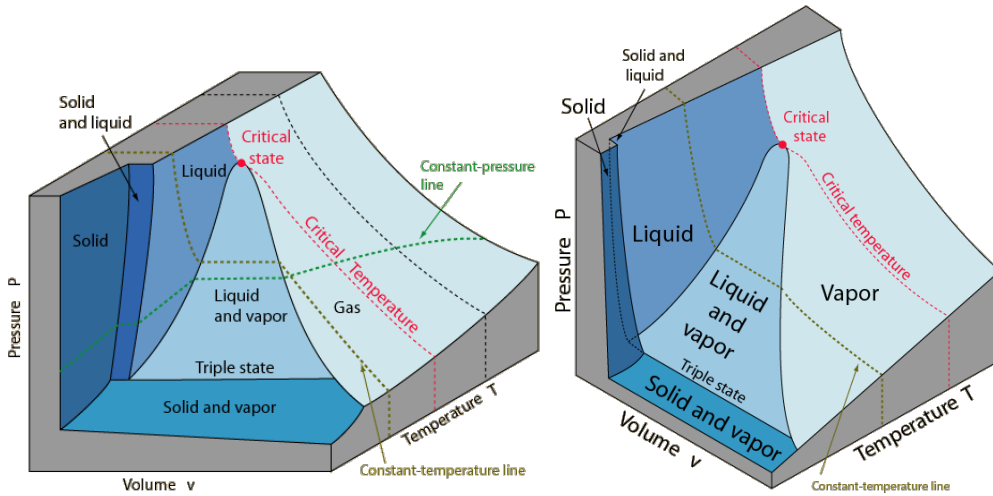




Property Plots and Tables



P-V-T surfaces for a substance that (left) contracts upon freezing and (right) expands upon freezing
<http://hyperphysics.phy-astr.gsu.edu/hbase/thermo/pvtsur.html>

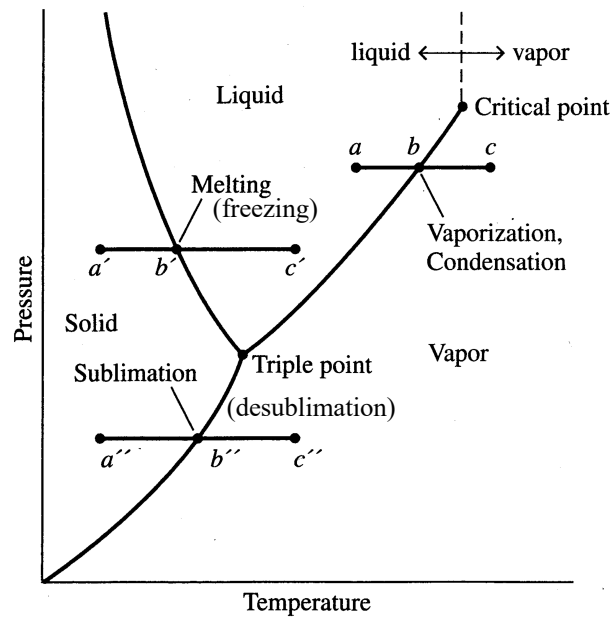
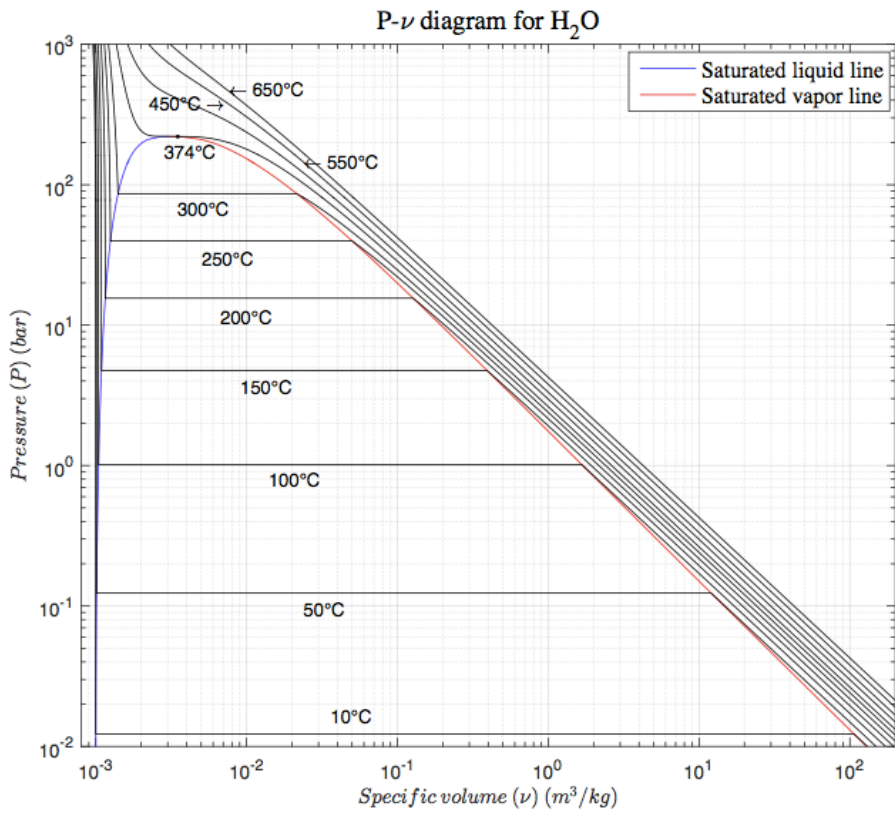
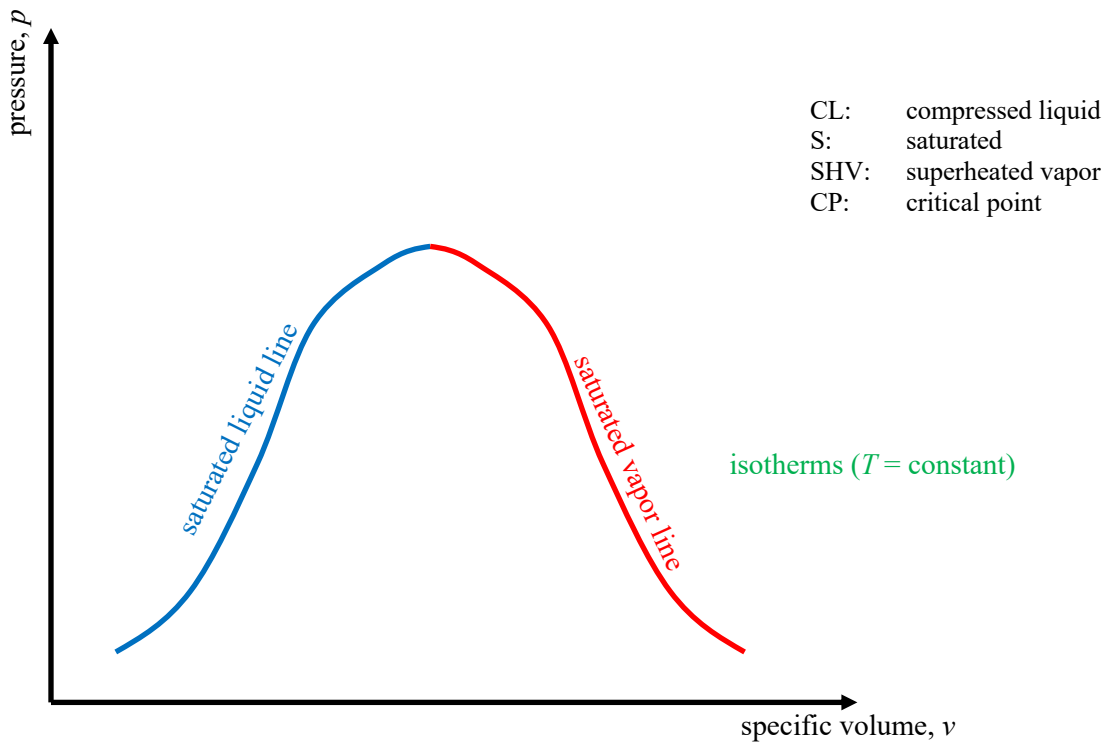
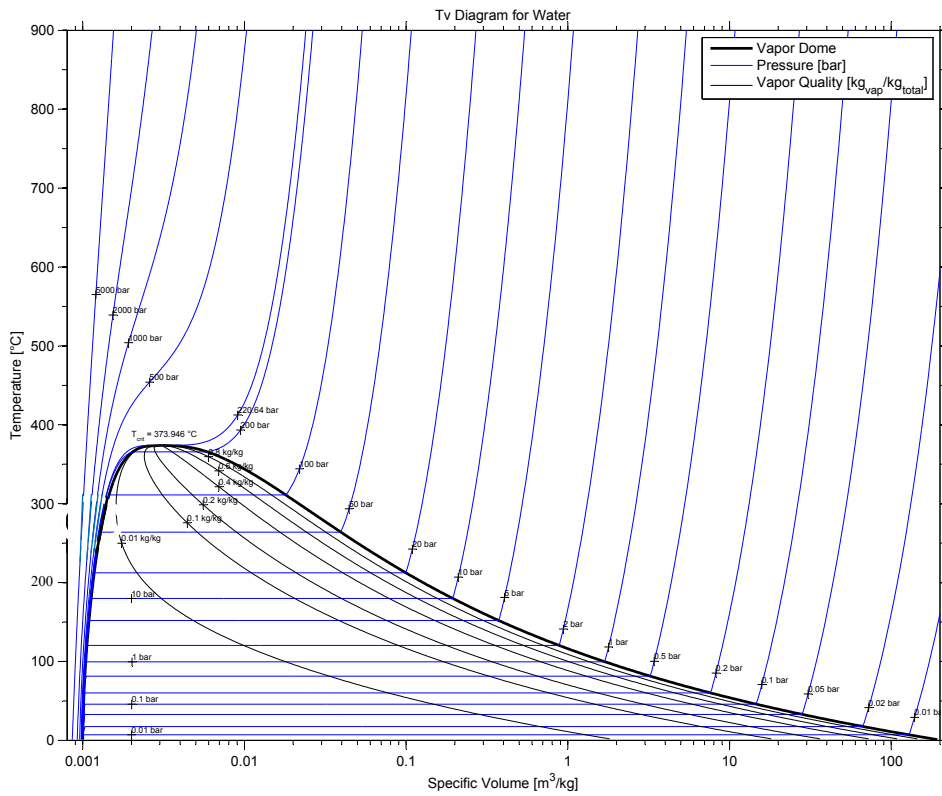
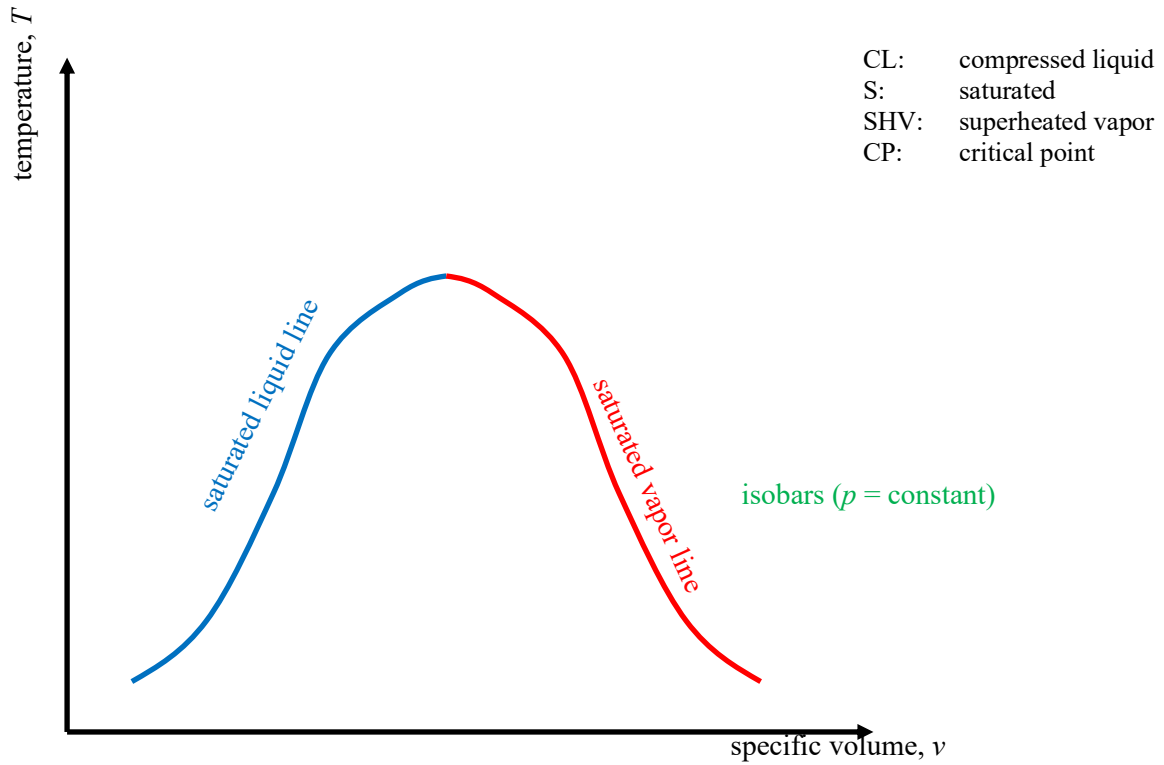


Fig. 3.5 Phase diagram for water (not to scale).





Properties of Saturated Water (Liquid-Vapor): Temperature Table (1 bar = 10⁵ Pa = 0.1 MPa)
 (from SLVM Tables)

Temp. (C)	Press. (bar)	Liquid				Vapor			
		Volume (v _f , m ³ /kg)	Internal Energy (u _f , kJ/kg)	Enthalpy (h _f , kJ/kg)	Entropy (s _f , kJ/kg/K)	Volume (v _g , m ³ /kg)	Internal Energy (u _g , kJ/kg)	Enthalpy (h _g , kJ/kg)	Entropy (s _g , kJ/kg/K)
0.01	0.0061165	0.0010002	0.0000	0.00061178	0.000000	205.99	2374.9	2500.9	9.1555
4	0.0081355	0.0010001	16.812	16.813	0.061103	157.12	2380.4	2508.2	9.0505
5	0.0087258	0.0010001	21.019	21.020	0.076254	147.01	2381.8	2510.1	9.0248
6	0.0093536	0.0010001	25.223	25.224	0.091342	137.63	2383.2	2511.9	8.9993
8	0.010730	0.0010002	33.626	33.627	0.121330	120.83	2385.9	2515.6	8.9491
10	0.012282	0.0010003	42.020	42.021	0.151090	106.30	2388.6	2519.2	8.8998
11	0.013130	0.0010004	46.215	46.216	0.165870	99.787	2390.0	2521.0	8.8754
12	0.014028	0.0010005	50.408	50.409	0.180610	93.719	2391.4	2522.9	8.8513
13	0.014981	0.0010007	54.600	54.601	0.195280	88.064	2392.8	2524.7	8.8274
14	0.015990	0.0010008	58.790	58.792	0.209900	82.793	2394.1	2526.5	8.8037
15	0.017058	0.0010009	62.980	62.981	0.224460	77.875	2395.5	2528.3	8.7803
16	0.018188	0.0010011	67.168	67.170	0.238970	73.286	2396.9	2530.2	8.7570
17	0.019384	0.0010013	71.355	71.357	0.253430	69.001	2398.2	2532.0	8.7339
18	0.020647	0.0010014	75.542	75.544	0.267830	64.998	2399.6	2533.8	8.7111
19	0.021983	0.0010016	79.727	79.729	0.282180	61.256	2401.0	2535.6	8.6884
20	0.023393	0.0010018	83.912	83.914	0.296480	57.757	2402.3	2537.4	8.6660
21	0.024882	0.0010021	88.096	88.098	0.310730	54.483	2403.7	2539.3	8.6437
22	0.026453	0.0010023	92.279	92.282	0.324930	51.418	2405.0	2541.1	8.6217
23	0.028111	0.0010025	96.462	96.465	0.339080	48.548	2406.4	2542.9	8.5998
24	0.029858	0.0010028	100.64	100.65	0.353180	45.858	2407.8	2544.7	8.5781
25	0.031699	0.0010030	104.83	104.83	0.367220	43.337	2409.1	2546.5	8.5566
26	0.033639	0.0010033	109.01	109.01	0.381230	40.973	2410.5	2548.3	8.5353
27	0.035681	0.0010035	113.19	113.19	0.395180	38.754	2411.8	2550.1	8.5142
28	0.037831	0.0010038	117.37	117.37	0.409080	36.672	2413.2	2551.9	8.4933
29	0.040092	0.0010041	121.55	121.55	0.422940	34.716	2414.6	2553.7	8.4725
30	0.042470	0.0010044	125.73	125.73	0.436750	32.878	2415.9	2555.5	8.4520
31	0.044969	0.0010047	129.91	129.91	0.450520	31.151	2417.3	2557.3	8.4316
32	0.047596	0.0010050	134.09	134.09	0.464240	29.526	2418.6	2559.2	8.4113
33	0.050354	0.0010054	138.27	138.27	0.477920	27.998	2420.0	2561.0	8.3913
34	0.053251	0.0010057	142.45	142.45	0.491550	26.560	2421.3	2562.8	8.3714
360	186.66	0.0018954	1726.3	1761.7	3.9167	0.0069493	2351.8	2481.5	5.0536
373.14	218.51	0.0025359	1920.5	1975.9	4.2404	0.0039827	2134.4	2221.4	4.6202

Properties of Saturated Water (Liquid-Vapor): Pressure Table (1 bar = 10⁵ Pa = 0.1 MPa)
 (from SLVM Tables)

		Liquid				Vapor			
Press. (bar)	Temp. (C)	Volume (v _f , m ³ /kg)	Internal Energy (u _f , kJ/kg)	Enthalpy (h _f , kJ/kg)	Entropy (s _f , kJ/kg/K)	Volume (v _g , m ³ /kg)	Internal Energy (u _g , kJ/kg)	Enthalpy (h _g , kJ/kg)	Entropy (s _g , kJ/kg/K)
0.01	6.970	0.0010001	29.298	29.299	0.10591	129.18	2384.5	2513.7	8.9749
0.02	17.50	0.0010014	73.426	73.428	0.26056	66.987	2398.9	2532.9	8.7226
0.03	24.08	0.0010028	100.97	100.98	0.35429	45.653	2407.9	2544.8	8.5764
0.04	28.96	0.0010041	121.38	121.39	0.42239	34.791	2414.5	2553.7	8.4734
0.05	32.87	0.0010053	137.74	137.75	0.47620	28.185	2419.8	2560.7	8.3938
0.06	36.16	0.0010065	151.47	151.48	0.52082	23.733	2424.2	2566.6	8.3290
0.07	39.00	0.0010075	163.34	163.35	0.55903	20.524	2428.0	2571.7	8.2745
0.08	41.51	0.0010085	173.83	173.84	0.59249	18.099	2431.4	2576.2	8.2273
0.09	43.76	0.0010094	183.24	183.25	0.62230	16.199	2434.4	2580.2	8.1858
0.1	45.81	0.0010103	191.80	191.81	0.64920	14.670	2437.2	2583.9	8.1488
0.2	60.06	0.0010172	251.40	251.42	0.83202	7.6480	2456.0	2608.9	7.9072
0.3	69.10	0.0010222	289.24	289.27	0.94407	5.2284	2467.7	2624.5	7.7675
0.4	75.86	0.0010264	317.58	317.62	1.0261	3.9930	2476.3	2636.1	7.6690
0.5	81.32	0.0010299	340.49	340.54	1.0912	3.2400	2483.2	2645.2	7.5930
0.6	85.93	0.0010331	359.84	359.91	1.1454	2.7317	2489.0	2652.9	7.5311
0.7	89.93	0.0010359	376.68	376.75	1.1921	2.3648	2493.9	2659.4	7.4790
0.8	93.49	0.0010385	391.63	391.71	1.2330	2.0871	2498.2	2665.2	7.4339
0.9	96.69	0.0010409	405.10	405.20	1.2696	1.8694	2502.1	2670.3	7.3943
1.0	99.61	0.0010432	417.40	417.50	1.3028	1.6939	2505.6	2674.9	7.3588
1.5	111.35	0.0010527	466.97	467.13	1.4337	1.1593	2519.2	2693.1	7.2230
2.0	120.21	0.0010605	504.49	504.70	1.5302	0.88568	2529.1	2706.2	7.1269
2.5	127.41	0.0010672	535.08	535.34	1.6072	0.71866	2536.8	2716.5	7.0524
3.0	133.52	0.0010732	561.10	561.43	1.6717	0.60576	2543.2	2724.9	6.9916
3.5	138.86	0.0010786	583.88	584.26	1.7274	0.52418	2548.5	2732.0	6.9401
4.0	143.61	0.0010836	604.22	604.65	1.7765	0.46238	2553.1	2738.1	6.8955
4.5	147.90	0.0010882	622.65	623.14	1.8205	0.41390	2557.1	2743.4	6.8560
5	151.83	0.0010925	639.54	640.09	1.8604	0.37481	2560.7	2748.1	6.8207
6	158.83	0.0011006	669.72	670.38	1.9308	0.31558	2566.8	2756.1	6.7592
7	164.95	0.0011080	696.23	697.00	1.9918	0.27277	2571.8	2762.8	6.7071
8	170.41	0.0011148	719.97	720.86	2.0457	0.24034	2576.0	2768.3	6.6616
9	175.35	0.0011212	741.55	742.56	2.0940	0.21489	2579.6	2773.0	6.6213
10	179.88	0.0011272	761.39	762.52	2.1381	0.19436	2582.7	2777.1	6.5850
220.64	373.95	0.0031056	2015.7	2084.3	4.4070	0.0031056	2015.7	2084.3	4.4070

Properties of Superheated Water Vapor (1 bar = 10⁵ Pa = 0.1 MPa)
(from SHV Tables)

Temp. (C)	Volume (m ³ /kg)	Internal Energy (kJ/kg)	Enthalpy (kJ/kg)	Entropy (kJ/kg/K)	Volume (m ³ /kg)	Internal Energy (kJ/kg)	Enthalpy (kJ/kg)	Entropy (kJ/kg/K)
p = 0.06 bar, T _{sat} = 36.16°C					p = 0.35 bar = 0.035 MPa, T _{sat} = 72.69°C			
Sat.	23.73300	2424.2	2566.6	8.329	4.52520	2472.3	2630.7	7.715
80	27.13300	2487.2	2650.0	8.581	4.62470	2483.3	2645.2	7.756
120	30.22000	2544.7	2726.0	8.785	5.16330	2542.5	2723.2	7.965
160	33.30300	2602.7	2802.5	8.970	5.69680	2601.3	2800.7	8.153
200	36.38300	2661.5	2879.8	9.141	6.22790	2660.5	2878.5	8.325
240	39.46300	2721.1	2957.9	9.299	6.75780	2720.4	2956.9	8.484
280	42.54100	2781.7	3037.0	9.448	7.28700	2781.1	3036.2	8.633
320	45.61900	2843.2	3117.0	9.587	7.81570	2842.8	3116.3	8.773
360	48.69700	2905.8	3198.0	9.720	8.34410	2905.4	3197.4	8.905
400	51.77400	2969.4	3280.0	9.845	8.87230	2969.0	3279.6	9.031
440	54.85200	3034.0	3363.1	9.965	9.40040	3033.7	3362.7	9.151
500	59.46800	3132.9	3489.7	10.136	10.19200	3132.7	3489.4	9.321

Temp. (C)	Volume (m ³ /kg)	Internal Energy (kJ/kg)	Enthalpy (kJ/kg)	Entropy (kJ/kg/K)	Volume (m ³ /kg)	Internal Energy (kJ/kg)	Enthalpy (kJ/kg)	Entropy (kJ/kg/K)
p = 0.7 bar = 0.07 MPa, T _{sat} = 89.95°C					p = 1.0 bar = 0.10 MPa, T _{sat} = 99.63°C			
Sat.	2.36490	2493.9	2659.5	7.479	1.69400	2505.6	2675.0	7.359
100	2.43430	2509.4	2679.8	7.534	1.69590	2506.2	2675.8	7.361
120	2.57100	2539.7	2719.7	7.639	1.79320	2537.3	2716.6	7.468
160	2.84090	2599.5	2798.4	7.829	1.98410	2598.0	2796.4	7.661
200	3.10830	2659.3	2876.8	8.002	2.17240	2658.2	2875.5	7.836
240	3.37450	2719.5	2955.7	8.162	2.35950	2718.7	2954.6	7.996
280	3.64000	2780.4	3035.2	8.312	2.54590	2779.8	3034.4	8.146
320	3.90500	2842.2	3115.6	8.452	2.73170	2841.7	3114.9	8.286
360	4.16970	2904.9	3196.8	8.584	2.91730	2904.5	3196.3	8.419
400	4.43410	2968.6	3279.0	8.710	3.10270	2968.3	3278.6	8.545
440	4.69850	3033.4	3362.3	8.830	3.28790	3033.1	3361.9	8.665
500	5.09480	3132.4	3489.1	9.001	3.56550	3132.2	3488.7	8.836

Temp. (C)	Volume (m ³ /kg)	Internal Energy (kJ/kg)	Enthalpy (kJ/kg)	Entropy (kJ/kg/K)	Volume (m ³ /kg)	Internal Energy (kJ/kg)	Enthalpy (kJ/kg)	Entropy (kJ/kg/K)
p = 1.5 bar = 0.15 MPa, T _{sat} = 111.37°C					p = 3.0 bar = 0.30 MPa, T _{sat} = 133.55°C			
Sat.	1.15940	2519.2	2693.1	7.223	0.60581	2543.2	2724.9	6.992
120	1.18800	2533.2	2711.4	7.270				
160	1.31760	2595.4	2793.1	7.468	0.65081	2587.4	2782.6	7.129
200	1.44450	2656.4	2873.1	7.645	0.71642	2651.0	2865.9	7.313
240	1.57010	2717.4	2952.9	7.807	0.78055	2713.4	2947.5	7.479
280	1.69490	2778.8	3033.0	7.957	0.84388	2775.7	3028.8	7.631
320	1.81920	2840.9	3113.8	8.098	0.90672	2838.4	3110.4	7.774
360	1.94330	2903.8	3195.3	8.231	0.96924	2901.8	3192.6	7.908
400	2.06710	2967.7	3277.8	8.357	1.03150	2966.0	3275.5	8.035
440	2.19080	3032.6	3361.2	8.478	1.09370	3031.1	3359.2	8.156
500	2.37610	3131.8	3488.2	8.649	1.18670	3130.6	3486.6	8.327
600	2.68460	3302.5	3705.2	8.912	1.34140	3301.6	3704.0	8.591

Properties of Compressed Liquid Water (1 bar = 10⁵ Pa = 0.1 MPa)
(from CL Tables)

Temp. (C)	Volume (m ³ /kg)	Internal Energy (kJ/kg)	Enthalpy (kJ/kg)	Entropy (kJ/kg/K)
p = 25 bar, T_{sat} = 223.95°C				
20	1.0007E-03	83.76	86.26	0.2960
40	1.0068E-03	167.22	169.74	0.5714
80	1.0279E-03	334.39	336.96	1.0740
100	1.0422E-03	418.36	420.97	1.3053
140	1.0784E-03	587.85	590.55	1.7370
180	1.1261E-03	760.99	763.81	2.1372
200	1.1556E-03	849.76	852.65	2.3290
220	1.1899E-03	940.65	943.63	2.5173
Sat.	1.1974E-03	958.91	961.91	2.5543

Volume (m ³ /kg)	Internal Energy (kJ/kg)	Enthalpy (kJ/kg)	Entropy (kJ/kg/K)
p = 50 bar = 5.0 MPa, T_{sat} = 263.94°C			
9.9956E-04	83.61	88.61	0.2954
1.0057E-03	166.92	171.95	0.5705
1.0267E-03	333.82	338.95	1.0723
1.0410E-03	417.64	422.85	1.3034
1.0769E-03	586.79	592.18	1.7344
1.1240E-03	759.46	765.08	2.1338
1.1531E-03	847.91	853.68	2.3251
1.1868E-03	938.39	944.32	2.5127
1.2864E-03	1148.20	1154.60	2.9210

Temp. (C)	Volume (m ³ /kg)	Internal Energy (kJ/kg)	Enthalpy (kJ/kg)	Entropy (kJ/kg/K)
p = 75 bar = 7.5 MPa, T_{sat} = 290.54°C				
20	9.9843E-04	83.46	90.95	0.2949
40	1.0046E-03	166.63	174.16	0.5695
80	1.0256E-03	333.25	340.95	1.0707
100	1.0397E-03	416.93	424.73	1.3015
140	1.0753E-03	585.75	593.81	1.7319
180	1.1220E-03	757.96	766.37	2.1304
220	1.1838E-03	936.17	945.05	2.5082
260	1.2703E-03	1125.00	1134.50	2.8775
Sat.	1.3682E-03	1282.70	1292.90	3.1662

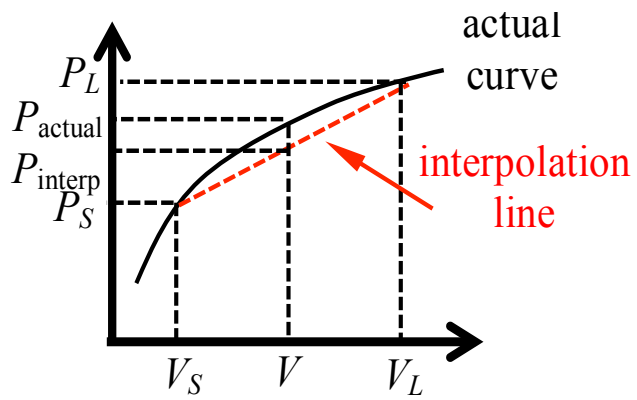
Volume (m ³ /kg)	Internal Energy (kJ/kg)	Enthalpy (kJ/kg)	Entropy (kJ/kg/K)
p = 100 bar = 10.0 MPa, T_{sat} = 311.00°C			
9.9731E-04	83.31	93.28	0.2944
1.0035E-03	166.33	176.36	0.5685
1.0244E-03	332.69	342.94	1.0691
1.0385E-03	416.23	426.62	1.2996
1.0738E-03	584.71	595.45	1.7293
1.1200E-03	756.48	767.68	2.1271
1.1809E-03	934.00	945.81	2.5037
1.2653E-03	1121.60	1134.30	2.8710
1.4526E-03	1393.50	1408.10	3.3606

Approximations for CLs:

$$v(T, p)_{CL} \approx v_l(T),$$

$$u(T, p)_{CL} \approx u_l(T)$$

Linear Interpolation



$$P_{\text{interp}} - P_S = \underbrace{\left(\frac{P_L - P_S}{V_L - V_S} \right)}_{\text{slope}} (V - V_S)$$