

PROPERTIES OF STEAM

Steam is water vapor which exists in the vaporous condition because sufficient heat has been added to the water to supply the latent heat of evaporation and change the liquid into vapor. This change in state takes place at a definite and constant temperature which is determined solely by the pressure of the steam. The volume of a pound of steam is the *specific volume* which decreases as the pressure increases. The reciprocal of this, or the weight of steam per cubic foot, is the *density*. (See Table 7.)

Steam which is in contact with the water from which it was generated is known as *saturated steam*. If it contains no actual water in the form of mist or priming, it is called *dry saturated steam*. If this be heated and the pressure maintained the same as when it was vaporized, its temperature will increase and it will become *superheated*, that is, its temperature will be higher than that of saturated steam at the same pressure.

PROPERTIES OF WATER

Composition of Water. Water is a chemical compound (H_2O) formed by the union of two volumes of hydrogen and one volume of oxygen, or two parts by weight of hydrogen and 16 parts by weight of oxygen.

Density of Water. Water has its greatest density at 39.2 F, and it expands when heated or cooled from this temperature. At 62 F a U. S. gallon of 231 cu in. of water weighs approximately $8\frac{1}{8}$ lb, and a cubic foot of water is equal to 7.48 gal. The specific volume of water depends on the temperature and it is always the reciprocal of its density. (See Table 8.)

Water Pressures. Pressures are often stated in feet or inches of water column. At 62 F, with h equal to the head in feet, the pressure of a column of water is $62.383h$ lb per square foot, or $0.433h$ lb per square inch. A column of water 2.309 ft (27.71 in.) high exerts a pressure of one pound per square inch at 62 F.

Boiling Point of Water. The boiling point of water varies with the pressure; it is lower at higher altitudes. A change in pressure will always be accompanied by a change in the boiling point, and there will be a corresponding change in the latent heat of evaporation. These values are given in Table 7.

Specific Heat. The specific heat of water, or the amount of heat (Btu) required to raise the temperature of one pound of water one degree Fahrenheit, varies with the temperature, but it is commonly assumed to be unity at all temperatures. Steam tables are based on exact values, however. The specific heat of ice at 32 F is 0.492 Btu per pound. The amount of heat required to raise one pound of water at 32 F through a known temperature interval depends on the average specific heat for the temperature range.

Sensible and Latent Heat. The heat necessary to raise the temperature of one pound of water from 32 F to the boiling point is known as the *heat of the liquid or sensible heat*. When more heat is added, the water begins to evaporate and expand at constant temperature until the water is entirely changed into steam. The heat thus added is known as the *latent heat of evaporation*.

CHAPTER 1—FUNDAMENTALS OF HEATING AND AIR CONDITIONING

TABLE 7. PROPERTIES OF SATURATED STEAM: PRESSURE TABLE*

Abs. Press. Lb./Sq. In.	Temp. Deg. F.	Specific Volume			Total Heat			Entropy			Abs. Press. Lb./Sq. In.
		Sat. Liquid ft ³ /Lb.	Evap. ft ³ /Lb.	Sat. Vapor ft ³ /Lb.	Sat. Liquid Btu/Lb.	Evap. Btu/Lb.	Sat. Vapor Btu/Lb.	Sat. Liquid Btu/Lb.	Evap. Btu/Lb.	Sat. Vapor Btu/Lb.	
1/4" Hg	58.83	0.01603	1256.9	1256.9	26.88	1058.8	1085.7	0.0533	2.0422	2.0955	1/4" Hg
1/2" Hg	59.83	0.01605	856.5	856.5	38.47	1052.5	1091.0	0.0754	1.9856	2.0609	1/2" Hg
3/4" Hg	70.44	0.01607	652.7	652.7	47.06	1047.8	1094.9	0.0914	1.9451	2.0365	3/4" Hg
1" Hg	79.06	0.01610	445.3	445.3	59.72	1040.8	1100.6	0.1147	1.8877	2.0024	1" Hg
1 1/2" Hg	91.75	0.01613	339.5	339.5	69.10	1035.7	1104.8	0.1316	1.8468	1.9784	1 1/2" Hg
2" Hg	101.17	0.01616	275.2	275.2	76.63	1031.5	1108.1	0.1450	1.8148	1.9598	2" Hg
2 1/2" Hg	108.73	0.01618	231.8	231.8	82.96	1027.9	1110.8	0.1561	1.7885	1.9446	2 1/2" Hg
3" Hg	115.08	0.01614	333.8	333.9	69.69	1035.3	1105.0	0.1326	1.8442	1.9769	3" Hg
1.0	101.76	0.01623	173.94	173.96	93.97	1021.6	1115.6	0.1750	1.7442	1.9192	1.0
2.0	126.10	0.01630	118.84	118.86	109.33	1012.7	1122.0	0.2099	1.6847	1.8856	2.0
3.0	141.49	0.01636	90.72	90.74	120.83	1005.9	1126.8	0.2198	1.6420	1.8618	3.0
4.0	152.99	0.01641	73.59	73.61	130.10	1000.4	1130.6	0.2348	1.6088	1.8435	4.0
5.0	162.25	0.01645	62.03	62.05	137.92	995.8	1133.7	0.2473	1.5814	1.8287	5.0
6.0	170.07	0.01649	53.68	53.70	144.71	991.7	1136.4	0.2580	1.5582	1.8162	6.0
7.0	176.85	0.01652	47.38	47.39	150.75	988.1	1138.9	0.2674	1.5379	1.8053	7.0
8.0	182.87	0.01656	42.42	42.44	156.19	984.8	1141.0	0.2758	1.5200	1.7958	8.0
9.0	188.28	0.01658	38.44	38.45	161.13	981.8	1143.0	0.2834	1.5040	1.7874	9.0
10.0	193.21	0.01661	35.15	35.17	165.68	979.1	1144.8	0.2903	1.4894	1.7797	10.0
11.0	197.75	0.01664	32.40	32.42	169.91	976.5	1146.4	0.2968	1.4760	1.7727	11.0
12.0	201.96	0.01666	30.06	30.08	173.85	974.1	1147.9	0.3027	1.4636	1.7663	12.0
13.0	205.88	0.01669	28.05	28.06	177.55	971.8	1149.3	0.3082	1.4521	1.7604	13.0
14.0	209.56	0.01670	26.80	26.82	180.00	970.2	1150.2	0.3119	1.4446	1.7564	14.0
14.696	212.00	0.01673	24.75	24.76	184.35	967.4	1151.8	0.3184	1.4312	1.7496	14.696
16.0	216.32	0.01678	22.16	22.18	190.48	963.5	1154.0	0.3274	1.4127	1.7402	16.0
18.0	222.40	0.01682	20.078	20.095	196.09	959.9	1156.0	0.3356	1.3960	1.7317	18.0
20.0	227.96	0.01685	18.363	18.380	201.25	956.6	1157.8	0.3431	1.3809	1.7240	20.0
22.0	233.07	0.01689	16.924	16.941	206.05	953.4	1159.5	0.3500	1.3670	1.7170	22.0
24.0	237.82	0.01692	15.701	15.718	210.54	950.4	1161.0	0.3564	1.3542	1.7106	24.0
26.0	242.25	0.01695	14.647	14.664	214.75	947.7	1162.4	0.3624	1.3422	1.7046	26.0
28.0	246.41	0.01698	13.728	13.745	218.73	945.0	1163.7	0.3680	1.3310	1.6990	28.0
30.0	250.34	0.01701	12.923	12.940	222.50	942.5	1165.0	0.3732	1.3206	1.6938	30.0
32.0	254.05	0.01704	12.209	12.226	226.09	940.0	1166.1	0.3783	1.3107	1.6890	32.0
34.0	257.58	0.01707	11.570	11.587	229.51	937.7	1167.2	0.3830	1.3014	1.6844	34.0
36.0	260.94	0.01710	10.998	11.015	232.79	935.5	1168.3	0.3876	1.2925	1.6800	36.0
38.0	264.16	0.01712	10.480	10.497	235.93	933.3	1169.2	0.3919	1.2840	1.6759	38.0
40.0	267.24	0.01715	10.010	10.027	238.95	931.2	1170.2	0.3961	1.2759	1.6720	40.0
42.0	270.21	0.01717	9.582	9.599	241.86	929.2	1171.1	0.4000	1.2682	1.6683	42.0
44.0	273.06	0.01719	9.189	9.207	244.67	927.2	1171.9	0.4039	1.2608	1.6647	44.0
46.0	275.81	0.01722	8.829	8.846	247.37	925.4	1172.7	0.4076	1.2537	1.6613	46.0
48.0	278.45	0.01724	8.496	8.514	249.98	923.5	1173.5	0.4111	1.2469	1.6580	48.0
50.0	281.01	0.01726	8.189	8.206	252.52	921.7	1174.3	0.4145	1.2404	1.6549	50.0
52.0	283.49	0.01728	7.902	7.919	254.99	920.0	1175.0	0.4178	1.2340	1.6518	52.0
54.0	285.90	0.01730	7.636	7.653	257.38	918.3	1175.7	0.4210	1.2279	1.6489	54.0
56.0	288.23	0.01732	7.388	7.405	259.71	916.6	1176.4	0.4241	1.2220	1.6461	56.0
58.0	290.50	0.01735	7.155	7.172	261.98	915.0	1177.0	0.4271	1.2162	1.6434	58.0
60.0	292.71	0.01737	6.937	6.955	264.18	913.4	1177.6	0.4300	1.2107	1.6407	60.0
62.0	294.85	0.01739	6.732	6.749	266.33	911.9	1178.2	0.4329	1.2053	1.6382	62.0
64.0	296.94	0.01741	6.539	6.556	268.43	910.4	1178.8	0.4356	1.2001	1.6357	64.0
66.0	298.98	0.01743	6.357	6.375	270.49	908.9	1179.4	0.4384	1.1950	1.6333	66.0
68.0	300.98	0.01744	6.186	6.203	272.49	907.4	1179.9	0.4410	1.1900	1.6310	68.0
70.0	302.92	0.01746	6.024	6.041	274.45	906.0	1180.5	0.4435	1.1852	1.6287	70.0
72.0	304.82	0.01748	5.870	5.887	276.37	904.6	1181.0	0.4460	1.1805	1.6265	72.0
74.0	306.68	0.01750	5.723	5.741	278.25	903.2	1181.5	0.4485	1.1759	1.6244	74.0
76.0	308.50	0.01752	5.584	5.602	280.09	901.9	1182.0	0.4509	1.1714	1.6223	76.0
78.0	310.28	0.01754	5.452	5.470	281.90	900.5	1182.4	0.4532	1.1670	1.6202	78.0
80.0	312.03	0.01756	5.325	5.343	283.67	899.2	1182.9	0.4555	1.1627	1.6182	80.0
82.0	313.74	0.01757	5.204	5.222	285.42	897.9	1183.4	0.4578	1.1586	1.6163	82.0
84.0	315.42	0.01759	5.089	5.107	287.13	896.7	1183.8	0.4599	1.1545	1.6144	84.0
86.0	317.06	0.01761	4.979	4.997	288.80	895.4	1184.2	0.4621	1.1505	1.6126	86.0
88.0	318.68	0.01763	4.874	4.892	290.45	894.2	1184.6	0.4642	1.1465	1.6107	88.0
90.0	320.27	0.01764	4.773	4.791	292.07	893.0	1185.0	0.4663	1.1427	1.6090	90.0
92.0	321.83	0.01766	4.676	4.694	293.67	891.8	1185.4	0.4683	1.1389	1.6072	92.0
94.0	323.37	0.01768	4.584	4.602	295.25	890.6	1185.8	0.4703	1.1352	1.6055	94.0
96.0	324.88	0.01769	4.494	4.512	296.80	889.4	1186.2	0.4723	1.1316	1.6038	96.0
98.0	326.37										98.0

*Abstracted from *Steam Tables and Mollier Diagram*, by Prof. J. H. Keenan, 1930 edition, by permission of the publisher, *The American Society of Mechanical Engineers*.