TABLE 2-304 Saturated Solid/Vapor Water*

Temp., °F	Pressure, lb/in² abs.	Volume, ft³/lb		Enthalpy, Btu/lb		Entropy, Btu/(lb)(°F)	
		Solid	Vapor	Solid	Vapor	Solid	Vapor
−160	4.949.−8	0.01722	3.607.+9	−222.05	990.38	−0.4907	3.5549
−150	1.620.−7	0.01723	1.139.+9	−218.82	994.80	−0.4801	3.4387
−140	4.928.−7	0.01724	3.864.+8	−215.49	999.21	−0.4695	3.3301
−130	1.403.−6	0.01725	1.400.+8	−212.08	1003.63	−0.4590	3.2284
−120	3.757.−6	0.01726	5.386.+7	−208.58	1008.05	−0.4485	3.1330
−110	9.517.−6	0.01728	2.189.+7	−204.98	1012.47	−0.4381	3.0434
−100	2.291.−5	0.01729	9.352.+6	−201.28	1016.89	−0.4277	2.9591
−90	5.260.−5	0.01730	4.186.+6	−197.49	1021.31	−0.4173	2.8796
−80	1.157.−4	0.01731	1.955.+6	−193.60	1025.73	−0.4069	2.8045
−70	2.443.−4	0.01732	9.501.+5	−189.61	1030.15	−0.3965	2.7336
−60	4.972.−4	0.01734	4.788.+5	−185.52	1034.58	−0.3862	2.6664
−50	9.776.−4	0.01735	2.496.+5	−181.34	1039.00	−0.3758	2.6028
−45	1.354.−3	0.01736	1.824.+5	−179.21	1041.21	−0.3707	2.5723
−40	1.861.−3	0.01737	1.343.+5	−177.06	1043.42	−0.3655	2.5425
−35	2.540.−3	0.01737	9.961.+4	−174.88	1045.63	−0.3604	2.5135
−30	3.440.−3	0.01738	7.441.+4	−172.68	1047.84	−0.3552	2.4853
−25	4.627.−3	0.01739	5.596.+4	−170.46	1050.05	−0.3501	2.4577
−20	6.181.−3	0.01739	4.237.+4	−168.21	1052.26	−0.3449	2.4308
−15	8.204.−3	0.01740	3.228.+4	−165.94	1054.47	−0.3398	2.4046
−10	1.082.−2	0.01741	2.475.+4	−163.65	1056.67	−0.3347	2.3791
−5	1.419.−2	0.01741	1.909.+4	−161.33	1058.88	−0.3295	2.3541
0	1.849.−2	0.01742	1.481.+4	−158.98	1061.09	−0.3244	2.3297
5	2.396.−2	0.01743	1.155.+4	−156.61	1063.29	−0.3193	2.3039
10	3.087.−2	0.01744	9.060.+3	−154.22	1065.50	−0.3142	2.2827
15	3.957.−2	0.01744	7.144.+3	−151.80	1067.70	−0.3090	2.2600
16	4.156.−2	0.01745	6.817.+3	−151.32	1068.14	−0.3080	2.2555
18	4.581.−2	0.01745	6.210.+3	−150.34	1069.02	−0.3060	2.2466
20	5.045.−2	0.01745	5.662.+3	−149.36	1069.90	−0.3039	2.2378
22	5.552.−2	0.01746	5.166.+3	−148.38	1070.38	−0.3019	2.2291
24	6.105.−2	0.01746	4.717.+3	−147.39	1071.66	−0.2998	2.2205
26	6.708.−2	0.01746	4.311.+3	−146.40	1072.53	−0.2978	2.2119
28	7.365.−2	0.01746	3.943.+3	−145.40	1073.41	−0.2957	2.2034
30	8.080.−2	0.01747	3.608.+3	−144.40	1074.29	−0.2937	2.1950
31	8.461.−2	0.01747	3.453.+3	−143.90	1074.73	−0.2927	2.1908
32	8.858.−2	0.01747	3.305.+3	−143.40	1075.16	−0.2916	2.1867

*Condensed from *Fundamentals,* American Society of Heating, Refrigerating and Air-Conditioning Engineers, 1967 and 1972. Reproduced by permission. The validity of many standard reference tables has been critically reviewed by Jancso, Pupezin, and van Hook, *J. Phys. Chem.,* **74** (1970):2984. Current information on the properties of solid, vapor, and liquid water properties can be found at http://www.iapws.org. The notation 4.949.−8, 3.607.+9, etc., means 4.949×10^{-8}, 3.607×10^{9}, etc.

TABLE 2-305 Thermodynamic Properties of Water

Temperature K	Pressure MPa	Density mol/dm^3	Volume dm^3/mol	Int. energy kJ/mol	Enthalpy kJ/mol	Entropy kJ/(mol·K)	C_v kJ/(mol·K)	C_p kJ/(mol·K)	Sound speed m/s	Joule-Thomson K/MPa	Therm. cond. mW/(m·K)	Viscosity μPa·s
Saturated Properties												
273.16	0.000612	55.497	0.018019	0	1.1E-05	0	0.075978	0.076023	1402.3	–0.24142	561.04	1791.2
280	0.000992	55.501	0.018018	0.51875	0.51877	0.001876	0.075669	0.075688	1434.1	–0.23515	574.04	1433.7
290	0.001920	55.440	0.018038	1.2742	1.2742	0.004527	0.075095	0.075429	1472.1	–0.22720	592.73	1084.0
300	0.003537	55.315	0.018078	2.0278	2.0279	0.007082	0.074412	0.075320	1501.4	–0.22024	610.28	853.84
310	0.006231	55.139	0.018136	2.7808	2.7810	0.009551	0.073645	0.075294	1523.2	–0.21393	626.05	693.54
320	0.010546	54.919	0.018209	3.5339	3.5340	0.011941	0.072811	0.075317	1538.7	–0.20804	639.71	577.02
330	0.017213	54.662	0.018294	4.2873	4.2876	0.014260	0.071927	0.075373	1548.7	–0.20241	651.18	489.49
340	0.027188	54.371	0.018392	5.0414	5.0419	0.016511	0.071008	0.075456	1553.9	–0.19690	660.55	421.97
350	0.041682	54.049	0.018502	5.7964	5.7972	0.018700	0.070070	0.075567	1554.8	–0.19140	668.00	368.77
360	0.062194	53.698	0.018623	6.5526	6.5538	0.020830	0.069124	0.075708	1552.0	–0.18581	673.76	326.10
370	0.090535	53.321	0.018754	7.3104	7.3121	0.022906	0.068180	0.075883	1545.8	–0.18005	678.02	291.36
380	0.12885	52.918	0.018897	8.0701	8.0725	0.024932	0.067247	0.076098	1536.5	–0.17404	681.00	262.69
390	0.17964	52.490	0.019051	8.8320	8.8354	0.026911	0.066331	0.076357	1524.3	–0.16769	682.83	238.77
400	0.24577	52.038	0.019217	9.5966	9.6013	0.028847	0.065438	0.076664	1509.5	–0.16092	683.64	218.60
410	0.33045	51.563	0.019394	10.364	10.371	0.030743	0.064570	0.077026	1492.2	–0.15366	683.52	201.43
420	0.43730	51.064	0.019583	11.136	11.144	0.032602	0.063731	0.077447	1472.5	–0.14581	682.53	186.68
430	0.57026	50.541	0.019786	11.911	11.923	0.034427	0.062920	0.077934	1450.6	–0.13728	680.70	173.91
440	0.73367	49.994	0.020003	12.692	12.706	0.036222	0.062140	0.078495	1426.5	–0.12794	678.05	162.77
450	0.9322	49.421	0.020234	13.477	13.496	0.037988	0.061390	0.079136	1400.4	–0.11767	674.59	152.98
460	1.1709	48.824	0.020482	14.269	14.293	0.039729	0.060671	0.079869	1372.2	–0.10631	670.28	144.31
470	1.4551	48.199	0.020748	15.068	15.098	0.041448	0.059984	0.080706	1342.0	–0.09369	665.12	136.58
480	1.7905	47.545	0.021033	15.875	15.913	0.043147	0.059327	0.081662	1309.8	–0.07959	659.07	129.64
490	2.1831	46.861	0.021340	16.690	16.737	0.044830	0.058702	0.082757	1275.7	–0.06372	652.06	123.37
500	2.6392	46.145	0.021671	17.515	17.573	0.046498	0.058109	0.084013	1239.6	–0.04578	644.05	117.66
510	3.1655	45.393	0.022030	18.352	18.421	0.048156	0.057548	0.085464	1201.5	–0.02534	634.95	112.42
520	3.7690	44.603	0.022420	19.200	19.285	0.049807	0.057023	0.087149	1161.3	–0.00189	624.68	107.57
530	4.4569	43.770	0.022847	20.064	20.165	0.051454	0.056536	0.089124	1119.1	0.025264	613.15	103.05
540	5.2369	42.889	0.023316	20.943	21.065	0.053102	0.056089	0.091464	1074.6	0.057002	600.26	98.792
550	6.1172	41.954	0.023836	21.841	21.987	0.054756	0.055690	0.094275	1027.9	0.094527	585.95	94.746
560	7.1062	40.956	0.024417	22.762	22.935	0.056422	0.055347	0.097713	978.54	0.13949	570.21	90.857
570	8.2132	39.885	0.025072	23.709	23.915	0.058106	0.055071	0.10201	926.44	0.19425	553.08	87.074
580	9.448	38.725	0.025823	24.688	24.932	0.059821	0.054881	0.10754	871.23	0.26220	534.74	83.342
590	10.821	37.456	0.026698	25.707	25.996	0.061577	0.054808	0.11491	812.49	0.34857	515.43	79.600
600	12.345	36.048	0.027741	26.777	27.119	0.063396	0.054902	0.12526	749.57	0.46172	495.46	75.773
610	14.033	34.451	0.029026	27.917	28.324	0.065309	0.055258	0.14100	681.27	0.61660	475.03	71.759
620	15.901	32.577	0.030697	29.160	29.648	0.067371	0.056100	0.16852	604.73	0.84473	454.10	67.382
630	17.969	30.210	0.033101	30.585	31.180	0.069715	0.058152	0.23108	513.19	1.2251	432.51	62.244
640	20.265	26.729	0.037413	32.422	33.180	0.072737	0.064521	0.46736	400.66	1.9542	414.93	55.247
647.1	22.064	17.874	0.055948	36.314	37.548	0.079393			0	3.7410		
273.16	0.000612	0.000269	3711.0	42.785	45.055	0.16494	0.025553	0.033947	409.00	592.65	17.071	9.2163
280	0.000992	0.000426	2345.4	42.954	45.280	0.16174	0.025657	0.034073	413.92	477.26	17.442	9.3815
290	0.001920	0.000797	1254.3	43.201	45.609	0.15741	0.025816	0.034270	420.99	351.65	18.031	9.6414
300	0.003537	0.001420	704.01	43.446	45.936	0.15344	0.025982	0.034483	427.89	264.35	18.673	9.9195
310	0.006231	0.002424	412.60	43.690	46.261	0.14981	0.026158	0.034716	434.63	203.74	19.369	10.213
320	0.010546	0.003978	251.39	43.931	46.582	0.14647	0.026350	0.034980	441.18	161.25	20.117	10.518
330	0.017213	0.006304	158.62	44.169	46.900	0.14339	0.026568	0.035287	447.54	130.92	20.922	10.833
340	0.027188	0.009681	103.30	44.404	47.212	0.14054	0.026821	0.035653	453.68	108.77	21.784	11.157
350	0.041682	0.014448	69.213	44.634	47.519	0.13791	0.027118	0.036091	459.58	92.178	22.707	11.487
360	0.062194	0.021014	47.586	44.860	47.819	0.13546	0.027469	0.036617	465.22	79.440	23.695	11.823
370	0.090535	0.029859	33.491	45.079	48.111	0.13317	0.027883	0.037249	470.57	69.427	24.750	12.162
380	0.12885	0.041537	24.075	45.291	48.393	0.13104	0.028372	0.038004	475.61	61.373	25.875	12.504
390	0.17964	0.056683	17.642	45.496	48.665	0.12904	0.028944	0.038903	480.32	54.749	27.074	12.848
400	0.24577	0.076014	13.156	45.691	48.924	0.12715	0.029608	0.039963	484.67	49.181	28.347	13.192
410	0.33045	0.10034	9.9666	45.876	49.170	0.12537	0.030369	0.041203	488.65	44.405	29.699	13.538
420	0.43730	0.13055	7.6601	46.050	49.400	0.12369	0.031230	0.042634	492.22	40.237	31.128	13.883
430	0.57026	0.16765	5.9649	46.211	49.613	0.12208	0.032187	0.044269	495.39	36.550	32.638	14.228
440	0.73367	0.21276	4.7002	46.359	49.807	0.12054	0.033234	0.046114	498.12	33.259	34.230	14.573

TABLE 2-305 Thermodynamic Properties of Water (*Continued*)

Temperature K	Pressure MPa	Density mol/dm^3	Volume dm^3/mol	Int. energy kJ/mol	Enthalpy kJ/mol	Entropy kJ/(mol·K)	C_v kJ/(mol·K)	C_p kJ/(mol·K)	Sound speed m/s	Joule-Thomson K/MPa	Therm. cond. mW/(m·K)	Viscosity μPa·s
Saturated Properties												
450	0.93220	0.26711	3.7438	46.492	49.982	0.11907	0.034362	0.048177	500.41	30.307	35.904	14.917
460	1.1709	0.33209	3.0113	46.609	50.134	0.11764	0.035561	0.050469	502.24	27.653	37.663	15.261
470	1.4551	0.40925	2.4435	46.708	50.263	0.11627	0.036821	0.053005	503.60	25.265	39.512	15.606
480	1.7905	0.50035	1.9986	46.788	50.367	0.11493	0.038137	0.055809	504.45	23.118	41.455	15.952
490	2.1831	0.60738	1.6464	46.848	50.442	0.11362	0.039503	0.058919	504.78	21.187	43.502	16.300
500	2.6392	0.73265	1.3649	46.885	50.487	0.11233	0.040920	0.062388	504.55	19.450	45.666	16.653
510	3.1655	0.87884	1.1379	46.898	50.500	0.11105	0.042391	0.066289	503.71	17.886	47.969	17.011
520	3.7690	1.0491	0.95318	46.883	50.475	0.10979	0.043920	0.070723	502.23	16.475	50.442	17.377
530	4.4569	1.2473	0.80174	46.838	50.411	0.10852	0.045519	0.075827	500.05	15.197	53.130	17.755
540	5.2369	1.4780	0.67659	46.758	50.302	0.10724	0.047197	0.081789	497.10	14.035	56.102	18.149
550	6.1172	1.7471	0.57238	46.641	50.142	0.10595	0.048968	0.088873	493.31	12.973	59.456	18.563
560	7.1062	2.0620	0.48497	46.478	49.925	0.10462	0.050848	0.097461	488.58	11.997	63.341	19.007
570	8.2132	2.4325	0.41110	46.264	49.641	0.10324	0.052856	0.10813	482.79	11.093	67.981	19.489
580	9.4480	2.8720	0.34819	45.988	49.278	0.10180	0.055017	0.12178	475.80	10.248	73.721	20.024
590	10.821	3.3994	0.29417	45.636	48.819	0.10026	0.057361	0.13994	467.41	9.4499	81.108	20.634
600	12.345	4.0434	0.24732	45.188	48.242	0.098600	0.059939	0.16540	457.33	8.6837	91.052	21.350
610	14.033	4.8497	0.20620	44.613	47.506	0.096755	0.062831	0.20384	445.11	7.9329	105.17	22.229
620	15.901	5.9009	0.16946	43.855	46.550	0.094631	0.066197	0.26923	429.99	7.1743	126.66	23.374
630	17.969	7.3737	0.13562	42.801	45.238	0.092029	0.070465	0.40819	410.21	6.3669	163.44	25.018
640	20.265	9.8331	0.10170	41.095	43.156	0.088324	0.077576	0.94736	379.64	5.3854	250.01	27.938
647.1	22.064	17.874	0.055948	36.314	37.548	0.079393			0	3.7410		
Single-Phase Properties												
300	0.1	55.317	0.018078	2.0277	2.0295	0.007081	0.074406	0.075315	1501.5	–0.22024	610.32	853.83
372.76	0.1	53.212	0.018793	7.5196	7.5214	0.02347	0.067921	0.075938	1543.5	–0.17843	678.97	282.91
372.76	0.1	0.032769	30.517	45.138	48.190	0.13257	0.02801	0.037444	471.99	67.038	25.053	12.256
400	0.1	0.030397	32.898	45.900	49.189	0.13516	0.02717	0.036170	490.31	47.254	27.008	13.285
500	0.1	0.024154	41.401	48.619	52.759	0.14313	0.02717	0.035693	548.31	19.298	35.861	17.270
600	0.1	0.020086	49.786	51.387	56.365	0.14970	0.028103	0.036513	598.61	10.567	46.367	21.407
700	0.1	0.017201	58.136	54.256	60.069	0.15541	0.029225	0.037592	643.92	6.6444	57.964	25.564
800	0.1	0.015044	66.471	57.240	63.887	0.16050	0.030431	0.038778	685.47	4.5167	70.385	29.669
900	0.1	0.013369	74.799	60.347	67.827	0.16514	0.031687	0.040024	724.03	3.2280	83.466	33.685
1000	0.1	0.012030	83.123	63.581	71.893	0.16943	0.032963	0.041293	760.17	2.3885	97.085	37.592
1100	0.1	0.010936	91.444	66.941	76.085	0.17342	0.034228	0.042554	794.33	1.8122	111.15	41.382
1200	0.1	0.010024	99.763	70.426	80.402	0.17718	0.035458	0.043781	826.85	1.4006	125.58	45.054
300	1	55.340	0.018070	2.0263	2.0444	0.007077	0.074353	0.075270	1503.0	–0.22022	610.73	853.67
400	1	52.060	0.019209	9.5914	9.6106	0.028834	0.065422	0.076628	1511.3	–0.16113	684.10	218.80
453.03	1	49.243	0.020307	13.717	13.737	0.038518	0.061169	0.079348	1392.0	–0.11435	673.37	150.24
453.03	1	0.28559	3.5015	46.529	50.030	0.11863	0.034718	0.048846	501.02	29.473	36.427	15.021
500	1	0.25158	3.9749	48.111	52.086	0.12295	0.030084	0.041065	535.74	19.741	38.799	17.051
600	1	0.20466	4.8861	51.123	56.009	0.13011	0.029002	0.038358	592.58	10.615	47.636	21.329
700	1	0.17377	5.7547	54.087	59.842	0.13602	0.029629	0.038495	640.55	6.6387	58.735	25.550
800	1	0.15134	6.6074	57.121	63.729	0.14121	0.030651	0.039301	683.48	4.5077	70.983	29.687
900	1	0.13418	7.4524	60.258	67.710	0.14590	0.031821	0.040358	722.85	3.2212	84.000	33.718
1000	1	0.12058	8.2932	63.511	71.804	0.15021	0.033051	0.041522	759.50	2.3837	97.573	37.630
1100	1	0.10951	9.1313	66.885	76.016	0.15422	0.034290	0.042719	794.01	1.8089	111.57	41.420
1200	1	0.10032	9.9677	70.380	80.347	0.15799	0.035504	0.043905	826.77	1.3982	125.89	45.088
300	5	55.439	0.018038	2.0204	2.1106	0.007057	0.074119	0.075070	1509.8	–0.22012	612.54	853.00
400	5	52.173	0.019167	9.5643	9.6601	0.028766	0.065337	0.076438	1520.9	–0.16222	686.54	219.84
500	5	46.267	0.021614	17.474	17.582	0.046415	0.058082	0.083643	1250.0	–0.04945	646.52	118.27
537.09	5	43.151	0.023175	20.685	20.801	0.052622	0.056215	0.090740	1087.8	0.047232	604.15	100.01
537.09	5	1.4072	0.71063	46.785	50.338	0.10762	0.046699	0.079952	498.04	14.362	55.203	18.032
600	5	1.1320	0.88340	49.734	54.151	0.11436	0.034611	0.051045	561.07	10.407	54.653	21.062
700	5	0.91269	1.0957	53.286	58.765	0.12148	0.031678	0.043318	624.59	6.5536	62.680	25.547

800	5	0.77805	1.2853	56.576	63.002	0.12714	0.031683	0.041848	674.39	4.4532	73.950	29.806
900	5	0.68224	1.4658	59.855	67.183	0.13207	0.032430	0.041922	717.57	3.1856	86.626	33.891
1000	5	0.60918	1.6416	63.197	71.405	0.13652	0.033447	0.042571	756.57	2.3599	99.971	37.821
1100	5	0.55109	1.8146	66.632	75.705	0.14061	0.034565	0.043465	792.63	1.7924	113.64	41.606
1200	5	0.50355	1.9859	70.172	80.101	0.14444	0.035704	0.044458	826.45	1.3865	127.51	45.257
300	10	55.561	0.017998	2.0131	2.1931	0.007031	0.073834	0.074829	1518.2	–0.21999	614.81	852.28
400	10	52.312	0.019116	9.5311	9.7222	0.028682	0.065233	0.076208	1532.7	–0.16351	689.57	221.13
500	10	46.517	0.021497	17.389	17.604	0.046244	0.058028	0.082910	1271.3	–0.05669	651.64	119.55
584.15	10	38.213	0.026169	25.105	25.367	0.060543	0.054835	0.11032	847.33	0.29540	526.83	81.795
584.15	10	3.0787	0.32482	45.852	49.100	0.10117	0.055964	0.128640	472.51	9.9124	76.543	20.267
600	10	2.7628	0.36195	47.183	50.802	0.10405	0.047271	0.092535	503.34	9.4382	71.110	21.036
700	10	1.9625	0.50956	52.145	57.241	0.11405	0.034838	0.051779	602.20	6.3228	69.301	25.704
800	10	1.6157	0.61893	55.851	62.040	0.12046	0.033089	0.045603	662.61	4.3529	78.476	30.054
900	10	1.3945	0.71709	59.334	66.505	0.12572	0.033219	0.044062	710.98	3.1289	90.516	34.176
1000	10	1.2345	0.81002	62.798	70.898	0.13035	0.033947	0.043952	753.03	2.3241	103.50	38.111
1100	10	1.1111	0.90002	66.314	75.314	0.13456	0.034908	0.044427	791.02	1.7683	116.73	41.882
1200	10	1.0119	0.98820	69.910	79.792	0.13846	0.035954	0.045164	826.16	1.3695	130.00	45.506
300	100	57.573	0.017369	1.8921	3.6290	0.006516	0.069812	0.071696	1667.9	–0.21618	654.50	856.88
400	100	54.500	0.018349	9.0423	10.877	0.027360	0.063582	0.073086	1717.3	–0.17905	741.80	243.50
500	100	49.914	0.020034	16.289	18.292	0.043895	0.057324	0.075607	1555.7	–0.12564	730.42	138.92
600	100	43.935	0.022761	23.820	26.097	0.058109	0.052776	0.081104	1300.4	–0.02079	645.83	101.51
700	100	36.179	0.027640	31.916	34.680	0.071320	0.049610	0.091576	1020.0	0.21155	510.14	79.363
800	100	26.768	0.037359	40.700	44.435	0.084331	0.047143	0.10108	813.97	0.65939	351.46	62.042
900	100	19.073	0.052429	48.805	54.048	0.095669	0.043932	0.088057	765.30	1.0399	257.03	53.250
1000	100	14.734	0.067868	55.188	61.975	0.10404	0.041345	0.071678	792.50	1.0944	232.07	51.518
1100	100	12.246	0.081656	60.470	68.635	0.11039	0.040131	0.062539	832.67	0.98401	223.70	52.497
1200	100	10.631	0.094062	65.222	74.628	0.11561	0.039810	0.057826	872.28	0.83544	219.07	54.415
300	500	63.750	0.015686	1.5247	9.3678	0.003746	0.063403	0.068296	2228.6	–0.19915	763.82	1089.4
400	500	60.862	0.016431	7.9635	16.179	0.023347	0.059634	0.067603	2258.7	–0.19486	929.09	320.18
500	500	57.695	0.017332	14.264	22.930	0.038412	0.055769	0.067522	2200.7	–0.18339	1096.6	189.08
600	500	54.316	0.018411	20.481	29.687	0.050731	0.052734	0.067584	2093.8	–0.16883	1097.9	141.83
700	500	50.847	0.019667	26.606	36.439	0.061141	0.050315	0.067436	1970.5	–0.15188	935.15	118.47
800	500	47.385	0.021104	32.615	43.167	0.070124	0.048442	0.067080	1850.1	–0.13256	738.72	104.70
900	500	44.018	0.022718	38.492	49.851	0.077998	0.047068	0.066596	1743.4	–0.11124	572.49	95.388
1000	500	40.814	0.024501	44.233	56.484	0.084987	0.046126	0.066041	1655.7	–0.08910	445.17	88.418
1100	500	37.834	0.026432	49.839	63.055	0.091251	0.045537	0.065356	1589.3	–0.06907	350.97	83.021
1200	500	35.124	0.028470	55.312	69.547	0.096900	0.045218	0.064451	1543.9	–0.05511	282.78	78.952
400	1000	65.942	0.015165	7.4792	22.644	0.019833	0.057934	0.065743	2718.6	–0.19303	1172.7	329.93
500	1000	63.253	0.015810	13.357	29.167	0.034391	0.055063	0.064967	2677.2	–0.19158	2199.5	190.55
600	1000	60.572	0.016509	19.141	35.650	0.046212	0.053055	0.064676	2602.3	–0.18789	3250.5	137.73
700	1000	57.937	0.017260	24.836	42.096	0.056150	0.051393	0.064219	2513.7	–0.18439	3202.2	108.98
800	1000	55.384	0.018056	30.435	48.491	0.064689	0.050059	0.063663	2423.7	–0.18105	2408.7	91.430
900	1000	52.937	0.018890	35.938	54.828	0.072155	0.049062	0.063101	2338.7	–0.17779	1610.7	80.198
1000	1000	50.611	0.019759	41.354	61.113	0.078776	0.048373	0.062594	2261.5	–0.17459	1052.9	72.716
1100	1000	48.415	0.020655	46.695	67.350	0.084722	0.047942	0.062176	2193.2	–0.17139	703.41	67.520
1200	1000	46.349	0.021575	51.976	73.551	0.090117	0.047713	0.061861	2133.6	–0.16808	487.61	63.774

The values in these tables were generated from the NIST REFPROP software (Lemmon, E. W., McLinden, M. O., and Huber, M. L., NIST Standard Reference Database 23: Reference Fluid Thermodynamic and Transport Properties—REFPROP, National Institute of Standards and Technology, Standard Reference Data Program, Gaithersburg, Md., 2002, Version 7.1). The primary source for the thermodynamic properties is Wagner, W., and Pruss, A., "The IAPWS Formulation 1995 for the Thermodynamic Properties of Ordinary Water Substance for General and Scientific Use," *J. Phys. Chem. Ref. Data* **31**(2):387–535, 2002. The source for viscosity is International Association for the Properties of Water and Steam, *Revised Release on the IAPS Formulation 1985 for the Viscosity of Ordinary Water Substance*, IAPWS, 1997. The source for thermal conductivity is the International Association for the Properties of Water and Steam, *Revised Release on the IAPS Formulation 1985 for the Thermal Conductivity of Ordinary Water Substance*, IAPWS, 1998.

Properties at the triple point temperature and the critical point temperature are given in the first and last entries of the saturation tables, respectively. In the single-phase table, when the temperature range for a given isobar includes a vapor-liquid phase boundary, the temperature of phase equilibrium is noted, and properties for both the saturated liquid and saturated vapor are given (with liquid properties given in the upper line). Lines are omitted from the temperature-pressure grid of the single-phase table, when the system would be in the solid phase or if there are potential problems with the source property surface.

The uncertainty in density of the equation of state is 0.0001% at 1 atm in the liquid phase, and 0.001% at other liquid states at pressures up to 10 MPa and temperatures to 423 K. In the vapor phase, the uncertainty is 0.05% or less. The uncertainties rise at higher temperatures and/or pressures, but are generally less than 0.1% in density except at extreme conditions. The uncertainty in pressure in the critical region is 0.1%. The uncertainty of the speed of sound is 0.15% in the vapor and 0.1% or less in the liquid, and increases near the critical region and at high temperatures and pressures. The uncertainty in isobaric heat capacity is 0.2% in the vapor and 0.1% in the liquid, with increasing values in the critical region and at high pressures. The uncertainties of saturation conditions are 0.025% in vapor pressure, 0.0025% in saturated-liquid density, and 0.1% in saturated-vapor density. The uncertainties in the saturated densities increase substantially as the critical region is approached. For the uncertainties in the viscosity and thermal conductivity, see the IAPWS Release.

TABLE 2-306 Thermodynamic Properties of Water Substance along the Melting Line

P, bar	T, °C	$10^3\, v_f$, m³/kg	h_f, kJ/kg	s_f, kJ/kg·K	c_{pf}, kJ/kg·K	c_{melt}, kJ/kg·K	$10^6\alpha_f$, K^{-1}	$10^6 K_{f,T}$ bar^{-1}
6.117×10^{-3t}	0.0100	1.00021	0	0	4.219	3.969	–67.42	50.90
1.01325	0.0026	1.00016	0.0719	–0.0001	4.218	3.970	–67.17	50.88
50	–0.3618	0.99770	3.5140	–0.0054	4.196	3.997	–54.92	50.30
100	–0.7410	0.99523	6.9794	–0.0110	4.174	4.023	–42.52	49.73
150	–1.1249	0.99278	10.3964	–0.0167	4.152	4.047	–30.24	49.17
200	–1.5166	0.99037	13.7648	–0.0225	4.132	4.070	–18.05	48.63
250	–1.9151	0.98798	17.0843	–0.0285	4.112	4.092	–5.93	48.11
300	–2.3206	0.98562	20.3547	–0.0347	4.092	4.113	6.12	47.59
400	–3.1532	0.98098	26.7472	–0.0474	4.056	4.150	30.09	46.61
500	–4.0156	0.97643	32.9403	–0.0607	4.022	4.184	53.97	45.68
600	–4.909	0.97196	38.932	–0.0747	3.992	4.215	77.87	44.80
800	–6.790	0.96326	50.300	–0.1046	3.937	4.270	126.18	43.19
1000	–8.803	0.95493	60.836	–0.1371	3.893	4.320	175.98	41.74

Condensed from U. Grigull, Private communication, January 18, 1995.

Materials prepared at Technical University München, Germany by U. Grigull and S. Marek. For a table as a function of temperature, see Grigull, U. and S. Marek, *Warme u. Stoff.,* **30** (1994): 1–8.

t = the triple point (at 6.117×10^{-3} bar, 0.01 °C); $v_f = 0.0010021$ m³/kg: $\alpha_f = -67.42 \times 10^{-6}$/K.

Other equations for properties are given by Jones, F. E. and G. L. Harris, *J. Res. N.I.S.T.,* **97,** 3 (1992): 335–340, and by Wagner, W. and A. Pruss, *J. Phys. Chem. Ref. Data,* **22,** 3 (1993): 783–787. Steam tables include Walker, W. A., U.S. Naval Ordn. Lab. rept. NOLTR NOLTR-66-217 = AD 651105 (0–1000 bar, 0–150°C), 1967 (72 pp.); Grigull, U., J. Straub, et al., *Steam Tables in S.I. Units* (0.01–1000 bar, 0–1000 °C), Springer-Verlag, Berlin, 1990 (133 pp.); Tseng, C. M., T. A. Hamp, et al., Atomic Energy of Canada rept. (30 props, sat liq & vap., 1–220 bar), AECL-5910 1977 (90 pp.). For dissociation, see e.g., Knonicek, V., *Rozpr. Cesko Acad Ved., Rada techn ved* (0.01–100 bar, 1000–5000 K). **77,** 1 (1967). The proceedings of the 10th international conference on the properties of steam were edited by Sytchev, V. V. and A. A. Aleksandrov, Plenum, NY, 1984; and for the 11th conference by Pichal, M. and O. Sifner, Hemisphere, 1989 (550 pp.). Current information on the properties of solid, vapor, and liquid water properties can be found at http://www.iapws.org.

For electrical conductivity, see e.g., Marshall, W. L., *J. Chem. Eng. Data,* **32** (1987): 221–226.