UNIVERSITY OF JOHANNESBURG

PROGRAM	:	BACHELOR OF ENGINEERING TECHNOLOGY (BENGTECH) *ENGINEERING : MECHANICAL*
SUBJECT	:	**STEAM PLANT**
CODE	:	**SPLM1B2**
DATE	:	SUPPLEMENTARY EXAM 09 January 2020
DURATION	:	(SESSION 1) 08:00 - 11:00 (3 hours)
WEIGHT	:	
TOTAL MARKS	:	96 = 100%
MAXIMUM MARKS	:	100
ASSESSOR	:	Mr. E. BAKAYA-KYAHURWA
MODERATOR	:	Mr. S. GQIBANI
NUMBER OF PAGES	:	PAGES: 2 excluding the cover page.
INSTRUCTIONS	:	ONLY ONE POCKET CALCULATOR PER CANDIDATE MAY BE USED.

1. This paper contains 5 questions
2. PLEASE ANSWER **ALL** the QUESTIONS
3. Make sure that you understand what the question requires before attempting it.
4. Any additional examination material is to be placed in the answer book and must indicate clearly the question number, and Student number.
5. Draw proper sketches where required with all relevant information
6. Answers without calculations will not be considered
7. Number all answer according to the numbering in question paper.

REQUIREMENTS: Calculator, steam tables, Mollier diagram.

Graduate Attribute:
This assessment is a build up to Graduate Attribute **9**; Independent Learning. Engage in independent and life-long learning through well-developed learning skills.

If required take the specific heat of steam at 1.0 bar (Cp_S) as 2.1 kJ/kgK

QUESTION 1

1.1 The following data was obtained during a trial of a steam boiler at Hendrina power station: Feed water temperature, 75°C. Mass of feed water supplied per hour 4,900 kg. Steam pressure, 11 bar; dryness fraction of steam, 0.9; coal fired per hour, 490 kg; calorific value of 1 kg of dry coal, 35,600 kJ/kg; moisture in coal, 4% on mass basis; temperature of flue gases, 300°C; boiler house temperature, 16°C; barometric (atmospheric) pressure 1.013 bar. Analysis of dry coal on mass basis, C = 89%; H_2 = 3%; ash = 4%; and other matter = 4%; The air fuel ratio required for combustion is 17.7 kg per kg of fuel. Take specific heat of dry flue gases as 1.02 kJ/kg K. Draw up the heat balance sheet for the boiler per kg of coal fired and determine its thermal efficiency. (24)

1.2 The steam boiler in this question forms part of a steam plant operating on a Rankine cycle. The steam from the boiler enters the superheater which raises its temperature to 420°C before it expands in turbine and exhausts dry saturated at 10 kPa. For the turbine estimate the turbine power developed and the isentropic efficiency. 10

[34]

[**34**]

QUESTION 2

A closed vessel of 0.7 m^3 capacity contains saturated water vapour and air at a temperature of 42.7°C and pressure of 0.127 bar. Due to further air leakage into the vessel, the pressure rises to 0.28 bar and temperature falls to 37.7°C. Calculate the mass of air which has leaked in. Take R 0.287 kJ/kg K for air.

[10]

[**10**]

QUESTION 3

3.1 Dry saturated steam at a pressure 15 bar expands reversibly in a cylinder behind a piston until the pressure is 1.0 bar. If heat is supplied continuously during the process in order to keep the temperature constant, estimate the change in internal energy per unit mass of steam. [8]

3.2 A certain quantity of steam in a closed vessel of fixed volume of 0.3 m^3 exerts a pressure of 15 bar at 280°C. If the vessel is cooled so that the pressure falls to 10 bar, evaluate the final quality of steam, and determine the change in internal energy, during the process. [12]

[**20**]

QUESTION 4

A student in the steam plant class carried out an experiment to determine the performance of a cooling tower. The following readings were taken. Estimate the tower characteric and evaluate its effectiveness. Make up water is supplied outside the tower.

inlet dry-bulb temperature (°C)	20.7
air inlet wet bulb temperature (°C)	8
air outlet dry bulb temperature (°C)	21
air outlet wet bulb temperature (°C)	21
water inlet temperature to Tower (°C)	27
water outlet temperature from tower (°C)	15
water flow rate (g/s)	40

[**12**]

QUESTION 5

A turbine connected to boiler number 4 at Medupi power station, operating, receives steam at 36 bar and 470°C and exhausts at 0.1 bar. At an optimal reheat pressure, the steam is withdrawn and part of it is used for feed water heating in a closed feed heater, while the remainder passes through a re-heater. The steam re-enters the turbine at the reheat pressure and 370°C. Evaluate the thermal efficiency of the steam plant taking pump work into consideration. State your assumptions.

[20]

[**20**]

TOTAL [96]

Saturated Water and Steam (Pressure-based)

p_{tp} = 611.657 Pa = 0.000611657 MPa

p	T_{sat}	Volume, m^3/kg		Energy, kJ/kg		Enthalpy, kJ/kg			Entropy, kJ/(kg K)		
MPa	°C	v_f	v_g	u_f	u_g	h_f	h_g	h_{fg}	s_f	s_g	s_{fg}
p_{tp}	**0.01**	0.00100021	205.991	0	2374.9	0.00	2500.9	2500.9	0	9.1555	9.1555
0.0007	1.881	0.00100011	181.217	7.89	2377.4	7.89	2504.3	2496.5	0.02878	9.1058	9.0770
0.0008	3.761	0.00100008	159.640	15.81	2380.1	15.81	2507.8	2492.0	0.05748	9.0567	8.9992
0.0009	5.444	0.00100009	142.757	22.89	2382.4	22.89	2510.9	2488.0	0.08297	9.0135	8.9305
0.0010	6.970	0.00100014	129.178	29.30	2384.5	29.30	2513.7	2484.4	0.10591	8.9749	8.8690
0.0012	9.654	0.00100032	108.670	40.57	2388.2	40.57	2518.6	2478.0	0.14595	8.9082	8.7623
0.0014	11.969	0.00100054	93.899	50.28	2391.3	50.28	2522.8	2472.5	0.18015	8.8521	8.6719
0.0016	14.010	0.00100080	82.743	58.83	2394.1	58.83	2526.5	2467.7	0.21004	8.8035	8.5935
0.0018	15.837	0.00100108	74.011	66.49	2396.7	66.49	2529.9	2463.4	0.23662	8.7608	8.5241
0.0020	17.495	0.00100136	66.987	73.43	2398.9	73.43	2532.9	2459.4	0.26056	8.7226	8.4620
0.0024	20.414	0.00100193	56.375	85.65	2402.9	85.65	2538.2	2452.5	0.30239	8.6567	8.3544
0.0028	22.935	0.00100249	48.729	96.19	2406.4	96.19	2542.8	2446.6	0.33816	8.6012	8.2631
0.0032	25.158	0.00100305	42.952	105.49	2409.4	105.49	2546.8	2441.3	0.36945	8.5533	8.1838
0.0036	27.152	0.00100358	38.430	113.83	2412.1	113.83	2550.4	2436.6	0.39729	8.5110	8.1138
0.0040	28.960	0.00100410	34.791	121.39	2414.5	121.39	2553.7	2432.3	0.42239	8.4734	8.0510
0.0045	31.012	0.00100473	31.131	129.96	2417.3	129.96	2557.4	2427.4	0.45069	8.4313	7.9806
0.0050	32.874	0.00100533	28.185	137.74	2419.8	137.75	2560.7	2423.0	0.47620	8.3938	7.9176
0.0055	34.581	0.00100590	25.762	144.87	2422.1	144.88	2563.8	2418.9	0.49945	8.3599	7.8605
0.0060	36.159	0.00100645	23.733	151.47	2424.2	151.48	2566.6	2415.2	0.52082	8.3290	7.8082
0.0065	37.627	0.00100699	22.009	157.60	2426.2	157.61	2569.3	2411.6	0.54060	8.3007	7.7601
0.0070	39.000	0.00100750	20.524	163.34	2428.0	163.35	2571.7	2408.4	0.55903	8.2745	7.7154
0.0075	40.290	0.00100800	19.233	168.74	2429.8	168.75	2574.0	2405.3	0.57627	8.2501	7.6738
0.0080	41.509	0.00100848	18.099	173.83	2431.4	173.84	2576.2	2402.4	0.59249	8.2273	7.6348
0.0085	42.663	0.00100895	17.095	178.66	2433.0	178.67	2578.3	2399.6	0.60780	8.2060	7.5982
0.0090	43.761	0.00100940	16.199	183.24	2434.4	183.25	2580.2	2397.0	0.62230	8.1858	7.5635
0.0095	44.807	0.00100984	15.396	187.62	2435.8	187.63	2582.1	2394.5	0.63607	8.1668	7.5308
0.010	45.806	0.00101027	14.670	191.80	2437.2	191.81	2583.9	2392.1	0.64920	8.1488	7.4996
0.011	47.683	0.00101110	13.412	199.64	2439.7	199.65	2587.2	2387.5	0.67372	8.1154	7.4417
0.012	49.419	0.00101188	12.358	206.90	2442.0	206.91	2590.3	2383.4	0.69628	8.0849	7.3887
0.013	51.034	0.00101263	11.462	213.66	2444.1	213.67	2593.1	2379.4	0.71717	8.0570	7.3398
0.014	52.547	0.00101335	10.691	219.98	2446.1	219.99	2595.8	2375.8	0.73664	8.0311	7.2945
0.016	55.313	0.00101471	9.4306	231.55	2449.7	231.57	2600.6	2369.1	0.77201	7.9846	7.2126
0.018	57.798	0.00101597	8.4431	241.94	2453.0	241.96	2605.0	2363.0	0.80355	7.9437	7.1402
0.020	60.058	0.00101716	7.6480	251.40	2455.9	251.42	2608.9	2357.5	0.83202	7.9072	7.0752
0.024	64.053	0.00101934	6.4453	268.13	2461.2	268.15	2615.9	2347.7	0.88191	7.8442	6.9623
0.028	67.518	0.00102131	5.5778	282.63	2465.6	282.66	2621.8	2339.2	0.92472	7.7912	6.8664
0.032	70.586	0.00102312	4.9215	295.49	2469.6	295.52	2627.1	2331.6	0.96228	7.7453	6.7830
0.036	73.345	0.00102480	4.4072	307.05	2473.1	307.09	2631.8	2324.7	0.99579	7.7050	6.7092
0.040	75.857	0.00102638	3.9930	317.58	2476.4	317.62	2636.1	2318.4	1.0261	7.6690	6.6429
0.045	78.715	0.00102821	3.5759	329.57	2480.0	329.62	2640.9	2311.2	1.0603	7.6288	6.5686
0.050	81.317	0.00102993	3.2400	340.49	2483.2	340.54	2645.2	2304.7	1.0912	7.5930	6.5018

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p MPa	T_{sat} °C	Volume, m^3/kg v_f	v_g	Energy, kJ/kg u_f	u_g	Enthalpy, kJ/kg h_f	h_g	h_{fg}	Entropy, kJ/(kg K) s_f	s_g	s_{fg}
0.050	81.317	0.00102993	3.2400	340.49	2483.2	340.54	2645.2	2304.7	1.0912	7.5930	6.5018
0.055	83.709	0.00103154	2.9635	350.53	2486.2	350.59	2649.2	2298.6	1.1194	7.5606	6.4412
0.060	85.926	0.00103307	2.7317	359.85	2489.0	359.91	2652.9	2292.9	1.1454	7.5311	6.3857
0.065	87.993	0.00103452	2.5346	368.53	2491.6	368.60	2656.3	2287.7	1.1696	7.5040	6.3345
0.070	89.932	0.00103590	2.3648	376.68	2493.9	376.75	2659.4	2282.7	1.1921	7.4790	6.2869
0.075	91.758	0.00103723	2.2170	384.36	2496.1	384.44	2662.4	2277.9	1.2132	7.4557	6.2425
0.080	93.486	0.00103850	2.0871	391.63	2498.2	391.71	2665.2	2273.5	1.2330	7.4339	6.2009
0.085	95.125	0.00103972	1.9720	398.53	2500.2	398.62	2667.8	2269.2	1.2518	7.4135	6.1617
0.090	96.687	0.00104091	1.8694	405.11	2502.1	405.20	2670.3	2265.1	1.2696	7.3943	6.1246
0.095	98.178	0.00104205	1.7772	411.38	2503.9	411.48	2672.7	2261.2	1.2866	7.3761	6.0895
0.10	99.606	0.00104315	1.6939	417.40	2505.5	417.50	2674.9	2257.4	1.3028	7.3588	6.0561
0.11	102.292	0.00104527	1.5495	428.73	2508.8	428.84	2679.2	2250.3	1.3330	7.3269	5.9938
0.12	104.784	0.00104727	1.4284	439.23	2511.7	439.36	2683.1	2243.7	1.3609	7.2977	5.9367
0.13	107.109	0.00104917	1.3253	449.05	2514.3	449.19	2686.6	2237.5	1.3868	7.2709	5.8840
0.14	109.292	0.00105099	1.2366	458.27	2516.9	458.42	2690.0	2231.6	1.4110	7.2461	5.8351
0.15	111.349	0.00105273	1.1593	466.97	2519.2	467.13	2693.1	2226.0	1.4337	7.2230	5.7893
0.16	113.297	0.00105440	1.0914	475.21	2521.4	475.38	2696.0	2220.7	1.4551	7.2014	5.7463
0.17	115.148	0.00105600	1.0312	483.04	2523.5	483.22	2698.8	2215.6	1.4753	7.1812	5.7059
0.18	116.911	0.00105756	0.97747	490.51	2525.5	490.70	2701.4	2210.7	1.4945	7.1621	5.6676
0.19	118.596	0.00105906	0.92924	497.65	2527.3	497.85	2703.9	2206.0	1.5127	7.1440	5.6313
0.20	120.210	0.00106052	0.88568	504.49	2529.1	504.70	2706.2	2201.5	1.5302	7.1269	5.5967
0.21	121.759	0.00106193	0.84614	511.07	2530.8	511.29	2708.5	2197.2	1.5469	7.1106	5.5638
0.22	123.250	0.00106330	0.81007	517.40	2532.4	517.63	2710.6	2193.0	1.5628	7.0951	5.5323
0.23	124.686	0.00106464	0.77704	523.50	2534.0	523.74	2712.7	2188.9	1.5782	7.0803	5.5021
0.24	126.072	0.00106594	0.74668	529.38	2535.4	529.64	2714.6	2185.0	1.5930	7.0661	5.4731
0.25	127.411	0.00106722	0.71866	535.07	2536.8	535.34	2716.5	2181.1	1.6072	7.0524	5.4452
0.26	128.708	0.00106846	0.69273	540.59	2538.2	540.87	2718.3	2177.4	1.6210	7.0394	5.4184
0.27	129.965	0.00106968	0.66865	545.95	2539.5	546.24	2720.0	2173.8	1.6343	7.0268	5.3925
0.28	131.185	0.00107086	0.64624	551.14	2540.8	551.44	2721.7	2170.3	1.6471	7.0146	5.3675
0.29	132.370	0.00107203	0.62533	556.19	2542.0	556.50	2723.3	2166.8	1.6596	7.0029	5.3433
0.30	133.522	0.00107317	0.60576	561.11	2543.2	561.43	2724.9	2163.5	1.6717	6.9916	5.3199
0.31	134.644	0.00107429	0.58741	565.89	2544.3	566.22	2726.4	2160.2	1.6835	6.9807	5.2972
0.32	135.737	0.00107539	0.57017	570.56	2545.3	570.90	2727.8	2157.0	1.6949	6.9701	5.2752
0.33	136.802	0.00107647	0.55395	575.10	2546.5	575.46	2729.3	2153.8	1.7060	6.9598	5.2538
0.34	137.842	0.00107753	0.53864	579.54	2547.5	579.91	2730.6	2150.7	1.7168	6.9498	5.2330
0.35	138.857	0.00107857	0.52418	583.88	2548.5	584.26	2732.0	2147.7	1.7274	6.9401	5.2128
0.36	139.849	0.00107960	0.51050	588.13	2549.4	588.52	2733.2	2144.7	1.7377	6.9307	5.1931
0.37	140.819	0.00108061	0.49753	592.28	2550.4	592.68	2734.5	2141.8	1.7477	6.9216	5.1739
0.38	141.769	0.00108161	0.48522	596.34	2551.3	596.75	2735.7	2139.0	1.7575	6.9126	5.1551
0.39	142.698	0.00108259	0.47352	600.32	2552.2	600.74	2736.9	2136.2	1.7671	6.9040	5.1369
0.40	143.608	0.00108355	0.46238	604.22	2553.1	604.65	2738.1	2133.4	1.7765	6.8955	5.1190

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T [°C]	p_s [bar]	v_g [m³/kg]	h_f [kJ/kg]	h_{fg} [kJ/kg]	h_g [kJ/kg]	s_f [kJ/kg K]	s_{fg} [kJ/kg K]	s_g [kJ/kg K]
0.01	0.006112	206.1	0*	2500.8	2500.8	0†	9.155	9.155
1	0.006566	192.6	4.2	2498.3	2502.5	0.015	9.113	9.128
2	0.007054	179.9	8.4	2495.9	2504.3	0.031	9.071	9.102
3	0.007575	168.2	12.6	2493.6	2506.2	0.046	9.030	9.076
4	0.008129	157.3	16.8	2491.3	2508.1	0.061	8.989	9.050
5	0.008719	147.1	21.0	2488.9	2509.9	0.076	8.948	9.024
6	0.009346	137.8	25.2	2486.6	2511.8	0.091	8.908	8.999
7	0.01001	129.1	29.4	2484.3	2513.7	0.106	8.868	8.974
8	0.01072	121.0	33.6	2481.9	2515.5	0.121	8.828	8.949
9	0.01147	113.4	37.8	2479.6	2517.4	0.136	8.788	8.924
10	0.01227	106.4	42.0	2477.2	2519.2	0.151	8.749	8.900
11	0.01312	99.90	46.2	2474.9	2521.1	0.166	8.710	8.876
12	0.01401	93.83	50.4	2472.5	2522.9	0.180	8.671	8.851
13	0.01497	88.17	54.6	2470.2	2524.8	0.195	8.633	8.828
14	0.01597	82.89	58.8	2467.8	2526.6	0.210	8.594	8.804
15	0.01704	77.97	62.9	2465.5	2528.4	0.224	8.556	8.780
16	0.01817	73.38	67.1	2463.1	2530.2	0.239	8.518	8.757
17	0.01936	69.09	71.3	2460.8	2532.1	0.253	8.481	8.734
18	0.02063	65.08	75.5	2458.4	2533.9	0.268	8.444	8.712
19	0.02196	61.34	79.7	2456.0	2535.7	0.282	8.407	8.689
20	0.02337	57.84	83.9	2453.7	2537.6	0.296	8.370	8.666
21	0.02486	54.56	88.0	2451.4	2539.4	0.310	8.334	8.644
22	0.02642	51.49	92.2	2449.0	2541.2	0.325	8.297	8.622
23	0.02808	48.62	96.4	2446.6	2543.0	0.339	8.261	8.600
24	0.02982	45.92	100.6	2444.2	2544.8	0.353	8.226	8.579
25	0.03166	43.40	104.8	2441.8	2546.6	0.367	8.190	8.557
26	0.03360	41.03	108.9	2439.5	2548.4	0.381	8.155	8.536
27	0.03564	38.81	113.1	2437.2	2550.3	0.395	8.120	8.515
28	0.03778	36.73	117.3	2434.8	2552.1	0.409	8.085	8.494
29	0.04004	34.77	121.5	2432.4	2553.9	0.423	8.050	8.473
30	0.04242	32.93	125.7	2430.0	2555.7	0.436	8.016	8.452
32	0.04754	29.57	134.0	2425.3	2559.3	0.464	7.948	8.412
34	0.05318	26.60	142.4	2420.5	2562.9	0.491	7.881	8.372
36	0.05940	23.97	150.7	2415.8	2566.5	0.518	7.814	8.332
38	0.06624	21.63	159.1	2411.0	2570.1	0.545	7.749	8.294
40	0.07375	19.55	167.5	2406.2	2573.7	0.572	7.684	8.256
42	0.08198	17.69	175.8	2401.4	2577.2	0.599	7.620	8.219
44	0.09100	16.03	184.2	2396.6	2580.8	0.625	7.557	8.182
46	0.1009	14.56	192.5	2391.8	2584.3	0.651	7.494	8.145
48	0.1116	13.23	200.9	2387.0	2587.9	0.678	7.433	8.111
50	0.1233	12.04	209.3	2382.1	2591.4	0.704	7.371	8.075
55	0.1574	9.578	230.2	2370.1	2600.3	0.768	7.223	7.991
60	0.1992	7.678	251.1	2357.9	2609.0	0.831	7.078	7.909
65	0.2501	6.201	272.0	2345.7	2617.7	0.893	6.937	7.830
70	0.3116	5.045	293.0	2333.3	2626.3	0.955	6.800	7.755
75	0.3855	4.133	313.9	2320.8	2634.7	1.015	6.666	7.681
80	0.4736	3.408	334.9	2308.3	2643.2	1.075	6.536	7.611
85	0.5780	2.828	355.9	2295.6	2651.5	1.134	6.410	7.544
90	0.7011	2.361	376.9	2282.8	2659.7	1.192	6.286	7.478
95	0.8453	1.982	398.0	2269.8	2667.8	1.250	6.166	7.416
100	1.01325	1.673	419.1	2256.7	2675.8	1.307	6.048	7.355

† u and s are chosen to be zero for saturated liquid at the triple point.

Note: values of v_f can be found on p. 10.

p [bar]	T_s [°C]	v_g [m³/kg]	u_f [kJ/kg]	u_g [kJ/kg]	h_f [kJ/kg]	h_{fg} [kJ/kg]	h_g [kJ/kg]	s_f [kJ/kg K]	s_{fg} [kJ/kg K]	s_g [kJ/kg K]
0.006112	0.01	206.1	0†	2375	0*	2501	2501	0†	9.155	9.155
0.010	7.0	129.2	29	2385	29	2485	2514	0.106	8.868	8.974
0.015	13.0	87.98	55	2393	55	2470	2525	0.196	8.631	8.827
0.020	17.5	67.01	73	2399	73	2460	2533	0.261	8.462	8.723
0.025	21.1	54.26	88	2403	88	2451	2539	0.312	8.330	8.642
0.030	24.1	45.67	101	2408	101	2444	2545	0.354	8.222	8.576
0.035	26.7	39.48	112	2412	112	2438	2550	0.391	8.130	8.521
0.040	29.0	34.80	121	2415	121	2433	2554	0.422	8.051	8.473
0.045	31.0	31.14	130	2418	130	2428	2558	0.451	7.980	8.431
0.050	32.9	28.20	138	2420	138	2423	2561	0.476	7.918	8.394
0.055	34.6	25.77	145	2422	145	2419	2564	0.500	7.860	8.360
0.060	36.2	23.74	152	2425	152	2415	2567	0.521	7.808	8.329
0.065	37.7	22.02	158	2427	158	2412	2570	0.541	7.760	8.301
0.070	39.0	20.53	163	2428	163	2409	2572	0.559	7.715	8.274
0.075	40.3	19.24	169	2430	169	2405	2574	0.576	7.674	8.250
0.080	41.5	18.10	174	2432	174	2402	2576	0.593	7.634	8.227
0.085	42.7	17.10	179	2434	179	2400	2579	0.608	7.598	8.206
0.090	43.8	16.20	183	2435	183	2397	2580	0.622	7.564	8.186
0.095	44.8	15.40	188	2436	188	2394	2582	0.636	7.531	8.167
0.100	45.8	14.67	192	2437	192	2392	2584	0.649	7.500	8.149
0.12	49.4	12.36	207	2442	207	2383	2590	0.696	7.389	8.085
0.14	52.6	10.69	220	2446	220	2376	2596	0.737	7.294	8.031
0.16	55.3	9.432	232	2450	232	2369	2601	0.772	7.213	7.985
0.18	57.8	8.444	242	2453	242	2363	2605	0.804	7.140	7.944
0.20	60.1	7.648	251	2456	251	2358	2609	0.832	7.075	7.907
0.22	62.2	6.994	260	2459	260	2353	2613	0.858	7.016	7.874
0.24	64.1	6.445	268	2461	268	2348	2616	0.882	6.962	7.844
0.26	65.9	5.979	276	2464	276	2343	2619	0.904	6.913	7.817
0.28	67.5	5.578	283	2466	283	2339	2622	0.925	6.866	7.791
0.30	69.1	5.228	289	2468	289	2336	2625	0.944	6.823	7.767
0.32	70.6	4.921	295	2470	295	2332	2627	0.962	6.783	7.745
0.34	72.0	4.649	302	2472	302	2328	2630	0.980	6.745	7.725
0.36	73.4	4.407	307	2473	307	2325	2632	0.996	6.709	7.705
0.38	74.7	4.189	312	2475	312	2322	2634	1.011	6.675	7.686
0.40	75.9	3.992	318	2476	318	2318	2636	1.026	6.643	7.669
0.42	77.1	3.814	323	2478	323	2315	2638	1.040	6.612	7.652
0.44	78.2	3.651	327	2479	327	2313	2640	1.054	6.582	7.636
0.46	79.3	3.502	332	2481	332	2310	2642	1.067	6.554	7.621
0.48	80.3	3.366	336	2482	336	2308	2644	1.079	6.528	7.607
0.50	81.3	3.239	340	2483	340	2305	2645	1.091	6.502	7.593
0.55	83.7	2.964	351	2486	351	2298	2649	1.119	6.442	7.561
0.60	86.0	2.731	360	2489	360	2293	2653	1.145	6.386	7.531
0.65	88.0	2.535	369	2492	369	2288	2657	1.169	6.335	7.504
0.70	90.0	2.364	377	2494	377	2283	2660	1.192	6.286	7.478
0.75	91.8	2.217	384	2496	384	2278	2662	1.213	6.243	7.456
0.80	93.5	2.087	392	2498	392	2273	2665	1.233	6.201	7.434
0.85	95.2	1.972	399	2500	399	2269	2668	1.252	6.162	7.414
0.90	96.7	1.869	405	2502	405	2266	2671	1.270	6.124	7.394
0.95	98.2	1.777	411	2504	411	2262	2673	1.287	6.089	7.376
1.00	99.6	1.694	417	2506	417	2258	2675	1.303	6.056	7.359

$$* \quad \frac{h_f}{[\mathrm{kJ/kg}]} = \frac{pv_f}{[\mathrm{kJ/kg}]} = \frac{p}{[\mathrm{bar}]} \times \frac{10^5[\mathrm{N}]}{[\mathrm{m}^2]} \times \frac{v_f}{[\mathrm{m}^3/\mathrm{kg}]} \times \left[\frac{\mathrm{m}^3}{\mathrm{kg}}\right] \times \frac{[\mathrm{kJ}]}{10^3[\mathrm{N\,m}]} \times \frac{1}{[\mathrm{kJ/kg}]}$$

$$= \frac{p}{[\mathrm{bar}]} \times \frac{v_f}{[\mathrm{m}^3/\mathrm{kg}]} \times 10^2 = 0.006112 \times 0.0010002 \times 10^2 = 0.0006112$$

p [bar]	T_s [°C]	v_g [m³/kg]	u_f [kJ/kg]	u_g [kJ/kg]	h_f [kJ/kg]	h_{fg} [kJ/kg]	h_g [kJ/kg]	s_f [kJ/kg K]	s_{fg} [kJ/kg K]	s_g [kJ/kg K]
1.0	99.6	1.694	417	2506	417	2258	2675	1.303	6.056	7.359
1.1	102.3	1.549	429	2510	429	2251	2680	1.333	5.994	7.327
1.2	104.8	1.428	439	2512	439	2244	2683	1.361	5.937	7.298
1.3	107.1	1.325	449	2515	449	2238	2687	1.387	5.884	7.271
1.4	109.3	1.236	458	2517	458	2232	2690	1.411	5.835	7.246
1.5	111.4	1.159	467	2519	467	2226	2693	1.434	5.789	7.223
1.6	113.3	1.091	475	2521	475	2221	2696	1.455	5.747	7.202
1.7	115.2	1.031	483	2524	483	2216	2699	1.475	5.707	7.182
1.8	116.9	0.9774	491	2526	491	2211	2702	1.494	5.669	7.163
1.9	118.6	0.9292	498	2528	498	2206	2704	1.513	5.632	7.145
2.0	120.2	0.8856	505	2530	505	2202	2707	1.530	5.597	7.127
2.1	121.8	0.8461	511	2531	511	2198	2709	1.547	5.564	7.111
2.2	123.3	0.8100	518	2533	518	2193	2711	1.563	5.533	7.096
2.3	124.7	0.7770	524	2534	524	2189	2713	1.578	5.503	7.081
2.4	126.1	0.7466	530	2536	530	2185	2715	1.593	5.474	7.067
2.5	127.4	0.7186	535	2537	535	2182	2717	1.607	5.446	7.053
2.6	128.7	0.6927	541	2539	541	2178	2719	1.621	5.419	7.040
2.7	130.0	0.6686	546	2540	546	2174	2720	1.634	5.393	7.027
2.8	131.2	0.6462	551	2541	551	2171	2722	1.647	5.368	7.015
2.9	132.4	0.6253	556	2543	556	2168	2724	1.660	5.344	7.004
3.0	133.5	0.6057	561	2544	561	2164	2725	1.672	5.321	6.993
3.5	138.9	0.5241	584	2549	584	2148	2732	1.727	5.214	6.941
4.0	143.6	0.4623	605	2554	605	2134	2739	1.776	5.121	6.897
4.5	147.9	0.4139	623	2558	623	2121	2744	1.820	5.037	6.857
5.0	151.8	0.3748	639	2562	640	2109	2749	1.860	4.962	6.822
5.5	155.5	0.3427	655	2565	656	2097	2753	1.897	4.893	6.790
6	158.8	0.3156	669	2568	670	2087	2757	1.931	4.830	6.761
7	165.0	0.2728	696	2573	697	2067	2764	1.992	4.717	6.709
8	170.4	0.2403	720	2577	721	2048	2769	2.046	4.617	6.663
9	175.4	0.2149	742	2581	743	2031	2774	2.094	4.529	6.623
10	179.9	0.1944	762	2584	763	2015	2778	2.138	4.448	6.586
11	184.1	0.1774	780	2586	781	2000	2781	2.179	4.375	6.554
12	188.0	0.1632	797	2588	798	1986	2784	2.216	4.307	6.523
13	191.6	0.1512	813	2590	815	1972	2787	2.251	4.244	6.495
14	195.0	0.1408	828	2593	830	1960	2790	2.284	4.185	6.469
15	198.3	0.1317	843	2595	845	1947	2792	2.315	4.130	6.445
16	201.4	0.1237	857	2596	859	1935	2794	2.344	4.078	6.422
17	204.3	0.1167	870	2597	872	1923	2795	2.372	4.028	6.400
18	207.1	0.1104	883	2598	885	1912	2797	2.398	3.981	6.379
19	209.8	0.1047	895	2599	897	1901	2798	2.423	3.936	6.359
20	212.4	0.09957	907	2600	909	1890	2799	2.447	3.893	6.340
22	217.2	0.09069	928	2601	931	1870	2801	2.492	3.813	6.305
24	221.8	0.08323	949	2602	952	1850	2802	2.534	3.738	6.272
26	226.0	0.07689	969	2603	972	1831	2803	2.574	3.668	6.242
28	230.0	0.07142	988	2603	991	1812	2803	2.611	3.602	6.213
30	233.8	0.06665	1004	2603	1008	1795	2803	2.645	3.541	6.186
32	237.4	0.06246	1021	2603	1025	1778	2803	2.679	3.482	6.161
34	240.9	0.05875	1038	2603	1042	1761	2803	2.710	3.426	6.136
36	244.2	0.05544	1054	2602	1058	1744	2802	2.740	3.373	6.113
38	247.3	0.05246	1068	2602	1073	1729	2802	2.769	3.322	6.091
40	250.3	0.04977	1082	2602	1087	1714	2801	2.797	3.273	6.070

Saturated Water and Steam

p [bar]	T_s [°C]	v_g [m³/kg]	u_f [kJ/kg]	u_g [kJ/kg]	h_f [kJ/kg]	h_{fg} [kJ/kg]	h_g [kJ/kg]	s_f [kJ/kg K]	s_{fg} [kJ/kg K]	s_g [kJ/kg K]
40	250.3	0.04977	1082	2602	1087	1714	2801	2.797	3.273	6.070
42	253.2	0.04732	1097	2601	1102	1698	2800	2.823	3.226	6.049
44	256.0	0.04509	1109	2600	1115	1683	2798	2.849	3.180	6.029
46	258.8	0.04305	1123	2599	1129	1668	2797	2.874	3.136	6.010
48	261.4	0.04117	1136	2598	1142	1654	2796	2.897	3.094	5.991
50	263.9	0.03944	1149	2597	1155	1639	2794	2.921	3.052	5.973
55	269.9	0.03563	1178	2594	1185	1605	2790	2.976	2.955	5.931
60	275.6	0.03244	1206	2590	1214	1570	2784	3.027	2.863	5.890
65	280.8	0.02972	1232	2586	1241	1538	2779	3.076	2.775	5.851
70	285.8	0.02737	1258	2581	1267	1505	2772	3.122	2.692	5.814
75	290.5	0.02532	1283	2576	1293	1473	2766	3.166	2.613	5.779
80	295.0	0.02352	1306	2570	1317	1441	2758	3.207	2.537	5.744
85	299.2	0.02192	1329	2565	1341	1410	2751	3.248	2.463	5.711
90	303.3	0.02048	1351	2559	1364	1379	2743	3.286	2.393	5.679
95	307.2	0.01919	1372	2552	1386	1348	2734	3.324	2.323	5.647
100	311.0	0.01802	1393	2545	1408	1317	2725	3.360	2.255	5.615
105	314.6	0.01696	1414	2537	1429	1286	2715	3.395	2.189	5.584
110	318.0	0.01598	1434	2529	1450	1255	2705	3.430	2.123	5.553
115	321.4	0.01508	1454	2522	1471	1224	2695	3.463	2.060	5.523
120	324.6	0.01426	1473	2514	1491	1194	2685	3.496	1.997	5.493
125	327.8	0.01349	1492	2505	1511	1163	2674	3.529	1.934	5.463
130	330.8	0.01278	1511	2496	1531	1131	2662	3.561	1.872	5.433
135	333.8	0.01211	1530	2487	1551	1099	2650	3.592	1.811	5.403
140	336.6	0.01149	1548	2477	1571	1067	2638	3.623	1.750	5.373
145	339.4	0.01090	1567	2467	1591	1034	2625	3.654	1.689	5.343
150	342.1	0.01035	1585	2456	1610	1001	2611	3.685	1.627	5.312
155	344.8	0.00982	1604	2445	1630	967	2597	3.715	1.565	5.280
160	347.3	0.00932	1623	2433	1650	932	2582	3.746	1.502	5.248
165	349.8	0.00884	1641	2420	1670	895	2565	3.777	1.437	5.214
170	352.3	0.00838	1660	2406	1690	858	2548	3.808	1.373	5.181
175	354.6	0.00794	1679	2391	1711	819	2530	3.839	1.305	5.144
180	357.0	0.00751	1699	2375	1732	778	2510	3.872	1.236	5.108
185	359.2	0.00709	1719	2358	1754	735	2489	3.905	1.163	5.068
190	361.4	0.00668	1740	2339	1777	689	2466	3.941	1.086	5.027
195	363.6	0.00627	1762	2318	1801	639	2440	3.977	1.004	4.981
200	365.7	0.00585	1786	2294	1827	584	2411	4.014	0.914	4.928
202	366.5	0.00569	1796	2283	1838	560	2398	4.031	0.875	4.906
204	367.4	0.00552	1806	2271	1849	535	2384	4.049	0.835	4.884
206	368.2	0.00534	1817	2259	1861	508	2369	4.067	0.792	4.859
208	369.0	0.00517	1829	2245	1874	479	2353	4.087	0.745	4.832
210	369.8	0.00498	1842	2231	1889	447	2336	4.108	0.695	4.803
212	370.6	0.00479	1856	2214	1904	412	2316	4.131	0.640	4.771
214	371.4	0.00458	1871	2196	1921	373	2294	4.157	0.579	4.736
216	372.1	0.00436	1888	2174	1940	328	2268	4.186	0.508	4.694
218	372.9	0.00409	1911	2146	1965	270	2235	4.224	0.417	4.641
220	373.7	0.00368	1949	2097	2008	170	2178	4.289	0.263	4.552
221.2	374.15	0.00317	2014	2014	2084	0	2084	4.406	0.000	4.406

Superheated Steam†

p/[bar] (T_s/[°C])		T [°C]	50	100	150	200	250	300	400	500
0	$u = h - RT$ at $p = 0$	v								
		u	2446	2517	2589	2662	2737	2812	2969	3132
		h	2595	2689	2784	2880	2978	3077	3280	3489
		s								
0.006112 (0.01)	v_g 206.1	v	243.9	281.7	319.5	357.3	395.0	432.8	508.3	583.8
	u_g 2375	u	2446	2517	2589	2662	2737	2812	2969	3132
	h_g 2501	h	2595	2689	2784	2880	2978	3077	3280	3489
	s_g 9.155	s	9.468	9.739	9.978	10.193	10.390	10.571	10.897	11.187
0.01 (7.0)	v_g 129.2	v	149.1	172.2	195.3	218.4	241.4	264.5	310.7	356.8
	u_g 2385	u	2446	2517	2589	2662	2737	2812	2969	3132
	h_g 2514	h	2595	2689	2784	2880	2978	3077	3280	3489
	s_g 8.974	s	9.241	9.512	9.751	9.966	10.163	10.344	10.670	10.960
0.05 (32.9)	v_g 28.20	v	29.78	34.42	39.04	43.66	48.28	52.90	62.13	71.36
	u_g 2420	u	2445	2516	2589	2662	2737	2812	2969	3132
	h_g 2561	h	2594	2688	2784	2880	2978	3077	3280	3489
	s_g 8.394	s	8.496	8.768	9.008	9.223	9.420	9.601	9.927	10.217
0.1 (45.8)	v_g 14.67	v	14.87	17.20	19.51	21.83	24.14	26.45	31.06	35.68
	u_g 2437	u	2443	2516	2588	2662	2736	2812	2969	3132
	h_g 2584	h	2592	2688	2783	2880	2977	3077	3280	3489
	s_g 8.149	s	8.173	8.447	8.688	8.903	9.100	9.281	9.607	9.897
0.5 (81.3)	v_g 3.239	v		3.420	3.890	4.356	4.821	5.284	6.209	7.134
	u_g 2483	u		2512	2585	2660	2735	2812	2969	3132
	h_g 2645	h		2683	2780	2878	2976	3076	3279	3489
	s_g 7.593	s		7.694	7.940	8.158	8.355	8.537	8.864	9.154
0.75 (91.8)	v_g 2.217	v		2.271	2.588	2.901	3.211	3.521	4.138	4.755
	u_g 2496	u		2510	2585	2659	2734	2811	2969	3132
	h_g 2662	h		2680	2779	2877	2975	3075	3279	3489
	s_g 7.456	s		7.500	7.750	7.969	8.167	8.349	8.676	8.967
1 (99.6)	v_g 1.694	v		1.696	1.937	2.173	2.406	2.639	3.103	3.565
	u_g 2506	u		2506	2583	2659	2734	2811	2968	3131
	h_g 2675	h		2676	2777	2876	2975	3075	3278	3488
	s_g 7.359	s		7.360	7.614	7.834	8.033	8.215	8.543	8.834
1.01325 (100.0)	v_g 1.673	v			1.912	2.145	2.375	2.604	3.062	3.519
	u_g 2506	u			2583	2659	2734	2811	2968	3131
	h_g 2676	h			2777	2876	2975	3075	3278	3488
	s_g 7.355	s			7.608	7.828	8.027	8.209	8.537	8.828
1.5 (111.4)	v_g 1.159	v			1.286	1.445	1.601	1.757	2.067	2.376
	u_g 2519	u			2580	2656	2733	2809	2967	3131
	h_g 2693	h			2773	2873	2973	3073	3277	3488
	s_g 7.223	s			7.420	7.643	7.843	8.027	8.355	8.646
2 (120.2)	v_g 0.8856	v			0.9602	1.081	1.199	1.316	1.549	1.781
	u_g 2530	u			2578	2655	2731	2809	2967	3131
	h_g 2707	h			2770	2871	2971	3072	3277	3487
	s_g 7.127	s			7.280	7.507	7.708	7.892	8.221	8.513
3 (133.5)	v_g 0.6057	v			0.6342	0.7166	0.7965	0.8754	1.031	1.187
	u_g 2544	u			2572	2651	2729	2807	2966	3130
	h_g 2725	h			2762	2866	2968	3070	3275	3486
	s_g 6.993	s			7.078	7.312	7.517	7.702	8.032	8.324
4 (143.6)	v_g 0.4623	v/[m^3/kg]			0.4710	0.5345	0.5953	0.6549	0.7725	0.8893
	u_g 2554	u/[kJ/kg]			2565	2648	2727	2805	2965	3129
	h_g 2739	h/[kJ/kg]			2753	2862	2965	3067	3274	3485
	s_g 6.897	s/[kJ/kg K]			6.929	7.172	7.379	7.566	7.898	8.191

† The entries in all tables are regarded as pure numbers and therefore the symbols for the physical quantities should be divided by the appropriate units as shown for the entries at p/[bar] = 4. Because of lack of space, this has not been done consistently in the superheat and supercritical tables on pp. 6–9 and in the tables on pp. 11 and 23.

Superheated Steam*

p/[bar] (T_s/[°C])		T [°C]	200	250	300	350	400	450	500	600
5 (151.8)	v_g 0.3748	v	0.4252	0.4745	0.5226	0.5701	0.6172	0.6641	0.7108	0.8040
	u_g 2562	u	2644	2725	2804	2883	2963	3045	3129	3300
	h_g 2749	h	2857	2962	3065	3168	3272	3377	3484	3702
	s_g 6.822	s	7.060	7.271	7.460	7.633	7.793	7.944	8.087	8.351
6 (158.8)	v_g 0.3156	v	0.3522	0.3940	0.4344	0.4743	0.5136	0.5528	0.5919	0.6697
	u_g 2568	u	2640	2722	2801	2881	2962	3044	3128	3299
	h_g 2757	h	2851	2958	3062	3166	3270	3376	3483	3701
	s_g 6.761	s	6.968	7.182	7.373	7.546	7.707	7.858	8.001	8.267
7 (165.0)	v_g 0.2728	v	0.3001	0.3364	0.3714	0.4058	0.4397	0.4734	0.5069	0.5737
	u_g 2573	u	2636	2720	2800	2880	2961	3043	3127	3298
	h_g 2764	h	2846	2955	3060	3164	3269	3374	3482	3700
	s_g 6.709	s	6.888	7.106	7.298	7.473	7.634	7.786	7.929	8.195
8 (170.4)	v_g 0.2403	v	0.2610	0.2933	0.3242	0.3544	0.3842	0.4138	0.4432	0.5018
	u_g 2577	u	2631	2716	2798	2878	2960	3042	3126	3298
	h_g 2769	h	2840	2951	3057	3162	3267	3373	3481	3699
	s_g 6.663	s	6.817	7.040	7.233	7.409	7.571	7.723	7.866	8.132
9 (175.4)	v_g 0.2149	v	0.2305	0.2597	0.2874	0.3144	0.3410	0.3674	0.3937	0.4458
	u_g 2581	u	2628	2714	2796	2877	2959	3041	3126	3298
	h_g 2774	h	2835	2948	3055	3160	3266	3372	3480	3699
	s_g 6.623	s	6.753	6.980	7.176	7.352	7.515	7.667	7.811	8.077
10 (179.9)	v_g 0.1944	v	0.2061	0.2328	0.2580	0.2825	0.3065	0.3303	0.3540	0.4010
	u_g 2584	u	2623	2711	2794	2875	2957	3040	3124	3297
	h_g 2778	h	2829	2944	3052	3158	3264	3370	3478	3698
	s_g 6.586	s	6.695	6.926	7.124	7.301	7.464	7.617	7.761	8.028
15 (198.3)	v_g 0.1317	v	0.1324	0.1520	0.1697	0.1865	0.2029	0.2191	0.2351	0.2667
	u_g 2595	u	2597	2697	2784	2868	2952	3035	3120	3294
	h_g 2792	h	2796	2925	3039	3148	3256	3364	3473	3694
	s_g 6.445	s	6.452	6.711	6.919	7.102	7.268	7.423	7.569	7.838
20 (212.4)	v_g 0.0996	v		0.1115	0.1255	0.1386	0.1511	0.1634	0.1756	0.1995
	u_g 2600	u		2681	2774	2861	2946	3030	3116	3291
	h_g 2799	h		2904	3025	3138	3248	3357	3467	3690
	s_g 6.340	s		6.547	6.768	6.957	7.126	7.283	7.431	7.701
30 (233.8)	v_g 0.0666	v		0.0706	0.0812	0.0905	0.0993	0.1078	0.1161	0.1324
	u_g 2603	u		2646	2751	2845	2933	3020	3108	3285
	h_g 2803	h		2858	2995	3117	3231	3343	3456	3682
	s_g 6.186	s		6.289	6.541	6.744	6.921	7.082	7.233	7.507
40 (250.3)	v_g 0.0498	v			0.0588	0.0664	0.0733	0.0800	0.0864	0.0988
	u_g 2602	u			2728	2828	2921	3010	3099	3279
	h_g 2801	h			2963	3094	3214	3330	3445	3674
	s_g 6.070	s			6.364	6.584	6.769	6.935	7.089	7.368
50 (263.9)	v_g 0.0394	v			0.0453	0.0519	0.0578	0.0632	0.0685	0.0786
	u_g 2597	u			2700	2810	2907	3000	3090	3273
	h_g 2794	h			2927	3070	3196	3316	3433	3666
	s_g 5.973	s			6.212	6.451	6.646	6.818	6.975	7.258
60 (275.6)	v_g 0.0324	v			0.0362	0.0422	0.0473	0.0521	0.0566	0.0652
	u_g 2590	u			2670	2792	2893	2988	3081	3266
	h_g 2784	h			2887	3045	3177	3301	3421	3657
	s_g 5.890	s			6.071	6.336	6.541	6.719	6.879	7.166
70 (285.8)	v_g 0.0274	v/[m^3/kg]			0.0295	0.0352	0.0399	0.0441	0.0481	0.0556
	u_g 2581	u/[kJ/kg]			2634	2772	2879	2978	3073	3260
	h_g 2772	h/[kJ/kg]			2841	3018	3158	3287	3410	3649
	s_g 5.814	s/[kJ/kg K]			5.934	6.231	6.448	6.632	6.796	7.088

* See footnote on p. 6.

Superheated Steam*

p/[bar] (T_s/[°C])			T [°C]	350	375	400	425	450	500	600	700
80 (295.0)	v_g	0.02352	$v/10^{-2}$	2.994	3.220	3.428	3.625	3.812	4.170	4.839	5.476
	h_g	2758	h	2990	3067	3139	3207	3272	3398	3641	3881
	s_g	5.744	s	6.133	6.255	6.364	6.463	6.555	6.723	7.019	7.279
90 (303.3)	v_g	0.02048	$v/10^{-2}$	2.578	2.794	2.991	3.173	3.346	3.673	4.279	4.852
	h_g	2743	h	2959	3042	3118	3189	3256	3385	3633	3874
	s_g	5.679	s	6.039	6.171	6.286	6.390	6.484	6.657	6.958	7.220
100 (311.0)	v_g	0.01802	$v/10^{-2}$	2.241	2.453	2.639	2.812	2.972	3.275	3.831	4.353
	h_g	2725	h	2926	3017	3097	3172	3241	3373	3624	3868
	s_g	5.615	s	5.947	6.091	6.213	6.321	6.419	6.596	6.902	7.166
110 (318.0)	v_g	0.01598	$v/10^{-2}$	1.960	2.169	2.350	2.514	2.666	2.949	3.465	3.945
	h_g	2705	h	2889	2989	3075	3153	3225	3360	3616	3862
	s_g	5.553	s	5.856	6.014	6.143	6.257	6.358	6.539	6.850	7.117
120 (324.6)	v_g	0.01426	$v/10^{-2}$	1.719	1.931	2.107	2.265	2.410	2.677	3.159	3.605
	h_g	2685	h	2849	2960	3052	3134	3209	3348	3607	3856
	s_g	5.493	s	5.762	5.937	6.076	6.195	6.301	6.487	6.802	7.072
130 (330.8)	v_g	0.01278	$v/10^{-2}$	1.509	1.726	1.901	2.053	2.193	2.447	2.901	3.318
	h_g	2662	h	2804	2929	3028	3114	3192	3335	3599	3850
	s_g	5.433	s	5.664	5.862	6.011	6.136	6.246	6.437	6.758	7.030
140 (336.6)	v_g	0.01149	$v/10^{-2}$	1.321	1.548	1.722	1.872	2.006	2.250	2.679	3.071
	h_g	2638	h	2753	2896	3003	3093	3175	3322	3590	3843
	s_g	5.373	s	5.559	5.784	5.946	6.079	6.193	6.390	6.716	6.991
150 (342.1)	v_g	0.01035	$v/10^{-2}$	1.146	1.391	1.566	1.714	1.844	2.078	2.487	2.857
	h_g	2611	h	2693	2861	2977	3073	3157	3309	3581	3837
	s_g	5.312	s	5.443	5.707	5.883	6.023	6.142	6.345	6.677	6.954
160 (347.3)	v_g	0.00932	$v/10^{-2}$	0.976	1.248	1.427	1.573	1.702	1.928	2.319	2.670
	h_g	2582	h	2617	2821	2949	3051	3139	3295	3573	3831
	s_g	5.248	s	5.304	5.626	5.820	5.968	6.093	6.301	6.639	6.919
170 (352.3)	v_g	0.00838	$v/10^{-2}$		1.117	1.303	1.449	1.576	1.796	2.171	2.506
	h_g	2548	h		2778	2920	3028	3121	3281	3564	3825
	s_g	5.181	s		5.541	5.756	5.914	6.044	6.260	6.603	6.886
180 (357.0)	v_g	0.00751	$v/10^{-2}$		0.997	1.191	1.338	1.463	1.678	2.039	2.359
	h_g	2510	h		2729	2888	3004	3102	3268	3555	3818
	s_g	5.108	s		5.449	5.691	5.861	5.997	6.219	6.569	6.855
190 (361.4)	v_g	0.00668	$v/10^{-2}$		0.882	1.089	1.238	1.362	1.572	1.921	2.228
	h_g	2466	h		2674	2855	2980	3082	3254	3546	3812
	s_g	5.027	s		5.348	5.625	5.807	5.950	6.180	6.536	6.825
200 (365.7)	v_g	0.00585	$v/10^{-2}$[m³/kg]		0.768	0.995	1.147	1.270	1.477	1.815	2.110
	h_g	2411	h/[kJ/kg]		2605	2819	2955	3062	3239	3537	3806
	s_g	4.928	s/[kJ/kg K]		5.228	5.556	5.753	5.904	6.142	6.505	6.796
210 (369.8)	v_g	0.00498	$v/10^{-2}$		0.650	0.908	1.064	1.187	1.390	1.719	2.003
	h_g	2336	h		2500	2781	2928	3041	3225	3528	3799
	s_g	4.803	s		5.050	5.484	5.699	5.859	6.105	6.474	6.768
220 (373.7)	v_g	0.00368	$v/10^{-2}$		0.450	0.825	0.987	1.111	1.312	1.632	1.906
	h_g	2178	h		2300	2738	2900	3020	3210	3519	3793
	s_g	4.552	s		4.725	5.409	5.645	5.813	6.068	6.444	6.742
221.2 (374.15)	v_c	0.00317	$v/10^{-2}$	0.163	0.351	0.816	0.978	1.103	1.303	1.622	1.895
	h_c	2084	h	1637	2139	2733	2896	3017	3208	3518	3792
	s_c	4.406	s	3.708	4.490	5.398	5.638	5.807	6.064	6.441	6.739

* See footnote on p. 6.

Note: linear interpolation is not accurate near the critical point.

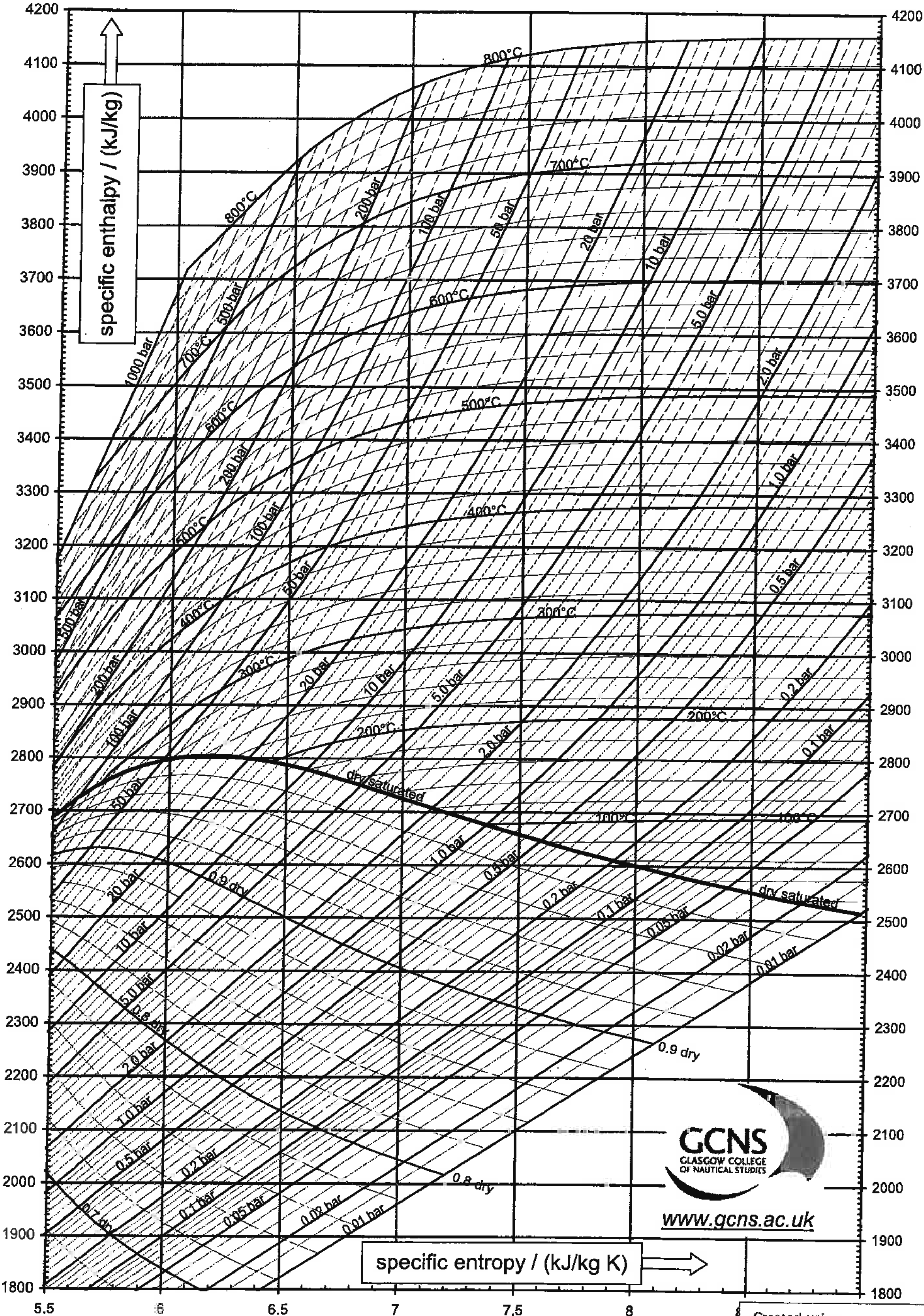
Supercritical Steam*

p [bar]	T [°C]	350	375	400	425	450	500	600	700	800
225	$v/10^{-2}$[m³/kg]	0.163	0.249	0.786	0.951	1.076	1.275	1.591	1.861	2.109
	h/[kJ/kg]	1635	1980	2716	2885	3009	3203	3514	3790	4055
	s/[kJ/kg K]	3.704	4.470	5.369	5.616	5.790	6.050	6.430	6.729	6.988
250	$v/10^{-2}$	0.160	0.198	0.601	0.789	0.917	1.113	1.412	1.662	1.890
	h	1625	1850	2580	2807	2951	3165	3491	3774	4043
	s	3.682	4.026	5.142	5.474	5.677	5.962	6.361	6.667	6.931
275	$v/10^{-2}$	0.158	0.187	0.419	0.650	0.786	0.980	1.265	1.500	1.710
	h	1617	1814	2382	2718	2890	3125	3468	3758	4032
	s	3.662	3.985	4.828	5.320	5.562	5.878	6.296	6.610	6.878
300	$v/10^{-2}$	0.155	0.180	0.282	0.530	0.674	0.868	1.143	1.364	1.561
	h	1610	1791	2157	2614	2823	3084	3445	3742	4020
	s	3.645	3.933	4.482	5.157	5.444	5.795	6.234	6.557	6.829
350	$v/10^{-2}$	0.152	0.171	0.211	0.343	0.496	0.693	0.952	1.152	1.327
	h	1599	1762	1992	2375	2673	2998	3397	3709	3997
	s	3.614	3.875	4.219	4.776	5.197	5.633	6.120	6.459	6.741
400	$v/10^{-2}$	0.149	0.164	0.191	0.255	0.369	0.562	0.809	0.993	1.152
	h	1590	1743	1935	2203	2514	2906	3348	3677	3974
	s	3.588	3.832	4.119	4.510	4.947	5.474	6.014	6.371	6.662
450	$v/10^{-2}$	0.146	0.160	0.181	0.219	0.291	0.463	0.698	0.870	1.016
	h	1583	1729	1901	2115	2380	2813	3299	3644	3951
	s	3.565	3.797	4.056	4.368	4.740	5.320	5.914	6.290	6.590
500	$v/10^{-2}$	0.144	0.156	0.173	0.201	0.249	0.388	0.611	0.772	0.908
	h	1577	1717	1879	2064	2288	2722	3249	3612	3928
	s	3.544	3.768	4.009	4.279	4.594	5.176	5.821	6.214	6.524
550	$v/10^{-2}$	0.143	0.153	0.168	0.190	0.224	0.334	0.540	0.693	0.820
	h	1572	1709	1862	2030	2227	2641	3200	3579	3905
	s	3.525	3.742	3.971	4.218	4.494	5.047	5.731	6.144	6.462
600	$v/10^{-2}$	0.141	0.151	0.164	0.182	0.209	0.295	0.483	0.627	0.747
	h	1568	1702	1848	2005	2184	2571	3152	3548	3883
	s	3.506	3.718	3.939	4.168	4.419	4.937	5.648	6.077	6.405
650	$v/10^{-2}$	0.139	0.148	0.160	0.176	0.198	0.267	0.436	0.572	0.685
	h	1565	1696	1837	1986	2151	2514	3106	3517	3860
	s	3.489	3.697	3.910	4.128	4.360	4.845	5.568	6.014	6.352
700	$v/10^{-2}$	0.138	0.146	0.157	0.171	0.189	0.247	0.397	0.526	0.633
	h	1561	1691	1829	1971	2127	2468	3062	3486	3839
	s	3.473	3.678	3.886	4.093	4.312	4.769	5.494	5.955	6.300
750	$v/10^{-2}$	0.137	0.145	0.154	0.167	0.183	0.231	0.365	0.486	0.587
	h	1559	1687	1821	1958	2107	2431	3021	3456	3817
	s	3.459	3.659	3.863	4.064	4.272	4.705	5.425	5.899	6.252
800	$v/10^{-2}$	0.136	0.143	0.152	0.163	0.178	0.219	0.338	0.452	0.548
	h	1557	1684	1815	1948	2091	2400	2983	3428	3797
	s	3.444	3.642	3.842	4.037	4.237	4.651	5.361	5.845	6.206
900	$v/10^{-2}$	0.133	0.140	0.148	0.158	0.169	0.202	0.296	0.396	0.484
	h	1554	1678	1805	1932	2066	2353	2916	3373	3756
	s	3.418	3.612	3.805	3.991	4.179	4.563	5.248	5.746	6.120
1000	$v/10^{-2}$	0.131	0.138	0.145	0.153	0.163	0.189	0.267	0.354	0.434
	h	1552	1674	1798	1920	2048	2319	2860	3324	3718
	s	3.394	3.584	3.773	3.951	4.131	4.493	5.153	5.656	6.042

* See footnote on p. 6.

Enthalpy Entropy Chart for Steam

(using data from NEL Steam Tables 1964 and other formulations: for exercises only)



psychrometric chart (by permission of CIBSE)

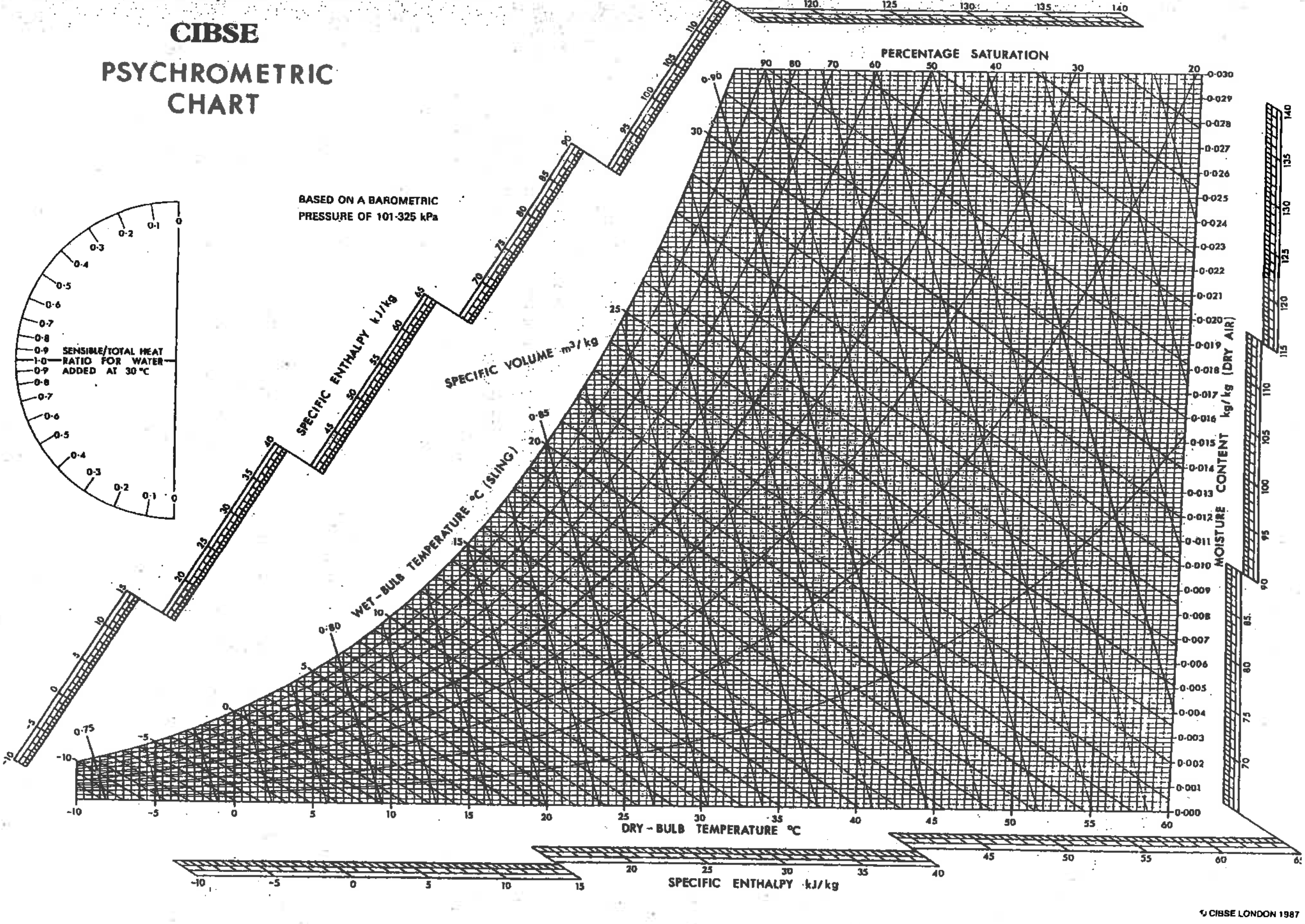


Table 2 Thermodynamic Properties of Moist Air at Standard Atmospheric Pressure, 101.325 kPa (*Continued*)

Temp., °C	Humidity Ratio, kg(w)/kg(da)	Specific Volume, m³/kg (dry air)			Specific Enthalpy, kJ/kg (dry air)			Specific Entropy, kJ/(kg·K) (dry air)			Condensed Water: Specific Enthalpy, kJ/kg	Condensed Water: Specific Entropy, kJ/(kg·K)	Condensed Water: Vapor Pressure, kPa	Temp., °C
t	W_s	v_{da}	v_{as}	v_s	h_{da}	h_{as}	h_s	s_{da}	s_{as}	s_s	h_w	s_w	p_s	t
14	0.010012	0.8132	0.0131	0.8262	14.084	25.286	39.370	0.0503	0.0927	0.1430	58.88	0.2099	1.5987	14
15	0.010692	0.8160	0.0140	0.8300	15.090	27.023	42.113	0.0538	0.0987	0.1525	63.07	0.2244	1.7055	15
16	0.011413	0.8188	0.0150	0.8338	16.096	28.867	44.963	0.0573	0.1051	0.1624	67.26	0.2389	1.8185	16
17	0.012178	0.8217	0.0160	0.8377	17.102	30.824	47.926	0.0607	0.1119	0.1726	71.44	0.2534	1.9380	17
18	0.012989	0.8245	0.0172	0.8417	18.108	32.900	51.008	0.0642	0.1190	0.1832	75.63	0.2678	2.0643	18
19	0.013848	0.8274	0.0184	0.8457	19.114	35.101	54.216	0.0677	0.1266	0.1942	79.81	0.2821	2.1979	19
20	0.014758	0.8302	0.0196	0.8498	20.121	37.434	57.555	0.0711	0.1346	0.2057	84.00	0.2965	2.3389	20
21	0.015721	0.8330	0.0210	0.8540	21.127	39.908	61.035	0.0745	0.1430	0.2175	88.18	0.3107	2.4878	21
22	0.016741	0.8359	0.0224	0.8583	22.133	42.527	64.660	0.0779	0.1519	0.2298	92.36	0.3249	2.6448	22
23	0.017821	0.8387	0.0240	0.8627	23.140	45.301	68.440	0.0813	0.1613	0.2426	96.55	0.3390	2.8105	23
24	0.018963	0.8416	0.0256	0.8671	24.146	48.239	72.385	0.0847	0.1712	0.2559	100.73	0.3531	2.9852	24
25	0.020170	0.8444	0.0273	0.8717	25.153	51.347	76.500	0.0881	0.1817	0.2698	104.91	0.3672	3.1693	25
26	0.021448	0.8472	0.0291	0.8764	26.159	54.638	80.798	0.0915	0.1927	0.2842	109.09	0.3812	3.3633	26
27	0.022798	0.8501	0.0311	0.8811	27.165	58.120	85.285	0.0948	0.2044	0.2992	113.27	0.3951	3.5674	27
28	0.024226	0.8529	0.0331	0.8860	28.172	61.804	89.976	0.0982	0.2166	0.3148	117.45	0.4090	3.7823	28
29	0.025735	0.8558	0.0353	0.8910	29.179	65.699	94.878	0.1015	0.2296	0.3311	121.63	0.4229	4.0084	29
30	0.027329	0.8586	0.0376	0.8962	30.185	69.820	100.006	0.1048	0.2432	0.3481	125.81	0.4367	4.2462	30
31	0.029014	0.8614	0.0400	0.9015	31.192	74.177	105.369	0.1082	0.2576	0.3658	129.99	0.4505	4.4961	31
32	0.030793	0.8643	0.0426	0.9069	32.198	78.780	110.979	0.1115	0.2728	0.3842	134.17	0.4642	4.7586	32
33	0.032674	0.8671	0.0454	0.9125	33.205	83.652	116.857	0.1148	0.2887	0.4035	138.35	0.4779	5.0345	33
34	0.034660	0.8700	0.0483	0.9183	34.212	88.799	123.011	0.1180	0.3056	0.4236	142.53	0.4915	5.3242	34
35	0.036756	0.8728	0.0514	0.9242	35.219	94.236	129.455	0.1213	0.3233	0.4446	146.71	0.5051	5.6280	35
36	0.038971	0.8756	0.0546	0.9303	36.226	99.983	136.209	0.1246	0.3420	0.4666	150.89	0.5186	5.9468	36
37	0.041309	0.8785	0.0581	0.9366	37.233	106.058	143.290	0.1278	0.3617	0.4895	155.07	0.5321	6.2812	37
38	0.043778	0.8813	0.0618	0.9431	38.239	112.474	150.713	0.1311	0.3824	0.5135	159.25	0.5456	6.6315	38
39	0.046386	0.8842	0.0657	0.9498	39.246	119.258	158.504	0.1343	0.4043	0.5386	163.43	0.5590	6.9988	39
40	0.049141	0.8870	0.0698	0.9568	40.253	126.430	166.683	0.1375	0.4273	0.5649	167.61	0.5724	7.3838	40
41	0.052049	0.8898	0.0741	0.9640	41.261	134.005	175.265	0.1407	0.4516	0.5923	171.79	0.5857	7.7866	41
42	0.055119	0.8927	0.0788	0.9714	42.268	142.007	184.275	0.1439	0.4771	0.6211	175.97	0.5990	8.2081	42
43	0.058365	0.8955	0.0837	0.9792	43.275	150.475	193.749	0.1471	0.5041	0.6512	180.15	0.6122	8.6495	43
44	0.061791	0.8983	0.0888	0.9872	44.282	159.417	203.699	0.1503	0.5325	0.6828	184.33	0.6254	9.1110	44
45	0.065411	0.9012	0.0943	0.9955	45.289	168.874	214.164	0.1535	0.5624	0.7159	188.51	0.6386	9.5935	45
46	0.069239	0.9040	0.1002	1.0042	46.296	178.882	225.179	0.1566	0.5940	0.7507	192.69	0.6517	10.0982	46
47	0.073282	0.9069	0.1063	1.0132	47.304	189.455	236.759	0.1598	0.6273	0.7871	196.88	0.6648	10.6250	47
48	0.077556	0.9097	0.1129	1.0226	48.311	200.644	248.955	0.1629	0.6624	0.8253	201.06	0.6778	11.1754	48
49	0.082077	0.9125	0.1198	1.0323	49.319	212.485	261.803	0.1661	0.6994	0.8655	205.24	0.6908	11.7502	49
50	0.086858	0.9154	0.1272	1.0425	50.326	225.019	275.345	0.1692	0.7385	0.9077	209.42	0.7038	12.3503	50
51	0.091918	0.9182	0.1350	1.0532	51.334	238.290	289.624	0.1723	0.7798	0.9521	213.60	0.7167	12.9764	51
52	0.097272	0.9211	0.1433	1.0643	52.341	252.340	304.682	0.1754	0.8234	0.9988	217.78	0.7296	13.6293	52
53	0.102948	0.9239	0.1521	1.0760	53.349	267.247	320.596	0.1785	0.8695	1.0480	221.97	0.7424	14.3108	53
54	0.108954	0.9267	0.1614	1.0882	54.357	283.031	337.388	0.1816	0.9182	1.0998	226.15	0.7552	15.0205	54
55	0.115321	0.9296	0.1713	1.1009	55.365	299.772	355.137	0.1847	0.9698	1.1544	230.33	0.7680	15.7601	55
56	0.122077	0.9324	0.1819	1.1143	56.373	317.549	373.922	0.1877	1.0243	1.2120	234.52	0.7807	16.5311	56
57	0.129243	0.9353	0.1932	1.1284	57.381	336.417	393.798	0.1908	1.0820	1.2728	238.70	0.7934	17.3337	57
58	0.136851	0.9381	0.2051	1.1432	58.389	356.461	414.850	0.1938	1.1432	1.3370	242.88	0.8061	18.1691	58
59	0.144942	0.9409	0.2179	1.1588	59.397	377.788	437.185	0.1969	1.2081	1.4050	247.07	0.8187	19.0393	59
60	0.15354	0.9438	0.2315	1.1752	60.405	400.458	460.863	0.1999	1.2769	1.4768	251.25	0.8313	19.9439	60
61	0.16269	0.9466	0.2460	1.1926	61.413	424.624	486.036	0.2029	1.3500	1.5530	255.44	0.8438	20.8858	61
62	0.17244	0.9494	0.2614	1.2109	62.421	450.377	512.798	0.2059	1.4278	1.6337	259.62	0.8563	21.8651	62
63	0.18284	0.9523	0.2780	1.2303	63.429	477.837	541.266	0.2089	1.5104	1.7194	263.81	0.8688	22.8826	63
64	0.19393	0.9551	0.2957	1.2508	64.438	507.177	571.615	0.2119	1.5985	1.8105	268.00	0.8812	23.9405	64
65	0.20579	0.9580	0.3147	1.2726	65.446	538.548	603.995	0.2149	1.6925	1.9074	272.18	0.8936	25.0397	65
66	0.21848	0.9608	0.3350	1.2958	66.455	572.116	638.571	0.2179	1.7927	2.0106	276.37	0.9060	26.1810	66
67	0.23207	0.9636	0.3568	1.3204	67.463	608.103	675.566	0.2209	1.8999	2.1208	280.56	0.9183	27.3664	67
68	0.24664	0.9665	0.3803	1.3467	68.472	646.724	715.196	0.2238	2.0147	2.2385	284.75	0.9306	28.5967	68
69	0.26231	0.9693	0.4055	1.3749	69.481	688.261	757.742	0.2268	2.1378	2.3646	288.94	0.9429	29.8741	69
70	0.27916	0.9721	0.4328	1.4049	70.489	732.959	803.448	0.2297	2.2699	2.4996	293.13	0.9551	31.1986	70
71	0.29734	0.9750	0.4622	1.4372	71.498	781.208	852.706	0.2327	2.4122	2.6448	297.32	0.9673	32.5734	71
72	0.31698	0.9778	0.4941	1.4719	72.507	833.335	905.842	0.2356	2.5655	2.8010	301.51	0.9794	33.9983	72
73	0.33824	0.9807	0.5287	1.5093	73.516	889.807	963.323	0.2385	2.7311	2.9696	305.70	0.9916	35.4759	73
74	0.36130	0.9835	0.5662	1.5497	74.525	951.077	1025.603	0.2414	2.9104	3.1518	309.89	1.0037	37.0063	74
75	0.38641	0.9863	0.6072	1.5935	75.535	1017.841	1093.375	0.2443	3.1052	3.3496	314.08	1.0157	38.5940	75
76	0.41377	0.9892	0.6519	1.6411	76.543	1090.628	1167.172	0.2472	3.3171	3.5644	318.28	1.0278	40.2369	76
77	0.44372	0.9920	0.7010	1.6930	77.553	1170.328	1247.881	0.2501	3.5486	3.7987	322.47	1.0398	41.9388	77
78	0.47663	0.9948	0.7550	1.7498	78.562	1257.921	1336.483	0.2530	3.8023	4.0553	326.67	1.0517	43.7020	78
79	0.51284	0.9977	0.8145	1.8121	79.572	1354.347	1433.918	0.2559	4.0810	4.3368	330.86	1.0636	45.5248	79
80	0.55295	1.0005	0.8805	1.8810	80.581	1461.200	1541.781	0.2587	4.3890	4.6477	335.06	1.0755	47.4135	80
81	0.59751	1.0034	0.9539	1.9572	81.591	1579.961	1661.552	0.2616	4.7305	4.9921	339.25	1.0874	49.3670	81
82	0.64724	1.0062	1.0360	2.0422	82.600	1712.547	1795.148	0.2644	5.1108	5.3753	343.45	1.0993	51.3860	82
83	0.70311	1.0090	1.1283	2.1373	83.610	1861.548	1945.158	0.2673	5.5372	5.8045	347.65	1.1111	53.4746	83
84	0.76624	1.0119	1.2328	2.2446	84.620	2029.983	2114.603	0.2701	6.0181	6.2882	351.85	1.1228	55.6337	84
85	0.83812	1.0147	1.3518	2.3666	85.630	2221.806	2307.436	0.2729	6.5644	6.8373	356.05	1.1346	57.8658	85
86	0.92062	1.0175	1.4887	2.5062	86.640	2442.036	2528.677	0.2757	7.1901	7.4658	360.25	1.1463	60.1727	86
87	1.01611	1.0204	1.6473	2.6676	87.650	2697.016	2784.666	0.2785	7.9128	8.1914	364.45	1.1580	62.5544	87
88	1.12800	1.0232	1.8333	2.8565	88.661	2995.890	3084.551	0.2813	8.7580	9.0393	368.65	1.1696	65.0166	88
89	1.26064	1.0261	2.0540	3.0800	89.671	3350.254	3439.925	0.2841	9.7577	10.0419	372.86	1.1812	67.5581	89
90	1.42031	1.0289	2.3199	3.3488	90.681	3776.918	3867.599	0.2869	10.9586	11.2455	377.06	1.1928	70.1817	90