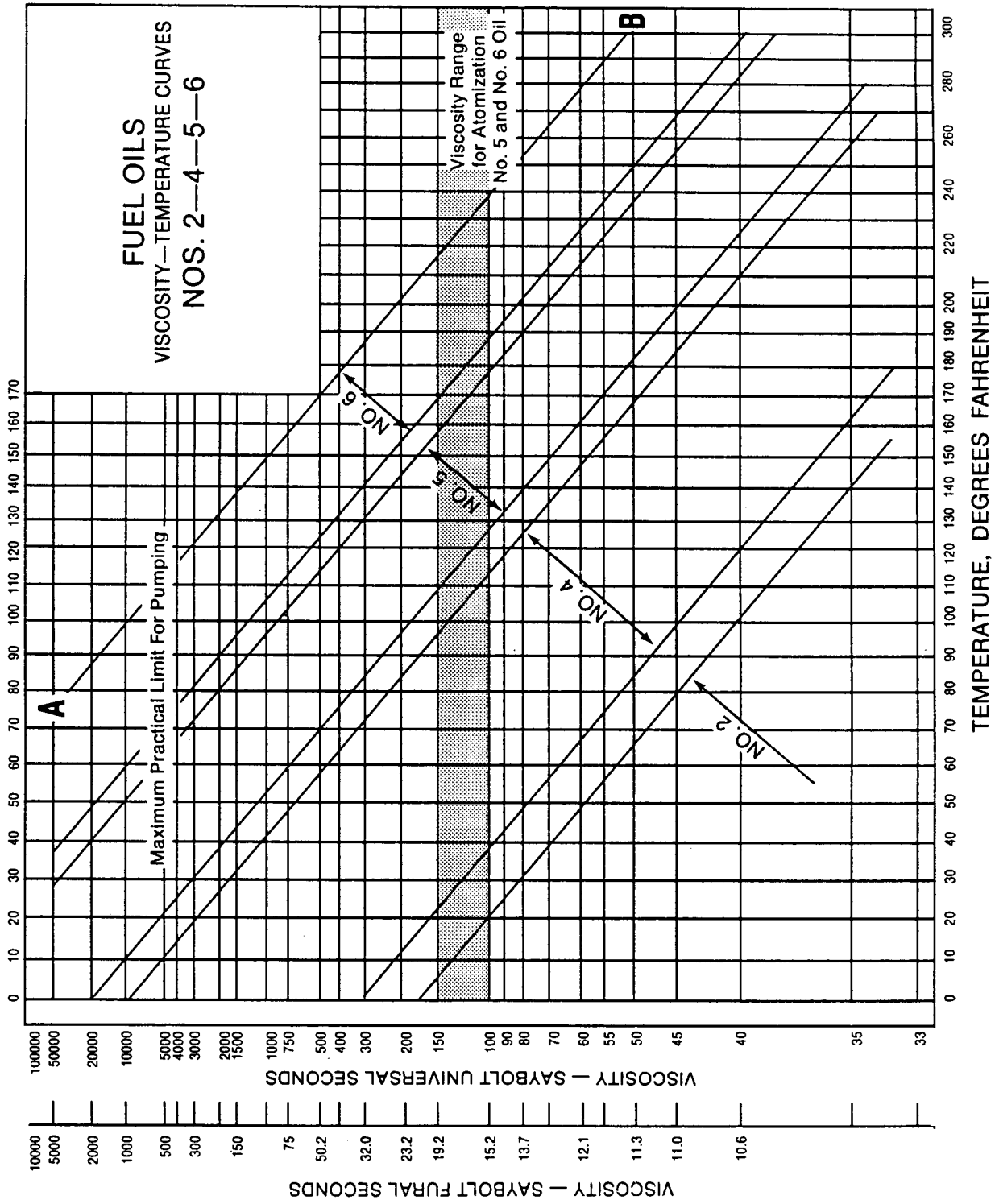


Figure 6. Fuel Oil Viscosity and Temperature Curves

## General Engineering Data

### Water

The relevant properties of water are shown in Table 14.

**Table 14. Thermal Properties of Water**

Water Temperature (Degrees F)	Saturation Pressure (Inches of Mercury Vacuum or (psig))	Specific Volume (Cu ft/lb)	Density (lb/cu ft)	Weight (lb/gal.)	Specific Heat (Btu/lb – Degrees F – Hr)	Specific Gravity
32	29.8	.01602	62.42	8.345	1.0093	1.001
40	29.7	.01602	62.42	8.345	1.0048	1.001
50	29.6	.01603	62.38	8.340	1.0015	1.000
60	29.5	.01604	62.34	8.334	.9995	1.000
70	29.3	.01606	62.27	8.325	.9982	.998
80	28.9	.01608	62.19	8.314	.9975	.997
90	28.6	.01610	62.11	8.303	.9971	.996
100	28.1	.01613	62.00	8.289	.9970	.994
110	27.4	.01617	61.84	8.267	.9971	.991
120	26.6	.01620	61.73	8.253	.9974	.990
130	25.5	.01625	61.54	8.227	.9978	.987
140	24.1	.01629	61.39	8.207	.9984	.984
150	22.4	.01634	61.20	8.182	.9990	.981
160	20.3	.01639	61.01	8.156	.9998	.978
170	17.8	.01645	60.79	8.127	1.0007	.975
180	14.7	.01651	60.57	8.098	1.0017	.971
190	10.9	.01657	60.35	8.068	1.0028	.968
200	6.5	.01663	60.13	8.039	1.0039	.964
210	1.2	.01670	59.88	8.005	1.0052	.960
212	0.0	.01672	59.81	7.996	1.0055	.959
220	2.5	.01677	59.63	7.972	1.0068	.956
240	10.3	.01692	59.10	7.901	1.0104	.947
260	20.7	.01709	58.51	7.822	1.0148	.938
280	34.5	.01726	57.94	7.746	1.020	.929
300	52.3	.01745	57.31	7.662	1.026	.919
350	119.9	.01799	55.59	7.432	1.044	.891
400	232.6	.01864	53.65	7.172	1.067	.860
450	407.9	.0194	51.55	6.892	1.095	.826
500	666.1	.0204	49.02	6.553	1.130	.786
550	1030.5	.0218	45.87	6.132	1.200	.735
600	1528.2	.0236	42.37	5.664	1.362	.679
700	3079.0	.0369	27.10	3.623		.434

Steam

Steam properties are shown in Table 15 and Table 16.

**Table 15. Saturated Steam Properties, Temperature Table (Sheet 1 of 7)**

TEMP °F	ABS. PRESSURE		SPECIFIC VOLUME (ft. <sup>3</sup> /lb)			ENTHALPY (Btu/lb)			ENTROPY (Btu/lb,°F)		
	PSIA	IN. HG	SAT. LIQUID	EVAP.	SAT. VAPOR	SAT. LIQUID	EVAP.	SAT. VAPOR	SAT. LIQUID	EVAP.	SAT. VAPOR
t	p	p	v <sub>f</sub>	v <sub>fg</sub>	v <sub>g</sub>	h <sub>f</sub>	h <sub>fg</sub>	h <sub>g</sub>	s <sub>f</sub>	s <sub>fg</sub>	s <sub>g</sub>
32	0.08854	0.1803	0.01602	3306	3306	0.00	1075.8	1075.8	0.0000	2.1877	2.1877
33	0.09223	0.1878	0.01602	3180	3180	1.01	1075.2	1076.2	0.0020	2.1821	2.1841
34	0.09603	0.1955	0.01602	3061	3061	2.02	1074.7	1076.7	0.0041	2.1764	2.1805
35	0.09995	0.2035	0.01602	2947	2947	3.02	1074.1	1077.1	0.0061	2.1709	2.1770
36	0.10401	0.2118	0.01602	2837	2837	4.03	1073.6	1077.6	0.0081	2.1654	2.1735
37	0.10821	0.2203	0.01602	2732	2732	5.04	1073.0	1078.0	0.0102	2.1598	2.1700
38	0.11256	0.2292	0.01602	2632	2632	6.04	1072.4	1078.4	0.0122	2.1544	2.1666
39	0.11705	0.2383	0.01602	2536	2536	7.04	1071.9	1078.9	0.0142	2.1489	2.1631
40	0.12170	0.2478	0.01602	2444	2444	8.05	1071.3	1079.3	0.0162	2.1435	2.1597
41	0.12652	0.2576	0.01602	2356	2356	9.05	1070.7	1079.7	0.0182	2.1381	2.1563
42	0.13150	0.2677	0.01602	2271	2271	10.05	1070.1	1080.2	0.0202	2.1327	2.1529
43	0.13665	0.2782	0.01602	2190	2190	11.06	1069.5	1080.6	0.0222	2.1274	2.1496
44	0.14199	0.2891	0.01602	2112	2112	12.06	1068.9	1081.0	0.0242	2.1220	2.1462
45	0.14752	0.3004	0.01602	2036.4	2036.4	13.06	1068.4	1081.5	0.0262	2.1167	2.1429
46	0.15323	0.3120	0.01602	1964.3	1964.3	14.06	1067.8	1081.9	0.0282	2.1113	2.1395
47	0.15914	0.3240	0.01603	1895.1	1895.1	15.07	1067.3	1082.4	0.0302	2.1060	2.1362
48	0.16525	0.3364	0.01603	1828.6	1828.6	16.07	1066.7	1082.8	0.0321	2.1008	2.1329
49	0.17157	0.3493	0.01603	1764.7	1764.7	17.07	1066.1	1083.2	0.0341	2.0956	2.1297
50	0.17811	0.3626	0.01603	1703.2	1703.2	18.07	1065.6	1083.7	0.0361	2.0903	2.1264
51	0.18486	0.3764	0.01603	1644.2	1644.2	19.07	1065.0	1084.1	0.0380	2.0852	2.1232
52	0.19182	0.3906	0.01603	1587.6	1587.6	20.07	1064.4	1084.5	0.0400	2.0799	2.1199
53	0.19900	0.4052	0.01603	1533.3	1533.3	21.07	1063.9	1085.0	0.0420	2.0747	2.1167
54	0.20642	0.4203	0.01603	1481.0	1481.0	22.07	1063.3	1085.4	0.0439	2.0697	2.1136
55	0.2141	0.4359	0.01603	1430.7	1430.7	23.07	1062.7	1085.8	0.0459	2.0645	2.1104
56	0.2220	0.4520	0.01603	1382.4	1382.4	24.06	1062.2	1086.3	0.0478	2.0594	2.1072
57	0.2302	0.4686	0.01603	1335.9	1335.9	25.06	1061.6	1086.7	0.0497	2.0544	2.1041
58	0.2386	0.4858	0.01604	1291.1	1291.1	26.06	1061.0	1087.1	0.0517	2.0493	2.1010
59	0.2473	0.5035	0.01604	1248.1	1248.1	27.06	1060.5	1087.6	0.0536	2.0443	2.0979
60	0.2563	0.5218	0.01604	1206.6	1206.7	28.06	1059.9	1088.0	0.0555	2.0393	2.0948
61	0.2655	0.5407	0.01604	1166.8	1166.8	29.06	1059.3	1088.4	0.0574	2.0343	2.0917
62	0.2751	0.5601	0.01604	1128.4	1128.4	30.05	1058.8	1088.9	0.0593	2.0293	2.0886
63	0.2850	0.5802	0.01604	1091.4	1091.4	31.05	1058.2	1089.3	0.0613	2.0243	2.0856
64	0.2951	0.6009	0.01605	1055.7	1055.7	32.05	1057.6	1089.7	0.0632	2.0194	2.0826
65	0.3056	0.6222	0.01605	1021.4	1021.4	33.05	1057.1	1090.2	0.0651	2.0145	2.0796
66	0.3164	0.6442	0.01605	988.4	988.4	34.05	1056.5	1090.6	0.0670	2.0096	2.0766
67	0.3276	0.6669	0.01605	956.6	956.6	35.05	1056.0	1091.0	0.0689	2.0047	2.0736
68	0.3390	0.6903	0.01605	925.9	925.9	36.04	1055.5	1091.5	0.0708	1.9998	2.0706
69	0.3509	0.7144	0.01605	896.3	896.3	37.04	1054.9	1091.9	0.0726	1.9950	2.0676
70	0.3631	0.7392	0.01606	867.8	867.9	38.04	1054.3	1092.3	0.0745	1.9902	2.0647
71	0.3756	0.7648	0.01606	840.4	840.4	39.04	1053.8	1092.8	0.0764	1.9854	2.0618
72	0.3886	0.7912	0.01606	813.9	813.9	40.04	1053.2	1093.2	0.0783	1.9805	2.0588
73	0.4019	0.8183	0.01606	788.3	788.4	41.03	1052.6	1093.6	0.0802	1.9757	2.0559
74	0.4156	0.8462	0.01606	763.7	763.8	42.03	1052.1	1094.1	0.0820	1.9710	2.0530
75	0.4298	0.8750	0.01607	740.0	740.0	43.03	1051.5	1094.5	0.0839	1.9663	2.0502

Table I4-15. Saturated Steam Properties, Temperature Table (Sheet 2 of 7)

TEMP °F	ABS. PRESSURE		SPECIFIC VOLUME (ft. <sup>3</sup> /lb)			ENTHALPY (Btu/lb)			ENTROPY (Btu/lb,°F)		
	PSIA	IN. HG	SAT. LIQUID	EVAP.	SAT. VAPOR	SAT. LIQUID	EVAP.	SAT. VAPOR	SAT. LIQUID	EVAP.	SAT. VAPOR
	t	p	p	v <sub>f</sub>	v <sub>fg</sub>	v <sub>g</sub>	h <sub>f</sub>	h <sub>fg</sub>	h <sub>g</sub>	s <sub>f</sub>	s <sub>fg</sub>
76	0.4443	0.9046	0.01607	717.1	717.1	44.03	1050.9	1094.9	0.0858	1.9615	2.0473
77	0.4593	0.9352	0.01607	694.9	694.9	45.02	1050.4	1095.4	0.0876	1.9569	2.0445
78	0.4747	0.9666	0.01607	673.6	673.6	46.02	1049.8	1095.8	0.0895	1.9521	2.0416
79	0.4906	0.9989	0.01608	653.0	653.0	47.02	1049.2	1096.2	0.0913	1.9475	2.0388
80	0.5069	1.0321	0.01608	633.1	633.1	48.02	1048.6	1096.6	0.0932	1.9428	2.0360
81	0.5237	1.0664	0.01608	613.9	613.9	49.02	1048.1	1097.1	0.0950	1.9382	2.0332
82	0.5410	1.1016	0.01608	595.3	595.3	50.01	1047.5	1097.5	0.0969	1.9335	2.0304
83	0.5588	1.1378	0.01609	577.4	577.4	51.01	1046.9	1097.9	0.0987	1.9290	2.0277
84	0.5771	1.1750	0.01609	560.1	560.2	52.01	1046.4	1098.4	0.1005	1.9244	2.0249
85	0.5959	1.2133	0.01609	543.4	543.5	53.00	1045.8	1098.8	0.1024	1.9198	2.0222
86	0.6152	1.2527	0.01609	527.3	527.3	54.00	1045.2	1099.2	0.1042	1.9153	2.0195
87	0.6351	1.2931	0.01610	511.7	511.7	55.00	1044.7	1099.7	0.1060	1.9108	2.0168
88	0.6556	1.3347	0.01610	496.6	496.7	56.00	1044.1	1100.1	0.1079	1.9062	2.0141
89	0.6766	1.3775	0.01610	482.1	482.1	56.99	1043.5	1100.5	0.1097	1.9017	2.0114
90	0.6982	1.4215	0.01610	468.0	468.0	57.99	1042.9	1100.9	0.1115	1.8972	2.0087
91	0.7204	1.4667	0.01611	454.4	454.4	58.99	1042.4	1101.4	0.1133	1.8927	2.0060
92	0.7432	1.5131	0.01611	441.2	441.3	59.99	1041.8	1101.8	0.1151	1.8883	2.0034
93	0.7666	1.5608	0.01611	428.5	428.5	60.98	1041.2	1102.2	0.1169	1.8838	2.0007
94	0.7906	1.6097	0.01612	416.2	416.2	61.98	1040.7	1102.6	0.1187	1.8794	1.9981
95	0.8153	1.6600	0.01612	404.3	404.3	62.98	1040.1	1103.1	0.1205	1.8750	1.9955
96	0.8407	1.7117	0.01612	392.8	392.8	63.98	1039.5	1103.5	0.1223	1.8706	1.9929
97	0.8668	1.7647	0.01612	381.7	381.7	64.97	1038.9	1103.9	0.1241	1.8662	1.9903
98	0.8935	1.8192	0.01613	370.9	370.9	65.97	1038.4	1104.4	0.1259	1.8618	1.9877
99	0.9210	1.8751	0.01613	360.4	360.5	66.97	1037.8	1104.8	0.1277	1.8575	1.9852
100	0.9492	1.9325	0.01613	350.3	350.4	67.97	1037.2	1105.2	0.1295	1.8531	1.9826
101	0.9781	1.9915	0.01614	340.6	340.6	68.96	1036.6	1105.6	0.1313	1.8488	1.9801
102	1.0078	2.0519	0.01614	331.1	331.1	69.96	1036.1	1106.1	0.1330	1.8445	1.9775
103	1.0382	2.1138	0.01614	321.9	321.9	70.96	1035.5	1106.5	0.1348	1.8402	1.9750
104	1.0695	2.1775	0.01615	313.1	313.1	71.96	1034.9	1106.9	0.1366	1.8359	1.9725
105	1.1016	2.2429	0.01615	304.5	304.5	72.95	1034.3	1107.3	0.1383	1.8317	1.9700
106	1.1345	2.3099	0.01615	296.1	296.2	73.95	1033.8	1107.8	0.1401	1.8274	1.9675
107	1.1683	2.3786	0.01616	288.1	288.1	74.95	1033.3	1108.2	0.1419	1.8232	1.9651
108	1.2029	2.4491	0.01616	280.3	280.3	75.95	1032.7	1108.6	0.1436	1.8190	1.9626
109	1.2384	2.5214	0.01616	272.7	272.7	76.94	1032.1	1109.0	0.1454	1.8147	1.9601
110	1.2748	2.5955	0.01617	265.3	265.4	77.94	1031.6	1109.5	0.1471	1.8106	1.9577
111	1.3121	2.6715	0.01617	258.2	258.3	78.94	1031.0	1109.9	0.1489	1.8064	1.9553
112	1.3504	2.7494	0.01617	251.3	251.4	79.94	1030.4	1110.3	0.1506	1.8023	1.9529
113	1.3896	2.8293	0.01618	244.6	244.7	80.94	1029.8	1110.7	0.1524	1.7981	1.9505
114	1.4298	2.9111	0.01618	238.2	238.2	81.93	1029.2	1111.1	0.1541	1.7940	1.9481
115	1.4709	2.9948	0.01618	231.9	231.9	82.93	1028.7	1111.6	0.1559	1.7898	1.9457
116	1.5130	3.0806	0.01619	225.8	225.8	83.93	1028.1	1112.0	0.1576	1.7857	1.9433
117	1.5563	3.1687	0.01619	219.9	219.9	84.93	1027.5	1112.4	0.1593	1.7816	1.9409
118	1.6006	3.2589	0.01620	214.2	214.2	85.92	1026.9	1112.8	0.1610	1.7776	1.9386
119	1.6459	3.3512	0.01620	208.6	208.7	86.92	1026.3	1113.2	0.1628	1.7735	1.9363
120	1.6924	3.4458	0.01620	203.25	203.27	87.92	1025.8	1113.7	0.1645	1.7694	1.9339
121	1.7400	3.5427	0.01621	198.02	198.03	88.92	1025.2	1114.1	0.1662	1.7654	1.9316
122	1.7888	3.6420	0.01621	192.93	192.95	89.92	1024.6	1114.5	0.1679	1.7614	1.9293
123	1.8387	3.7436	0.01622	188.01	188.02	90.91	1024.0	1114.9	0.1696	1.7574	1.9270
124	1.8897	3.8475	0.01622	183.23	183.25	91.91	1023.4	1115.3	0.1714	1.7533	1.9247
125	1.9420	3.9539	0.01622	178.59	178.61	92.91	1022.9	1115.8	0.1731	1.7493	1.9224

Table I4-15. Saturated Steam Properties, Temperature Table (Sheet 3 of 7)

TEMP °F	ABS. PRESSURE		SPECIFIC VOLUME (ft. <sup>3</sup> /lb)			ENTHALPY (Btu/lb)			ENTROPY (Btu/lb, °F)		
	PSIA	IN. HG	SAT. LIQUID	EVAP.	SAT. VAPOR	SAT. LIQUID	EVAP.	SAT. VAPOR	SAT. LIQUID	EVAP.	SAT. VAPOR
	t	p	v <sub>f</sub>	v <sub>fg</sub>	v <sub>g</sub>	h <sub>f</sub>	h <sub>fg</sub>	h <sub>g</sub>	s <sub>f</sub>	s <sub>fg</sub>	s <sub>g</sub>
126	1.9955	4.0629	0.01623	174.09	174.10	93.91	1022.3	1116.2	0.1748	1.7454	1.9202
127	2.0503	4.1745	0.01623	169.71	169.72	94.91	1021.7	1116.6	0.1765	1.7414	1.9179
128	2.1064	4.2887	0.01624	165.46	165.47	95.91	1021.1	1117.0	0.1782	1.7374	1.9156
129	2.1638	4.4055	0.01624	161.33	161.35	96.90	1020.5	1117.4	0.1799	1.7335	1.9134
130	2.2225	4.5251	0.01625	157.32	157.34	97.90	1020.0	1117.9	0.1816	1.7296	1.9112
131	2.2826	4.6474	0.01625	153.43	153.44	98.90	1019.4	1118.3	0.1833	1.7257	1.9090
132	2.3440	4.7725	0.01626	149.65	149.66	99.90	1018.8	1118.7	0.1849	1.7218	1.9067
133	2.4069	4.9005	0.01626	145.97	145.99	100.90	1018.2	1119.1	0.1866	1.7179	1.9045
134	2.4712	5.0314	0.01626	142.40	142.42	101.90	1017.6	1119.5	0.1883	1.7141	1.9023
135	2.5370	5.1653	0.01627	138.93	138.95	102.90	1017.0	1119.9	0.1900	1.7102	1.9002
136	2.6042	5.3022	0.01627	135.56	135.58	103.90	1016.4	1120.3	0.1917	1.7063	1.8980
137	2.6729	5.4421	0.01628	132.29	132.30	104.89	1015.9	1120.8	0.1934	1.7024	1.8958
138	2.7432	5.5852	0.01628	129.10	129.12	105.89	1015.3	1121.2	0.1950	1.6987	1.8937
139	2.8151	5.7316	0.01629	126.00	126.02	106.89	1014.7	1121.6	0.1967	1.6948	1.8915
140	2.8886	5.8812	0.01629	122.99	123.01	107.89	1014.1	1122.0	0.1984	1.6910	1.8894
141	2.9637	6.0341	0.01630	120.06	120.08	108.89	1013.5	1122.4	0.2000	1.6873	1.8873
142	3.0404	6.1903	0.01630	117.22	117.23	109.89	1012.9	1122.8	0.2016	1.6835	1.8851
143	3.1188	6.3500	0.01631	114.45	114.46	110.89	1012.3	1123.2	0.2033	1.6797	1.8830
144	3.1990	6.5132	0.01631	111.75	111.77	111.89	1011.7	1123.6	0.2049	1.6760	1.8809
145	3.281	6.680	0.01632	109.13	109.15	112.89	1011.2	1124.1	0.2066	1.6722	1.8788
146	3.365	6.850	0.01632	106.58	106.60	113.89	1010.6	1124.5	0.2083	1.6685	1.8768
147	3.450	7.024	0.01633	104.10	104.12	114.89	1010.0	1124.9	0.2099	1.6648	1.8747
148	3.537	7.202	0.01633	101.69	101.71	115.89	1009.4	1125.3	0.2116	1.6610	1.8726
149	3.627	7.384	0.01634	99.34	99.36	116.89	1008.8	1125.7	0.2133	1.6573	1.8706
150	3.718	7.569	0.01634	97.06	97.07	117.89	1008.2	1126.1	0.2149	1.6537	1.8685
151	3.811	7.759	0.01635	94.83	94.85	118.89	1007.6	1126.5	0.2165	1.6500	1.8665
152	3.906	7.952	0.01635	92.67	92.68	119.89	1007.0	1126.9	0.2182	1.6463	1.8645
153	4.003	8.150	0.01636	90.56	90.57	120.89	1006.4	1127.3	0.2198	1.6427	1.8624
154	4.102	8.351	0.01636	88.51	88.52	121.89	1005.8	1127.7	0.2214	1.6390	1.8604
155	4.203	8.557	0.01637	86.51	86.52	122.89	1005.2	1128.1	0.2230	1.6354	1.8584
156	4.306	8.767	0.01637	84.56	84.58	123.89	1004.7	1128.6	0.2246	1.6318	1.8564
157	4.411	8.981	0.01638	82.67	82.69	124.89	1004.1	1129.0	0.2263	1.6282	1.8545
158	4.519	9.200	0.01638	80.82	80.84	125.89	1003.5	1129.4	0.2279	1.6246	1.8525
159	4.629	9.424	0.01639	79.03	79.04	126.89	1002.9	1129.8	0.2295	1.6210	1.8505
160	4.741	9.652	0.01639	77.27	77.29	127.89	1002.3	1130.2	0.2311	1.6174	1.8485
161	4.855	9.885	0.01640	75.57	75.58	128.89	1001.7	1130.6	0.2327	1.6138	1.8466
162	4.971	10.122	0.01640	73.91	73.92	129.89	1001.1	1131.0	0.2343	1.6103	1.8446
163	5.090	10.364	0.01641	72.29	72.30	130.89	1000.5	1131.4	0.2360	1.6067	1.8427
164	5.212	10.611	0.01641	70.71	70.73	131.89	999.9	1131.8	0.2376	1.6032	1.8408
165	5.335	10.863	0.01642	69.17	69.19	132.89	999.3	1132.2	0.2392	1.5997	1.8388
166	5.461	11.120	0.01643	67.67	67.69	133.89	998.7	1132.6	0.2408	1.5961	1.8369
167	5.590	11.382	0.01643	66.21	66.23	134.89	998.1	1133.0	0.2424	1.5926	1.8350
168	5.721	11.649	0.01644	64.79	64.80	135.90	997.5	1133.4	0.2440	1.5891	1.8331
169	5.855	11.921	0.01644	63.40	63.41	136.90	996.9	1133.8	0.2455	1.5857	1.8312
170	5.992	12.199	0.01645	62.04	62.06	137.90	996.3	1134.2	0.2472	1.5822	1.8293
171	6.131	12.483	0.01645	60.72	60.74	138.90	995.7	1134.6	0.2488	1.5787	1.8275
172	6.273	12.772	0.01646	59.43	59.45	139.90	995.1	1135.0	0.2503	1.5753	1.8256
173	6.417	13.066	0.01647	58.18	58.20	140.90	994.5	1135.4	0.2519	1.5718	1.8237
174	6.565	13.366	0.01647	56.96	56.97	141.90	993.9	1135.8	0.2535	1.5684	1.8219
175	6.715	13.671	0.01648	55.76	55.78	142.91	993.3	1136.2	0.2551	1.5649	1.8200

# General Engineering Data

Table I4-15. Saturated Steam Properties, Temperature Table (Sheet 4 of 7)

TEMP °F	ABS. PRESSURE		SPECIFIC VOLUME (ft. <sup>3</sup> /lb)			ENTHALPY (Btu/lb)			ENTROPY (Btu/lb,°F)		
	PSIA	IN. HG	SAT. LIQUID	EVAP.	SAT. VAPOR	SAT. LIQUID	EVAP.	SAT. VAPOR	SAT. LIQUID	EVAP.	SAT. VAPOR
t	p	p	v <sub>f</sub>	v <sub>fg</sub>	v <sub>g</sub>	h <sub>f</sub>	h <sub>fg</sub>	h <sub>g</sub>	s <sub>f</sub>	s <sub>fg</sub>	s <sub>g</sub>
176	6.868	13.983	0.01648	54.60	54.61	143.91	992.7	1136.6	0.2567	1.5615	1.8182
177	7.024	14.301	0.01649	53.46	53.48	144.91	992.1	1137.0	0.2583	1.5581	1.8164
178	7.183	14.625	0.01650	52.35	52.37	145.91	991.5	1137.4	0.2599	1.5547	1.8146
179	7.345	14.955	0.01650	51.27	51.29	146.92	990.8	1137.7	0.2614	1.5513	1.8127
180	7.510	15.291	0.01651	50.21	50.23	147.92	990.2	1138.1	0.2630	1.5480	1.8109
181	7.678	15.633	0.01651	49.18	49.20	148.92	989.6	1138.5	0.2645	1.5446	1.8091
182	7.850	15.982	0.01652	48.18	48.19	149.92	989.0	1138.9	0.2661	1.5412	1.8073
183	8.024	16.337	0.01653	47.19	47.21	150.93	988.4	1139.3	0.2676	1.5379	1.8055
184	8.202	16.699	0.01653	46.24	46.25	151.93	987.8	1139.7	0.2692	1.5346	1.8038
185	8.383	17.068	0.01654	45.29	45.31	152.93	987.2	1140.1	0.2708	1.5312	1.8020
186	8.567	17.443	0.01654	44.39	44.40	153.94	986.6	1140.5	0.2723	1.5279	1.8002
187	8.755	17.825	0.01655	43.50	43.51	154.94	986.0	1140.9	0.2739	1.5246	1.7985
188	8.946	18.214	0.01656	42.62	42.64	155.94	985.4	1141.3	0.2754	1.5213	1.7967
189	9.141	18.611	0.01656	41.77	41.79	156.95	984.8	1141.7	0.2770	1.5180	1.7950
190	9.339	19.014	0.01657	40.94	40.96	157.95	984.1	1142.0	0.2785	1.5147	1.7932
191	9.541	19.425	0.01658	40.13	40.15	158.95	983.4	1142.4	0.2801	1.5114	1.7915
192	9.746	19.843	0.01658	39.34	39.36	159.96	982.8	1142.8	0.2816	1.5082	1.7898
193	9.955	20.269	0.01659	38.57	38.58	160.96	982.2	1143.2	0.2831	1.5049	1.7880
194	10.168	20.703	0.01659	37.81	37.83	161.97	981.6	1143.6	0.2846	1.5017	1.7863
195	10.385	21.144	0.01660	37.07	37.09	162.97	981.0	1144.0	0.2862	1.4984	1.7846
196	10.605	21.593	0.01661	36.35	36.37	163.97	980.4	1144.4	0.2877	1.4952	1.7829
197	10.830	22.050	0.01661	35.64	35.66	164.98	979.7	1144.7	0.2892	1.4920	1.7812
198	11.058	22.515	0.01662	34.95	34.97	165.98	979.1	1145.1	0.2907	1.4888	1.7795
199	11.290	22.987	0.01663	34.28	34.30	166.99	978.5	1145.5	0.2923	1.4856	1.7779
200	11.526	23.467	0.01663	33.62	33.64	167.99	977.9	1145.9	0.2938	1.4824	1.7762
202	12.011	24.455	0.01665	32.35	32.37	170.00	976.6	1146.6	0.2969	1.4760	1.7729
204	12.512	25.475	0.01666	31.14	31.15	172.02	975.4	1147.4	0.2999	1.4697	1.7696
206	13.031	26.531	0.01667	29.97	29.99	174.03	974.2	1148.2	0.3029	1.4634	1.7663
208	13.568	27.625	0.01669	28.86	28.88	176.04	972.9	1148.9	0.3059	1.4571	1.7630
210	14.123	28.755	0.01670	27.80	27.82	178.05	971.6	1149.7	0.3090	1.4508	1.7598
212	14.696	29.922	0.01672	26.78	26.80	180.07	970.3	1150.4	0.3120	1.4446	1.7566
214	15.289	31.129	0.01673	25.81	25.83	182.08	969.0	1151.1	0.3149	1.4385	1.7534
216	15.901	32.375	0.01674	24.88	24.90	184.10	967.8	1151.9	0.3179	1.4323	1.7502
218	16.533	33.662	0.01676	23.99	24.01	186.11	966.5	1152.6	0.3209	1.4262	1.7471
220	17.186	34.992	0.01677	23.13	23.15	188.13	965.2	1153.4	0.3239	1.4201	1.7440
222	17.861	36.365	0.01679	22.31	22.33	190.15	963.9	1154.1	0.3268	1.4141	1.7409
224	18.557	37.782	0.01680	21.53	21.55	192.17	962.6	1154.8	0.3298	1.4080	1.7378
226	19.275	39.244	0.01682	20.78	20.79	194.18	961.3	1155.5	0.3328	1.4020	1.7348
228	20.016	40.753	0.01683	20.06	20.07	196.20	960.1	1156.3	0.3357	1.3961	1.7318
230	20.780	42.308	0.01684	19.365	19.382	198.23	958.8	1157.0	0.3387	1.3901	1.7288
232	21.567	43.911	0.01686	18.703	18.720	200.25	957.4	1157.7	0.3416	1.3842	1.7258
234	22.379	45.564	0.01688	18.067	18.084	202.27	956.1	1158.4	0.3444	1.3784	1.7228
236	23.217	47.269	0.01689	17.456	17.473	204.29	954.8	1159.1	0.3473	1.3725	1.7199
238	24.080	49.027	0.01691	16.869	16.886	206.32	953.5	1159.8	0.3502	1.3667	1.7169
240	24.969	50.837	0.01692	16.306	16.323	208.34	952.2	1160.5	0.3531	1.3609	1.7140
242	25.884	52.701	0.01694	15.765	15.782	210.37	950.8	1161.2	0.3560	1.3551	1.7111
244	26.827	54.620	0.01696	15.245	15.262	212.39	949.5	1161.9	0.3589	1.3494	1.7083
246	27.798	56.597	0.01697	14.745	14.762	214.42	948.2	1162.6	0.3618	1.3436	1.7054
248	28.797	58.631	0.01699	14.265	14.282	216.45	946.8	1163.3	0.3647	1.3379	1.7026
250	29.825	60.725	0.01700	13.804	13.821	218.48	945.5	1164.0	0.3675	1.3323	1.6998



Table I4-15. Saturated Steam Properties, Temperature Table (Sheet 5 of 7)

TEMP °F	ABS. PRESSURE		SPECIFIC VOLUME (ft. <sup>3</sup> /lb)			ENTHALPY (Btu/lb)			ENTROPY (Btu/lb,°F)		
	PSIA	IN. HG	SAT. LIQUID	EVAP.	SAT. VAPOR	SAT. LIQUID	EVAP.	SAT. VAPOR	SAT. LIQUID	EVAP.	SAT. VAPOR
	t	p	v <sub>f</sub>	v <sub>fg</sub>	v <sub>g</sub>	h <sub>f</sub>	h <sub>fg</sub>	h <sub>g</sub>	s <sub>f</sub>	s <sub>fg</sub>	s <sub>g</sub>
252	30.884	62.880	0.01702	13.360	13.377	220.51	944.2	1164.7	0.3704	1.3266	1.6970
254	31.973	65.098	0.01704	12.933	12.950	222.54	942.8	1165.3	0.3732	1.3210	1.6942
256	33.093	67.378	0.01705	12.522	12.539	224.58	941.4	1166.0	0.3761	1.3154	1.6915
258	34.245	69.723	0.01707	12.127	12.144	226.61	940.1	1166.7	0.3789	1.3099	1.6888
260	35.429	72.134	0.01709	11.746	11.763	228.64	938.7	1167.3	0.3817	1.3043	1.6860
262	36.646	74.612	0.01710	11.379	11.396	230.68	937.3	1168.0	0.3845	1.2988	1.6833
264	37.897	77.159	0.01712	11.026	11.043	232.72	936.0	1168.7	0.3874	1.2933	1.6807
266	39.182	79.775	0.01714	10.687	10.704	234.76	934.5	1169.3	0.3902	1.2878	1.6780
268	40.502	82.463	0.01715	10.359	10.376	236.80	933.2	1170.0	0.3930	1.2824	1.6753
270	41.858	85.225	0.01717	10.044	10.061	238.84	931.8	1170.6	0.3958	1.2769	1.6727
272	43.252	88.062	0.01719	9.739	9.756	240.88	930.3	1171.2	0.3986	1.2715	1.6701
274	44.682	90.974	0.01721	9.446	9.463	242.92	929.0	1171.9	0.4014	1.2661	1.6675
276	46.150	93.963	0.01722	9.163	9.181	244.96	927.5	1172.5	0.4041	1.2608	1.6649
278	47.657	97.031	0.01724	8.891	8.908	247.01	926.1	1173.1	0.4069	1.2554	1.6623
280	49.203	100.18	0.01726	8.628	8.645	249.06	924.7	1173.8	0.4096	1.2501	1.6597
282	50.790	103.41	0.01728	8.374	8.391	251.10	923.3	1174.4	0.4124	1.2448	1.6572
284	52.418	106.72	0.01730	8.129	8.146	253.15	921.8	1175.0	0.4152	1.2395	1.6547
286	54.088	110.12	0.01732	7.892	7.910	255.20	920.4	1175.6	0.4179	1.2343	1.6522
288	55.800	113.61	0.01733	7.664	7.682	257.26	918.9	1176.2	0.4207	1.2290	1.6497
290	57.556	117.19	0.01735	7.444	7.461	259.31	917.5	1176.8	0.4234	1.2238	1.6472
292	59.356	120.85	0.01737	7.231	7.248	261.36	916.0	1177.4	0.4261	1.2186	1.6447
294	61.201	124.61	0.01739	7.025	7.043	263.42	914.6	1178.0	0.4288	1.2134	1.6422
296	63.091	128.46	0.01741	6.827	6.844	265.48	913.1	1178.6	0.4315	1.2083	1.6398
298	65.028	132.40	0.01743	6.635	6.652	267.53	911.6	1179.1	0.4343	1.2031	1.6374
300	67.013	136.44	0.01745	6.449	6.466	269.59	910.1	1179.7	0.4369	1.1980	1.6350
302	69.046	140.58	0.01747	6.269	6.287	271.66	908.6	1180.3	0.4397	1.1929	1.6326
304	71.127	144.82	0.01749	6.096	6.114	273.72	907.2	1180.9	0.4424	1.1878	1.6302
306	73.259	149.16	0.01751	5.928	5.946	275.78	905.6	1181.4	0.4450	1.1828	1.6278
308	75.442	153.60	0.01753	5.766	5.783	277.85	904.1	1182.0	0.4477	1.1777	1.6254
310	77.68	—	0.01755	5.609	5.626	279.92	902.6	1182.5	0.4504	1.1727	1.6231
312	79.96	—	0.01757	5.457	5.474	281.99	901.0	1183.1	0.4530	1.1677	1.6207
314	82.30	—	0.01759	5.310	5.327	284.06	899.5	1183.6	0.4557	1.1627	1.6184
316	84.70	—	0.01761	5.167	5.185	286.13	898.0	1184.1	0.4584	1.1577	1.6161
318	87.15	—	0.01763	5.030	5.047	288.20	896.5	1184.7	0.4611	1.1527	1.6138
320	89.66	—	0.01765	4.896	4.914	290.28	894.9	1185.2	0.4637	1.1478	1.6115
322	92.22	—	0.01768	4.767	4.785	292.36	893.3	1185.7	0.4664	1.1428	1.6092
324	94.84	—	0.01770	4.642	4.660	294.43	891.8	1186.2	0.4690	1.1379	1.6069
326	97.52	—	0.01772	4.521	4.538	296.52	890.2	1186.7	0.4717	1.1330	1.6047
328	100.26	—	0.01774	4.403	4.421	298.60	888.6	1187.2	0.4743	1.1281	1.6024
330	103.06	—	0.01776	4.289	4.307	300.68	887.0	1187.7	0.4769	1.1233	1.6002
332	105.92	—	0.01778	4.179	4.197	302.77	885.4	1188.2	0.4795	1.1184	1.5979
334	108.85	—	0.01781	4.072	4.090	304.86	883.8	1188.7	0.4821	1.1136	1.5957
336	111.84	—	0.01783	3.968	3.986	306.95	882.2	1189.2	0.4847	1.1088	1.5935
338	114.89	—	0.01785	3.868	3.886	309.04	880.6	1189.6	0.4873	1.1040	1.5913
340	118.01	—	0.01787	3.770	3.788	311.13	879.0	1190.1	0.4900	1.0992	1.5891
342	121.20	—	0.01790	3.675	3.693	313.23	877.4	1190.6	0.4926	1.0944	1.5870
344	124.45	—	0.01792	3.584	3.602	315.33	875.7	1191.0	0.4952	1.0896	1.5848
346	127.77	—	0.01794	3.495	3.513	317.43	874.1	1191.5	0.4978	1.0848	1.5826
348	131.17	—	0.01797	3.408	3.426	319.53	872.4	1191.9	0.5004	1.0801	1.5805
350	134.63	—	0.01799	3.324	3.342	321.63	870.7	1192.3	0.5029	1.0754	1.5783

# General Engineering Data

Table I4-15. Saturated Steam Properties, Temperature Table (Sheet 6 of 7)

TEMP °F	ABS. PRESSURE		SPECIFIC VOLUME (ft. <sup>3</sup> /lb)			ENTHALPY (Btu/lb)			ENTROPY (Btu/lb,°F)		
	PSIA	IN. HG	SAT. LIQUID	EVAP.	SAT. VAPOR	SAT. LIQUID	EVAP.	SAT. VAPOR	SAT. LIQUID	EVAP.	SAT. VAPOR
	t	p	v <sub>f</sub>	v <sub>fg</sub>	v <sub>g</sub>	h <sub>f</sub>	h <sub>fg</sub>	h <sub>g</sub>	s <sub>f</sub>	s <sub>fg</sub>	s <sub>g</sub>
352	138.16	—	0.01801	3.243	3.261	323.74	869.1	1192.8	0.5055	1.0707	1.5762
354	141.77	—	0.01804	3.164	3.182	325.85	867.3	1193.2	0.5081	1.0660	1.5741
356	145.45	—	0.01806	3.087	3.105	327.96	865.6	1193.6	0.5106	1.0613	1.5719
358	149.21	—	0.01808	3.012	3.030	330.07	863.9	1194.0	0.5132	1.0566	1.5698
360	153.04	—	0.01811	2.939	2.957	332.18	862.2	1194.4	0.5158	1.0519	1.5677
362	156.95	—	0.01813	2.869	2.887	334.30	860.5	1194.8	0.5183	1.0473	1.5656
364	160.93	—	0.01816	2.801	2.819	336.42	858.8	1195.2	0.5209	1.0426	1.5635
366	165.00	—	0.01818	2.734	2.752	338.54	857.1	1195.6	0.5235	1.0380	1.5615
368	169.15	—	0.01821	2.669	2.687	340.66	855.3	1196.0	0.5260	1.0334	1.5594
370	173.37	—	0.01823	2.606	2.625	342.79	853.5	1196.3	0.5286	1.0287	1.5573
372	177.68	—	0.01826	2.545	2.564	344.91	851.8	1196.7	0.5311	1.0241	1.5553
374	182.07	—	0.01829	2.486	2.504	347.04	850.0	1197.0	0.5336	1.0196	1.5532
376	186.55	—	0.01831	2.428	2.446	349.18	848.2	1197.4	0.5362	1.0150	1.5512
378	191.12	—	0.01834	2.372	2.390	351.31	846.4	1197.7	0.5388	1.0104	1.5492
380	195.77	—	0.01836	2.317	2.335	353.45	844.6	1198.1	0.5413	1.0059	1.5471
382	200.50	—	0.01839	2.264	2.282	355.59	842.8	1198.4	0.5438	1.0013	1.5451
384	205.33	—	0.01842	2.212	2.231	357.73	841.0	1198.7	0.5463	0.9968	1.5431
386	210.25	—	0.01844	2.162	2.180	359.88	839.1	1199.0	0.5488	0.9923	1.5411
388	215.26	—	0.01847	2.113	2.131	362.02	837.3	1199.3	0.5514	0.9877	1.5391
390	220.37	—	0.01850	2.0651	2.0836	364.17	835.4	1199.6	0.5539	0.9832	1.5371
392	225.56	—	0.01853	2.0187	2.0372	366.33	833.6	1199.9	0.5564	0.9787	1.5351
394	230.85	—	0.01855	1.9734	1.9920	368.48	831.7	1200.2	0.5589	0.9742	1.5331
396	236.24	—	0.01858	1.9293	1.9479	370.64	829.9	1200.5	0.5614	0.9698	1.5311
398	241.73	—	0.01861	1.8864	1.9050	372.80	827.9	1200.7	0.5639	0.9653	1.5292
400	247.31	—	0.01864	1.8447	1.8633	374.97	826.0	1201.0	0.5664	0.9608	1.5272
405	261.71	—	0.01871	1.7448	1.7635	380.39	821.2	1201.6	0.5726	0.9497	1.5223
410	276.75	—	0.01878	1.6512	1.6700	385.83	816.3	1202.1	0.5788	0.9386	1.5174
415	292.45	—	0.01886	1.5635	1.5823	391.29	811.3	1202.6	0.5850	0.9276	1.5126
420	308.83	—	0.01894	1.4811	1.5000	396.77	806.3	1203.1	0.5912	0.9166	1.5078
425	325.92	—	0.01902	1.4036	1.4226	402.27	801.2	1203.5	0.5974	0.9056	1.5030
430	343.72	—	0.01910	1.3308	1.3499	407.79	796.0	1203.8	0.6035	0.8947	1.4982
435	362.27	—	0.01918	1.2623	1.2815	413.34	790.8	1204.1	0.6097	0.8838	1.4935
440	381.59	—	0.01926	1.1979	1.2171	418.90	785.4	1204.3	0.6158	0.8730	1.4887
445	401.68	—	0.01935	1.1371	1.1565	424.49	780.0	1204.5	0.6219	0.8622	1.4840
450	422.6	—	0.0194	1.0799	1.0993	430.1	774.5	1204.6	0.6280	0.8513	1.4793
455	444.3	—	0.0195	1.0258	1.0453	435.7	768.9	1204.6	0.6341	0.8406	1.4746
460	466.9	—	0.0196	0.9748	0.9944	441.4	763.2	1204.6	0.6402	0.8298	1.4700
465	490.3	—	0.0197	0.9266	0.9463	447.1	757.4	1204.5	0.6463	0.8190	1.4653
470	514.7	—	0.0198	0.8811	0.9009	452.8	751.5	1204.3	0.6523	0.8083	1.4606
475	539.9	—	0.0199	0.8380	0.8579	458.6	745.4	1204.0	0.6584	0.7976	1.4560
480	566.1	—	0.0200	0.7972	0.8172	464.4	739.4	1203.7	0.6645	0.7868	1.4513
485	593.3	—	0.0201	0.7586	0.7787	470.2	733.1	1203.3	0.6705	0.7761	1.4466
490	621.4	—	0.0202	0.7221	0.7423	476.0	726.8	1202.8	0.6766	0.7653	1.4419
495	650.6	—	0.0203	0.6874	0.7077	481.9	720.4	1202.3	0.6826	0.7546	1.4372
500	680.8	—	0.0204	0.6545	0.6749	487.8	713.9	1201.7	0.6887	0.7438	1.4325
505	712.0	—	0.0205	0.6233	0.6438	493.8	707.1	1200.9	0.6948	0.7331	1.4278
510	744.3	—	0.0207	0.5935	0.6142	499.8	700.3	1200.1	0.7008	0.7223	1.4231
515	777.8	—	0.0208	0.5653	0.5861	505.8	693.4	1199.2	0.7069	0.7115	1.4184
520	812.4	—	0.0209	0.5385	0.5594	511.9	686.4	1198.2	0.7130	0.7006	1.4136
525	848.1	—	0.0210	0.5130	0.5340	518.0	679.1	1197.1	0.7191	0.6897	1.4088

Table 14-15. Saturated Steam Properties, Temperature Table (Sheet 7 of 7)

TEMP °F	ABS. PRESSURE		SPECIFIC VOLUME (ft. <sup>3</sup> /lb)			ENTHALPY (Btu/lb)			ENTROPY (Btu/lb,°F)		
	PSIA	IN. HG	SAT. LIQUID	EVAP.	SAT. VAPOR	SAT. LIQUID	EVAP.	SAT. VAPOR	SAT. LIQUID	EVAP.	SAT. VAPOR
	t	p	p	v <sub>f</sub>	v <sub>fg</sub>	v <sub>g</sub>	h <sub>f</sub>	h <sub>fg</sub>	h <sub>g</sub>	s <sub>f</sub>	s <sub>fg</sub>
530	885.0	—	0.0212	0.4886	0.5098	524.1	671.8	1195.9	0.7252	0.6788	1.4040
535	923.2	—	0.0213	0.4655	0.4868	530.3	664.3	1194.6	0.7313	0.6679	1.3991
540	962.5	—	0.0215	0.4434	0.4649	536.6	656.6	1193.2	0.7374	0.6568	1.3942
545	1003.2	—	0.0216	0.4224	0.4440	542.9	648.8	1191.7	0.7435	0.6458	1.3893
550	1045.2	—	0.0218	0.4022	0.4240	549.3	640.8	1190.0	0.7497	0.6346	1.3843
555	1088.5	—	0.0219	0.3831	0.4050	555.7	632.6	1188.3	0.7559	0.6234	1.3793
560	1133.1	—	0.0221	0.3647	0.3868	562.2	624.2	1186.4	0.7621	0.6121	1.3742
565	1179.1	—	0.0222	0.3472	0.3694	568.8	615.5	1184.3	0.7683	0.6007	1.3690
570	1226.5	—	0.0224	0.3304	0.3528	575.4	606.7	1182.1	0.7746	0.5893	1.3638
575	1275.4	—	0.0226	0.3143	0.3369	582.1	597.7	1179.8	0.7809	0.5777	1.3585
580	1325.8	—	0.0228	0.2989	0.3217	588.9	588.4	1177.3	0.7872	0.5659	1.3532
585	1377.7	—	0.0230	0.2841	0.3071	595.8	578.8	1174.6	0.7936	0.5541	1.3477
590	1431.2	—	0.0232	0.2700	0.2931	602.8	569.0	1171.8	0.8001	0.5421	1.3422
595	1486.2	—	0.0234	0.2563	0.2797	609.8	558.9	1168.7	0.8066	0.5299	1.3365
600	1542.9	—	0.0236	0.2432	0.2668	617.0	548.5	1165.5	0.8131	0.5176	1.3307
605	1601.2	—	0.0239	0.2306	0.2545	624.3	537.7	1162.0	0.8197	0.5051	1.3248
610	1661.2	—	0.0241	0.2185	0.2426	631.6	526.7	1158.4	0.8264	0.4924	1.3188
615	1723.0	—	0.0244	0.2068	0.2312	639.1	515.3	1154.4	0.8331	0.4795	1.3126
620	1786.6	—	0.0247	0.1955	0.2201	646.7	503.6	1150.3	0.8398	0.4664	1.3062
625	1852.0	—	0.0250	0.1845	0.2095	654.4	491.4	1145.8	0.8467	0.4530	1.2997
630	1919.3	—	0.0253	0.1740	0.1992	662.3	478.8	1141.1	0.8536	0.4394	1.2930
635	1988.5	—	0.0256	0.1637	0.1893	670.4	465.6	1136.0	0.8607	0.4254	1.2861
640	2059.7	—	0.0260	0.1538	0.1798	678.6	452.0	1130.5	0.8679	0.4110	1.2789
645	2132.9	—	0.0264	0.1441	0.1705	687.0	437.7	1124.7	0.8752	0.3962	1.2715
650	2208.2	—	0.0268	0.1348	0.1616	695.7	422.8	1118.5	0.8828	0.3809	1.2637
655	2285.7	—	0.0273	0.1256	0.1528	704.8	406.9	1111.7	0.8906	0.3651	1.2557
660	2365.4	—	0.0278	0.1165	0.1442	714.2	390.2	1104.4	0.8987	0.3485	1.2472
665	2447.4	—	0.0283	0.1076	0.1359	724.1	372.4	1096.4	0.9071	0.3311	1.2382
670	2531.8	—	0.0290	0.0987	0.1277	734.4	353.2	1087.7	0.9159	0.3127	1.2285
675	2618.7	—	0.0297	0.0899	0.1196	745.4	332.6	1078.0	0.9251	0.2931	1.2183
680	2708.1	—	0.0305	0.0810	0.1115	757.3	309.9	1067.2	0.9351	0.2719	1.2071
685	2800.2	—	0.0315	0.0719	0.1034	770.1	284.7	1054.8	0.9459	0.2487	1.1946
690	2895.1	—	0.0328	0.0625	0.0953	784.4	256.0	1040.4	0.9578	0.2227	1.1805
695	2992.9	—	0.0344	0.0520	0.0864	801.2	220.7	1021.9	0.9719	0.1911	1.1630
700	3093.7	—	0.0369	0.0392	0.0761	823.3	172.1	995.4	0.9905	0.1484	1.1389
702	3134.9	—	0.0385	0.0325	0.0710	835.4	145.2	980.6	1.0006	0.1249	1.1256
704	3176.7	—	0.0410	0.0234	0.0645	852.7	106.0	958.7	1.0152	0.0911	1.1063
705	3197.7	—	0.0438	0.0152	0.0589	869.2	69.1	938.4	1.0293	0.0593	1.0886
705.4	3206.2	—	0.0503	0	0.0503	902.7	0	902.7	1.0580	0	1.0580

Table 16. Saturated Steam Properties, Pressure Table (Sheet 1 of 5)

ABS. PRESS	TEMP	SPECIFIC VOLUME (ft. <sup>3</sup> /lb)		ENTHALPY (Btu/lb)			ENTROPY (Btu/lb,°F)			INTERNAL ENERGY (Btu/lb)		
		PSIA	°F	SAT. LIQUID	SAT. VAPOR	SAT. LIQUID	EVAP.	SAT. VAPOR	SAT. LIQUID	EVAP.	SAT. VAPOR	SAT. LIQUID
p	t	v <sub>f</sub>	v <sub>g</sub>	h <sub>f</sub>	h <sub>fg</sub>	h <sub>g</sub>	s <sub>f</sub>	s <sub>fg</sub>	s <sub>g</sub>	u <sub>f</sub>	u <sub>fg</sub>	u <sub>g</sub>
14.696	212.00	0.01672	26.80	180.07	970.3	1150.4	0.3120	1.4446	1.7566	180.02	897.5	1077.5
15	213.03	0.01672	26.29	181.11	969.7	1150.8	0.3135	1.4415	1.7549	181.06	896.7	1077.8
16	216.32	0.01674	24.75	184.42	967.6	1152.0	0.3184	1.4313	1.7497	184.37	894.3	1078.7
17	219.44	0.01677	23.39	187.56	965.5	1153.1	0.3231	1.4218	1.7449	187.51	892.0	1079.5
18	222.41	0.01679	22.17	190.56	963.6	1154.2	0.3275	1.4128	1.7403	190.50	889.9	1080.4
19	225.24	0.01681	21.08	193.42	961.9	1155.3	0.3317	1.4043	1.7360	193.36	887.8	1081.2
20	227.96	0.01683	20.089	196.16	960.1	1156.3	0.3356	1.3962	1.7319	196.10	885.8	1081.9
21	230.57	0.01685	19.192	198.79	958.4	1157.2	0.3395	1.3885	1.7280	198.73	883.9	1082.6
22	233.07	0.01687	18.375	201.33	956.8	1158.1	0.3431	1.3811	1.7242	201.26	882.0	1083.3
23	235.49	0.01689	17.627	203.78	955.2	1159.0	0.3466	1.3740	1.7206	203.71	880.2	1083.9
24	237.82	0.01691	16.938	206.14	953.7	1159.8	0.3500	1.3672	1.7172	206.07	878.5	1084.6
25	240.07	0.01692	16.303	208.42	952.1	1160.6	0.3533	1.3606	1.7139	208.34	876.8	1085.1
26	242.25	0.01694	15.715	210.62	950.7	1161.3	0.3564	1.3544	1.7108	210.54	875.2	1085.7
27	244.36	0.01696	15.170	212.75	949.3	1162.0	0.3594	1.3484	1.7078	212.67	873.6	1086.3
28	246.41	0.01698	14.663	214.83	947.9	1162.7	0.3623	1.3425	1.7048	214.74	872.1	1086.8
29	248.40	0.01699	14.189	216.86	946.5	1163.4	0.3652	1.3368	1.7020	216.77	870.5	1087.3
30	250.33	0.01701	13.746	218.82	945.3	1164.1	0.3680	1.3313	1.6993	218.73	869.1	1087.8
31	252.22	0.01702	13.330	220.73	944.0	1164.7	0.3707	1.3260	1.6967	220.63	867.7	1088.3
32	254.05	0.01704	12.940	222.59	942.8	1165.4	0.3733	1.3209	1.6941	222.49	866.3	1088.7
33	255.84	0.01705	12.572	224.41	941.6	1166.0	0.3758	1.3159	1.6917	224.31	864.9	1089.2
34	257.58	0.01707	12.226	226.18	940.3	1166.5	0.3783	1.3110	1.6893	226.07	863.5	1089.6
35	259.28	0.01708	11.898	227.91	939.2	1167.1	0.3807	1.3063	1.6870	227.80	862.3	1090.1
36	260.95	0.01709	11.588	229.60	938.0	1167.6	0.3831	1.3017	1.6848	229.49	861.0	1090.5
37	262.57	0.01711	11.294	231.26	936.9	1168.2	0.3854	1.2972	1.6826	231.14	859.8	1090.9
38	264.16	0.01712	11.015	232.89	935.8	1168.7	0.3876	1.2929	1.6805	232.77	858.5	1091.3
39	265.72	0.01714	10.750	234.48	934.7	1169.2	0.3898	1.2886	1.6784	234.36	857.2	1091.6
40	267.25	0.01715	10.498	236.03	933.7	1169.7	0.3919	1.2844	1.6763	235.90	856.1	1092.0
41	268.74	0.01716	10.258	237.55	932.6	1170.2	0.3940	1.2803	1.6743	237.42	855.0	1092.4
42	270.21	0.01717	10.029	239.04	931.6	1170.7	0.3960	1.2764	1.6724	238.91	853.8	1092.7
43	271.64	0.01719	9.810	240.51	930.6	1171.1	0.3980	1.2726	1.6706	240.37	852.7	1093.1
44	273.05	0.01720	9.601	241.95	929.6	1171.6	0.4000	1.2687	1.6687	241.81	851.6	1093.4
45	274.44	0.01721	9.401	243.36	928.6	1172.0	0.4019	1.2650	1.6669	243.22	850.5	1093.7
46	275.80	0.01722	9.209	244.75	927.7	1172.4	0.4038	1.2613	1.6652	244.60	849.5	1094.1
47	277.13	0.01723	9.025	246.12	926.7	1172.9	0.4057	1.2577	1.6634	245.97	848.4	1094.4
48	278.45	0.01725	8.848	247.47	925.8	1173.3	0.4075	1.2542	1.6617	247.32	847.4	1094.7
49	279.74	0.01726	8.678	248.79	924.9	1173.7	0.4093	1.2508	1.6601	248.63	846.4	1095.0
50	281.01	0.01727	8.515	250.09	924.0	1174.1	0.4110	1.2474	1.6585	249.93	845.4	1095.3
48	278.45	0.01725	8.848	247.47	925.8	1173.3	0.4075	1.2542	1.6617	247.32	847.4	1094.7
49	279.74	0.01726	8.678	248.79	924.9	1173.7	0.4093	1.2508	1.6601	248.63	846.4	1095.0
50	281.01	0.01727	8.515	250.09	924.0	1174.1	0.4110	1.2474	1.6585	249.93	845.4	1095.3
51	282.26	0.01728	8.359	251.37	923.0	1174.4	0.4127	1.2442	1.6569	251.21	844.3	1095.5
52	283.49	0.01729	8.208	252.63	922.2	1174.8	0.4144	1.2409	1.6553	252.46	843.3	1095.8
53	284.70	0.01730	8.062	253.87	921.3	1175.2	0.4161	1.2377	1.6538	253.70	842.4	1096.1
54	285.90	0.01731	7.922	255.09	920.5	1175.6	0.4177	1.2346	1.6523	254.92	841.5	1096.4
55	287.07	0.01732	7.787	256.30	919.6	1175.9	0.4193	1.2316	1.6509	256.12	840.6	1096.7
56	288.23	0.01733	7.656	257.50	918.8	1176.3	0.4209	1.2285	1.6494	257.32	839.7	1097.0
57	289.37	0.01734	7.529	258.67	917.9	1176.6	0.4225	1.2255	1.6480	258.49	838.7	1097.2
58	290.50	0.01736	7.407	259.82	917.1	1176.9	0.4240	1.2226	1.6466	259.63	837.8	1097.4
59	291.61	0.01737	7.289	260.96	916.3	1177.3	0.4255	1.2197	1.6452	260.77	836.9	1097.7
60	292.71	0.01738	7.175	262.09	915.5	1177.6	0.4270	1.2168	1.6438	261.90	836.0	1097.9
61	293.79	0.01739	7.064	263.20	914.7	1177.9	0.4285	1.2140	1.6425	263.00	835.2	1098.2

Table I4-16. Saturated Steam Properties, Pressure Table (Sheet 2 of 5)

ABS. PRESS	TEMP	SPECIFIC VOLUME (ft. <sup>3</sup> /lb)		ENTHALPY (Btu/lb)			ENTROPY (Btu/lb, °F)			INTERNAL ENERGY (Btu/lb)		
		PSIA	°F	SAT. LIQUID	SAT. VAPOR	SAT. LIQUID	EVAP.	SAT. VAPOR	SAT. LIQUID	EVAP.	SAT. VAPOR	SAT. LIQUID
p	t	v <sub>f</sub>	v <sub>g</sub>	h <sub>f</sub>	h <sub>fg</sub>	h <sub>g</sub>	s <sub>f</sub>	s <sub>fg</sub>	s <sub>g</sub>	u <sub>f</sub>	u <sub>fg</sub>	u <sub>g</sub>
62	294.85	0.01740	6.957	264.30	913.9	1178.2	0.4300	1.2112	1.6412	264.10	834.3	1098.4
63	295.90	0.01741	6.853	265.38	913.1	1178.5	0.4314	1.2085	1.6399	265.18	833.4	1098.6
64	296.94	0.01742	6.752	266.45	912.3	1178.8	0.4328	1.2059	1.6387	266.24	832.6	1098.8
65	297.97	0.01743	6.655	267.50	911.6	1179.1	0.4342	1.2032	1.6374	267.29	831.8	1099.1
66	298.99	0.01744	6.560	268.55	910.8	1179.4	0.4356	1.2006	1.6362	268.34	831.0	1099.3
67	299.99	0.01745	6.468	269.58	910.1	1179.7	0.4369	1.1981	1.6350	269.36	830.2	1099.5
68	300.98	0.01746	6.378	270.60	909.4	1180.0	0.4383	1.1955	1.6338	270.38	829.4	1099.8
69	301.96	0.01747	6.291	271.61	908.7	1180.3	0.4396	1.1930	1.6326	271.39	828.6	1100.0
70	302.92	0.01748	6.206	272.61	907.9	1180.6	0.4409	1.1906	1.6315	272.38	827.8	1100.2
71	303.88	0.01749	6.124	273.60	907.2	1180.8	0.4422	1.1881	1.6303	273.37	827.0	1100.4
72	304.83	0.01750	6.044	274.57	906.5	1181.1	0.4435	1.1857	1.6292	274.34	826.3	1100.6
73	305.76	0.01751	5.966	275.54	905.8	1181.3	0.4447	1.1834	1.6281	275.30	825.5	1100.8
74	306.68	0.01752	5.890	276.49	905.1	1181.6	0.4460	1.1810	1.6270	276.25	824.7	1101.0
75	307.60	0.01753	5.816	277.43	904.5	1181.9	0.4472	1.1787	1.6259	277.19	824.0	1101.2
76	308.50	0.01754	5.743	278.37	903.7	1182.1	0.4484	1.1764	1.6248	278.12	823.3	1101.4
77	309.40	0.01754	5.673	279.30	903.1	1182.4	0.4496	1.1742	1.6238	279.05	822.5	1101.6
78	310.29	0.01755	5.604	280.21	902.4	1182.6	0.4508	1.1720	1.6228	279.96	821.7	1101.7
79	311.16	0.01756	5.537	281.12	901.7	1182.8	0.4520	1.1698	1.6217	280.86	821.0	1101.9
80	312.03	0.01757	5.472	282.02	901.1	1183.1	0.4531	1.1676	1.6207	281.76	820.3	1102.1
81	312.89	0.01758	5.408	282.91	900.4	1183.3	0.4543	1.1654	1.6197	282.65	819.6	1102.2
82	313.74	0.01759	5.346	283.79	899.7	1183.5	0.4554	1.1633	1.6187	283.52	818.9	1102.4
83	314.59	0.01760	5.285	284.66	899.1	1183.8	0.4565	1.1612	1.6177	284.39	818.2	1102.6
84	315.42	0.01761	5.226	285.53	898.5	1184.0	0.4576	1.1592	1.6168	285.26	817.5	1102.8
85	316.25	0.01761	5.168	286.39	897.8	1184.2	0.4587	1.1571	1.6158	286.11	816.8	1102.9
86	317.07	0.01762	5.111	287.24	897.2	1184.4	0.4598	1.1551	1.6149	286.96	816.1	1103.1
87	317.88	0.01763	5.055	288.08	896.5	1184.6	0.4609	1.1530	1.6139	287.80	815.4	1103.2
88	318.68	0.01764	5.001	288.91	895.9	1184.8	0.4620	1.1510	1.6130	288.63	814.8	1103.4
89	319.48	0.01765	4.948	289.74	895.3	1185.1	0.4630	1.1491	1.6121	289.45	814.1	1103.6
90	320.27	0.01766	4.896	290.56	894.7	1185.3	0.4641	1.1471	1.6112	290.27	813.4	1103.7
91	321.06	0.01767	4.845	291.38	894.1	1185.5	0.4651	1.1452	1.6103	291.08	812.8	1103.9
92	321.83	0.01768	4.796	292.18	893.5	1185.7	0.4661	1.1433	1.6094	291.88	812.2	1104.1
93	322.60	0.01768	4.747	292.98	892.9	1185.9	0.4672	1.1413	1.6085	292.68	811.5	1104.2
94	323.36	0.01769	4.699	293.78	892.3	1186.1	0.4682	1.1394	1.6076	293.47	810.9	1104.4
95	324.12	0.01770	4.652	294.56	891.7	1186.2	0.4692	1.1376	1.6068	294.25	810.2	1104.5
96	324.87	0.01771	4.606	295.34	891.1	1186.4	0.4702	1.1358	1.6060	295.03	809.6	1104.6
97	325.61	0.01772	4.561	296.12	890.5	1186.6	0.4711	1.1340	1.6051	295.80	808.9	1104.7
98	326.35	0.01772	4.517	296.89	889.9	1186.8	0.4721	1.1322	1.6043	296.57	808.3	1104.9
99	327.08	0.01773	4.474	297.65	889.4	1187.0	0.4731	1.1304	1.6035	297.33	807.7	1105.0
100	327.81	0.01774	4.432	298.40	888.8	1187.2	0.4740	1.1286	1.6026	298.08	807.1	1105.2
101	328.53	0.01775	4.391	299.15	888.2	1187.4	0.4750	1.1268	1.6018	298.82	806.5	1105.3
102	329.25	0.01775	4.350	299.90	887.6	1187.5	0.4759	1.1251	1.6010	299.57	805.9	1105.4
103	329.96	0.01776	4.310	300.64	887.1	1187.7	0.4768	1.1234	1.6002	300.30	805.3	1105.6
104	330.66	0.01777	4.271	301.37	886.5	1187.9	0.4778	1.1216	1.5994	301.03	804.7	1105.7
105	331.36	0.01778	4.232	302.10	886.0	1188.1	0.4787	1.1199	1.5986	301.75	804.1	1105.9
106	332.05	0.01778	4.194	302.82	885.4	1188.2	0.4796	1.1182	1.5978	302.47	803.5	1106.0
107	332.74	0.01779	4.157	303.54	884.9	1188.4	0.4805	1.1166	1.5971	303.19	802.9	1106.1
108	333.42	0.01780	4.120	304.26	884.3	1188.6	0.4814	1.1149	1.5963	303.90	802.4	1106.3
109	334.10	0.01781	4.084	304.97	883.7	1188.7	0.4823	1.1133	1.5956	304.61	801.8	1106.4
110	334.77	0.01782	4.049	305.66	883.2	1188.9	0.4832	1.1117	1.5948	305.30	801.2	1106.5
111	335.44	0.01782	4.015	306.37	882.6	1189.0	0.4840	1.1101	1.5941	306.00	800.6	1106.6
112	336.11	0.01783	3.981	307.06	882.1	1189.2	0.4849	1.1085	1.5934	306.69	800.0	1106.7

Table I4-16. Saturated Steam Properties, Pressure Table (Sheet 3 of 5)

ABS. PRESS	TEMP	SPECIFIC VOLUME (ft. <sup>3</sup> /lb)		ENTHALPY (Btu/lb)			ENTROPY (Btu/lb, °F)			INTERNAL ENERGY (Btu/lb)		
		SAT. LIQUID	SAT. VAPOR	SAT. LIQUID	EVAP.	SAT. VAPOR	SAT. LIQUID	EVAP.	SAT. VAPOR	SAT. LIQUID	EVAP.	SAT. VAPOR
PSIA	°F	v <sub>f</sub>	v <sub>g</sub>	h <sub>f</sub>	h <sub>fg</sub>	h <sub>g</sub>	s <sub>f</sub>	s <sub>fg</sub>	s <sub>g</sub>	u <sub>f</sub>	u <sub>fg</sub>	u <sub>g</sub>
p	t	v <sub>f</sub>	v <sub>g</sub>	h <sub>f</sub>	h <sub>fg</sub>	h <sub>g</sub>	s <sub>f</sub>	s <sub>fg</sub>	s <sub>g</sub>	u <sub>f</sub>	u <sub>fg</sub>	u <sub>g</sub>
113	336.77	0.01784	3.947	307.75	881.6	1189.4	0.4858	1.1069	1.5927	307.38	799.4	1106.8
114	337.42	0.01784	3.914	308.43	881.1	1189.5	0.4866	1.1053	1.5919	308.05	798.9	1106.9
115	338.07	0.01785	3.882	309.11	880.6	1189.7	0.4875	1.1037	1.5912	308.73	798.4	1107.1
116	338.72	0.01786	3.850	309.79	880.0	1189.8	0.4883	1.1022	1.5905	309.41	797.8	1107.2
117	339.36	0.01787	3.819	310.46	879.5	1190.0	0.4891	1.1007	1.5898	310.07	797.2	1107.3
118	339.99	0.01787	3.788	311.12	879.0	1190.1	0.4900	1.0992	1.5891	310.73	796.7	1107.4
119	340.62	0.01788	3.758	311.78	878.4	1190.2	0.4908	1.0977	1.5885	311.39	796.1	1107.5
120	341.25	0.01789	3.728	312.44	877.9	1190.4	0.4916	1.0962	1.5878	312.05	795.6	1107.6
121	341.88	0.01790	3.699	313.10	877.4	1190.5	0.4924	1.0947	1.5871	312.70	795.0	1107.7
122	342.50	0.01791	3.670	313.75	876.9	1190.7	0.4932	1.0933	1.5865	313.35	794.5	1107.8
123	343.11	0.01791	3.642	314.40	876.4	1190.8	0.4940	1.0918	1.5858	313.99	793.9	1107.9
124	343.72	0.01792	3.614	315.04	875.9	1190.9	0.4948	1.0903	1.5851	314.63	793.4	1108.0
125	344.33	0.01792	3.587	315.68	875.4	1191.1	0.4956	1.0888	1.5844	315.26	792.8	1108.1
126	344.94	0.01793	3.560	316.31	874.9	1191.2	0.4964	1.0874	1.5838	315.89	792.3	1108.2
127	345.54	0.01794	3.533	316.94	874.4	1191.3	0.4972	1.0859	1.5832	316.52	791.8	1108.3
128	346.13	0.01794	3.507	317.57	873.9	1191.5	0.4980	1.0845	1.5825	317.15	791.3	1108.4
129	346.73	0.01795	3.481	318.19	873.4	1191.6	0.4987	1.0832	1.5819	317.77	790.7	1108.5
130	347.32	0.01796	3.455	318.81	872.9	1191.7	0.4995	1.0817	1.5812	318.38	790.2	1108.6
131	347.90	0.01797	3.430	319.43	872.5	1191.9	0.5002	1.0804	1.5806	318.99	789.7	1108.7
132	348.48	0.01797	3.405	320.04	872.0	1192.0	0.5010	1.0790	1.5800	319.60	789.2	1108.8
133	349.06	0.01798	3.381	320.65	871.5	1192.1	0.5018	1.0776	1.5793	320.21	788.7	1108.9
134	349.64	0.01799	3.357	321.25	871.0	1192.2	0.5025	1.0762	1.5787	320.80	788.2	1109.0
135	350.21	0.01800	3.333	321.85	870.6	1192.4	0.5032	1.0749	1.5781	321.40	787.7	1109.1
136	350.78	0.01800	3.310	322.45	870.1	1192.5	0.5040	1.0735	1.5775	322.0	787.2	1109.2
137	351.35	0.01801	3.287	323.05	869.6	1192.6	0.5047	1.0722	1.5769	322.59	786.7	1109.3
138	351.91	0.01801	3.264	323.64	869.1	1192.7	0.5054	1.0709	1.5763	323.18	786.2	1109.4
139	352.47	0.01802	3.242	324.23	868.7	1192.9	0.5061	1.0696	1.5757	323.77	785.7	1109.5
140	353.02	0.01802	3.220	324.82	868.2	1193.0	0.5069	1.0682	1.5751	324.35	785.2	1109.6
141	353.57	0.01803	3.198	325.40	867.7	1193.1	0.5076	1.0669	1.5745	324.93	784.8	1109.7
142	354.12	0.01804	3.177	325.98	867.2	1193.2	0.5083	1.0657	1.5740	325.51	784.3	1109.8
143	354.67	0.01804	3.155	326.56	866.7	1193.3	0.5090	1.0644	1.5734	326.08	783.8	1109.8
144	355.21	0.01805	3.134	327.13	866.3	1193.4	0.5097	1.0631	1.5728	326.65	783.3	1109.9
145	355.76	0.01806	3.114	327.70	865.8	1193.5	0.5104	1.0618	1.5722	327.22	782.8	1110.0
146	356.29	0.01806	3.094	328.27	865.3	1193.6	0.5111	1.0605	1.5716	327.78	782.3	1110.1
147	356.83	0.01807	3.074	328.83	864.9	1193.8	0.5118	1.0592	1.5710	328.34	781.9	1110.2
148	357.36	0.01808	3.054	329.39	864.5	1193.9	0.5124	1.0580	1.5705	328.90	781.4	1110.3
149	357.89	0.01808	3.034	329.95	864.0	1194.0	0.5131	1.0568	1.5699	329.45	780.9	1110.4
150	358.42	0.01809	3.015	330.51	863.6	1194.1	0.5138	1.0556	1.5694	330.01	780.5	1110.5
152	359.46	0.01810	2.977	331.61	862.7	1194.3	0.5151	1.0532	1.5683	331.10	779.5	1110.6
154	360.49	0.01812	2.940	332.70	861.8	1194.5	0.5165	1.0507	1.5672	332.18	778.5	1110.7
156	361.52	0.01813	2.904	333.79	860.9	1194.7	0.5178	1.0483	1.5661	333.26	777.6	1110.9
158	362.53	0.01814	2.869	334.86	860.0	1194.9	0.5191	1.0459	1.5650	334.23	776.8	1111.0
160	363.53	0.01815	2.834	335.93	859.2	1195.1	0.5204	1.0436	1.5640	335.39	775.8	1111.2
162	364.53	0.01817	2.801	336.98	858.3	1195.3	0.5216	1.0414	1.5630	336.44	775.0	1111.4
164	365.51	0.01818	2.768	338.02	857.5	1195.5	0.5229	1.0391	1.5620	337.47	774.1	1111.5
166	366.48	0.01819	2.736	339.05	856.6	1195.7	0.5241	1.0369	1.5610	338.49	773.2	1111.7
168	367.45	0.01820	2.705	340.07	855.7	1195.8	0.5254	1.0346	1.5600	339.51	772.3	1111.8
170	368.41	0.01822	2.675	341.09	854.9	1196.0	0.5266	1.0324	1.5590	340.52	771.4	1111.9
172	369.35	0.01823	2.645	342.10	854.1	1196.2	0.5278	1.0302	1.5580	341.52	770.5	1112.0
174	370.29	0.01824	2.616	343.10	853.3	1196.4	0.5290	1.0280	1.5570	342.51	769.7	1112.2
176	371.22	0.01825	2.587	344.09	852.4	1196.5	0.5302	1.0259	1.5561	343.50	768.8	1112.3
178	372.14	0.01826	2.559	345.06	851.6	1196.7	0.5313	1.0238	1.5551	344.46	767.9	1112.4

Table I4-16. Saturated Steam Properties, Pressure Table (Sheet 4 of 5)

ABS. PRESS	TEMP	SPECIFIC VOLUME (ft. <sup>3</sup> /lb)		ENTHALPY (Btu/lb)			ENTROPY (Btu/lb,°F)			INTERNAL ENERGY (Btu/lb)		
		PSIA	°F	SAT. LIQUID	SAT. VAPOR	SAT. LIQUID	EVAP.	SAT. VAPOR	SAT. LIQUID	EVAP.	SAT. VAPOR	SAT. LIQUID
p	t	v <sub>f</sub>	v <sub>g</sub>	h <sub>f</sub>	h <sub>fg</sub>	h <sub>g</sub>	s <sub>f</sub>	s <sub>fg</sub>	s <sub>g</sub>	u <sub>f</sub>	u <sub>fg</sub>	u <sub>g</sub>
180	373.06	0.01827	2.532	346.03	850.8	1196.9	0.5325	1.0217	1.5542	345.42	767.1	1112.5
182	373.96	0.01829	2.505	347.00	850.0	1197.0	0.5336	1.0196	1.5532	346.38	766.2	1112.6
184	374.86	0.01830	2.479	347.96	849.2	1197.2	0.5348	1.0175	1.5523	347.34	765.4	1112.8
186	375.75	0.01831	2.454	348.92	848.4	1197.3	0.5359	1.0155	1.5514	348.29	764.6	1112.9
188	376.64	0.01832	2.429	349.86	847.6	1197.5	0.5370	1.0136	1.5506	349.22	763.8	1113.0
190	377.51	0.01833	2.404	350.79	846.8	1197.6	0.5381	1.0116	1.5497	350.15	763.0	1113.1
192	378.38	0.01834	2.380	351.72	846.1	1197.8	0.5392	1.0096	1.5488	351.07	762.1	1113.2
194	379.24	0.01835	2.356	352.64	845.3	1197.9	0.5403	1.0076	1.5479	351.98	761.3	1113.3
196	380.10	0.01836	2.333	353.55	844.5	1198.1	0.5414	1.0056	1.5470	352.89	760.6	1113.5
198	380.95	0.01838	2.310	354.46	843.7	1198.2	0.5425	1.0037	1.5462	353.79	759.8	1113.6
200	381.79	0.01839	2.288	355.36	843.0	1198.4	0.5435	1.0018	1.5453	354.68	759.0	1113.7
205	383.86	0.01842	2.234	357.58	841.1	1198.7	0.5461	0.9971	1.5432	356.88	757.1	1114.0
210	385.90	0.01844	2.183	359.77	839.2	1199.0	0.5487	0.9925	1.5412	359.05	755.2	1114.2
215	387.89	0.01847	2.134	361.91	837.4	1199.3	0.5512	0.9880	1.5392	361.18	753.2	1114.4
220	389.86	0.01850	2.087	364.02	835.6	1199.6	0.5537	0.9835	1.5372	363.27	751.3	1114.6
225	391.79	0.01852	2.0422	366.09	833.8	1199.9	0.5561	0.9792	1.5353	365.32	749.5	1114.8
230	393.68	0.01854	1.9992	368.13	832.0	1200.1	0.5585	0.9750	1.5334	367.34	747.7	1115.0
235	395.54	0.01857	1.9579	370.14	830.3	1200.4	0.5608	0.9708	1.5316	369.33	745.9	1115.3
240	397.37	0.01860	1.9183	372.12	828.5	1200.6	0.5631	0.9667	1.5298	371.29	744.1	1115.4
245	399.18	0.01863	1.8803	374.08	826.8	1200.9	0.5653	0.9627	1.5280	373.23	742.4	1115.6
250	400.95	0.01865	1.8438	376.00	825.1	1201.1	0.5675	0.9588	1.5263	375.14	740.7	1115.8
255	402.70	0.01868	1.8086	377.89	823.4	1201.3	0.5697	0.9549	1.5246	377.01	739.0	1116.0
260	404.42	0.01870	1.7748	379.76	821.8	1201.5	0.5719	0.9510	1.5229	378.86	737.3	1116.1
265	406.11	0.01873	1.7422	381.60	820.1	1201.7	0.5740	0.9472	1.5212	380.68	735.6	1116.3
270	407.78	0.01875	1.7107	383.42	818.5	1201.9	0.5760	0.9436	1.5196	382.48	733.9	1116.4
275	409.43	0.01878	1.6804	385.21	816.9	1202.1	0.5781	0.9399	1.5180	384.26	732.3	1116.6
280	411.05	0.01880	1.6511	386.98	815.3	1202.3	0.5801	0.9363	1.5164	386.01	730.7	1116.7
285	412.65	0.01883	1.6228	388.73	813.7	1202.4	0.5821	0.9327	1.5149	387.74	729.1	1116.8
290	414.23	0.01885	1.5954	390.46	812.1	1202.6	0.5841	0.9292	1.5133	389.45	727.5	1116.9
295	415.79	0.01887	1.5689	392.16	810.5	1202.7	0.5860	0.9258	1.5118	391.13	725.9	1117.0
300	417.33	0.01890	1.5433	393.84	809.0	1202.8	0.5879	0.9225	1.5104	392.79	724.3	1117.1
310	420.35	0.01894	1.4944	397.15	806.0	1203.1	0.5916	0.9159	1.5075	396.06	721.3	1117.4
320	423.29	0.01899	1.4485	400.39	803.0	1203.4	0.5952	0.9094	1.5046	399.26	718.3	1117.6
330	426.16	0.01904	1.4053	403.56	800.0	1203.6	0.5988	0.9031	1.5019	402.40	715.4	1117.8
340	428.97	0.01908	1.3645	406.66	797.1	1203.7	0.6022	0.8970	1.4992	405.46	712.4	1117.9
350	431.72	0.01913	1.3260	409.69	794.2	1203.9	0.6056	0.8910	1.4966	408.45	709.6	1118.0
360	434.40	0.01917	1.2895	412.67	791.4	1204.1	0.6090	0.8851	1.4941	411.39	706.8	1118.2
370	437.03	0.01921	1.2550	415.59	788.6	1204.2	0.6122	0.8794	1.4916	414.27	704.0	1118.3
380	439.60	0.01925	1.2222	418.45	785.8	1204.3	0.6153	0.8738	1.4891	417.10	701.3	1118.4
390	442.12	0.01930	1.1910	421.27	783.1	1204.4	0.6184	0.8683	1.4867	419.88	698.6	1118.5
400	444.59	0.0193	1.1613	424.0	780.5	1204.5	0.6214	0.8630	1.4844	422.6	695.9	1118.5
410	447.01	0.0194	1.1330	426.8	777.7	1204.5	0.6243	0.8578	1.4821	425.3	693.3	1118.6
420	449.39	0.0194	1.1061	429.4	775.2	1204.6	0.6272	0.8527	1.4799	427.9	690.8	1118.7
430	451.73	0.0194	1.0803	432.1	772.5	1204.6	0.6301	0.8476	1.4777	430.5	688.2	1118.7
440	454.02	0.0195	1.0556	434.6	770.0	1204.6	0.6329	0.8426	1.4755	433.0	685.7	1118.7
450	456.28	0.0195	1.0320	437.2	767.4	1204.6	0.6356	0.8378	1.4734	435.5	683.2	1118.7
460	458.50	0.0196	1.0094	439.7	764.9	1204.6	0.6383	0.8330	1.4713	438.0	680.7	1118.7
470	460.68	0.0196	0.9878	442.2	762.4	1204.6	0.6410	0.8283	1.4693	440.5	678.2	1118.7
480	462.82	0.0197	0.9670	444.6	759.9	1204.5	0.6436	0.8237	1.4673	442.9	675.7	1118.6
490	464.93	0.0197	0.9470	447.0	757.5	1204.5	0.6462	0.8191	1.4653	445.2	673.4	1118.6

Table I4-16. Saturated Steam Properties, Pressure Table (Sheet 5 of 5)

ABS. PRESS.	TEMP	SPECIFIC VOLUME (ft. <sup>3</sup> /in <sup>2</sup> )			ENTHALPY (Btu/lb)			ENTROPY (Btu/lb,°F)			INTERNAL ENERGY (Btu/lb)	
PSIA	°F	SAT. LIQUID	EVAP.	SAT. VA-POR	SAT. LIQUID	EVAP.	SAT. VA-POR	SAT. LIQUID	EVAP.	SAT. VA-POR	SAT. LIQUID	SAT. VA-POR
p	t	v <sub>f</sub>	v <sub>fg</sub>	v <sub>g</sub>	h <sub>f</sub>	h <sub>fg</sub>	h <sub>g</sub>	s <sub>f</sub>	s <sub>fg</sub>	s <sub>g</sub>	u <sub>f</sub>	u <sub>g</sub>
500	467.01	0.0197	0.9081	0.9278	449.4	755.0	1204.4	0.6487	0.8147	1.4634	447.6	1118.6
520	471.07	0.0198	0.8717	0.8915	454.1	750.1	1204.2	0.6536	0.8060	1.4596	452.2	1118.4
540	475.01	0.0199	0.8379	0.8578	458.6	745.4	1204.0	0.6584	0.7976	1.4560	456.6	1118.3
560	478.85	0.0200	0.8065	0.8265	463.0	740.8	1203.8	0.6631	0.7893	1.4524	460.9	1118.2
580	482.58	0.0201	0.7772	0.7973	467.4	736.1	1203.5	0.6676	0.7813	1.4489	465.2	1118.0
600	486.21	0.0201	0.7497	0.7698	471.6	731.6	1203.2	0.6720	0.7734	1.4454	469.4	1117.7
620	489.75	0.0202	0.7238	0.7440	475.7	727.2	1202.9	0.6763	0.7658	1.4421	473.4	1117.5
640	493.21	0.0203	0.6995	0.7198	479.8	722.7	1202.5	0.6805	0.7584	1.4389	477.4	1117.3
660	496.58	0.0204	0.6767	0.6971	483.8	718.3	1202.1	0.6846	0.7512	1.4358	481.3	1117.0
680	499.88	0.0204	0.6553	0.6757	487.7	714.0	1201.7	0.6886	0.7441	1.4327	485.1	1116.7
700	503.10	0.0205	0.6349	0.6554	491.5	709.7	1201.2	0.6925	0.7371	1.4296	488.8	1116.3
720	506.25	0.0206	0.6156	0.6362	495.3	705.4	1200.7	0.6963	0.7303	1.4266	492.5	1116.0
740	509.34	0.0207	0.5973	0.6180	499.0	701.2	1200.2	0.7001	0.7237	1.4237	496.2	1115.6
760	512.36	0.0207	0.5800	0.6007	502.6	697.1	1199.7	0.7037	0.7172	1.4209	499.7	1115.2
780	515.33	0.0208	0.5635	0.5843	506.2	692.9	1199.1	0.7073	0.7108	1.4181	503.2	1114.8
800	518.23	0.0209	0.5478	0.5687	509.7	688.9	1198.6	0.7108	0.7045	1.4153	506.6	1114.4
820	521.08	0.0209	0.5329	0.5538	513.2	684.8	1198.0	0.7143	0.6983	1.4126	510.0	1114.0
840	523.88	0.0210	0.5186	0.5396	516.6	680.8	1197.4	0.7177	0.6922	1.4099	513.3	1113.6
860	526.63	0.0211	0.5049	0.5260	520.0	676.8	1196.8	0.7210	0.6862	1.4072	516.6	1113.1
880	529.33	0.0212	0.4918	0.5130	523.3	672.8	1196.1	0.7243	0.6803	1.4046	519.9	1112.6
900	531.98	0.0212	0.4794	0.5006	526.6	668.8	1195.4	0.7275	0.6744	1.4020	523.1	1112.1

UNIT CONVERSIONS

Note that pressures are typically given in gauge pressure. This is the difference between the absolute pressure in the boiler and the absolute pressure of the surroundings. A gauge reads pressure differences (in most cases, the difference between the pressure of the substance and that of the atmosphere). Therefore, gauge pressure may be positive or negative (vacuum). Gauge pressures, in U.S. (English Engineering) units, are referred to as psig (pounds per square inch gauge, although the “g” is frequently omitted).

An absolute pressure is the pressure above zero pressure, which can only be positive. Most thermodynamic tables are based on absolute pressure. In U.S. units, absolute pressure is referred to as psia (pounds per square inch absolute).

Absolute pressure is calculated by adding the absolute pressure of the surroundings (atmospheric pressure) to the gauge pressure. In general, for U.S. units (psig) to convert gauge pressure to absolute pressure, add 14.696. Conversely, to convert absolute pressure to gauge pressure, subtract 14.696.

The following information is included for your convenience.

- Temperature Conversion
- Conversions Factors 2
- pH Values
- Salinity Indicating Readings Conversion Table
- Useful Physical Constants
- Conversions Table
- Approximate Common Equivalents
- Conversions Accurate to Parts per Million





Table 17. Temperature Conversion

Locate degrees F or degrees C in middle column. If degrees F, read equivalent degrees C in left hand column. If degrees C, read equivalent degrees F in right 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	-459.4		-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	-459.4	-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	950	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	93	200	392	421	790	1454	1371	2500	4532
			10.6	51	123.8	99	210	410	427	800	1472	1399	2550	4622
			11.1	52	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	1592	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

Table 18. Conversion Factors (Sheet 1 of 9)

TO CONVERT	MULTIPLY BY	TO OBTAIN
<b>A</b>		
abamperes	$1. \times 10^1$	amperes
abcoulombs	$2.998 \times 10^{10}$	statcoulombs
abfarads	$1. \times 10^9$	farads
abfarads	$1. \times 10^{15}$	microfarads
abhenries	$1. \times 10^{-9}$	henries
abhenries	$1. \times 10^{-6}$	millihenries
abohms	$1. \times 10^{-9}$	ohms
abohms	$1. \times 10^{-15}$	megohms
abvolts	$1. \times 10^{-8}$	volts
acres	$1. \times 10^9$	sq. chains (gunters)
acres	$1.60 \times 10^2$	rods
acres	$1. \times 10^8$	sq. links
acres	$4.047 \times 10^{-1}$	hectares or sq. hectometers
acres	$4.35 \times 10^4$	sq. ft.
acres	$4.047 \times 10^3$	sq. meters
acres	$1.562 \times 10^{-3}$	sq. miles
acres	$4.840 \times 10^3$	sq. yards
acre-feet	$4.356 \times 10^4$	cu. feet
acre-feet	$3.259 \times 10^9$	gallons
amperes/sq. cm.	6.452	amps/sq. in.
amperes/sq. cm.	$1. \times 10^4$	amps/sq. meter
amperes/sq. in.	$1.550 \times 10^{-1}$	amps/sq. cm.
amperes/sq. in.	$1.550 \times 10^3$	amps/sq. meter
amperes/sq. meter	$1.0 \times 10^{-4}$	amps/sq. cm.
amperes/sq. meter	$6.452 \times 10^{-4}$	amps/sq. in.
ampere-hours	$3.600 \times 10^3$	coulombs
ampere-hours	$3.731 \times 10^{-2}$	faradays
ampere-turns	1.257	gilberts
ampere-turns/cm.	2.540	amp-turns/in.
ampere-turns/cm.	$1. \times 10^2$	amp-turns/meter
ampere-turns/in.	$3.937 \times 10^{-1}$	amp-turns/cm.
ampere-turns/in.	$3.937 \times 10^1$	amp-turns/meter
ampere-turns/in.	$4.950 \times 10^{-1}$	gilberts/cm.
ampere-turns/meter	$1. \times 10^{-2}$	amp-turns/cm.
ampere-turns/meter	$2.54 \times 10^{-2}$	amp-turns/in.
ampere-turns/meter	$1.257 \times 10^{-2}$	gilberts/cm.
angstrom unit	$3.937 \times 10^{-9}$	inches
angstrom unit	$1. \times 10^{-10}$	meters
angstrom unit	$1. \times 10^{-4}$	microns or ( $\mu$ )
acres	$2.471 \times 10^{-2}$	acres (u.s.)
acres	$1.196 \times 10^2$	sq. yards
acres	$1. \times 10^2$	sq. meters
astronomical unit	$1.495 \times 10^8$	kilometers
atmospheres	$7.348 \times 10^{-3}$	tons/sq. in.
atmospheres	1.058	tons/sq. foot
atmospheres	$7.6 \times 10^1$	cms. of mercury (at 0°C.)
atmospheres	$3.39 \times 10^1$	ft. of water (at 4°C.)
atmospheres	$2.992 \times 10^1$	in. of mercury (at 0°C.)
atmospheres	$7.6 \times 10^{-1}$	meters of mercury (at 0°C.)
atmospheres	$7.6 \times 10^2$	millimeters of mercury (at 0°C.)
atmospheres	1.0333	kgs./sq. cm.
atmospheres	$1.0333 \times 10^4$	kgs./sq. meter
atmospheres	$1.47 \times 10^1$	pounds/sq. in.
<b>B</b>		
barrels (u.s., dry)	3.281	bushels
barrels (u.s., dry)	$7.056 \times 10^3$	cu. inches
barrels (u.s., dry)	$1.05 \times 10^2$	quarts (dry)
barrels (u.s. liquid)	$3.15 \times 10^1$	gallons
barrels (oil)	$4.2 \times 10^1$	gallons (oil)
bars	$9.869 \times 10^{-1}$	atmospheres
bars	$1. \times 10^6$	dynes/sq. cm.

Table 14-18. Conversions Factors (Sheet 2 of 9)

TO CONVERT	MULTIPLY BY	TO OBTAIN	TO CONVERT	MULTIPLY BY	TO OBTAIN
bars	$1.020 \times 10^4$	kgs./sq. meter	centimeters of mercury	$2.785 \times 10^1$	pounds/sq. ft.
bars	$2.089 \times 10^9$	pounds/sq. ft.	centimeters of mercury	$1.934 \times 10^{-1}$	pounds/sq. in.
bars	$1.45 \times 10^1$	pounds/sq. in.	centimeters/sec.	1.969	feet/min.
barye	1.00	dynes/sq. cm.	centimeters/sec.	$3.281 \times 10^{-2}$	feet/sec.
bolt (u.s., cloth)	$3.6576 \times 10^1$	meters	centimeters/sec.	$3.6 \times 10^{-2}$	kilometers/hr.
btu	$1.0409 \times 10^1$	liter-atmospheres	centimeters/sec.	$1.943 \times 10^{-2}$	knots
btu	$1.0550 \times 10^{10}$	ergs	centimeters/sec.	$6.0 \times 10^{-1}$	meters/min.
btu	$7.7816 \times 10^2$	foot-pounds	centimeters/sec.	$2.237 \times 10^{-2}$	miles/hr.
btu	$2.52 \times 10^2$	gram-calories	centimeters/sec.	$3.728 \times 10^{-4}$	miles/min.
btu	$3.927 \times 10^{-4}$	horsepower-hours	centimeters/sec./sec.	$3.281 \times 10^{-2}$	ft./sec./sec.
btu	$1.055 \times 10^3$	joules	centimeters/sec./sec.	$3.6 \times 10^{-2}$	kms./hr./sec.
btu	$2.52 \times 10^{-1}$	kilogram-calories	centimeters/sec./sec.	$1.0 \times 10^{-2}$	meters/sec./sec.
btu	$1.0758 \times 10^2$	kilogrammeters	centipoise	$1.0 \times 10^{-2}$	gr./cm.-sec.
btu	$2.928 \times 10^{-4}$	kilowatt-hours	centipoise	$6.72 \times 10^{-4}$	pound/ft.-sec.
btu/hr.	$2.162 \times 10^{-1}$	ft.-pounds/sec.	centipoise	2.4	pound/ft.-hr.
btu/hr.	$7.0 \times 10^{-2}$	gram-cal./sec.	chains (gunters)	$7.92 \times 10^2$	inches
btu/hr.	$2.931 \times 10^{-1}$	watts	chains (gunters)	$2.012 \times 10^1$	meters
btu/min.	$1.296 \times 10^1$	ft.-pounds/sec.	chains (gunters)	$2.2 \times 10^1$	yards
btu/min.	$2.356 \times 10^{-2}$	horsepower	circular mils	$5.067 \times 10^{-6}$	sq. cm.
btu/min.	$1.757 \times 10^{-2}$	kilowatts	circular mils	$7.854 \times 10^{-1}$	sq. mils
btu/min.	$1.757 \times 10^1$	watts	circular mils	$7.854 \times 10^{-7}$	sq. inches
btu/sq. ft./min.	$1.22 \times 10^{-1}$	watts/sq. in.	circumference	6.283	radians
bucket (br. dry)	$1.8184 \times 10^4$	cubic cm.	cords	8.0	cord ft.
bushels	1.2445	cubic ft.	cord ft.	$1.6 \times 10^1$	cubic ft.
bushels	$2.1504 \times 10^9$	cubic in.	coulombs	$2.998 \times 10^9$	statcoulombs
bushels	$3.524 \times 10^{-2}$	cubic meters	coulombs	$1.036 \times 10^{-5}$	faradays
bushels	$3.524 \times 10^1$	liters	coulombs/sq. cm.	6.452	coulombs/sq. in.
bushels	4.0	pecks	coulombs/sq. cm.	$1.0 \times 10^4$	coulombs/sq. meter
bushels	$6.4 \times 10^1$	pints (dry)	coulombs/sq. in.	$1.550 \times 10^{-1}$	coulombs/sq. cm.
bushels	$3.2 \times 10^1$	quarts (dry)	coulombs/sq. in.	$1.550 \times 10^3$	coulombs/sq. meter
	<b>C</b>		coulombs/sq. meter	$1.0 \times 10^{-4}$	coulombs/sq. cm.
calories, gram (mean)	$3.9685 \times 10^{-3}$	btu (mean)	coulombs/sq. meter	$6.452 \times 10^{-4}$	coulombs/sq. in.
candle/sq. cm.	3.1456	lamberts	cubic centimeters	$3.531 \times 10^{-5}$	cubic ft.
candle/sq. in.	$4.870 \times 10^{-1}$	lamberts	cubic centimeters	$6.102 \times 10^{-2}$	cubic in.
centares	1.0	sq. meters	cubic centimeters	$1.0 \times 10^{-6}$	cubic meters
centigrade (degrees)	$(^{\circ}\text{C} \times 9/5) + 32$	fahrenheit (degrees)	cubic centimeters	$1.308 \times 10^{-6}$	cubic yards
centigrade (degrees)	$^{\circ}\text{C} + 273.18$	kelvin (degrees)	cubic centimeters	$2.642 \times 10^{-4}$	gallons (u.s. liquid)
centigrams	$1. \times 10^{-2}$	grams	cubic centimeters	$1.0 \times 10^{-3}$	liters
centiliters	$3.382 \times 10^{-1}$	ounce (fluid) u.s.	cubic centimeters	$2.113 \times 10^{-3}$	pints (u.s. liquid)
centiliters	$6.103 \times 10^{-1}$	cubic in.	cubic centimeters	$1.057 \times 10^{-3}$	quarts (u.s. liquid)
centiliters	2.705	drams	cubic feet	$8.036 \times 10^{-1}$	bushels (dry)
centiliters	$1.0 \times 10^{-2}$	liters	cubic feet	$2.8320 \times 10^4$	cu. cms.
centimeters	$3.281 \times 10^{-2}$	feet	cubic feet	$1.728 \times 10^3$	cu. inches
centimeters	$3.937 \times 10^{-1}$	inches	cubic feet	$2.832 \times 10^{-2}$	cu. meters
centimeters	$1. \times 10^{-5}$	kilometers	cubic feet	$3.704 \times 10^{-2}$	cu. yards
centimeters	$1. \times 10^{-2}$	meters	cubic feet	7.48052	gallons (u.s. liquid)
centimeters	$6.214 \times 10^{-6}$	miles	cubic feet	$2.832 \times 10^1$	liters
centimeters	$1. \times 10^1$	millimeters	cubic feet	$5.984 \times 10^1$	pints (u.s. liquid)
centimeters	$3.937 \times 10^2$	mils	cubic feet	$2.992 \times 10^1$	quarts (u.s. liquid)
centimeters	$1.094 \times 10^{-2}$	yards	cubic feet/min.	$4.72 \times 10^2$	cu. cms./sec.
centimeters	$1. \times 10^4$	microns	cubic feet/min.	$1.247 \times 10^{-1}$	gallons/sec.
centimeters	$1. \times 10^8$	angstrom units	cubic feet/min.	$4.720 \times 10^{-1}$	liters/sec.
centimeter-dynes	$1.020 \times 10^{-3}$	cn-grams	cubic feet/min.	$6.243 \times 10^1$	pounds water/min.
centimeter-dynes	$1.020 \times 10^{-8}$	meter-kgs.	cubic feet/sec.	$6.46317 \times 10^{-1}$	million gals./day
centimeter-dynes	$7.376 \times 10^{-8}$	pound-ft.	cubic feet/sec.	$4.48831 \times 10^2$	gallons/min.
centimeter-dynes	$9.807 \times 10^2$	cm.-dynes	cubic inches	$1.639 \times 10^1$	cu cms.
centimeter-grams	$1. \times 10^{-5}$	meter-kgs.	cubic inches	$5.787 \times 10^{-4}$	cu. ft.
centimeter-grams	$7.233 \times 10^{-5}$	pound-ft.	cubic inches	$1.639 \times 10^{-5}$	cu. meters
centimeters of mercury	$1.316 \times 10^{-2}$	atmospheres	cubic inches	$2.143 \times 10^{-5}$	cu. yards
centimeters of mercury	$4.461 \times 10^{-1}$	ft. of water	cubic inches	$4.329 \times 10^{-3}$	gallons
centimeters of mercury	$1.36 \times 10^2$	kgs./sq. meter	cubic inches	$1.639 \times 10^{-2}$	liters
			cubic inches	$3.463 \times 10^{-2}$	pints (u.s. liquid)
			cubic inches	$1.732 \times 10^{-2}$	quarts (u.s. liquid)
			cubic meters	$2.838 \times 10^1$	bushels (dry)
			cubic meters	$1.0 \times 10^4$	cu. cms.
			cubic meters	$3.531 \times 10^1$	cu. ft.

Table I4-18. Conversions Factors (Sheet 3 of 9)

TO CONVERT	MULTIPLY BY	TO OBTAIN	TO CONVERT	MULTIPLY BY	TO OBTAIN
cubic meters	6.1023 x 10 <sup>-4</sup>	cu. inches	ergs	1.0 x 10 <sup>-7</sup>	joules
cubic meters	1.308	cu. yards	ergs	2.389 x 10 <sup>-11</sup>	kg.-calories
cubic meters	2.642 x 10 <sup>2</sup>	gallons (u.s. liquid)	ergs	1.020 x 10 <sup>-8</sup>	kg.-meters
cubic meters	1.0 x 10 <sup>3</sup>	liters	ergs	2.773 x 10 <sup>-14</sup>	kilowatt-hrs.
cubic meters	2.113 x 10 <sup>3</sup>	pints (u.s. liquid)	ergs	2.773 x 10 <sup>-11</sup>	watt-hrs.
cubic meters	1.057 x 10 <sup>3</sup>	quarts (u.s. liquid)	ergs/sec.	5.668 x 10 <sup>-9</sup>	btu/min.
cubic yards	7.646 x 10 <sup>5</sup>	cu. cms.	ergs/sec.	4.426 x 10 <sup>-6</sup>	ft.-lbs./min.
cubic yards	2.7 x 10 <sup>1</sup>	cu. ft.	ergs/sec.	7.3756 x 10 <sup>-8</sup>	ft.-lbs./sec.
cubic yards	4.6656 x 10 <sup>4</sup>	cu. inches	ergs/sec.	1.341 x 10 <sup>-10</sup>	horsepower
cubic yards	7.646 x 10 <sup>-1</sup>	cu. meters	ergs/sec.	1.433 x 10 <sup>-9</sup>	kg.-calories/min.
cubic yards	2.02 x 10 <sup>2</sup>	gallons (u.s. liquid)	ergs/sec.	1. x 10 <sup>-10</sup>	kilowatts
cubic yards	7.646 x 10 <sup>2</sup>	liters		<b>F</b>	
cubic yards	1.6159 x 10 <sup>3</sup>	pints (u.s. liquid)	farads	1. x 10 <sup>6</sup>	microfarads
cubic yards	8.079 x 10 <sup>2</sup>	quarts (u.s. liquid)	faraday/sec.	9.65 x 10 <sup>4</sup>	ampere (absolute)
cubic yards/min.	4.5 x 10 <sup>-1</sup>	cubic ft./sec.	faradays	2.68 x 10 <sup>1</sup>	ampere-hours
cubic yards/min.	3.367	gallons/sec.	faradays	9.649 x 10 <sup>4</sup>	coulombs
cubic yards/min.	1.274 x 10 <sup>1</sup>	liters/sec.	fathoms	1.8288	meters
	<b>D</b>		fathoms	6.0	feet
dalltons	1.650 x 10 <sup>-24</sup>	grams	feet	3.048 x 10 <sup>1</sup>	centimeters
days	8.64 x 10 <sup>4</sup>	seconds	feet	3.048 x 10 <sup>-4</sup>	kilometers
days	1.44 x 10 <sup>3</sup>	minutes	feet	3.048 x 10 <sup>-1</sup>	meters
days	2.4 x 10 <sup>1</sup>	hours	feet	1.645 x 10 <sup>-4</sup>	miles (naut.)
decigrams	1.0 x 10 <sup>-1</sup>	grams	feet	1.894 x 10 <sup>-4</sup>	miles (stat.)
deciliters	1.0 x 10 <sup>-1</sup>	liters	feet	3.048 x 10 <sup>2</sup>	millimeters
decimeters	1.0 x 10 <sup>-1</sup>	meters	feet	1.2 x 10 <sup>4</sup>	mils
degrees (angle)	1.111 x 10 <sup>-2</sup>	quadrants	feet of water	2.95 x 10 <sup>-2</sup>	atmospheres
degrees (angle)	1.745 x 10 <sup>-2</sup>	radians	feet of water	8.826 x 10 <sup>-1</sup>	in. of mercury
degrees (angle)	3.6 x 10 <sup>3</sup>	seconds	feet of water	3.048 x 10 <sup>-2</sup>	kgs./sq. cm.
degrees/sec.	1.745 x 10 <sup>-2</sup>	radians/sec.	feet of water	3.048 x 10 <sup>2</sup>	kgs./sq. meter
degrees/sec.	1.667 x 10 <sup>-1</sup>	revolutions/min.	feet of water	6.243 x 10 <sup>1</sup>	pounds/sq. ft.
degrees/sec.	2.778 x 10 <sup>-3</sup>	revolutions/sec.	feet of water	4.335 x 10 <sup>-1</sup>	pounds/sq. in.
dekagrams	1.0 x 10 <sup>1</sup>	grams	feet/min.	5.080 x 10 <sup>-1</sup>	cms./sec.
dekaliters	1.0 x 10 <sup>1</sup>	liters	feet/min.	1.667 x 10 <sup>-2</sup>	feet/sec.
dekameters	1.0 x 10 <sup>1</sup>	meters	feet/min.	1.829 x 10 <sup>-2</sup>	kms./hr.
drams (apoth. ortroy)	1.3714 x 10 <sup>-1</sup>	ounces (avdp.)	feet/min.	3.048 x 10 <sup>-1</sup>	meters/min.
drams (apoth. ortroy)	1.25 x 10 <sup>-1</sup>	ounces (troy)	feet/min.	1.136 x 10 <sup>-2</sup>	miles/hr.
drams (u.s. fluid)	3.6967	cubic cm.	feet/sec.	3.048 x 10 <sup>1</sup>	cms./sec.
drams (u.s. fluid)			feet/sec.	1.097	kms./hr.
drams	1.7718	grams	feet/sec.	5.921 x 10 <sup>-1</sup>	knots
drams	2.7344 x 10 <sup>1</sup>	grains	feet/sec.	1.829 x 10 <sup>1</sup>	meters/min.
drams	6.25 x 10 <sup>-2</sup>	ounces	feet/sec.	6.818 x 10 <sup>-1</sup>	miles/hr.
dynes/sq. cm.	1.0 x 10 <sup>-2</sup>	ergs/sq. millimeter	feet/sec.	1.136 x 10 <sup>-2</sup>	miles/min.
dynes/sq. cm.	9.869 x 10 <sup>-7</sup>	atmospheres	feet/sec./sec.	3.048 x 10 <sup>1</sup>	cms./sec./sec.
dynes/sq. cm.	2.953 x 10 <sup>-5</sup>	in. of mercury	feet/sec./sec.	1.097	kms./hr./sec.
dynes/sq. cm.		(at 0°C.)	feet/sec./sec.	3.048 x 10 <sup>-1</sup>	meters/sec./sec.
dynes/sq. cm.	4.015 x 10 <sup>-4</sup>	in. of water (at 4°C.)	feet/sec./sec.	6.818 x 10 <sup>-1</sup>	miles/hr./sec.
dynes	1.020 x 10 <sup>-3</sup>	grams	feet/100/feet	1.0	per cent grade
dynes	1.0 x 10 <sup>-7</sup>	joules/cm.	foot-candle	1.0764 x 10 <sup>1</sup>	lumen/sq. meter
dynes	1.0 x 10 <sup>-5</sup>	joules/meter	foot-candle	1.0764 x 10 <sup>1</sup>	lux
dynes		(newtons)	foot-pounds	1.286 x 10 <sup>-3</sup>	btu
dynes	1.020 x 10 <sup>-6</sup>	kilograms	foot-pounds	1.356 x 10 <sup>7</sup>	ergs
dynes	7.233 x 10 <sup>-6</sup>	poundals	foot-pounds	3.241 x 10 <sup>-1</sup>	gram-calories
dynes	2.248 x 10 <sup>-6</sup>	pounds	foot-pounds	5.050 x 10 <sup>-7</sup>	horsepower-hrs.
dynes/sq. cm.	1.0 x 10 <sup>-6</sup>	bars	foot-pounds	1.356	joules
	<b>E</b>		foot-pounds	3.241 x 10 <sup>-4</sup>	kg.-calories
ell	1.1430 x 10 <sup>2</sup>	cm.	foot-pounds	1.383 x 10 <sup>-1</sup>	kg.-meters
ell	4.5 x 10 <sup>1</sup>	inches	foot-pounds	3.766 x 10 <sup>-7</sup>	kilowatt-hrs.
em, pica	1.67 x 10 <sup>-1</sup>	inch	foot-pounds/min.	1.286 x 10 <sup>-3</sup>	btu/min.
em, pica	4.233 x 10 <sup>-1</sup>	cm.	foot-pounds/min.	1.667 x 10 <sup>-2</sup>	foot-pounds/sec.
erg/sec.	1.0	dyne-cm./sec.	foot-pounds/min.	3.030 x 10 <sup>-5</sup>	horsepower
ergs	9.486 x 10 <sup>-11</sup>	btu	foot-pounds/min.	3.241 x 10 <sup>-4</sup>	kg.-calories/min.
ergs	1.0	dyne-centimeters	foot-pounds/min.	2.260 x 10 <sup>-5</sup>	kilowatts
ergs	7.376 x 10 <sup>-8</sup>	foot-pounds	foot-pounds/sec.	4.6263	btu/hr.
ergs	2.389 x 10 <sup>-8</sup>	gram-calories	foot-pounds/sec.	7.717 x 10 <sup>-2</sup>	btu/min.
ergs	1.020 x 10 <sup>-3</sup>	gram-cms.	foot-pounds/sec.	1.818 x 10 <sup>-3</sup>	horsepower
ergs	3.7250 x 10 <sup>-14</sup>	horsepower-hrs.	foot-pounds/sec.	1.945 x 10 <sup>-2</sup>	kg.-calories/min.
			foot-pounds/sec.	1.356 x 10 <sup>-3</sup>	kilowatts

# General Engineering Data

TO CONVERT	MULTIPLY BY	TO OBTAIN
furlongs	$1.25 \times 10^{-1}$	miles (u.s.)
furlongs	$4.0 \times 10^1$	rods
furlongs	$6.6 \times 10^2$	feet
furlongs	$2.0117 \times 10^2$	meters
<b>G</b>		
gallons	$3.785 \times 10^3$	cu. cms.
gallons	$1.337 \times 10^{-1}$	cu. feet
gallons	$2.31 \times 10^2$	cu. inches
gallons	$3.785 \times 10^{-3}$	cu. meters
gallons	$4.951 \times 10^{-3}$	cu. yards
gallons	3.785	liters
gallons (liq. br. imp.)	1.20095	gallons (u.s. liquid)
gallons (u.s.)	$8.3267 \times 10^{-1}$	gallons (imp.)
gallons of water	8.337	pounds of water
gallons/min.	$2.228 \times 10^{-3}$	cu. feet/sec.
gallons/min.	$6.308 \times 10^{-2}$	liters/sec.
gallons/min.	8.0208	cu. feet/hr.
gausses	6.452	lines/sq. in.
gausses	$1.0 \times 10^{-8}$	webers/sq. cm.
gausses	$6.452 \times 10^{-6}$	webers/sq. in.
gausses	$1.0 \times 10^{-4}$	webers/sq. meter
gausses	$7.958 \times 10^{-1}$	amp.-turn/cm.
gausses	1.0	gilbert/cm.
gilberts	$7.958 \times 10^{-1}$	ampere-turns
gilberts/cm.	$7.958 \times 10^{-1}$	ampere-turns/cm.
gilberts/cm.	2.021	ampere-turns/in.
gilberts/cm.	$7.958 \times 10^1$	ampere-turns/meter
gills (british)	$1.4207 \times 10^2$	cubic cm.
gills (u.s.)	$1.18295 \times 10^2$	cubic cm.
gills (u.s.)	$1.183 \times 10^{-1}$	liters
gills (u.s.)	$2.5 \times 10^{-1}$	pints (liq.)
grade	$1.571 \times 10^{-2}$	radian
grains	$3.657 \times 10^{-2}$	drams (avdp.)
grains (troy)	1.0	grains (avdp.)
grains (troy)	$6.48 \times 10^{-2}$	grams
grains (troy)	$2.0833 \times 10^{-3}$	ounces (avdp.)
grains (troy)	$4.167 \times 10^{-2}$	pennyweight (troy)
grains u.s. gallon	$1.7118 \times 10^1$	parts/million
grains u.s. gallon	$1.4286 \times 10^2$	pounds/million
grains imp. gallon	$1.4286 \times 10^1$	gallons
grams	$9.807 \times 10^2$	parts/million
grams	$1.543 \times 10^1$	dynes
grams	$9.807 \times 10^5$	grains (troy)
grams	$9.807 \times 10^{-3}$	joules/cm.
grams	$9.807 \times 10^{-3}$	joules/meter (newtons)
grams	$1.0 \times 10^{-3}$	kilograms
grams	$1.0 \times 10^3$	milligrams
grams	$3.527 \times 10^{-2}$	ounces (avdp.)
grams	$3.215 \times 10^{-2}$	ounces (troy)
grams	$7.093 \times 10^{-2}$	poundals
grams	$2.205 \times 10^{-3}$	pounds
grams/cm	$5.6 \times 10^{-3}$	pounds/in.
grams/cu. cm.	$6.243 \times 10^1$	pounds/cu. ft.
grams/cu. cm.	$3.613 \times 10^{-2}$	pounds/cu. in.
grams/cu. cm.	$3.405 \times 10^{-7}$	pounds/mil-foot
grams/liter	$5.8417 \times 10^1$	grains/gal.
grams/liter	8.345	pounds/1,000 gal.
grams/liter	$6.2427 \times 10^{-2}$	pounds/cu. ft.
grams/sq. cm.	2.0481	pounds/sq. ft.
gram-calories	$3.9683 \times 10^{-3}$	btu
gram-calories	$4.184 \times 10^7$	ergs
gram-calories	3.086	foot-pounds
gram-calories	$1.5596 \times 10^{-6}$	horsepower-hrs.
gram-calories	$1.162 \times 10^{-6}$	kilowatt-hrs.
gram-calories	$1.162 \times 10^{-3}$	watt-hrs.

TO CONVERT	MULTIPLY BY	TO OBTAIN
gram-calories/sec.	$1.4286 \times 10^1$	btu/hr.
gram-centimeters	$9.297 \times 10^{-8}$	btu
gram-centimeters	$9.807 \times 10^2$	ergs
gram-centimeters	$9.807 \times 10^{-5}$	joules
gram-centimeters	$2.343 \times 10^{-8}$	kg.-calories
gram-centimeters	$1.0 \times 10^{-5}$	kg.-meters
<b>H</b>		
hand	$1.016 \times 10^1$	cm.
hectares	2.471	acres
hectares	$1.076 \times 10^5$	sq. feet
hectograms	$1.0 \times 10^2$	grams
hectoliters	$1.0 \times 10^2$	liters
hectometers	$1.0 \times 10^2$	meters
hectowatts	$1.0 \times 10^2$	watts
henries	$1.0 \times 10^3$	millihenries
hogsheads (british)	$1.0114 \times 10^1$	cubic ft.
hogsheads (u.s.)	8.42184	cubic ft.
hogsheads (u.s.)	$6.3 \times 10^1$	gallons (u.s.)
horsepower	$4.244 \times 10^1$	btu/min.
horsepower	$3.3 \times 10^4$	foot-lbs./min.
horsepower	$5.50 \times 10^2$	foot-lbs./sec.
horsepower (metric)	$9.863 \times 10^{-1}$	horsepower
horsepower	1.014	horsepower (metric)
horsepower	$1.068 \times 10^1$	kg.-calories/min.
horsepower	$7.457 \times 10^{-1}$	kilowatts
horsepower	$7.457 \times 10^2$	watts
horsepower (boiler)	$3.352 \times 10^4$	btu/hr.
horsepower (boiler)	9.803	kilowatts
horsepower-hours	$2.547 \times 10^3$	btu
horsepower-hours	$2.6845 \times 10^3$	ergs
horsepower-hours	$1.98 \times 10^6$	foot-lbs.
horsepower-hours	$6.4119 \times 10^5$	gram-calories
horsepower-hours	$2.684 \times 10^6$	joules
horsepower-hours	$6.417 \times 10^2$	kg.-calories
horsepower-hours	$2.737 \times 10^5$	kg.-meters
horsepower-hours	$7.457 \times 10^{-1}$	kilowatt-hrs.
hours	$4.167 \times 10^{-2}$	days
hours	$5.952 \times 10^{-3}$	weeks
hours	$3.6 \times 10^3$	seconds
hundredwts (long)	$1.12 \times 10^2$	pounds
hundredwts (long)	$5.0 \times 10^{-2}$	tons (long)
hundredwts (long)	$5.08023 \times 10^1$	kilograms
hundredwts (short)	$4.53592 \times 10^{-2}$	tons (metric)
hundredwts (short)	$4.46429 \times 10^2$	tons (long)
hundredwts (short)	$4.53592 \times 10^1$	kilograms
<b>I</b>		
inches	2.540	centimeters
inches	$2.540 \times 10^{-2}$	meters
inches	$1.578 \times 10^{-5}$	miles
inches	$2.54 \times 10^1$	millimeters
inches	$1.0 \times 10^3$	mils
inches	$2.778 \times 10^{-2}$	yards
inches	$2.54 \times 10^0$	angstrom units
inches	$5.0505 \times 10^{-3}$	rods
inches of mercury	$3.342 \times 10^{-2}$	atmospheres
inches of mercury	1.133	feet of water
inches of mercury	$3.453 \times 10^{-2}$	kgs./sq. cm.
inches of mercury	$3.453 \times 10^2$	kgs./sq. meter
inches of mercury	$7.073 \times 10^1$	pounds/sq. ft.
inches of mercury	$4.912 \times 10^{-1}$	pounds/sq. in.
in. of water (at 4°C.)	$2.458 \times 10^{-3}$	atmospheres
in. of water (at 4°C.)	$7.355 \times 10^{-2}$	inches of mercury
in. of water (at 4°C.)	$2.54 \times 10^{-3}$	kgs./sq. cm.
in. of water (at 4°C.)	$5.781 \times 10^{-1}$	ounces/sq. in.
in. of water (at 4°C.)	5.204	pounds/sq. ft.
in. of water (at 4°C.)	$3.613 \times 10^{-2}$	pounds/sq. in.

Table 14-18. Conversions Factors (Sheet 4 of 9)

TO CONVERT	MULTIPLY BY	TO OBTAIN	TO CONVERT	MULTIPLY BY	TO OBTAIN
internat'l ampere	$9.998 \times 10^{-1}$	absolute amp. (u.s.)	kiloliters	$1.0 \times 10^3$	liters
internat'l volt	1.00033	absolute volt (u.s.)	kiloliters	1.308	cubic yards
internat'l coulomb	$9.99835 \times 10^{-1}$	absolute coulomb	kiloliters	$3.5316 \times 10^1$	cubic feet
	<b>J</b>		kiloliters	$2.6418 \times 10^2$	gallons (u.s. liquid)
joules	$9.486 \times 10^{-4}$	btu	kilometers	$1.0 \times 10^5$	centimeters
joules	$1.0 \times 10^7$	ergs	kilometers	$3.281 \times 10^3$	feet
joules	$7.736 \times 10^{-1}$	foot-pounds	kilometers	$3.937 \times 10^4$	inches
joules	$2.389 \times 10^{-4}$	kg.-calories	kilometers	$1.0 \times 10^3$	meters
joules	$1.020 \times 10^{-1}$	kg.-meters	kilometers	$6.214 \times 10^{-1}$	miles (statute)
joules	$2.778 \times 10^{-4}$	watt-hrs.	kilometers	$5.396 \times 10^{-1}$	miles (nautical)
joules/cm.	$1.020 \times 10^4$	grams	kilometers	$1.0 \times 10^6$	millimeters
joules/cm.	$1.0 \times 10^7$	dynes	kilometers	$1.0936 \times 10^3$	yards
joules/cm.	$1.0 \times 10^2$	joules/meter (newtons)	kilometers/hr.	$2.778 \times 10^1$	cms./sec.
joules/cm.	$7.233 \times 10^2$	poundals	kilometers/hr.	$5.468 \times 10^1$	feet/min.
joules/cm.	$2.248 \times 10^1$	pounds	kilometers/hr.	$9.113 \times 10^{-1}$	feet/sec.
	<b>K</b>		kilometers/hr.	$5.396 \times 10^{-1}$	knots
kilograms	$9.80665 \times 10^5$	dynes	kilometers/hr.	$1.667 \times 10^1$	meters/min.
kilograms	$1.0 \times 10^3$	grams	kilometers/hr.	$6.214 \times 10^{-1}$	miles/hr.
kilograms	$9.807 \times 10^{-2}$	grams/cm.	kilometers/hr./sec.	$2.778 \times 10^1$	cms./sec./sec.
kilograms	9.807	joules/meter (newtons)	kilometers/hr./sec.	$9.113 \times 10^{-1}$	ft./sec./sec.
kilograms	$7.093 \times 10^1$	poundals	kilometers/hr./sec.	$2.778 \times 10^{-1}$	meters/sec./sec.
kilograms	2.2046	pounds	kilometers/hr./sec.	$6.214 \times 10^{-1}$	miles/hr./sec.
kilograms	$9.842 \times 10^{-4}$	tons (long)	kilowatts	$5.692 \times 10^1$	btu/min.
kilograms	$1.102 \times 10^{-3}$	tons (short)	kilowatts	$4.426 \times 10^4$	foot-lbs./min.
kilograms	$3.5274 \times 10^1$	ounces (avdp.)	kilowatts	$7.376 \times 10^2$	foot-lbs./sec.
kilograms/cu. meter	$1.0 \times 10^{-3}$	grams/cu. cm.	kilowatts	1.341	horsepower
kilograms/cu. meter	$6.243 \times 10^{-2}$	pounds/cu. ft.	kilowatts	$1.434 \times 10^1$	kg.-calories/min.
kilograms/cu. meter	$3.613 \times 10^{-5}$	pounds/cu. in.	kilowatts	$1.0 \times 10^3$	watts
kilograms/cu. meter	$3.405 \times 10^{-10}$	pounds/mil-foot	kilowatt-hrs.	$3.413 \times 10^3$	btu
kilograms/meter	$6.72 \times 10^{-1}$	pounds/ft.	kilowatt-hrs.	$3.6 \times 10^{13}$	ergs
kilograms/sq. cm.	$9.80665 \times 10^5$	dynes/sq. cm.	kilowatt-hrs.	$2.655 \times 10^6$	foot-lbs.
kilograms/sq. cm.	$9.678 \times 10^{-1}$	atmospheres	kilowatt-hrs.	$8.5985 \times 10^3$	gram calories
kilograms/sq. cm.	$3.281 \times 10^1$	feet of water	kilowatt-hrs.	1.341	horsepower-hours
kilograms/sq. cm.	$2.896 \times 10^1$	inches of mercury	kilowatt-hrs.	$3.6 \times 10^6$	joules
kilograms/sq. cm.	$2.048 \times 10^3$	pounds/sq. ft.	kilowatt-hrs.	$8.605 \times 10^2$	kg.-calories
kilograms/sq. cm.	$1.422 \times 10^1$	pounds/sq. in.	kilowatt-hrs.	$3.671 \times 10^5$	kg.-meters
kilograms/sq. meter	$9.678 \times 10^{-5}$	atmospheres	kilowatt-hrs.	3.53	pounds of water evaporated from and at 212°F.
kilograms/sq. meter	$9.807 \times 10^{-5}$	bars	kilowatt-hrs.	$2.275 \times 10^1$	pounds of water raised from 62°F to 212°F.
kilograms/sq. meter	$3.281 \times 10^{-3}$	feet of water	knots	$6.080 \times 10^3$	feet/hr.
kilograms/sq. meter	$2.896 \times 10^{-3}$	inches of mercury	knots	1.8532	kilometers/hr.
kilograms/sq. meter	$2.048 \times 10^{-1}$	pounds/sq. ft.	knots	1.0	nautical miles/hr.
kilograms/sq. meter	$1.422 \times 10^{-3}$	pounds/sq. in.	knots	1.151	statute miles/hr.
kilograms/sq. meter	$9.80665 \times 10^1$	dynes/sq. cm.	knots	$2.027 \times 10^3$	yards/hr.
kilograms/sq. mm.	$1.0 \times 10^6$	kgs./sq. meter	knots	1.689	feet/sec.
kilogram-calories	3.968	btu	knots	$5.148 \times 10^1$	cm./sec.
kilogram-calories	$3.086 \times 10^3$	foot-pounds			
kilogram-calories	$1.558 \times 10^{-3}$	horsepower-hrs.			
kilogram-calories	$4.183 \times 10^3$	joules			
kilogram-calories	$4.269 \times 10^2$	kg.-meters	lambert	$3.183 \times 10^{-1}$	candle/sq. cm.
kilogram-calories	4.186	kilojoules	lambert	2.054	candle/sq. in.
kilogram-calories	$1.163 \times 10^{-3}$	kilowatt-hrs.	league	3.0	miles (approx.)
kilogram-calories	$5.143 \times 10^1$	ft.-lbs./sec.	light year	$5.9 \times 10^{12}$	miles
calories/min.			light year	$9.46091 \times 10^{12}$	kilometers
kilogram-calories/min.	$9.351 \times 10^{-2}$	horsepower	lines/sq. cm.	1.0	gausses
calories/min.			lines/sq. in.	$1.55 \times 10^{-1}$	gausses
kilogram-calories/min.	$6.972 \times 10^{-2}$	kilowatts	lines/sq. in.	$1.55 \times 10^{-9}$	webers/sq. cm.
calories/min.			lines/sq. in.	$1.0 \times 10^{-8}$	webers/sq. in.
kilogram-meters	$9.296 \times 10^{-3}$	btu	lines/sq. in.	$1.55 \times 10^{-5}$	webers/sq. meter
kilogram-meters	$9.807 \times 10^7$	ergs	links (engineers)	$1.2 \times 10^1$	inches
kilogram-meters	7.233	foot-pounds	links (surveyors)	7.92	inches
kilogram-meters	9.807	joules	liters	$2.838 \times 10^{-2}$	bushels (u.s. dry)
kilogram-meters	$2.342 \times 10^{-3}$	kg.-calories	liters	$1.0 \times 10^3$	cu. cm.
kilogram-meters	$2.723 \times 10^{-6}$	kilowatt-hrs.	liters	$3.531 \times 10^{-2}$	cu. ft.
kilolines	$1.0 \times 10^3$	maxwells	liters	$6.102 \times 10^1$	cu. inches
			liters	$1.0 \times 10^{-3}$	cu. meters

Table 14-18. Conversions Factors (Sheet 5 of 9)

TO CONVERT	MULTIPLY BY	TO OBTAIN	TO CONVERT	MULTIPLY BY	TO OBTAIN
internat'l ampere	9.998 x 10 <sup>-1</sup>	absolute amp. (u.s.)	kiloliters	1.0 x 10 <sup>3</sup>	liters
internat'l volt	1.00033	absolute volt (u.s.)	kiloliters	1.308	cubic yards
internat'l coulomb	9.99835 x 10 <sup>-1</sup>	absolute coulomb	kiloliters	3.5316 x 10 <sup>1</sup>	cubic feet
<b>J</b>			kiloliters	2.6418 x 10 <sup>2</sup>	gallons (u.s. liquid)
joules	9.486 x 10 <sup>-4</sup>	btu	kilometers	1.0 x 10 <sup>5</sup>	centimeters
joules	1.0 x 10 <sup>7</sup>	ergs	kilometers	3.281 x 10 <sup>3</sup>	feet
joules	7.736 x 10 <sup>-1</sup>	foot-pounds	kilometers	3.937 x 10 <sup>4</sup>	inches
joules	2.389 x 10 <sup>-4</sup>	kg.-calories	kilometers	1.0 x 10 <sup>3</sup>	meters
joules	1.020 x 10 <sup>-1</sup>	kg.-meters	kilometers	6.214 x 10 <sup>-1</sup>	miles (statute)
joules	2.778 x 10 <sup>-4</sup>	watt-hrs.	kilometers	5.396 x 10 <sup>-1</sup>	miles (nautical)
joules/cm.	1.020 x 10 <sup>4</sup>	grams	kilometers	1.0 x 10 <sup>6</sup>	millimeters
joules/cm.	1.0 x 10 <sup>7</sup>	dynes	kilometers	1.0936 x 10 <sup>3</sup>	yards
joules/cm.	1.0 x 10 <sup>2</sup>	joules/meter	kilometers/hr.	2.778 x 10 <sup>1</sup>	cms./sec.
		(newtons)	kilometers/hr.	5.468 x 10 <sup>1</sup>	feet/min.
joules/cm.	7.233 x 10 <sup>2</sup>	poundals	kilometers/hr.	9.113 x 10 <sup>-1</sup>	feet/sec.
joules/cm.	2.248 x 10 <sup>1</sup>	pounds	kilometers/hr.	5.396 x 10 <sup>-1</sup>	knots
<b>K</b>			kilometers/hr.	1.667 x 10 <sup>1</sup>	meters/min.
kilograms	9.80665 x 10 <sup>5</sup>	dynes	kilometers/hr.	6.214 x 10 <sup>-1</sup>	miles/hr.
kilograms	1.0 x 10 <sup>3</sup>	grams	kilometers/hr./sec.	2.778 x 10 <sup>1</sup>	cms./sec./sec.
kilograms	9.807 x 10 <sup>-2</sup>	joules/cm.	kilometers/hr./sec.	9.113 x 10 <sup>-1</sup>	ft./sec./sec.
kilograms	9.807	joules/meter	kilometers/hr./sec.	2.778 x 10 <sup>-1</sup>	meters/sec./sec.
		(newtons)	kilometers/hr./sec.	6.214 x 10 <sup>-1</sup>	miles/hr./sec.
kilograms	7.093 x 10 <sup>1</sup>	poundals	kilowatts	5.692 x 10 <sup>1</sup>	btu/min.
kilograms	2.2046	pounds	kilowatts	4.426 x 10 <sup>4</sup>	foot-lbs./min.
kilograms	9.842 x 10 <sup>-4</sup>	tons (long)	kilowatts	7.376 x 10 <sup>2</sup>	foot-lbs./sec.
kilograms	1.102 x 10 <sup>-3</sup>	tons (short)	kilowatts	1.341	horsepower
kilograms	3.5274 x 10 <sup>1</sup>	ounces (avdp.)	kilowatts	1.434 x 10 <sup>1</sup>	kg.-calories/min.
kilograms/cu. meter	1.0 x 10 <sup>-3</sup>	grams/cu. cm.	kilowatts	1.0 x 10 <sup>3</sup>	watts
kilograms/cu. meter	6.243 x 10 <sup>-2</sup>	pounds/cu. ft.	kilowatt-hrs.	3.413 x 10 <sup>3</sup>	btu
kilograms/cu. meter	3.613 x 10 <sup>-5</sup>	pounds/cu. in.	kilowatt-hrs.	3.6 x 10 <sup>13</sup>	ergs
kilograms/cu. meter	3.405 x 10 <sup>-10</sup>	pounds/mil-foot	kilowatt-hrs.	2.655 x 10 <sup>6</sup>	foot-lbs.
kilograms/meter	6.72 x 10 <sup>-1</sup>	pounds/ft.	kilowatt-hrs.	8.5985 x 10 <sup>3</sup>	gram calories
kilograms/sq. cm.	9.80665 x 10 <sup>5</sup>	dynes/sq. cm.	kilowatt-hrs.	1.341	horsepower-hours
kilograms/sq. cm.	9.678 x 10 <sup>-1</sup>	atmospheres	kilowatt-hrs.	3.6 x 10 <sup>6</sup>	joules
kilograms/sq. cm.	3.281 x 10 <sup>1</sup>	feet of water	kilowatt-hrs.	8.605 x 10 <sup>2</sup>	kg.-calories
kilograms/sq. cm.	2.896 x 10 <sup>1</sup>	inches of mercury	kilowatt-hrs.	3.671 x 10 <sup>5</sup>	kg.-meters
kilograms/sq. cm.	2.048 x 10 <sup>3</sup>	pounds/sq. ft.	kilowatt-hrs.	3.53	pounds of water
kilograms/sq. cm.	1.422 x 10 <sup>1</sup>	pounds/sq. in.			evaporated from
kilograms/sq. meter	9.678 x 10 <sup>-5</sup>	atmospheres	kilowatt hrs.	2.275 x 10 <sup>1</sup>	and at 212°F.
kilograms/sq. meter	9.807 x 10 <sup>-5</sup>	bars			pounds of water
kilograms/sq. meter	3.281 x 10 <sup>-3</sup>	feet of water			raised from 62°
kilograms/sq. meter	2.896 x 10 <sup>-3</sup>	inches of mercury	knots	6.080 x 10 <sup>3</sup>	to 212°F.
kilograms/sq. meter	2.048 x 10 <sup>-1</sup>	pounds/sq. ft.	knots	1.8532	feet/hr.
kilograms/sq. meter	1.422 x 10 <sup>-3</sup>	pounds/sq. in.	knots	1.0	kilometers/hr.
kilograms/sq. meter	9.80665 x 10 <sup>1</sup>	dynes/sq. cm.	knots	1.151	nautical miles/hr.
kilograms/sq. mm.	1.0 x 10 <sup>6</sup>	kgs./sq. meter	knots	2.027 x 10 <sup>3</sup>	statute miles/hr.
kilogram-calories	3.968	btu	knots	1.689	yards/hr.
kilogram-calories	3.086 x 10 <sup>3</sup>	foot-pounds	knots	5.148 x 10 <sup>1</sup>	feet/sec.
kilogram-calories	1.558 x 10 <sup>-3</sup>	horsepower-hrs.			cm./sec.
kilogram-calories	4.183 x 10 <sup>3</sup>	joules	<b>L</b>		
kilogram-calories	4.269 x 10 <sup>2</sup>	kg.-meters	lambert	3.183 x 10 <sup>-1</sup>	candle/sq. cm.
kilogram-calories	4.186	kilojoules	lambert	2.054	candle/sq. in.
kilogram-calories	1.163 x 10 <sup>-3</sup>	kilowatt-hrs.	league	3.0	miles (approx.)
kilogram-	5.143 x 10 <sup>1</sup>	ft.-lbs./sec.	light year	5.9 x 10 <sup>12</sup>	miles
calories/min.			light year	9.46091 x 10 <sup>12</sup>	kilometers
kilogram-			lines/sq. cm.	1.0	gausses
calories/min.	9.351 x 10 <sup>-2</sup>	horsepower	lines/sq. in.	1.55 x 10 <sup>-1</sup>	gausses
kilogram-			lines/sq. in.	1.55 x 10 <sup>-9</sup>	webers/sq. cm.
calories/min.	6.972 x 10 <sup>-2</sup>	kilowatts	lines/sq. in.	1.0 x 10 <sup>-6</sup>	webers/sq. in.
kilogram-meters	9.296 x 10 <sup>-3</sup>	btu	links (engineers)	1.55 x 10 <sup>-5</sup>	webers/sq. meter
kilogram-meters	9.807 x 10 <sup>7</sup>	ergs	links (surveyors)	1.2 x 10 <sup>1</sup>	inches
kilogram-meters	7.233	foot-pounds	liters	7.92	inches
kilogram-meters	9.807	joules	liters	2.838 x 10 <sup>-2</sup>	bushels (u.s. dry)
kilogram-meters	2.342 x 10 <sup>-3</sup>	kg.-calories	liters	1.0 x 10 <sup>3</sup>	cu. cm.
kilogram-meters	2.723 x 10 <sup>-6</sup>	kilowatt-hrs.	liters	3.531 x 10 <sup>-2</sup>	cu. ft.
kilolines	1.0 x 10 <sup>3</sup>	maxwells	liters	6.102 x 10 <sup>1</sup>	cu. inches
			liters	1.0 x 10 <sup>-3</sup>	cu. meters



Table 14-18. Conversions Factors (Sheet 6 of 9)

TO CONVERT	MULTIPLY BY	TO OBTAIN	TO CONVERT	MULTIPLY BY	TO OBTAIN
liters	$1.308 \times 10^{-3}$	cu. yards	miles (statute)	$1.609 \times 10^5$	centimeters
liters	$2.642 \times 10^{-1}$	gallons (u.s. liquid)	miles (statute)	$5.280 \times 10^3$	feet
liters	2.113	pints (u.s. liquid)	miles (statute)	$6.336 \times 10^4$	inches
liters	1.057	quarts (u.s. liquid)	miles (statute)	1.609	kilometers
liters/min.	$5.886 \times 10^{-4}$	cu. ft./sec.	miles (statute)	$1.609 \times 10^3$	meters
liters/min.	$4.403 \times 10^{-3}$	gals./sec.	miles (statute)	$8.684 \times 10^{-1}$	miles (nautical)
$\log_{10} n$	2.303	ln n	miles (statute)	$1.760 \times 10^3$	yards
ln n	$4.343 \times 10^{-1}$	$\log_{10} n$	miles (statute)	$1.69 \times 10^{-13}$	light years
lumen	$7.958 \times 10^{-2}$	spherical candle power	miles/hr.	$4.470 \times 10^1$	cms./sec.
lumen/sq. ft.	1.0	foot-candles	miles/hr.	$8.8 \times 10^1$	ft./min.
lumen/sq. ft.	$1.076 \times 10^1$	lumen-sq. meter	miles/hr.	1.467	ft./sec.
lux	$9.29 \times 10^{-2}$	foot-candles	miles/hr.	1.6093	kms./hr.
	<b>M</b>		miles/hr.	$2.682 \times 10^{-2}$	kms./min.
maxwells	$1.0 \times 10^{-3}$	kilolines	miles/hr.	$8.684 \times 10^{-1}$	knots
maxwells	$1.0 \times 10^{-8}$	webers	miles/hr.	$2.682 \times 10^1$	meters/min.
megalines	$1.0 \times 10^6$	maxwells	miles/hr./sec.	$1.667 \times 10^{-2}$	miles/min.
megohms	$1.0 \times 10^{12}$	microhms	miles/hr./sec.	$4.47 \times 10^1$	cms./sec./sec.
megohms	$1.0 \times 10^6$	ohms	miles/hr./sec.	1.467	ft./sec./sec.
megmhos/cubic cm.	$1.0 \times 10^{-3}$	abmhos/cubic cm.	miles/hr./sec.	1.6093	kms./hr./sec.
megmhos/cubic cm.	2.54	megmhos/cubic in.	miles/min.	$4.47 \times 10^{-1}$	meters/sec./sec.
megmhos/cubic cm.	$1.662 \times 10^{-1}$	mhos/mil. ft.	miles/min.	$2.682 \times 10^3$	cms./sec.
megmhos/in. cube	$3.937 \times 10^{-1}$	megmhos/cubic cm.	miles/min.	$8.8 \times 10^1$	feet/sec.
meters	$1.0 \times 10^{10}$	angstrom units	miles/min.	1.6093	kms./min.
meters	$1.0 \times 10^{12}$	centimeters	miles/min.	$8.684 \times 10^{-1}$	knots/min.
meters	$5.4681 \times 10^{-1}$	fathoms	miles/min.	$6.0 \times 10^1$	miles/hr.
meters	3.281	feet	milliers	$1.0 \times 10^3$	kilograms
meters	$3.937 \times 10^1$	inches	millimicrons	$1.0 \times 10^{-9}$	meters
meters	$1.0 \times 10^{-3}$	kilometers	milligrams	$1.5432 \times 10^{-2}$	grains
meters	$5.396 \times 10^{-4}$	miles (nautical)	milligrams	$1.0 \times 10^{-3}$	grams
meters	$6.214 \times 10^{-4}$	miles (statute)	milligrams/liter	1.0	parts/million
meters	$1.0 \times 10^3$	millimeters	millihenries	$1.0 \times 10^{-3}$	henries
meters	1.094	yards	milliliters	$1.0 \times 10^{-3}$	liters
meters/min.	1.667	cms./sec.	millimeters	$1.0 \times 10^{-1}$	centimeters
meters/min.	3.281	feet/min.	millimeters	$3.281 \times 10^{-3}$	feet
meters/min.	$5.468 \times 10^{-2}$	feet/sec.	millimeters	$3.937 \times 10^{-2}$	inches
meters/min.	$6.0 \times 10^{-2}$	kms./hr.	millimeters	$1.0 \times 10^{-6}$	kilometers
meters/min.	$3.238 \times 10^{-2}$	knots	millimeters	$1.0 \times 10^{-3}$	meters
meters/min.	$3.728 \times 10^{-2}$	miles/hr.	millimeters	$6.214 \times 10^{-7}$	miles
meters/sec.	$1.968 \times 10^2$	feet/min.	millimeters	$3.937 \times 10^1$	mils
meters/sec.	3.281	feet/sec.	millimeters	$1.094 \times 10^{-3}$	yards
meters/sec.	3.6	kilometers/hr.	million gals./day	1.54723	cu. ft./sec.
meters/sec.	$6.0 \times 10^{-2}$	kilometers/min.	mils	$2.54 \times 10^{-3}$	centimeters
meters/sec.	2.237	miles/hr.	mils	$8.333 \times 10^{-5}$	feet
meters/sec.	$3.728 \times 10^{-2}$	miles/min.	mils	$1.0 \times 10^{-3}$	inches
meters/sec./sec.	$1.0 \times 10^2$	cms./sec./sec.	mils	$2.54 \times 10^{-8}$	kilometers
meters/sec./sec.	3.281	ft./sec./sec.	mils	$2.778 \times 10^{-5}$	yards
meters/sec./sec.	3.6	kms./hr./sec.	miner's inches	1.5	cu. ft./min.
meters/sec./sec.	2.237	miles/hr./sec.	minims (british)	$5.9192 \times 10^{-2}$	cubic cm.
meter-kilograms	$9.807 \times 10^7$	cm.-dynes	minims (u.s. fluid)	$6.1612 \times 10^{-2}$	cubic cm.
meter-kilograms	$1.0 \times 10^9$	cm.-grams	minutes (angles)	$1.667 \times 10^{-2}$	degrees
meter-kilograms	7.233	pound-foot	minutes (angles)	$1.852 \times 10^{-4}$	quadrants
microfarads	$1.0 \times 10^{-15}$	abfarads	minutes (angles)	$2.909 \times 10^{-4}$	radians
microfarads	$1.0 \times 10^{-6}$	farads	minutes (angles)	$610 \times 10^1$	seconds
microfarads	$9.0 \times 10^5$	statfarads	minutes (time)	$9.9206 \times 10^{-5}$	weeks
micrograms	$1.0 \times 10^{-6}$	grams	minutes (time)	$6.944 \times 10^{-4}$	days
microhms	$1.0 \times 10^3$	abohms	minutes (time)	$1.667 \times 10^{-2}$	hours
microhms	$1.0 \times 10^{-12}$	megohms	minutes (time)	$6.0 \times 10^1$	seconds
microhms	$1.0 \times 10^{-6}$	ohms	myriagrams	$1.0 \times 10^1$	kilograms
microliters	$1.0 \times 10^{-6}$	liters	myriameters	$1.0 \times 10^1$	kilometers
micromicrons	$1.0 \times 10^{-12}$	meters	myriawatts	$1.0 \times 10^1$	kilowatts
microns	$1.0 \times 10^{-6}$	meters		<b>N</b>	
miles (nautical)	$6.076 \times 10^3$	feet	nails	2.25	inches
miles (nautical)	1.853	kilometers	newtons	$1.0 \times 10^5$	dynes
miles (nautical)	$1.853 \times 10^3$	meters		<b>O</b>	
miles (nautical)	1.1516	miles (statute)	ohm (international)	1.0005	ohm (absolute)
miles (nautical)	$2.0254 \times 10^3$	yards	ohms	$1.0 \times 10^{-6}$	megohms

Table 18. Conversions Factors (Sheet 7 of 9)

TO CONVERT	MULTIPLY BY	TO OBTAIN
ohms	1.0 x 10 <sup>6</sup>	microhms
ounces	8.0	drams
ounces	4.375 x 10 <sup>2</sup>	grains
ounces	2.8349 x 10 <sup>1</sup>	grams
ounces	6.25 x 10 <sup>-2</sup>	pounds
ounces	9.115 x 10 <sup>-1</sup>	ounces (troy)
ounces	2.790 x 10 <sup>-5</sup>	tons (long)
ounces	3.125 x 10 <sup>-5</sup>	tons (short)
ounces (fluid)	1.805	cu. inches
ounces (fluid)	2.957 x 10 <sup>-2</sup>	liters
ounces (troy)	4.80 x 10 <sup>2</sup>	grains
ounces (troy)	3.1103 x 10 <sup>1</sup>	grams
ounces (troy)	1.097	ounces (avdp.)
ounces (troy)	2.0 x 10 <sup>1</sup>	pennyweights (troy)
ounces (troy)	8.333 x 10 <sup>-2</sup>	pounds (troy)
ounce/sq. in.	4.309 x 10 <sup>3</sup>	dynes/sq. cm.
ounce/sq. in.	6.25 x 10 <sup>-2</sup>	pounds/sq. in.
<b>P</b>		
pace	3.0 x 10 <sup>1</sup>	inches
parsec	1.9 x 10 <sup>13</sup>	miles
parsec	3.084 x 10 <sup>13</sup>	kilometers
parts/million	5.84 x 10 <sup>-2</sup>	grains/u.s. gal.
parts/million	7.016 x 10 <sup>-2</sup>	grains/imp. gal.
parts/million	8.345	pounds/million gal.
pecks (british)	5.546 x 10 <sup>2</sup>	cubic inches
pecks (british)	9.0919	liters
pecks (u.s.)	2.5 x 10 <sup>-1</sup>	bushels
pecks (u.s.)	5.376 x 10 <sup>2</sup>	cubic inches
pecks (u.s.)	8.8096	liters
pecks (u.s.)	8	quarts (dry)
pennyweights (troy)	2.4 x 10 <sup>1</sup>	grains
pennyweights (troy)	5.0 x 10 <sup>-2</sup>	ounces (troy)
pennyweights (troy)	1.555	grams
pennyweights (troy)	4.1667 x 10 <sup>-3</sup>	pounds (troy)
pints (dry)	3.36 x 10 <sup>1</sup>	cubic inches
pints (dry)	1.5625 x 10 <sup>-2</sup>	bushels
pints (dry)	5.0 x 10 <sup>-1</sup>	quarts
pints (dry)	5.5059 x 10 <sup>-1</sup>	liters
pints (liquid)	4.732 x 10 <sup>2</sup>	cubic cms.
pints (liquid)	1.671 x 10 <sup>-2</sup>	cubic ft.
pints (liquid)	2.887 x 10 <sup>1</sup>	cubic inches
pints (liquid)	4.732 x 10 <sup>-4</sup>	cubic meters
pints (liquid)	6.189 x 10 <sup>-4</sup>	cubic yards
pints (liquid)	1.25 x 10 <sup>-1</sup>	gallons
pints (liquid)	4.732 x 10 <sup>-1</sup>	liters
pints (liquid)	5.0 x 10 <sup>-1</sup>	quarts (liquid)
planck's quantum	6.624 x 10 <sup>-27</sup>	erg-seconds
poise	1.0	gram/cm. -sec.
pounds (avdp.)	1.4583 x 10 <sup>1</sup>	ounces (troy)
poundals	1.3826 x 10 <sup>4</sup>	dynes
poundals	1.41 x 10 <sup>1</sup>	grams
poundals	1.383 x 10 <sup>-3</sup>	joules/cm.
poundals	1.383 x 10 <sup>-1</sup>	joules/meter (newtons)
poundals	1.41 x 10 <sup>-2</sup>	kilograms
poundals	3.108 x 10 <sup>-2</sup>	pounds
pounds	2.56 x 10 <sup>2</sup>	drams
pounds	4.448 x 10 <sup>5</sup>	dynes
pounds	7.0 x 10 <sup>3</sup>	grains
pounds	4.5359 x 10 <sup>2</sup>	grams
pounds	4.448 x 10 <sup>-2</sup>	joules/cm.
pounds	4.448	joules/meter (newtons)
pounds	4.536 x 10 <sup>-1</sup>	kilograms
pounds	1.6 x 10 <sup>1</sup>	ounces
pounds	1.458 x 10 <sup>1</sup>	ounces (troy)
pounds	3.217 x 10 <sup>1</sup>	poundals

TO CONVERT	MULTIPLY BY	TO OBTAIN
pounds	1.21528	pounds (troy)
pounds	5.0 x 10 <sup>-4</sup>	tons (short)
pounds (troy)	5.760 x 10 <sup>3</sup>	grains
pounds (troy)	3.7324 x 10 <sup>2</sup>	grams
pounds (troy)	1.3166 x 10 <sup>1</sup>	ounces (avdp.)
pounds (troy)	1.2 x 10 <sup>1</sup>	ounces (troy)
pounds (troy)	2.4 x 10 <sup>2</sup>	pennyweights (troy)
pounds (troy)	8.2286 x 10 <sup>-1</sup>	pounds (avdp.)
pounds (troy)	3.6735 x 10 <sup>-4</sup>	tons (long)
pounds (troy)	3.7324 x 10 <sup>-4</sup>	tons (metric)
pounds (troy)	4.1143 x 10 <sup>-4</sup>	tons (short)
pounds of water	1.602 x 10 <sup>-2</sup>	cu. ft.
pounds of water	2.768 x 10 <sup>1</sup>	cu. inches
pounds of water	1.198 x 10 <sup>-1</sup>	gallons
pounds of water/min.	2.670 x 10 <sup>-4</sup>	cu. ft./sec.
pound-feet	1.356 x 10 <sup>7</sup>	cm. -dynes
pound-feet	1.3825 x 10 <sup>4</sup>	cm. -grains
pound-feet	1.383 x 10 <sup>-1</sup>	meter-kgs.
pounds/cu. ft.	1.602 x 10 <sup>-2</sup>	grams/cu. cm.
pounds/cu. ft.	1.602 x 10 <sup>1</sup>	kgs./cu. meter
pounds/cu. ft.	5.787 x 10 <sup>-4</sup>	pounds/cu. inches
pounds/cu. ft.	5.456 x 10 <sup>-9</sup>	pounds/mil-foot
pounds/cu. in.	2.768 x 10 <sup>1</sup>	grams/cu. cm.
pounds/cu. in.	2.768 x 10 <sup>4</sup>	kgs./cu. meter
pounds/cu. in.	1.728 x 10 <sup>3</sup>	pounds/cu. ft.
pounds/cu. in.	9.425 x 10 <sup>-6</sup>	pounds/mil-foot
pounds/ft.	1.488	kgs./meter
pounds/ft.	1.786 x 10 <sup>2</sup>	grams/cm.
pounds/mil-foot	2.306 x 10 <sup>6</sup>	grams/cu. cm.
pounds/sq. ft.	4.725 x 10 <sup>-4</sup>	atmospheres
pounds/sq. ft.	1.602 x 10 <sup>-2</sup>	feet of water
pounds/sq. ft.	1.414 x 10 <sup>-2</sup>	inches of mercury
pounds/sq. ft.	4.882	kgs./sq. meter
pounds/sq. ft.	6.944 x 10 <sup>-3</sup>	pounds/sq. inch
pounds/sq. ft.	6.804 x 10 <sup>-2</sup>	atmospheres
pounds/sq. in.	2.307	feet of water
pounds/sq. in.	2.036	inches of mercury
pounds/sq. in.	7.031 x 10 <sup>2</sup>	kgs./sq. meter
pounds/sq. in.	1.44 x 10 <sup>2</sup>	pounds/sq. ft.
pounds/sq. in.	7.2 x 10 <sup>-2</sup>	short tons/sq. ft.
pounds/sq. in.	7.03 x 10 <sup>-2</sup>	kgs./sq. cm.
<b>Q</b>		
quadrants (angle)	9.0 x 10 <sup>1</sup>	degrees
quadrants (angle)	5.4 x 10 <sup>3</sup>	minutes
quadrants (angle)	1.571	radians
quadrants (angle)	3.24 x 10 <sup>5</sup>	seconds
quarts (dry)	6.72 x 10 <sup>1</sup>	cu. inches
quarts (liquid)	9.464 x 10 <sup>2</sup>	cu. cms.
quarts (liquid)	3.342 x 10 <sup>-2</sup>	cu. ft.
quarts (liquid)	5.775 x 10 <sup>1</sup>	cu. inches
quarts (liquid)	9.464 x 10 <sup>-4</sup>	cu. meters
quarts (liquid)	1.238 x 10 <sup>-3</sup>	cu. yards
quarts (liquid)	2.5 x 10 <sup>-1</sup>	gallons
quarts (liquid)	9.463 x 10 <sup>-1</sup>	liters
<b>R</b>		
radians	5.7296 x 10 <sup>1</sup>	degrees
radians	3.438 x 10 <sup>3</sup>	minutes
radians	6.366 x 10 <sup>-1</sup>	quadrants
radians	2.063 x 10 <sup>5</sup>	seconds
radians/sec.	5.7296 x 10 <sup>1</sup>	degrees/sec.
radians/sec.	9.549	revolutions/min.
radians/sec.	1.592 x 10 <sup>-1</sup>	revolution/sec.
radians/sec./sec.	5.7296 x 10 <sup>2</sup>	revs./min./min.
radians/sec./sec.	9.549	revs./min./sec.
radians/sec./sec.	1.592 x 10 <sup>-1</sup>	revs./sec./sec.
reams	5.0 x 10 <sup>2</sup>	sheets

Table I4-18. Conversions Factors (Sheet 8 of 9)

TO CONVERT	MULTIPLY BY	TO OBTAIN	TO CONVERT	MULTIPLY BY	TO OBTAIN
revolutions	$3.60 \times 10^2$	degrees	square meters	1.196	sq. yards
revolutions	4.0	quadrants	square miles	$6.40 \times 10^2$	acres
revolutions	6.283	radians	square miles	$2.788 \times 10^7$	sq. ft.
revolutions/min.	6.0	degrees/sec.	square miles	2.590	sq. kms.
revolutions/min.	$1.047 \times 10^{-1}$	radians/sec.	square miles	$2.590 \times 10^6$	sq. meters
revs./min./min.	$1.667 \times 10^{-2}$	revs./sec.	square miles	$3.098 \times 10^6$	sq. yards
revs./min./min.	$1.745 \times 10^{-3}$	radians/sec./sec.	square millimeters	$1.973 \times 10^3$	circular mils
revs./min./min.	$1.667 \times 10^{-2}$	revs./min./sec.	square millimeters	$1.0 \times 10^{-2}$	sq. cms.
revolutions/sec.	$2.778 \times 10^{-4}$	revs./sec./sec.	square millimeters	$1.076 \times 10^{-5}$	sq. ft.
revolutions/sec.	$3.6 \times 10^2$	degrees/sec.	square millimeters	$1.55 \times 10^{-3}$	sq. inches
revolutions/sec.	6.283	radians/sec.	square mils	1.273	circular mils
revs./sec./sec.	$6.0 \times 10^1$	revs./min.	square mils	$6.452 \times 10^{-9}$	sq. cms.
revs./sec./sec.	6.283	radians/sec./sec.	square mils	$1.0 \times 10^{-6}$	sq. inches
revs./sec./sec.	$3.6 \times 10^3$	revs./min./min.	square yards	$2.066 \times 10^{-4}$	acres
revs./sec./sec.	$6.0 \times 10^1$	revs./min./sec.	square yards	$8.361 \times 10^3$	sq. cms.
rods	$2.5 \times 10^{-1}$	chains (gunters)	square yards	9.0	sq. ft.
rods	5.029	meters	square yards	$1.296 \times 10^3$	sq. inches
rods (surveyors' meas.)	5.5	yards	square yards	$8.361 \times 10^{-1}$	sq. meters
rods	$1.65 \times 10^1$	feet	square yards	$3.228 \times 10^{-7}$	sq. miles
rods	$1.98 \times 10^2$	inches	square yards	$8.361 \times 10^6$	sq. millimeters
rods	$3.125 \times 10^{-3}$	miles	steradians	$7.958 \times 10^{-2}$	spheres
rope	$2.0 \times 10^1$	feet	steradians	$1.592 \times 10^{-1}$	hemispheres
	<b>S</b>		steradians	$6.366 \times 10^{-1}$	spherical right angles
scruples	$2.0 \times 10^1$	grains	steres	$3.283 \times 10^3$	square degrees
sea water	Aqua Chem	fresh water		$9.99973 \times 10^2$	liters
seconds (angle)	$2.778 \times 10^{-4}$	degrees		<b>T</b>	
seconds (angle)	$1.667 \times 10^{-2}$	minutes	temperature (°C.)	1.0	absolute temperature (°K.)
seconds (angle)	$3.087 \times 10^{-6}$	quadrants	+ 273		temperature (°F.)
seconds (angle)	$4.848 \times 10^{-6}$	radians	temperature (°C.)	1.8	
slugs	$1.459 \times 10^1$	kilograms	+ 17.78		absolute temperature (°R.)
slugs	$3.217 \times 10^1$	pounds	temperature (°F.)	1.0	temperature (°C.)
sphere (solid angle)	$1.257 \times 10^1$	steradians	+ 460		
square centimeters	$1.973 \times 10^5$	circular mils	temperature (°F.)	5/9	
square centimeters	$1.076 \times 10^{-3}$	sq. feet	- 32		
square centimeters	$1.550 \times 10^{-1}$	sq. inches	tons (long)	$1.016 \times 10^3$	kilograms
square centimeters	$1.0 \times 10^{-4}$	sq. meters	tons (long)	$2.24 \times 10^3$	pounds
square centimeters	$3.861 \times 10^{-11}$	sq. miles	tons (long)	1.12	tons (short)
square centimeters	$1.0 \times 10^2$	sq. millimeters	tons (metric)	$1.0 \times 10^3$	kilograms
square centimeters	$1.196 \times 10^{-4}$	steradians	tons (metric)	$2.205 \times 10^3$	pounds
square feet	$2.296 \times 10^{-5}$	acres	tons (short)	$9.0718 \times 10^2$	kilograms
square feet	$1.833 \times 10^8$	circular mils	tons (short)	$3.2 \times 10^4$	ounces
square feet	$9.29 \times 10^2$	sq. cms.	tons (short)	$2.9166 \times 10^4$	ounces (troy)
square feet	$1.44 \times 10^2$	sq. inches	tons (short)	$2.0 \times 10^3$	pounds
square feet	$9.29 \times 10^{-2}$	sq. meters	tons (short)	$2.43 \times 10^3$	pounds (troy)
square feet	$3.587 \times 10^{-6}$	sq. miles	tons (short)	$8.9287 \times 10^{-1}$	tons (long)
square feet	$9.29 \times 10^4$	sq. millimeters	tons (short)	$9.078 \times 10^{-1}$	tons (metric)
square feet	$1.111 \times 10^{-1}$	sq. yards	tons (short)/sq. ft.	$9.765 \times 10^3$	kgs./sq. meter
square inches	$1.273 \times 10^6$	circular mils	tons (short)/sq. ft.	$1.389 \times 10^1$	pounds/sq. in.
square inches	6.452	sq. cms.	tons (short)/sq. in.	$1.406 \times 10^6$	kgs./sq. meter
square inches	$6.944 \times 10^{-3}$	sq. ft.	tons (short)/sq. in.	$2.0 \times 10^3$	pounds/sq. in.
square inches	$6.452 \times 10^2$	sq. millimeters	tons of water/24 hrs.	$8.333 \times 10^1$	pounds of water/hr.
square inches	$1.0 \times 10^6$	sq. mils	tons of water/24 hrs.	$1.6643 \times 10^{-1}$	gallons/min.
square inches	$7.716 \times 10^{-4}$	sq. yards	tons of water/24 hrs.	1.3349	cu. ft./hr.
square kilometers	$2.471 \times 10^2$	acres		<b>V</b>	
square kilometers	$1.0 \times 10^{10}$	sq. cms.			
square kilometers	$1.076 \times 10^7$	sq. ft.			
square kilometers	$1.550 \times 10^9$	sq. inches			
square kilometers	$1.0 \times 10^6$	sq. meters			
square kilometers	$3.861 \times 10^{-1}$	sq. miles			
square kilometers	$1.196 \times 10^6$	sq. yards			
square meters	$2.471 \times 10^{-4}$	acres			
square meters	$1.0 \times 10^4$	sq. cms			
square meters	$1.076 \times 10^1$	sq. ft.			
square meters	$1.55 \times 10^3$	sq. inches			
square meters	$3.861 \times 10^{-7}$	sq. miles			
square meters	$1.0 \times 10^6$	sq. millimeters			
				<b>W</b>	
			watts	3.4129	btu/hr.
			watts	$5.688 \times 10^{-2}$	btu/min.
			watts	$1.0 \times 10^7$	ergs/sec.
			watts	$4.427 \times 10^1$	ft.-lbs./min.

Table 14-18. Conversions Factors (Sheet 9 of 9)

TO CONVERT	MULTIPLY BY	TO OBTAIN
watts	$7.378 \times 10^{-1}$	ft.-lbs./sec.
watts	$1.341 \times 10^{-3}$	horsepower
watts	$1.36 \times 10^{-3}$	horsepower (metric)
watts	$1.433 \times 10^{-2}$	kg.-calories/min.
watts	$1.0 \times 10^{-3}$	kilowatts
watts (abs.)	1.0	joules/sec.
watt-hours	3.413	btu
watt-hours	$3.6 \times 10^{10}$	ergs
watt-hours	$2.656 \times 10^3$	foot-lbs.
watt-hours	$8.605 \times 10^2$	gram-calories
watt-hours	$1.341 \times 10^{-3}$	horsepower-hours
watt-hours	$8.605 \times 10^{-1}$	kilogram-calories
watt-hours	$3.672 \times 10^2$	kilogram-meters
watt-hours	$1.0 \times 10^{-3}$	kilowatt-hours
watt (international)	1.000165	watt (absolute)
webers	$1.0 \times 10^8$	maxwells
webers	$1.0 \times 10^9$	kilolines
webers/sq. in.	$1.55 \times 10^7$	gausses
webers/sq. in.	$1.0 \times 10^8$	lines/sq. in.
webers/sq. in.	$1.55 \times 10^{-1}$	webers/sq. cm.
webers/sq. in.	$1.55 \times 10^3$	webers/sq. meter
webers/sq. meter	$1.0 \times 10^4$	gausses
webers/sq. meter	$6.452 \times 10^4$	lines/sq. in.
webers/sq. meter	$1.0 \times 10^{-4}$	webers/sq. cm.
webers/sq. meter	$6.452 \times 10^{-4}$	webers/sq. in.
weeks	$1.68 \times 10^2$	hours
weeks	$1.008 \times 10^4$	minutes
weeks	$6.048 \times 10^5$	seconds
<b>Y</b>		
yards	$9.144 \times 10^1$	centimeters
yards	$9.144 \times 10^{-4}$	kilometers
yards	$9.144 \times 10^{-1}$	meters
yards	$4.934 \times 10^{-4}$	miles (nautical)
yards	$5.682 \times 10^{-4}$	miles (statute)
yards	$9.144 \times 10^2$	millimeters
years	$3.65256 \times 10^2$	days (mean solar)
years	$8.7661 \times 10^3$	hours (mean solar)

Table 19. pH Values

pH Value	Number of times acidity or alkalinity exceed that of pure water
0	10,000,000
1	1,000,000
2	100,000
3	10,000
4	1,000
5	100
6	10
7	1
8	10
9	100
10	1,000
11	10,000
12	100,000
13	1,000,000
14	10,000,000

Acidity

Pure Distilled Water @ 77°F (25°C)

Alkalinity

Table 20. Salinity Indicating Readings Conversion Tables

GRAINS PER GALLON OF SEA SALT TO EQUIVALENT PARTS PER MILLION OF CHLORIDE TO PARTS PER MILLION OF CHLORIDES IN SEA WATER		
GPG	EPM	PPM
.108	.028	1.000
.250	.065	2.315
.50	.131	4.627
1.00	.261	9.254
2.00	.522	18.509
3.00	.783	27.763
3.83	1.000	35.457
4.00	1.044	37.017
5.00	1.305	46.271
5.75	1.501	43.221
6.00	1.566	55.526
7.00	1.827	64.780
8.00	2.088	74.034
9.00	2.349	83.289
10.00	2.61	92.542
10.80	2.82	100.00

Table 21. Useful Physical Constants

<b>GAS CONSTANTS (R)</b>	
R = 0.0821	(atm.) (liter)/(g.-mole) (°K)
R = 1.987	g.-cal./(g.-mole) (°K)
R = 1.987	B.t.u./(lb.-mole) (°R)
R = 1.987	c.h.u./(lb.-mole) (°K)
R = 8.314	joules/(gm.-mole) (°K)
R = 1.546	(ft.) (lb. force)/(lb.-mole) (°R)
R = 10.73	(lb.-force/sq. in.) (cu. ft.)/(lb.-mole) (°R)
R = 18510	(lb.-force/sq. in.) (cu. in.)/(lb.-mole) (°R)
R = 0.7302	(atm.) (cu. ft.)/(lb.-mole) (°R)
R = $8.48 \times 10^5$	(Kg./m <sup>2</sup> ) (cu. cm.)/(lb.-mole) (°K)
<b>ACCELERATION OF GRAVITY (STANDARD)</b>	
g = 32.17 ft./sec. <sup>2</sup> = 980.6 cm./sec. <sup>2</sup>	
<b>VELOCITY OF SOUND IN DRY AIR at 0°C and 1 atm.</b>	
33.136 cm./sec. = 1.089 ft./sec.	
<b>HEAT OF FUSION OF WATER</b>	
79.7 cal./gm = 144 Btu/lb.	
<b>HEAT OF VAPORIZATION OF WATER : 1.0 atm.</b>	
540 cal./gm = 970 Btu/lb.	
<b>SPECIFIC HEAT OF AIR</b>	
Cp = 0.238 cal./(gm) (°C)	
<b>DENSITY OF DRY AIR /0°C and 760 mm.</b>	
0.001293 gm/cu.cm.	

Table 22. Conversions Table

USGPH	USGPD	IGPH	IGPD	Tons/Hr M <sup>3</sup> /Hr	M <sup>3</sup> /Day Tons/Day	Liter/Hr	Lb/Hr
10	240	8	199	-	.9	38	83
42	1,000	34	832	-	3.7	158	350
50	1,200	42	999	-	4.5	189	417
55	1,320	46	1,099	-	4.9	208	458
85	2,000	69	1,665	-	7.5	379	709
100	2,400	83	1,998	-	9.0	378	834
110	2,640	92	2,198	-	9.9	413	917
125	3,000	104	2,498	-	11.3	473	1,043
170	4,000	139	3,330	-	15.1	631	1,418
200	4,800	166	3,996	.75	18.1	757	1,668
220	5,280	186	4,396	.8	19.9	833	1,835
250	6,000	208	4,996	.9	22.7	946	2,085
300	7,200	250	5,995	1.1	27.2	1,136	2,502
333	8,000	278	6,661	1.2	30.2	1,262	2,777
400	9,600	333	7,993	1.5	36.3	1,514	3,336
417	10,000	347	8,326	1.5	37.8	1,577	3,477
500	12,000	416	9,992	1.8	45.4	1,893	4,170
583	14,000	485	11,657	2.2	52.9	2,208	4,862
600	14,400	500	11,990	2.2	54.5	2,271	5,004
667	16,000	555	13,322	2.5	60.5	2,523	5,563
800	19,200	666	15,987	3.0	72.6	3,028	6,672
835	20,000	694	16,653	3.1	75.7	3,154	6,964
900	21,600	749	17,985	3.4	81.7	3,407	7,506
1,040	25,000	865	20,816	3.9	94.6	3,940	8,673
1,250	30,000	1,041	24,980	4.7	113.5	4,731	10,425
1,667	40,000	1,390	33,306	6.3	151.4	6,310	13,902
2,100	50,000	1,735	41,633	7.8	189.2	7,885	17,514
2,500	60,000	2,080	49,960	9.4	227.1	9,462	20,850
2,917	70,000	2,428	58,286	11.0	264.9	11,040	24,327
3,333	80,000	2,780	66,613	12.6	302.8	12,620	27,797
3,750	90,000	3,123	74,940	14.1	340.6	14,193	31,275
4,167	100,000	3,470	83,267	15.7	378.5	15,770	34,752
6,250	150,000	5,204	124,900	23.3	567.7	23,365	52,125
8,333	200,000	6,940	166,534	31.5	757.0	31,540	69,497
12,500	300,000	10,410	249,801	47.3	1135.5	47,312	104,250
25,000	600,000	20,816	499,602	94.6	2271.0	94,625	208,500
41,667	1,000,000	34,694	832,670	157.7	3785.0	151,708	347,502
50,000	1,200,000	41,663	999,204	189.2	4542.0	189,250	417,000
83,334	2,000,000	69,388	1,665,340	315.4	7,570.0	303,416	695,400
125,001	3,000,000	104,082	2,495,010	473.1	11,355.0	455,124	1,042,506
166,668	4,000,000	138,776	3,330,680	630.8	15,140.0	606,832	1,390,008
208,335	5,000,000	173,470	4,163,350	788.5	18,925.0	758,540	1,737,510
250,002	6,000,000	208,164	4,996,020	946.2	22,710.0	910,248	2,085,012
291,669	7,000,000	242,858	5,828,690	1,103.9	26,495.0	1,061,956	2,432,514
333,336	8,000,000	277,552	6,661,360	1,261.6	30,280.0	1,213,664	2,780,016
375,003	9,000,000	312,246	7,494,030	1,419.3	34,065.0	1,365,372	3,127,518
416,670	10,000,000	396,940	8,326,700	1,577.0	37,850.0	1,517,080	3,475,502

**Table 23. Approximate Common Equivalents**

1 inch	= 25 millimeters
1 foot	= 0.3 meter
1 yard	= 0.9 meter
1 mile	= 1.6 kilometers
1 square inch	= 6.5 square centimeters
1 square foot	= 0.09 square meter
1 square yard	= 0.8 square meter
1 acre	= 0.4 hectare †
1 cubic inch	= 16 cubic centimeters
1 cubic foot	= 0.03 cubic meter
1 cubic yard	= 0.8 cubic meter
1 quart (lq)	= 1 liter †
1 gallon	= 0.004 cubic meter
1 ounce (avdp)	= 28 grams
1 pound (avdp)	= 0.45 kilogram
1 horsepower	= 0.75 kilowatt
1 millimeter	= 0.04 inch
1 meter	= 3.3 feet
1 meter	= 1.1 yards
1 kilometer	= 0.6 mile
1 square centimeter	= 0.16 square inch
1 square meter	= 11 square feet
1 square meter	= 1.2 square yards
1 hectare †	= 2.5 acres
1 cubic centimeter	= 0.06 cubic inch
1 cubic meter	= 35 cubic feet
1 cubic meter	= 1.3 cubic yards
1 liter †	= 1 quart (lq)
1 cubic meter	= 250 gallons
1 gram	= 0.035 ounces (avdp)
1 kilogram	= 2.2 pounds (avdp)
1 kilowatt	= 1.3 horsepower

† Common term not used in SI

**Table 24. Conversions Accurate to Parts per Million**

inches x 25.4*	= millimeters
feet x 0.3048*	= meters
yards x 0.9144*	= meters
miles x 1.609 34	= kilometers
square inches x 6.4516*	= square centimeters
square feet x 0.0929030	= square meters
square yards x 0.836 127	= square meters
acres x 0.404686	= hectares
cubic inches x 16.3871	= cubic centimeters
cubic feet x 0.028 3168	= cubic meters
cubic yards x 0.764 555	= cubic meters
quarts (lq) x 0.946 353	= liters
gallons x 0.003 785 41	= cubic meters
ounces (avdp) x 28.349 5	= grams
pounds (avdp) x 0.453 592	= kilograms
horsepower x 0.745 700	= kilowatts
millimeters x 0.039 370 1	= inches
meters x 3.280 84	= feet
meters x 1.093 61	= yards
kilometers x 0.621 371	= miles
square centimeters x 0.155 000	= square inches
square meters x 10.763 9	= square feet
square meters x 1.195 99	= square yards
hectares x 2.471 05	= acres
cubic centimeters x 0.061 023 7	= cubic inches
cubic meters x 35.314 7	= cubic feet
cubic meters x 1.307 95	= cubic yards
liters x 1.056 69	= quarts (lq)
cubic meters x 264.172	= gallons
grams x 0.035 274 0	= ounces (avdp)
kilograms x 2.204 62	= pounds (avdp)
kilowatts x 1.341 02	= horsepower

\* Exact.

## STANDARDS ASSOCIATIONS

### **American Gas Association (AGA)**

400 North Capitol St. NW  
Washington, DC 20001  
202-824-7250

[www.aga.org](http://www.aga.org)

### **American National Standards Institute (ANSI)**

25 West 43rd Street, 4th Floor  
New York, NY 10036  
212-642-4900

[www.ansi.org](http://www.ansi.org)

ANSI acts as the national coordinating institution through which interested organizations voluntarily cooperate in establishing, recognizing, and improving standards.

### **American Society of Heating Refrigerating and Air Conditioning Engineers (ASHRAE)**

1791 Tullie Circle, NE  
Atlanta, GA 30329  
404-636-8400

[www.ashrae.org](http://www.ashrae.org)

### **American Society of Mechanical Engineers (ASME)**

Three Park Avenue  
New York, NY 10016-5990  
800-843-2763

[www.asme.org](http://www.asme.org)

The ASME develops test codes for boilers and pressure vessels and for power applications, and serves as a sponsor for ANSI in developing safety codes and standards.

### **American Society for Nondestructive Testing**

1171 Arlingate Lane  
Columbus, Ohio 43228-0511  
614-274-6003  
800-222-2768

[www.asnt.org](http://www.asnt.org)

### **American Society for Testing and Materials (ASTM)**

100 Barr Harbor Drive  
West Conshohocken, PA 19428-2959  
610-832-9500

[www.astm.org](http://www.astm.org)

ASTM is the largest voluntary standards development system in the world publishing standards for materials, products, systems and services.

### **Canadian Standards Association (CSA)**

178 Rexdale Blvd.  
Etobicoke, Ontario, Canada M9W 1R3  
416-747-4000

[www.csa-international.org](http://www.csa-international.org)

CSA, a nonprofit nongovernmental body, which promotes nationwide standards for product design, construction and performance for Canada. CSA is a recognized testing agency.

### **Canadian Gas Association (CGA)**

350 Sparks St., Suite 809  
Ottawa, Ontario K1R 7S8  
613-748-0057

[www.cga.ca](http://www.cga.ca)

CGA, a nonprofit association of manufacturers of gas utilities, provides certification service based on standards established by CSA.

### **FM Global**

1151 Boston-Providence Turnpike  
Norwood, MA 02062  
781-762-4300

[www.fmglobal.com](http://www.fmglobal.com)

FM is an association of 4 mutual insurance companies dedicated to minimizing loss of insured property. Through its research arm, the Factory Mutual Research Corporation, it investigates means of preventing and minimizing fire and other losses. FM laboratories provide product testing and approval.

### **XL Global Asset Protection Services (XL GAPS)**

[xlgaps.com](http://xlgaps.com)

Formerly IRI/GEGAP

### **National Board of Boiler and Pressure Vessel Inspectors**

1055 Crupper Avenue  
Columbus, OH 43229-1183  
614-888-8320

The National Board is an organization comprised of Chief Inspectors of states and cities of the US and provinces of Canada organized for the purpose of promoting greater safety in the construction, installation, inspection and repair of boilers and pressure vessels.

### **National Electric Code (NEC)**

1 Batterymarch Park  
Quincy, MA 02269-9101

The National Electric Code is a standard established for safe wiring procedures in the interest of personal safety and fire protection. The code is adopted and copyrighted by the NFPA (see National Fire Protection Association).



### **National Fire Protection Association (NFPA)**

1 Batterymarch Park  
Quincy, MA 02169-7471  
617-770-3000

[www.nfpa.org](http://www.nfpa.org)

NFPA develops and promotes standards for the purpose of advancing the science and improving the methods of fire protection and prevention.

### **Underwriters Laboratories (UL and cUL)**

333 Pfingsten Road  
Northbrook, IL 60062

[www.ul.com](http://www.ul.com)

UL is a nonprofit organization which operates laboratories for testing for public safety. They provide listings, classification, recognition and certification. UL is a recognized testing agency for the U.S. and Canada.

### **Underwriters Laboratories of Canada (ULC)**

7 Underwriters Road  
Toronto, Ontario M1R 3A9

[www.ul.com/canada](http://www.ul.com/canada)

ULC is an agency sponsored by the Canadian Underwriters Association that tests and certifies products and materials against ULC established standards. It has no relationship to UL of the U.S.

### **United States Department of Energy (DOE)**

100 Independence Avenue, SW  
Washington, DC 20585

[energy.gov](http://energy.gov)

### **United States Environmental Protection Agency (EPA)**

Ariel Rios Building  
1200 Pennsylvania Ave. NW  
Washington, DC  
202-272-0167

[www.epa.gov](http://www.epa.gov)

