

# Appendices

## Appendix 1: Properties of Gases

Gas	Chemical formula	Molar mass, kg/kmol	$R$ , kJ/kgK	$c_p$ , kJ/kgK	$c_v$ , kJ/kgK	$\gamma = \frac{c_p}{c_v}$
Air	—	28.97	0.2870	1.004	0.717	1.400
Ammonia	NH <sub>3</sub>	17.03	0.4882	2.130	1.642	1.297
Argon	Ar	39.95	0.2081	0.520	0.312	1.667
Butane	C <sub>4</sub> H <sub>10</sub>	58.12	0.1430	1.716	1.573	1.091
Carbon dioxide	CO <sub>2</sub>	44.01	0.1889	0.842	0.653	1.289
Carbon monoxide	CO	28.01	0.2968	1.041	0.744	1.400
Ethane	C <sub>2</sub> H <sub>6</sub>	30.07	0.2765	1.766	1.490	1.186
Ethylene	C <sub>2</sub> H <sub>4</sub>	28.05	0.2964	1.548	1.252	1.237
Helium	He	4.00	2.0770	5.193	3.116	1.667
Hydrogen	H <sub>2</sub>	2.02	4.1242	14.209	10.085	1.409
Methane	CH <sub>4</sub>	16.04	0.5184	2.254	1.736	1.299
Neon	Ne	20.18	0.4120	1.030	0.618	1.667
Nitrogen	N <sub>2</sub>	28.01	0.2968	1.042	0.745	1.400
Octane	C <sub>8</sub> H <sub>18</sub>	114.23	0.0728	1.711	1.638	1.044
Oxygen	O <sub>2</sub>	32.00	0.2598	0.922	0.662	1.393
Propane	C <sub>3</sub> H <sub>8</sub>	44.10	0.1886	1.679	1.490	1.126
Water (steam)	H <sub>2</sub> O	18.02	0.4615	1.872	1.410	1.327

Specific heats evaluated at 25 °C, 100 kPa

*Energy, Entropy and Engines: An Introduction to Thermodynamics*, First Edition. Sanjeev Chandra.

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# Appendix 2: Properties of Solids

## Metals

Substance	Density, $\rho$ (kg/m <sup>3</sup> )	Specific heat, $c$ (kJ/kg°C)	Molar mass, $M$ (kg/kmol)
Aluminum	2700	0.902	26.98
Copper	8900	0.386	63.55
Iron	7840	0.450	55.85
Lead	11 310	0.128	207.20
Magnesium	1730	1.000	24.31
Nickel	8890	0.440	58.69
Silver	10470	0.235	107.87
Steel, mild	7830	0.500	55.71
Tungsten	19400	0.130	183.85

## Non-Metals

Substance	Density, $\rho$ (kg/m <sup>3</sup> )	Specific heat, $c$ (kJ/kg°C)	Molar mass, $M$ (kg/kmol)
Asphalt	2110	0.920	200
Brick, common	1922	0.790	59.49
Concrete	2300	0.653	270.1
Clay	1000	0.920	258.16
Diamond	2420	0.616	12.01
Glass, window	2700	0.800	60.08
Graphite	2500	0.711	12.01
Granite	2700	1.017	62.44
Ice (0°C)	921	2.110	18.02
Marble	2600	0.880	100.09
Plywood (Douglas fir)	545	1.210	162.14
Sand	1520	0.800	60.08
Stone	1500	0.800	66.42

# Appendix 3: Properties of Liquids

Substance	Temperature, $T$ (°C)	Density, $\rho$ (kg/m <sup>3</sup> )	Specific heat, $c$ (kJ/kg°C)	Molar mass, $M$ (kg/kmol)
Ammonia	25	602	4.8	17.03
Argon	−185.6	1,394	1.14	39.95
Benzene	20	879	1.72	78.11
<i>n</i> -Butane	−0.5	601	2.31	58.12
Carbon dioxide	0	298	0.59	44.01
Ethanol	25	783	2.46	46.07
Ethylene glycol	20	1,109	2.84	62.07
Glycerine	20	1,261	2.32	92.09
Helium	−268.9	146	22.8	4.00
Hydrogen	−252.8	71	10	2.02
Kerosene	20	820	2	170.34
Mercury	25	13,560	0.139	200.59
Methane	−161.5	423	3.49	16.04
Methanol	25	787	2.55	32.04
Nitrogen	−195.8	809	2.06	28.01
Octane	20	703	2.1	114.23
Oil (light)	25	910	1.8	114.23
Oxygen	−183	1,141	1.71	32.00
Petroleum	20	640	2	95
Propane	−42.1	581	2.25	44.1
	0	529	2.53	44.1
	50	449	3.13	44.1
Refrigerant-134a	−50	1,443	1.23	102.03
	−26.1	1,374	1.27	102.03
	0	1,294	1.34	102.03
	25	1,206	1.42	102.03
Water	0	1,000	4.23	18.02
	25	997	4.18	18.02
	50	988	4.18	18.02
	75	975	4.19	18.02
	100	958	4.22	18.02

# Appendix 4: Specific Heats of Gases

Temp. (K)	Air			Carbon dioxide, CO <sub>2</sub>			Carbon monoxide, CO		
	$c_p$ (kJ/ kgK)	$c_v$ (kJ/ kgK)	$\gamma = c_p/c_v$	$c_p$ (kJ/ kgK)	$c_v$ (kJ/ kgK)	$\gamma = c_p/c_v$	$c_p$ (kJ/ kgK)	$c_v$ (kJ/ kgK)	$\gamma = c_p/c_v$
250	1.003	0.716	1.401	0.791	0.602	1.314	1.039	0.743	1.400
300	1.005	0.718	1.400	0.846	0.657	1.288	1.040	0.744	1.399
350	1.008	0.721	1.398	0.895	0.706	1.268	1.043	0.746	1.398
400	1.013	0.726	1.395	0.939	0.750	1.252	1.047	0.751	1.395
450	1.020	0.733	1.391	0.978	0.790	1.239	1.054	0.757	1.392
500	1.029	0.742	1.387	1.014	0.825	1.229	1.063	0.767	1.387
550	1.040	0.753	1.381	1.046	0.857	1.220	1.075	0.778	1.382
600	1.051	0.764	1.376	1.075	0.886	1.213	1.087	0.790	1.376
650	1.063	0.776	1.370	1.102	0.913	1.207	1.100	0.803	1.370
700	1.075	0.788	1.364	1.126	0.937	1.202	1.113	0.816	1.364
750	1.087	0.800	1.359	1.148	0.959	1.197	1.126	0.829	1.358
800	1.099	0.812	1.354	1.169	0.980	1.193	1.139	0.842	1.353
900	1.121	0.834	1.344	1.204	1.015	1.186	1.163	0.866	1.343
1000	1.142	0.855	1.336	1.234	1.045	1.181	1.185	0.888	1.335

Temp. (K)	Hydrogen, H <sub>2</sub>			Nitrogen, N <sub>2</sub>			Oxygen, O <sub>2</sub>		
	$c_p$ (kJ/ kgK)	$c_v$ (kJ/ kgK)	$\gamma = c_p/c_v$	$c_p$ (kJ/ kgK)	$c_v$ (kJ/ kgK)	$\gamma = c_p/c_v$	$c_p$ (kJ/ kgK)	$c_v$ (kJ/ kgK)	$\gamma = c_p/c_v$
250	14.051	9.927	1.416	1.039	0.742	1.400	0.913	0.653	1.398
300	14.307	10.183	1.405	1.039	0.743	1.400	0.918	0.658	1.395
350	14.427	10.302	1.400	1.041	0.744	1.399	0.928	0.668	1.389
400	14.476	10.352	1.398	1.044	0.747	1.397	0.941	0.681	1.382
450	14.501	10.377	1.398	1.049	0.752	1.395	0.956	0.696	1.373
500	14.513	10.389	1.397	1.056	0.759	1.391	0.972	0.712	1.365
550	14.530	10.405	1.396	1.065	0.768	1.387	0.988	0.728	1.358
600	14.546	10.422	1.396	1.075	0.778	1.382	1.003	0.743	1.350
650	14.571	10.447	1.395	1.086	0.789	1.376	1.017	0.758	1.343
700	14.604	10.480	1.394	1.098	0.801	1.371	1.031	0.771	1.337
750	14.645	10.521	1.392	1.110	0.813	1.365	1.043	0.783	1.332
800	14.695	10.570	1.390	1.121	0.825	1.360	1.054	0.794	1.327
900	14.822	10.698	1.385	1.145	0.849	1.349	1.074	0.814	1.319
1000	14.983	10.859	1.380	1.167	0.870	1.341	1.090	0.830	1.313

# Appendix 5: Polynomial Relations for Ideal Gas Specific Heat as a Function of Temperature

$$\bar{c}_p = Mc_p = a + bT + cT^2 + dT^3$$

Valid for temperatures ranging from 300 to 1500 K, with a typical accuracy of  $\pm 1\%$ .

Substance		a	b	c	d
Nitrogen	N <sub>2</sub>	28.9	$-0.1571 \times 10^{-2}$	$0.8081 \times 10^{-5}$	$-2.873 \times 10^{-9}$
Oxygen	O <sub>2</sub>	25.48	$1.52 \times 10^{-2}$	$-0.7155 \times 10^{-5}$	$1.312 \times 10^{-9}$
Air	—	28.11	$0.1967 \times 10^{-2}$	$0.4802 \times 10^{-5}$	$-1.966 \times 10^{-9}$
Hydrogen	H <sub>2</sub>	29.11	$-0.1916 \times 10^{-2}$	$0.4003 \times 10^{-5}$	$-0.8704 \times 10^{-9}$
Carbon monoxide	CO	28.16	$0.1675 \times 10^{-2}$	$0.5372 \times 10^{-5}$	$-2.222 \times 10^{-9}$
Carbon dioxide	CO <sub>2</sub>	22.26	$5.981 \times 10^{-2}$	$-3.501 \times 10^{-5}$	$7.469 \times 10^{-9}$
Water vapor	H <sub>2</sub> O	32.24	$0.1923 \times 10^{-2}$	$1.055 \times 10^{-5}$	$-3.595 \times 10^{-9}$
Nitric oxide	NO	29.34	$-0.09395 \times 10^{-2}$	$0.9747 \times 10^{-5}$	$-4.187 \times 10^{-9}$
Nitrous oxide	N <sub>2</sub> O	24.11	$5.8632 \times 10^{-2}$	$-3.562 \times 10^{-5}$	$10.58 \times 10^{-9}$
Nitrogen dioxide	NO <sub>2</sub>	22.9	$5.715 \times 10^{-2}$	$-3.52 \times 10^{-5}$	$7.87 \times 10^{-9}$
Ammonia	NH <sub>3</sub>	27.568	$2.563 \times 10^{-2}$	$0.99072 \times 10^{-5}$	$-6.6909 \times 10^{-9}$
Sulfur	S <sub>2</sub>	27.21	$2.218 \times 10^{-2}$	$-1.628 \times 10^{-5}$	$3.986 \times 10^{-9}$
Sulfur dioxide	SO <sub>2</sub>	25.78	$5.795 \times 10^{-2}$	$-3.812 \times 10^{-5}$	$8.612 \times 10^{-9}$
Sulfur trioxide	SO <sub>3</sub>	16.4	$14.58 \times 10^{-2}$	$-11.2 \times 10^{-5}$	$32.42 \times 10^{-9}$
Acetylene	C <sub>2</sub> H <sub>2</sub>	21.8	$9.2143 \times 10^{-2}$	$-6.527 \times 10^{-5}$	$18.21 \times 10^{-9}$
Benzene	C <sub>6</sub> H <sub>6</sub>	-36.22	$48.475 \times 10^{-2}$	$-31.57 \times 10^{-5}$	$77.62 \times 10^{-9}$
Methanol	CH <sub>4</sub> O	19	$9.152 \times 10^{-2}$	$-1.22 \times 10^{-5}$	$-8.039 \times 10^{-9}$
Ethanol	C <sub>2</sub> H <sub>6</sub> O	19.9	$20.96 \times 10^{-2}$	$-10.38 \times 10^{-5}$	$20.05 \times 10^{-9}$
Hydrogen chloride	HCl	30.33	$-0.762 \times 10^{-2}$	$1.327 \times 10^{-5}$	$-4.338 \times 10^{-9}$
Methane	CH <sub>4</sub>	19.89	$5.024 \times 10^{-2}$	$1.269 \times 10^{-5}$	$-11.01 \times 10^{-9}$
Ethane	C <sub>2</sub> H <sub>6</sub>	6.9	$17.27 \times 10^{-2}$	$-6.406 \times 10^{-5}$	$7.285 \times 10^{-9}$
Propane	C <sub>3</sub> H <sub>8</sub>	-4.04	$30.48 \times 10^{-2}$	$-15.72 \times 10^{-5}$	$31.74 \times 10^{-9}$
<i>n</i> -Butane	C <sub>4</sub> H <sub>10</sub>	3.96	$37.15 \times 10^{-2}$	$-18.34 \times 10^{-5}$	$35 \times 10^{-9}$
<i>i</i> -Butane	C <sub>4</sub> H <sub>10</sub>	-7.913	$41.6 \times 10^{-2}$	$-23.01 \times 10^{-5}$	$49.91 \times 10^{-9}$
<i>n</i> -Pentane	C <sub>5</sub> H <sub>12</sub>	6.774	$45.43 \times 10^{-2}$	$-22.46 \times 10^{-5}$	$42.29 \times 10^{-9}$
<i>n</i> -Hexane	C <sub>6</sub> H <sub>14</sub>	6.938	$55.22 \times 10^{-2}$	$-28.65 \times 10^{-5}$	$57.69 \times 10^{-9}$
Ethylene	C <sub>2</sub> H <sub>4</sub>	3.95	$15.64 \times 10^{-2}$	$-8.344 \times 10^{-5}$	$17.67 \times 10^{-9}$
Propylene	C <sub>3</sub> H <sub>6</sub>	3.15	$23.83 \times 10^{-2}$	$-12.18 \times 10^{-5}$	$24.62 \times 10^{-9}$

# Appendix 6: Critical Properties of Fluids

Substance	Formula	Molar mass, $M$ , kg/kmol	Temp., $T_c$ , K	Press., $P_c$ , MPa	Volume, $\bar{v}_c$ , m <sup>3</sup> /kmol
Air	—	28.97	132.5	3.77	0.0883
Ammonia	NH <sub>3</sub>	17.03	405.5	11.28	0.0724
Argon	Ar	39.948	151	4.86	0.0749
Benzene	C <sub>6</sub> H <sub>6</sub>	78.115	562	4.92	0.2603
Bromine	Br <sub>2</sub>	159.808	584	10.34	0.1355
<i>n</i> -Butane	C <sub>4</sub> H <sub>10</sub>	58.124	425.2	3.8	0.2547
Carbon dioxide	CO <sub>2</sub>	44.01	304.2	7.39	0.0943
Carbon monoxide	CO	28.011	133	3.5	0.093
Carbon tetrachloride	CCl <sub>4</sub>	153.82	556.4	4.56	0.2759
Chlorine	Cl <sub>2</sub>	70.906	417	7.71	0.1242
Chloroform	CHCl <sub>3</sub>	119.38	536.6	5.47	0.2403
Dichlorodifluoromethane (R-12)	CCl <sub>2</sub> F <sub>2</sub>	120.91	384.7	4.01	0.2179
Dichlorofluoromethane (R-21)	CHCl <sub>2</sub> F	102.92	451.7	5.17	0.1973
Ethane	C <sub>2</sub> H <sub>6</sub>	30.07	305.5	4.48	0.148
Ethyl alcohol	C <sub>2</sub> H <sub>5</sub> OH	46.07	516	6.38	0.1673
Ethylene	C <sub>2</sub> H <sub>4</sub>	28.054	282.4	5.12	0.1242
Helium	He	4.003	5.3	0.23	0.0578
<i>n</i> -Hexane	C <sub>6</sub> H <sub>14</sub>	86.179	507.9	3.03	0.3677
Hydrogen	H <sub>2</sub>	2.016	33.3	1.3	0.0649
Krypton	Kr	83.8	209.4	5.5	0.0924
Methane	CH <sub>4</sub>	16.043	191.1	4.64	0.0993
Methyl alcohol	CH <sub>3</sub> OH	32.042	513.2	7.95	0.118
Methyl chloride	CH <sub>3</sub> Cl	50.488	416.3	6.68	0.143
Neon	Ne	20.183	44.5	2.73	0.0417
Nitrogen	N <sub>2</sub>	28.013	126.2	3.39	0.0899
Nitrous oxide	N <sub>2</sub> O	44.013	309.7	7.27	0.0961
Oxygen	O <sub>2</sub>	31.999	154.8	5.08	0.078
Propane	C <sub>3</sub> H <sub>8</sub>	44.097	370	4.26	0.1998
Propylene	C <sub>3</sub> H <sub>6</sub>	42.081	365	4.62	0.181
Sulfur dioxide	SO <sub>2</sub>	64.063	430.7	7.88	0.1217
Tetrafluoroethane (R-134a)	CF <sub>3</sub> CH <sub>2</sub> F	102.03	374.3	4.067	0.1847
Trichlorofluoromethane (R-11)	CCl <sub>3</sub> F	137.37	471.2	4.38	0.2478
Water	H <sub>2</sub> O	18.015	647.3	22.09	0.0568
Xenon	Xe	131.3	289.8	5.88	0.1186

# Appendix 7: Ideal Gas Tables for Air

$T, \text{K}$	$h, \text{kJ/kg}$	$P_r$	$u, \text{kJ/kg}$	$v_r$	$s^\circ, \text{kJ/kgK}$
200	199.97	0.3363	142.56	1707.0	1.29559
210	209.97	0.3987	149.69	1512.0	1.34444
220	219.97	0.4690	156.82	1346.0	1.39105
230	230.02	0.5477	164.00	1205.0	1.43557
240	240.02	0.6355	171.13	1084.0	1.47824
250	250.05	0.7329	178.28	979.0	1.51917
260	260.09	0.8405	185.45	887.8	1.55848
270	270.11	0.9590	192.60	808.0	1.59634
280	280.13	1.0889	199.75	738.0	1.63279
285	285.14	1.1584	203.33	706.1	1.65055
290	290.16	1.2311	206.91	676.1	1.66802
295	295.17	1.3068	210.49	647.9	1.68515
300	300.19	1.3860	214.07	621.2	1.70203
305	305.22	1.4686	217.67	596.0	1.71865
310	310.24	1.5546	221.25	572.3	1.73498
315	315.27	1.6442	224.85	549.8	1.75106
320	320.29	1.7375	228.42	528.6	1.76690
325	325.31	1.8345	232.02	508.4	1.78249
330	330.34	1.9352	235.61	489.4	1.79783
340	340.42	2.149	242.82	454.1	1.82790
350	350.49	2.379	250.02	422.2	1.85708
360	360.58	2.626	257.24	393.4	1.88543
370	370.67	2.892	264.46	367.2	1.91313
380	380.77	3.176	271.69	343.4	1.94001
390	390.88	3.481	278.93	321.5	1.96633
400	400.98	3.806	286.16	301.6	1.99194
410	411.12	4.153	293.43	283.3	2.01699
420	421.26	4.522	300.69	266.6	2.04142
430	431.43	4.915	307.99	251.1	2.06533
440	441.61	5.332	315.30	236.8	2.08870
450	451.80	5.775	322.62	223.6	2.11161
460	462.02	6.245	329.97	211.4	2.13407
470	472.24	6.742	337.32	200.1	2.15604
480	482.49	7.268	344.70	189.5	2.17760
490	492.74	7.824	352.08	179.7	2.19876
500	503.02	8.411	359.49	170.6	2.21952

(continued)

(continued)

$T, \text{K}$	$h, \text{kJ/kg}$	$P_r$	$u, \text{kJ/kg}$	$v_r$	$s^\circ, \text{kJ/kgK}$
510	513.32	9.031	366.92	162.1	2.23993
520	523.63	9.684	374.36	154.1	2.25997
530	533.98	10.37	381.84	146.7	2.27967
540	544.35	11.10	389.34	139.7	2.29906
550	555.74	11.86	396.86	133.1	2.31809
560	565.17	12.66	404.42	127.0	2.33685
570	575.59	13.50	411.97	121.2	2.35531
580	586.04	14.38	419.55	115.7	2.37348
590	596.52	15.31	427.15	110.6	2.39140
600	607.02	16.28	434.78	105.8	2.40902
610	617.53	17.30	442.42	101.2	2.42644
620	628.07	18.36	450.09	96.92	2.44356
630	638.63	19.84	457.78	92.84	2.46048
640	649.22	20.64	465.50	88.99	2.47716
650	659.84	21.86	473.25	85.34	2.49364
660	670.47	23.13	481.01	81.89	2.50985
670	681.14	24.46	488.81	78.61	2.52589
680	691.82	25.85	496.62	75.50	2.54175
690	702.52	27.29	504.45	72.56	2.55731
700	713.27	28.80	512.33	69.76	2.57277
710	724.04	30.38	520.23	67.07	2.58810
720	734.82	32.02	528.14	64.53	2.60319
730	745.62	33.72	536.07	62.13	2.61803
740	756.44	35.50	544.02	59.82	2.63280
750	767.29	37.35	551.99	57.63	2.64737
760	778.18	39.27	560.01	55.54	2.66176
780	800.03	43.35	576.12	51.64	2.69013
800	821.95	47.75	592.30	48.08	2.71787
820	843.98	52.59	608.59	44.84	2.74504
840	866.08	57.60	624.95	41.85	2.77170
860	888.27	63.09	641.40	39.12	2.79783
880	910.56	68.98	657.95	36.61	2.82344
900	932.93	75.29	674.58	34.31	2.84856
920	955.38	82.05	691.28	32.18	2.87324
940	977.92	89.28	708.08	30.22	2.89748
960	1000.55	97.00	725.02	28.40	2.92128
980	1023.25	105.2	741.98	26.73	2.94468
1000	1046.04	114.0	758.94	25.17	2.96770
1020	1068.89	123.4	776.10	23.72	2.99034
1040	1091.85	133.3	793.36	23.29	3.01260
1060	1114.86	143.9	810.62	21.14	3.03449
1080	1137.89	155.2	827.88	19.98	3.05608
1100	1161.07	167.1	845.33	18.896	3.07732
1120	1184.28	179.7	862.79	17.886	3.09825
1140	1207.57	193.1	880.35	16.946	3.11883
1160	1230.92	207.2	897.91	16.064	3.13916
1180	1254.34	222.2	915.57	15.241	3.15916



(continued)

$T, \text{K}$	$h, \text{kJ/kg}$	$P_r$	$u, \text{kJ/kg}$	$v_r$	$s^\circ, \text{kJ/kgK}$
1200	1277.79	238.0	933.33	14.470	3.17888
1220	1301.31	254.7	951.09	13.747	3.19834
1240	1324.93	272.3	968.95	13.069	3.21751
1260	1348.55	290.8	986.90	12.435	3.23638
1280	1372.24	310.4	1004.76	11.835	3.25510
1300	1395.97	330.9	1022.82	11.275	3.27345
1320	1419.76	352.5	1040.88	10.747	3.29160
1340	1443.60	375.3	1058.94	10.247	3.30959
1360	1467.49	399.1	1077.10	9.780	3.32724
1380	1491.44	424.2	1095.26	9.337	3.34474
1400	1515.42	450.5	1113.52	8.919	3.36200
1420	1539.44	478.0	1131.77	8.526	3.37901
1440	1563.51	506.9	1150.13	8.153	3.39586
1460	1587.63	537.1	1168.49	7.801	3.41247
1480	1611.79	568.8	1186.95	7.468	3.42892
1500	1635.97	601.9	1205.41	7.152	3.44516
1520	1660.23	636.5	1223.87	6.854	3.46120
1540	1684.51	672.8	1242.43	6.569	3.47712
1560	1708.82	710.5	1260.99	6.301	3.49276
1580	1733.17	750.0	1279.65	6.046	3.50829
1600	1757.57	791.2	1298.30	5.804	3.52364
1620	1782.00	834.1	1316.96	5.574	3.53879
1640	1806.46	878.9	1335.72	5.355	3.55381
1660	1830.96	925.6	1354.48	5.147	3.56867
1680	1855.50	974.2	1373.24	4.949	3.58335
1700	1880.1	1025	1392.7	4.761	3.5979
1750	1941.6	1161	1439.8	4.328	3.6336
1800	2003.3	1310	1487.2	3.994	3.6684
1850	2065.3	1475	1534.9	3.601	3.7023
1900	2127.4	1655	1582.6	3.295	3.7354
1950	2189.7	1852	1630.6	3.022	3.7677
2000	2252.1	2068	1678.7	2.776	3.7994
2050	2314.6	2303	1726.8	2.555	3.8303
2100	2377.7	2559	1775.3	2.356	3.8605
2150	2440.3	2837	1823.8	2.175	3.8901
2200	2503.2	3138	1872.4	2.012	3.9191
2250	2566.4	3464	1921.3	1.864	3.9474

# Appendix 8: Properties of Water

Appendix 8a: Properties of Saturated Water (Temperature Table)

Temp., °C	Pressure, MPa	Specific volume, m³/kg		Internal energy, kJ/kg		Enthalpy, kJ/kg		Entropy, kJ/kgK	
<i>T</i> <sub>sat</sub>	<i>P</i>	<i>v</i> <sub>f</sub>	<i>v</i> <sub>g</sub>	<i>u</i> <sub>f</sub>	<i>u</i> <sub>g</sub>	<i>h</i> <sub>f</sub>	<i>h</i> <sub>g</sub>	<i>s</i> <sub>f</sub>	<i>s</i> <sub>g</sub>
0.01	0.0006113	0.001000	206.14	0.00	2375.3	0.00	2501.4	0.0000	9.1562
5	0.0008721	0.001000	147.12	20.97	2382.3	20.98	2510.6	0.0761	9.0257
10	0.0012276	0.001000	106.38	42.00	2389.2	42.01	2519.8	0.1510	8.9008
15	0.0017051	0.001001	77.93	62.99	2396.1	62.99	2528.9	0.2245	8.7814
20	0.002339	0.001002	57.79	83.95	2402.9	83.96	2538.1	0.2966	8.6672
25	0.003169	0.001003	43.36	104.88	2409.8	104.89	2547.2	0.3674	8.5580
30	0.004246	0.001004	32.89	125.78	2416.6	125.79	2556.3	0.4369	8.4533
35	0.005628	0.001006	25.22	146.67	2423.4	146.68	2565.3	0.5053	8.3531
40	0.007384	0.001008	19.52	167.56	2430.1	167.57	2574.3	0.5725	8.2570
45	0.009593	0.001010	15.26	188.44	2436.8	188.45	2583.2	0.6387	8.1648
50	0.012349	0.001012	12.03	209.32	2443.5	209.33	2592.1	0.7038	8.0763
55	0.015758	0.001015	9.568	230.21	2450.1	230.23	2600.9	0.7679	7.9913
60	0.019940	0.001017	7.671	251.11	2456.6	251.13	2609.6	0.8312	7.9096
65	0.02503	0.001020	6.197	272.02	2463.1	272.06	2618.3	0.8935	7.8310
70	0.03119	0.001023	5.042	292.95	2469.6	292.98	2626.8	0.9549	7.7553
75	0.03858	0.001026	4.131	313.90	2475.9	313.93	2643.7	1.0155	7.6824
80	0.04739	0.001029	3.407	334.86	2482.2	334.91	2635.3	1.0753	7.6122
85	0.05783	0.001033	2.828	355.84	2488.4	355.90	2651.9	1.1343	7.5445
90	0.07014	0.001036	2.361	376.85	2494.5	376.92	2660.1	1.1925	7.4791
95	0.08455	0.001040	1.982	397.88	2500.6	397.96	2668.1	1.2500	7.4159
100	0.10135	0.001044	1.6729	418.94	2506.5	419.04	2676.1	1.3069	7.3549
105	0.12082	0.001048	1.4194	440.02	2512.4	440.15	2683.8	1.3630	7.2958
110	0.14327	0.001052	1.2102	461.14	2518.1	461.30	2691.5	1.4185	7.2387
115	0.16906	0.001056	1.0366	482.30	2523.7	482.48	2699.0	1.4734	7.1833
120	0.19853	0.001060	0.8919	503.50	2529.3	503.71	2706.3	1.5276	7.1296
125	0.2321	0.001065	0.7706	524.74	2534.6	524.99	2713.5	1.5813	7.0775
130	0.2701	0.001070	0.6685	546.02	2539.9	546.31	2720.5	1.6344	7.0269
135	0.3130	0.001075	0.5822	567.35	2545.0	567.69	2727.3	1.6870	6.9777
140	0.3613	0.001080	0.5089	588.74	2550.0	589.13	2733.9	1.7391	6.9299
145	0.4154	0.001085	0.4463	610.18	2554.9	610.63	2740.3	1.7907	6.8833
150	0.4758	0.001091	0.3928	631.68	2559.5	632.20	2746.5	1.8418	6.8379
155	0.5431	0.001096	0.3468	653.24	2564.1	653.84	2752.4	1.8925	6.7935
160	0.6178	0.001102	0.3071	674.87	2568.4	675.55	2758.1	1.9427	6.7502
165	0.7005	0.001108	0.2727	696.56	2572.5	697.34	2763.5	1.9925	6.7078

(continued)

Temp., °C	Pressure, MPa	Specific volume, m <sup>3</sup> /kg		Internal energy, kJ/kg		Enthalpy, kJ/kg		Entropy, kJ/kgK	
$T_{\text{sat}}$	$P$	$v_f$	$v_g$	$u_f$	$u_g$	$h_f$	$h_g$	$s_f$	$s_g$
170	0.7917	0.001114	0.2428	718.33	2576.5	719.21	2768.7	2.0419	6.6663
175	0.8920	0.001121	0.2168	740.17	2580.2	741.17	2773.6	2.0909	6.6256
180	1.0021	0.001127	0.19405	762.09	2583.7	763.22	2778.2	2.1396	6.5857
185	1.1227	0.001134	0.17409	784.10	2587.0	785.37	2782.4	2.1879	6.5465
190	1.2544	0.001141	0.15654	806.19	2590.0	807.62	2786.4	2.2359	6.5079
195	1.3978	0.001149	0.14105	828.37	2592.8	829.98	2790.0	2.2835	6.4698
200	1.5538	0.001157	0.12736	850.65	2595.3	852.45	2793.2	2.3309	6.4323
205	1.7230	0.001164	0.11521	873.04	2597.5	875.04	2796.0	2.3780	6.3952
210	1.9062	0.001173	0.10441	895.53	2599.5	897.76	2798.5	2.4248	6.3585
215	2.104	0.001181	0.09479	918.14	2601.1	920.62	2800.5	2.4714	6.3221
220	2.318	0.001190	0.08619	940.87	2602.4	943.62	2802.1	2.5178	6.2861
225	2.548	0.001199	0.07849	963.73	2603.3	966.78	2803.3	2.5639	6.2503
230	2.795	0.001209	0.07158	986.74	2603.9	990.12	2804.0	2.6099	6.2146
235	3.060	0.001219	0.06537	1009.89	2604.1	1013.62	2804.2	2.6558	6.1791
240	3.344	0.001229	0.05976	1033.21	2604.0	1037.32	2803.8	2.7015	6.1437
245	3.648	0.001240	0.05471	1056.71	2603.4	1061.23	2803.0	2.7472	6.1083
250	3.973	0.001251	0.05013	1080.39	2602.4	1085.36	2801.5	2.7927	6.0730
255	4.319	0.001263	0.04598	1104.28	2600.9	1109.73	2799.5	2.8383	6.0375
260	4.688	0.001276	0.04221	1128.39	2599.0	1134.37	2796.9	2.8838	6.0019
265	5.081	0.001289	0.03877	1152.74	2596.6	1159.28	2793.6	2.9294	5.9662
270	5.499	0.001302	0.03564	1177.36	2593.7	1184.51	2789.7	2.9751	5.9301
275	5.942	0.001317	0.03279	1202.25	2590.2	1210.07	2785.0	3.0208	5.8938
280	6.412	0.001332	0.03017	1227.46	2586.1	1235.99	2779.6	3.0668	5.8571
285	6.909	0.001348	0.02777	1253.00	2581.4	1262.31	2773.3	3.1130	5.8199
290	7.436	0.001366	0.02557	1278.92	2576.0	1289.07	2766.2	3.1594	5.7821
295	7.993	0.001384	0.02354	1305.20	2569.9	1316.30	2758.1	3.2062	5.7437
300	8.581	0.001404	0.02167	1332.00	2563.0	1344.00	2749.0	3.2534	5.7045
305	9.202	0.001425	0.019948	1359.30	2555.2	1372.40	2738.7	3.3010	5.6643
310	9.856	0.001447	0.018350	1387.10	2546.4	1401.30	2727.3	3.3493	5.6230
315	10.547	0.001472	0.016867	1415.50	2536.6	1431.00	2714.5	3.3982	5.5804
320	11.274	0.001499	0.015488	1444.60	2525.5	1461.50	2700.1	3.4480	5.5362
330	12.845	0.001561	0.012996	1505.30	2498.9	1525.30	2665.9	3.5507	5.4417
340	14.586	0.001638	0.010797	1570.30	2464.6	1594.20	2622.0	3.6594	5.3357
350	16.513	0.001740	0.008813	1641.90	2418.4	1670.60	2563.9	3.7777	5.2112
360	18.651	0.001893	0.006945	1725.20	2351.5	1760.50	2481.0	3.9147	5.0526
370	21.03	0.002213	0.004925	1844.00	2228.5	1890.50	2332.1	4.1106	4.7971
374.14	22.09	0.003155	0.003155	2029.60	2029.6	2099.30	2099.3	4.4298	4.4298

Appendix 8b: Properties of Saturated Water (Pressure Table)

Pressure, MPa	Temp., °C	Specific volume, m <sup>3</sup> /kg		Internal energy, kJ/kg		Enthalpy, kJ/kg		Entropy, kJ/kgK	
<i>P</i>	<i>T</i> <sub>sat</sub>	<i>v</i> <sub><i>f</i></sub>	<i>v</i> <sub><i>g</i></sub>	<i>u</i> <sub><i>f</i></sub>	<i>u</i> <sub><i>g</i></sub>	<i>h</i> <sub><i>f</i></sub>	<i>h</i> <sub><i>g</i></sub>	<i>s</i> <sub><i>f</i></sub>	<i>s</i> <sub><i>g</i></sub>
0.0006113	0.01	0.001000	206.14	0	2375.3	0.00	2501.4	0.0000	9.1562
0.0010	6.98	0.001000	129.21	29.3	2385.0	29.30	2514.2	0.1059	8.9756
0.0015	13.03	0.001001	87.98	54.71	2393.3	54.71	2525.3	0.1957	8.8279
0.0020	17.50	0.001001	67.00	73.48	2399.5	73.48	2533.5	0.2607	8.7237
0.0025	21.08	0.001002	54.25	88.48	2404.4	88.49	2540.0	0.3120	8.6432
0.0030	24.08	0.001003	45.67	101.04	2408.5	101.05	2545.5	0.3545	8.5776
0.0040	28.96	0.001004	34.80	121.45	2415.2	121.46	2554.4	0.4226	8.4746
0.0050	32.88	0.001005	28.19	137.81	2420.5	137.82	2561.5	0.4764	8.3951
0.0075	40.29	0.001008	19.24	168.78	2430.5	168.79	2574.8	0.5764	8.2515
0.010	45.81	0.001010	14.67	191.82	2437.9	191.83	2584.7	0.6493	8.1502
0.015	53.97	0.001014	10.02	225.92	2448.7	225.94	2599.1	0.7549	8.0085
0.020	60.06	0.001017	7.649	251.38	2456.7	251.40	2609.7	0.8320	7.9085
0.025	64.97	0.001020	6.204	271.90	2463.1	271.93	2618.2	0.8931	7.8314
0.030	69.10	0.001022	5.229	289.20	2468.4	289.23	2625.3	0.9439	7.7686
0.040	75.87	0.001027	3.993	317.53	2477.0	317.58	2636.8	1.0259	7.6700
0.050	81.33	0.001030	3.240	340.44	2483.9	340.49	2645.9	1.0910	7.5939
0.075	91.78	0.001037	2.217	384.31	2496.7	384.39	2663.0	1.2130	7.4564
0.100	99.63	0.001043	1.694	417.36	2506.1	417.46	2675.5	1.3026	7.3594
0.125	105.99	0.001048	1.3749	444.19	2513.5	444.32	2685.4	1.3740	7.2844
0.150	111.37	0.001053	1.1593	466.94	2519.7	467.11	2693.6	1.4336	7.2233
0.175	116.06	0.001057	1.0036	486.80	2524.9	486.99	2700.6	1.4849	7.1717
0.200	120.23	0.001061	0.8857	504.49	2529.5	504.70	2706.7	1.5301	7.1271
0.225	124.00	0.001064	0.7933	520.47	2533.6	520.72	2712.1	1.5706	7.0878
0.250	127.44	0.001067	0.7187	535.10	2537.2	535.37	2716.9	1.6072	7.0527
0.275	130.60	0.001070	0.6573	548.59	2540.5	548.89	2721.3	1.6408	7.0209
0.300	133.55	0.001073	0.6058	561.15	2543.6	561.47	2725.3	1.6718	6.9919
0.325	136.30	0.001076	0.5620	572.90	2546.4	573.25	2729.0	1.7006	6.9652
0.350	138.88	0.001079	0.5243	583.95	2548.9	584.33	2732.4	1.7275	6.9405
0.375	141.32	0.001081	0.4914	594.40	2551.3	594.81	2735.6	1.7528	6.9175
0.40	143.63	0.001084	0.4625	604.31	2553.6	604.74	2738.6	1.7766	6.8959
0.45	147.93	0.001088	0.4140	622.77	2557.6	623.25	2743.9	1.8207	6.8565
0.50	151.86	0.001093	0.3749	639.68	2561.2	640.23	2748.7	1.8607	6.8213
0.55	155.48	0.001097	0.3427	655.32	2564.5	665.93	2753.0	1.8973	6.7893
0.60	158.85	0.001101	0.3157	669.90	2567.4	670.56	2756.8	1.9312	6.7600
0.65	162.01	0.001104	0.2927	683.56	2570.1	684.28	2760.3	1.9627	6.7331
0.70	164.97	0.001108	0.2729	696.44	2572.5	697.22	2763.5	1.9922	6.7080
0.75	167.78	0.001112	0.2556	708.64	2574.7	709.47	2766.4	2.0200	6.6847
0.80	170.43	0.001115	0.2404	720.22	2576.8	721.11	2769.1	2.0462	6.6628
0.85	172.96	0.001118	0.2270	731.27	2578.7	732.22	2771.6	2.0710	6.6421
0.90	175.38	0.001121	0.2150	741.83	2580.5	742.83	2773.9	2.0946	6.6226
0.95	177.69	0.001124	0.2042	751.95	2582.1	753.02	2776.1	2.1172	6.6041
1.00	179.91	0.001127	0.19444	761.68	2583.6	762.81	2778.1	2.1387	6.5865

(continued)

Pressure, MPa	Temp., °C	Specific volume, m <sup>3</sup> /kg		Internal energy, kJ/kg		Enthalpy, kJ/kg		Entropy, kJ/kgK	
<i>P</i>	<i>T</i> <sub>sat</sub>	<i>v</i> <sub><i>f</i></sub>	<i>v</i> <sub><i>g</i></sub>	<i>u</i> <sub><i>f</i></sub>	<i>u</i> <sub><i>g</i></sub>	<i>h</i> <sub><i>f</i></sub>	<i>h</i> <sub><i>g</i></sub>	<i>s</i> <sub><i>f</i></sub>	<i>s</i> <sub><i>g</i></sub>
1.10	184.09	0.001133	0.17753	780.09	2586.4	781.34	2871.7	2.1792	6.5536
1.20	187.99	0.001139	0.16333	797.29	2588.8	798.65	2784.8	2.2166	6.5233
1.30	191.64	0.001144	0.15125	813.44	2591.0	814.93	2787.6	2.2515	6.4953
1.40	195.07	0.001149	0.14084	828.70	2592.8	830.30	2790.0	2.2842	6.4693
1.50	198.32	0.001154	0.13177	843.16	2594.5	844.89	2792.2	2.3150	6.4448
1.75	205.76	0.001166	0.11349	876.46	2597.8	878.50	2796.4	2.3851	6.3896
2.00	212.42	0.001177	0.09963	906.44	2600.3	908.79	2799.5	2.4474	6.3409
2.25	218.45	0.001187	0.08875	933.83	2602.0	936.49	2801.7	2.5035	6.2972
2.50	223.99	0.001197	0.07998	959.11	2603.1	962.11	2803.1	2.5547	6.2575
3.00	233.90	0.001217	0.06668	1004.78	2604.1	1008.42	2804.2	2.6457	6.1869
3.50	242.60	0.001235	0.05707	1045.43	2603.7	1049.75	2803.4	2.7253	6.1253
4	250.40	0.001252	0.04978	1082.31	2602.3	1087.31	2801.4	2.7964	6.0701
5	263.99	0.001286	0.03944	1147.81	2597.1	1154.23	2794.3	2.9202	5.9734
6	275.64	0.001319	0.03244	1205.44	2589.7	1213.35	2784.3	3.0267	5.8892
7	285.88	0.001351	0.02737	1257.55	2580.5	1267.00	2772.1	3.1211	5.8133
8	295.06	0.001384	0.02352	1305.57	2569.8	1316.64	2758.0	3.2068	5.7432
9	303.40	0.001418	0.02048	1350.51	2557.8	1363.26	2742.1	3.2858	5.6722
10	311.06	0.001452	0.018026	1393.04	2544.4	1407.56	2724.7	3.3596	5.6141
11	318.15	0.001489	0.015987	1433.7	2529.8	1450.1	2705.6	3.4295	5.5527
12	324.75	0.001527	0.014263	1473.0	2513.7	1491.3	2684.9	3.4962	5.4924
13	330.93	0.001567	0.012780	1511.1	2496.1	1531.5	2662.2	3.5606	5.4323
14	336.75	0.001611	0.011485	1548.6	2476.8	1571.1	2637.6	3.6232	5.3717
15	342.24	0.001658	0.010337	1585.6	2455.5	1610.5	2610.5	3.6848	5.3098
16	347.44	0.001711	0.009306	1622.7	2431.7	1650.1	2580.6	3.7461	5.2455
17	352.37	0.001770	0.008364	1660.2	2405.0	1690.3	2547.2	3.8079	5.1777
18	357.06	0.001840	0.007489	1698.9	2374.3	1732.0	2509.1	3.8715	5.1044
19	361.54	0.001924	0.006657	1739.9	2338.1	1776.5	2464.5	3.9388	5.0228
20	365.81	0.002036	0.005834	1785.6	2293.0	1826.3	2409.7	4.0139	4.9269
21	369.89	0.002207	0.004952	1842.1	2230.6	1888.4	2334.6	4.1075	4.8013
22	373.80	0.002742	0.003568	1961.9	2087.1	2022.2	2165.6	4.3110	4.5327
22.09	374.14	0.003155	0.003155	2029.6	2029.6	2099.3	2099.3	4.4298	4.4298

Appendix 8c: Properties of Superheated Steam

<i>P</i> = 0.01 MPa ( <i>T</i> <sub>sat</sub> = 45.81 °C)					<i>P</i> = 0.05 MPa ( <i>T</i> <sub>sat</sub> = 81.33 °C)				<i>P</i> = 0.10 MPa ( <i>T</i> <sub>sat</sub> = 99.63 °C)			
<i>T</i> , °C	<i>v</i> , m <sup>3</sup> /kg	<i>u</i> , kJ/kg	<i>h</i> , kJ/kg	<i>s</i> , kJ/kgK	<i>v</i> , m <sup>3</sup> /kg	<i>u</i> , kJ/kg	<i>h</i> , kJ/kg	<i>s</i> , kJ/kgK	<i>v</i> , m <sup>3</sup> /kg	<i>u</i> , kJ/kg	<i>h</i> , kJ/kg	<i>s</i> , kJ/kgK
<i>T</i> <sub>sat</sub>	14.674	2437.9	2584.7	8.1502	3.24	2483.9	2645.9	7.5939	1.694	2506.1	2675.5	7.3594
50	14.869	2443.9	2592.6	8.1749								
100	17.196	2515.5	2687.5	8.4479	3.418	2511.6	2682.5	7.6947	1.6958	2506.7	2676.2	7.3614
150	19.512	2587.9	2783.0	8.6882	3.889	2585.6	2780.1	7.9401	1.9364	2582.8	2776.4	7.6143
200	21.825	2661.3	2879.5	8.9038	4.356	2659.9	2877.7	8.1580	2.172	2658.1	2875.3	7.8343
250	24.136	2736.0	2977.3	9.1002	4.820	2735.0	2976.0	8.3556	2.406	2733.7	2974.3	8.0333
300	26.445	2812.1	3076.5	9.2813	5.284	2811.3	3075.5	8.5373	2.639	2810.4	3074.3	8.2158
400	31.063	2968.9	3279.6	9.6077	6.209	2968.5	3278.9	8.8642	3.103	2967.9	3278.2	8.5435
500	35.679	3132.3	3489.1	9.8978	7.134	3132.0	3488.7	9.1546	3.565	3131.6	3488.1	8.8342
600	40.295	3302.5	3705.4	10.1608	8.057	3302.2	3705.1	9.4178	4.028	3301.9	3704.4	9.0976
700	44.911	3479.6	3928.7	10.4028	8.981	3479.4	3928.5	9.6599	4.490	3479.2	3928.2	9.3398
800	49.526	3663.8	4159.0	10.6281	9.904	3663.6	4158.9	9.8852	4.952	3663.5	4158.6	9.5652
900	54.141	3855.0	4396.4	10.8396	10.828	3854.9	4396.3	10.0967	5.414	3854.8	4396.1	9.7767
1000	58.757	4053.0	4640.6	11.0393	11.751	4052.9	4640.5	10.2964	5.875	4052.8	4640.3	9.9764
1100	63.372	4257.5	4891.2	11.2287	12.674	4257.4	4891.1	10.4859	6.337	4257.3	4891.0	10.1659
1200	67.987	4467.9	5147.8	11.4091	13.597	4467.8	5147.7	10.6662	6.799	4467.7	5147.6	10.3463
1300	72.602	4683.7	5409.7	11.5811	14.521	4683.6	5409.6	10.8382	7.260	4683.5	5409.5	10.5183

<i>P</i> = 0.20 MPa ( <i>T</i> <sub>sat</sub> = 120.23 °C)					<i>P</i> = 0.30 MPa ( <i>T</i> <sub>sat</sub> = 133.35 °C)				<i>P</i> = 0.40 MPa ( <i>T</i> <sub>sat</sub> = 143.63 °C)			
<i>T</i> , °C	<i>v</i> , m <sup>3</sup> /kg	<i>u</i> , kJ/kg	<i>h</i> , kJ/kg	<i>s</i> , kJ/kgK	<i>v</i> , m <sup>3</sup> /kg	<i>u</i> , kJ/kg	<i>h</i> , kJ/kg	<i>s</i> , kJ/kgK	<i>v</i> , m <sup>3</sup> /kg	<i>u</i> , kJ/kg	<i>h</i> , kJ/kg	<i>s</i> , kJ/kgK
<i>T</i> <sub>sat</sub>	0.8857	2529.5	2706.7	7.1272	0.6058	2543.6	2725.3	6.9919	0.4625	2553.6	2738.6	6.8959
150	0.9596	2576.9	2768.8	7.2795	0.6339	2570.8	2761.0	7.0778	0.4708	2564.5	2752.8	6.9299
200	1.0803	2654.4	2870.5	7.5066	0.7163	2650.7	2865.6	7.3115	0.5342	2646.8	2860.5	7.1706
250	1.1988	2731.2	2971.0	7.7086	0.7964	2728.7	2967.6	7.5166	0.5951	2726.1	2964.2	7.3789
300	1.3162	2808.6	3071.8	7.8926	0.8753	2806.7	3069.3	7.7022	0.6548	2804.8	3066.8	7.5662

400	1.5493	2966.7	3276.6	8.2218	1.0315	2965.6	3275.0	8.0330	0.7726	2964.4	3273.4	7.8985
500	1.7814	3130.8	3487.1	8.5133	1.1867	3130.0	3486.0	8.3251	0.8893	3129.2	3484.9	8.1913
600	2.013	3301.4	3704.0	8.7770	1.3414	3300.8	3703.2	8.5892	1.0055	3300.2	3702.4	8.4558
700	2.244	3478.8	3927.6	9.0194	1.4957	3478.4	3927.1	8.8319	1.1215	3477.9	3926.5	8.6987
800	2.475	3663.1	4158.2	9.2449	1.6499	3662.9	4157.8	9.0576	1.2372	3662.4	4157.3	8.9244
900	2.705	3854.5	4395.8	9.4566	1.8041	3854.2	4395.4	9.2692	1.3529	3853.9	4395.1	9.1362
1000	2.937	4052.5	4640.0	9.6563	1.9581	4052.3	4639.7	9.4690	1.4685	4052.0	4639.4	9.3360
1100	3.168	4257.0	4890.7	9.8458	2.1121	4256.8	4890.4	9.6585	1.5840	4256.5	4890.2	9.5256
1200	3.399	4467.5	5147.5	10.0262	2.2661	4467.2	5147.1	9.8389	1.6996	4467.0	5146.8	9.7060
1300	3.630	4683.2	5409.3	10.1982	2.4201	4683.0	5409.0	10.0110	1.8151	4682.8	5408.8	9.8780

$P = 0.50 \text{ MPa } (T_{\text{sat}} = 151.86^\circ\text{C})$					$P = 0.60 \text{ MPa } (T_{\text{sat}} = 158.85^\circ\text{C})$					$P = 0.80 \text{ MPa } (T_{\text{sat}} = 170.43^\circ\text{C})$				
$T, ^\circ\text{C}$	$v, \text{m}^3/\text{kg}$	$u, \text{kJ/kg}$	$h, \text{kJ/kg}$	$s, \text{kJ/kgK}$	$v, \text{m}^3/\text{kg}$	$u, \text{kJ/kg}$	$h, \text{kJ/kg}$	$s, \text{kJ/kgK}$		$v, \text{m}^3/\text{kg}$	$u, \text{kJ/kg}$	$h, \text{kJ/kg}$	$s, \text{kJ/kgK}$	
$T_{\text{sat}}$	0.3749	2561.2	2748.7	6.8213	0.3175	2567.4	2756.8	6.7600		0.2404	2576.8	2769.1	6.6628	
200	0.4249	2642.9	2855.4	7.0592	0.3520	2638.9	2850.1	6.9665		0.2608	2630.6	2839.3	6.8158	
250	0.4744	2723.5	2960.7	7.2709	0.3938	2720.9	2957.2	7.1816		0.2931	2715.5	2950.0	7.0384	
300	0.5226	2802.9	3064.2	7.4599	0.4344	2801.0	3061.6	7.3724		0.3241	2797.2	3056.5	7.2328	
350	0.5701	2882.6	3167.7	7.6329	0.4742	2881.2	3165.7	7.5464		0.3544	2878.2	3161.7	7.4089	
400	0.6173	2963.2	3271.9	7.7938	0.5137	2962.1	3270.3	7.7079		0.3843	2959.7	3267.1	7.5716	
500	0.7109	3128.4	3483.9	8.0873	0.5920	3127.6	3482.8	8.0021		0.4433	3126.0	3480.6	7.8673	
600	0.8041	3299.6	3701.7	8.3522	0.6697	3299.1	3700.9	8.2674		0.5018	3297.9	3699.4	8.1333	
700	0.8969	3477.5	3925.9	8.5952	0.7472	3477.0	3925.3	8.5107		0.5601	3476.2	3924.2	8.3770	
800	0.9896	3662.1	4156.9	8.8211	0.8245	3661.8	4156.6	8.7367		0.6181	3661.1	4155.6	8.6033	
900	1.0822	3853.6	4394.7	9.0329	0.9017	3853.4	4394.4	8.9486		0.6761	3852.8	4393.7	8.8153	
1000	1.1747	4051.8	4639.1	9.2328	0.9788	4051.5	4638.8	9.1485		0.7340	4051.0	4638.2	9.0153	
1100	1.2672	4256.3	4889.9	9.4224	1.0559	4256.1	4889.6	9.3381		0.7919	4255.6	4889.1	9.2050	
1200	1.3956	4466.8	5146.6	9.6029	1.1330	4466.5	5146.3	9.5185		0.8497	4466.1	5145.9	9.3855	
1300	1.4521	4682.5	5408.6	9.7749	1.2101	4682.3	5408.3	9.6906		0.9076	4681.8	5407.9	9.5575	

(continued)

(continued)

$P = 1.00 \text{ MPa } (T_{\text{sat}} = 179.91 \text{ }^{\circ}\text{C})$					$P = 1.20 \text{ MPa } (T_{\text{sat}} = 187.99 \text{ }^{\circ}\text{C})$				$P = 1.40 \text{ MPa } (T_{\text{sat}} = 195.07 \text{ }^{\circ}\text{C})$			
$T, \text{ }^{\circ}\text{C}$	$v, \text{ m}^3/\text{kg}$	$u, \text{ kJ/kg}$	$h, \text{ kJ/kg}$	$s, \text{ kJ/kgK}$	$v, \text{ m}^3/\text{kg}$	$u, \text{ kJ/kg}$	$h, \text{ kJ/kg}$	$s, \text{ kJ/kgK}$	$v, \text{ m}^3/\text{kg}$	$u, \text{ kJ/kg}$	$h, \text{ kJ/kg}$	$s, \text{ kJ/kgK}$
$T_{\text{sat}}$	0.19444	2583.6	2778.1	6.5865	0.16333	2588.8	2784.4	6.5233	0.14084	2592.8	2790.0	6.4693
200	0.2060	2621.9	2827.9	6.6940	0.16930	2612.8	2815.9	6.5898	0.14302	2603.1	2803.3	6.4975
250	0.2327	2709.9	2942.6	6.9247	0.19234	2704.2	2935.0	6.8294	0.16350	2698.3	2927.2	6.7467
300	0.2579	2793.2	3051.2	7.1229	0.2138	2789.2	3045.8	7.0317	0.18228	2785.2	3040.4	6.9534
350	0.2825	2875.2	3157.7	7.3011	0.2345	2872.2	3153.6	7.2121	0.2003	2869.2	3149.5	7.1360
400	0.3066	2957.3	3263.9	7.4651	0.2548	2954.9	3260.7	7.3774	0.2178	2952.5	3257.5	7.3026
500	0.3541	3124.4	3478.5	7.7622	0.2946	3122.8	3476.3	7.6759	0.2521	3121.1	3474.1	7.6027
600	0.4011	3296.8	3697.9	8.0290	0.3339	3295.6	3696.3	7.9435	0.2860	3294.4	3694.8	7.8710
700	0.4478	3475.3	3923.1	8.2731	0.3729	3474.4	3922.0	8.1881	0.3195	3473.6	3920.8	8.1160
800	0.4943	3660.4	4154.7	8.4996	0.4118	3659.7	4153.8	8.4148	0.3528	3659.0	4153.0	8.3431
900	0.5407	3852.2	4392.9	8.7118	0.4505	3851.6	4392.2	8.6272	0.3861	3851.1	4391.5	8.5556
1000	0.5871	4050.5	4637.6	8.9119	0.4892	4050.0	4637.0	8.8274	0.4192	4049.5	4636.4	8.7559
1100	0.6335	4255.1	4888.6	9.1017	0.5278	4254.6	4888.0	9.0172	0.4524	4254.1	4887.5	8.9457
1200	0.6798	4465.6	5145.4	9.2822	0.5665	4465.1	5144.9	9.1977	0.4855	4464.7	5144.4	9.1262
1300	0.7261	4681.3	5407.4	9.4543	0.6051	4680.9	5407.0	9.3698	0.5186	4680.4	5406.5	9.2984

$P = 1.60 \text{ MPa } (T_{\text{sat}} = 201.41 \text{ }^{\circ}\text{C})$					$P = 1.80 \text{ MPa } (T_{\text{sat}} = 207.15 \text{ }^{\circ}\text{C})$				$P = 2.00 \text{ MPa } (T_{\text{sat}} = 212.42 \text{ }^{\circ}\text{C})$			
$T, \text{ }^{\circ}\text{C}$	$v, \text{ m}^3/\text{kg}$	$u, \text{ kJ/kg}$	$h, \text{ kJ/kg}$	$s, \text{ kJ/kgK}$	$v, \text{ m}^3/\text{kg}$	$u, \text{ kJ/kg}$	$h, \text{ kJ/kg}$	$s, \text{ kJ/kgK}$	$v, \text{ m}^3/\text{kg}$	$u, \text{ kJ/kg}$	$h, \text{ kJ/kg}$	$s, \text{ kJ/kgK}$
$T_{\text{sat}}$	0.12380	2596.0	2794.0	6.4218	0.11042	2598.4	2797.1	6.3794	0.09963	2600.3	2799.5	6.3409
225	0.13287	2644.7	2857.3	6.5518	0.11673	2636.6	2846.7	6.4808	0.10377	2628.3	2835.8	6.4147
250	0.14184	2692.3	2919.2	6.6732	0.12497	2686.0	2911.0	6.6066	0.11144	2679.6	2902.5	6.5453
300	0.15862	2781.1	3034.8	6.8844	0.14021	2776.9	3029.2	6.8226	0.12547	2772.6	3023.5	6.7664
350	0.17456	2866.1	3145.4	7.0694	0.15457	2863.0	3141.2	7.0100	0.13857	2859.8	3137.0	6.9563
400	0.19005	2950.1	3254.2	7.2374	0.16847	2947.7	3250.9	7.1794	0.15120	2945.2	3247.6	7.1271
500	0.2203	3119.5	3472.0	7.5390	0.19550	3117.9	3469.8	7.4825	0.17568	3116.2	3467.6	7.4317
600	0.2500	3293.3	3693.2	7.8080	0.2220	3292.1	3691.7	7.7523	0.19960	3290.9	3690.1	7.7024
700	0.2794	3472.7	3919.7	8.0535	0.2482	3471.8	3918.5	7.9983	0.2232	3470.9	3917.4	7.9487
800	0.3086	3658.3	4152.1	8.2808	0.2742	3657.6	4151.2	8.2258	0.2467	3657.0	4150.3	8.1765



900	0.3377	3850.5	4390.8	8.4935	0.3001	3849.9	4390.1	8.4386	0.2700	3849.3	4389.4	8.3895
1000	0.3668	4049.0	4635.8	8.6938	0.3260	4048.5	4635.2	8.6391	0.2933	4048.0	4634.6	8.5901
1100	0.3958	4253.7	4887.0	8.8837	0.3518	4253.2	4886.4	8.8290	0.3166	4252.7	4885.9	8.7800
1200	0.4248	4464.2	5143.9	9.0643	0.3776	4463.7	5143.4	9.0096	0.3398	4463.3	5142.9	8.9607
1300	0.4538	4679.9	5406.0	9.2364	0.4034	4679.5	5405.6	9.1818	0.3631	4679.0	5405.1	9.1329

$P = 2.50 \text{ MPa } (T_{\text{sat}} = 223.99^\circ\text{C})$					$P = 3.00 \text{ MPa } (T_{\text{sat}} = 233.90^\circ\text{C})$				$P = 3.50 \text{ MPa } (T_{\text{sat}} = 242.60^\circ\text{C})$			
$T, ^\circ\text{C}$	$v, \text{ m}^3/\text{kg}$	$u, \text{ kJ/kg}$	$h, \text{ kJ/kg}$	$s, \text{ kJ/kgK}$	$v, \text{ m}^3/\text{kg}$	$u, \text{ kJ/kg}$	$h, \text{ kJ/kg}$	$s, \text{ kJ/kgK}$	$v, \text{ m}^3/\text{kg}$	$u, \text{ kJ/kg}$	$h, \text{ kJ/kg}$	$s, \text{ kJ/kgK}$
$T_{\text{sat}}$	0.07998	2603.1	2803.1	6.2575	0.06668	2604.1	2804.2	6.1869	0.05070	2603.7	2803.4	6.1253
225	0.08027	2605.6	2806.3	6.2639								
250	0.08700	2662.6	2880.1	6.4085	0.07058	2644.0	2855.8	6.2872	0.05872	2623.7	2829.2	6.1749
300	0.09890	2761.6	3008.8	6.6438	0.08114	2750.1	2993.5	6.5390	0.06842	2738	2977.5	6.4461
350	0.10976	2851.9	3126.3	6.8403	0.09053	2843.7	3115.3	6.7428	0.07678	2835.3	3104.0	6.6579
400	0.12010	2939.1	3239.3	7.0148	0.09936	2932.8	3230.9	6.9212	0.08453	2926.4	3222.3	6.8405
450	0.13014	3025.5	3350.8	7.1746	0.10787	3020.4	3344.0	7.0834	0.09196	3015.3	3337.2	7.0052
500	0.13993	3112.1	3462.1	7.3234	0.11619	3108.0	3456.5	7.2338	0.09918	3103.0	3450.9	7.1572
600	0.15930	3288.0	3686.3	7.5960	0.13243	3285.0	3682.3	7.5085	0.11324	3282.1	3678.4	7.4339
700	0.17832	3468.7	3914.5	7.8435	0.14838	3466.5	3911.7	7.7571	0.12699	3464.3	3908.8	7.6837
800	0.19716	3655.3	4148.2	8.0720	0.16414	3653.5	4145.9	7.9862	0.14056	3651.8	4143.7	7.9134
900	0.21590	3847.9	4387.6	8.2853	0.17980	3846.5	4385.9	8.1999	0.15402	3845.0	4384.1	8.1276
1000	0.2346	4046.7	4633.1	8.4861	0.19541	4045.4	4631.6	8.4009	0.16743	4044.1	4630.1	8.3288
1100	0.2532	4251.5	4884.6	8.6762	0.21098	4250.3	4883.3	8.5912	0.18080	4249.2	4881.9	8.5192
1200	0.2718	4462.1	5141.7	8.8569	0.22652	4460.9	5140.5	8.7720	0.19415	4459.8	5139.3	8.7000
1300	0.2905	4677.8	5404.0	9.0291	0.24206	4676.6	5402.8	8.9442	0.20749	4675.5	5401.7	8.8723

(continued)

(continued)

$P=4.0\text{ MPa } (T_{\text{sat}}=250.40\text{ }^{\circ}\text{C})$					$P=4.5\text{ MPa } (T_{\text{sat}}=257.49\text{ }^{\circ}\text{C})$				$P=5.0\text{ MPa } (T_{\text{sat}}=263.99\text{ }^{\circ}\text{C})$			
$T, \text{ }^{\circ}\text{C}$	$v, \text{ m}^3/\text{kg}$	$u, \text{ kJ/kg}$	$h, \text{ kJ/kg}$	$s, \text{ kJ/kgK}$	$v, \text{ m}^3/\text{kg}$	$u, \text{ kJ/kg}$	$h, \text{ kJ/kg}$	$s, \text{ kJ/kgK}$	$v, \text{ m}^3/\text{kg}$	$u, \text{ kJ/kg}$	$h, \text{ kJ/kg}$	$s, \text{ kJ/kgK}$
$T_{\text{sat}}$	0.04978	2602.3	2801.4	6.0701	0.04406	2600.1	2798.3	6.0198	0.03944	2597.1	2794.3	5.9734
275	0.05457	2667.9	2886.2	6.2285	0.04730	2650.3	2863.2	6.1401	0.04141	2631.3	2838.3	6.0544
300	0.05884	2725.3	2960.7	6.3615	0.05135	2712.0	2943.1	6.2828	0.04532	2698.0	2924.5	6.2084
350	0.06645	2826.7	3092.5	6.5821	0.05840	2817.8	3080.6	6.5131	0.05194	2808.7	3068.4	6.4493
400	0.07341	2919.9	3213.6	6.7690	0.06475	2913.3	3204.7	6.7047	0.05781	2906.6	3195.7	6.6459
450	0.08002	3010.2	3330.3	6.9363	0.07074	3005.0	3323.3	6.8746	0.06330	2999.7	3316.2	6.8186
500	0.08643	3099.5	3445.3	7.0901	0.07651	3095.3	3439.6	7.0301	0.06857	3091.0	3433.8	6.9759
600	0.09885	3279.1	3674.4	7.3688	0.08765	3276.0	3670.5	7.3110	0.07869	3273.0	3666.5	7.2589
700	0.11095	3462.1	3905.9	7.6198	0.09847	3459.9	3903.0	7.5631	0.08849	3457.6	3900.1	7.5122
800	0.12287	3650.0	4141.5	7.8502	0.10911	3648.3	4139.3	7.7942	0.09811	3646.6	4137.1	7.7440
900	0.13469	3843.6	4382.3	8.0647	0.11965	3842.2	4380.6	8.0091	0.10762	3840.7	4378.8	7.9593
1000	0.14645	4042.9	4628.7	8.2662	0.13013	4041.6	4627.2	8.2108	0.11707	4040.4	4625.7	8.1612
1100	0.15817	4248.0	4880.6	8.4567	0.14056	4246.8	4879.3	8.4015	0.12648	4245.6	4878.0	8.3520
1200	0.16987	4458.6	5138.1	8.6376	0.15098	4457.5	5136.9	8.5825	0.13587	4456.3	5135.7	8.5331
1300	0.18156	4674.3	5400.5	8.8100	0.16139	4673.1	5399.4	8.7549	0.14526	4672.0	5398.2	8.705

$P=6.0\text{ MPa } (T_{\text{sat}}=257.64\text{ }^{\circ}\text{C})$					$P=7.0\text{ MPa } (T_{\text{sat}}=285.88\text{ }^{\circ}\text{C})$				$P=8.0\text{ MPa } (T_{\text{sat}}=295.06\text{ }^{\circ}\text{C})$			
$T, \text{ }^{\circ}\text{C}$	$v, \text{ m}^3/\text{kg}$	$u, \text{ kJ/kg}$	$h, \text{ kJ/kg}$	$s, \text{ kJ/kgK}$	$v, \text{ m}^3/\text{kg}$	$u, \text{ kJ/kg}$	$h, \text{ kJ/kg}$	$s, \text{ kJ/kgK}$	$v, \text{ m}^3/\text{kg}$	$u, \text{ kJ/kg}$	$h, \text{ kJ/kg}$	$s, \text{ kJ/kgK}$
$T_{\text{sat}}$	0.03244	2589.7	2784.3	5.8892	0.02737	2580.5	2772.1	5.8133	0.02352	2569.8	2758.0	5.7432
300	0.03616	2667.2	2884.2	6.0674	0.02947	2632.2	2838.4	5.9305	0.02426	2590.9	2785.0	5.7906
350	0.04223	2789.6	3043.0	6.3335	0.03524	2769.4	3016.0	6.2283	0.02995	2747.7	2987.3	6.1301
400	0.04739	2892.9	3177.2	6.5408	0.03993	2878.6	3158.1	6.4478	0.03432	2863.8	3138.3	6.3634
450	0.05214	2988.9	3301.8	6.7193	0.04416	2978.0	3287.1	6.6327	0.03817	2966.7	3272.0	6.5551
500	0.05665	3082.2	3422.2	6.8803	0.04814	3073.4	3410.3	6.7975	0.04175	3064.3	3398.3	6.7240
550	0.06101	3174.6	3540.6	7.0288	0.05195	3167.2	3530.9	6.9486	0.04516	3159.8	3521.0	6.8778
600	0.06525	3266.9	3658.4	7.1677	0.05565	3260.7	3650.3	7.0894	0.04845	3254.4	3642.0	7.0206
700	0.07352	3453.1	3894.2	7.4234	0.06283	3448.5	3888.3	7.3476	0.05481	3443.9	3882.4	7.2812
800	0.0816	3643.1	4132.7	7.6566	0.06981	3639.5	4128.2	7.5822	0.06097	3636.0	4123.8	7.5173
900	0.08958	3837.8	4375.3	7.8727	0.07669	3835.0	4371.8	7.7991	0.06702	3832.1	4368.3	7.7351
1000	0.09749	4037.8	4622.7	8.0751	0.08350	4035.3	4619.8	8.0020	0.07301	4032.8	4616.9	7.9384

1100	0.10536	4243.3	4875.4	8.2661	0.09027	4240.9	4872.8	8.1933	0.07896	4238.6	4870.3	8.1300
1200	0.11321	4454.0	5133.3	8.4474	0.09703	4451.7	5130.9	8.3747	0.08489	4449.5	5128.5	8.3115
1300	0.12106	4669.6	5396.0	8.6199	0.10377	4667.3	5393.7	8.5475	0.09080	4665.0	5391.5	8.4842

$P=9.0\text{ MPa } (T_{\text{sat}}=303.4\text{ }^{\circ}\text{C})$					$P=10.0\text{ MPa } (T_{\text{sat}}=311.06\text{ }^{\circ}\text{C})$				$P=12.5\text{ MPa } (T_{\text{sat}}=327.89\text{ }^{\circ}\text{C})$			
$T, \text{ }^{\circ}\text{C}$	$v, \text{ m}^3/\text{kg}$	$u, \text{ kJ/kg}$	$h, \text{ kJ/kg}$	$s, \text{ kJ/kgK}$	$v, \text{ m}^3/\text{kg}$	$u, \text{ kJ/kg}$	$h, \text{ kJ/kg}$	$s, \text{ kJ/kgK}$	$v, \text{ m}^3/\text{kg}$	$u, \text{ kJ/kg}$	$h, \text{ kJ/kg}$	$s, \text{ kJ/kgK}$
$T_{\text{sat}}$	0.02048	2557.8	2742.1	5.6772	0.018026	2544.4	2724.7	5.6141	0.013495	2505.1	2673.8	5.4624
325	0.02327	2646.6	2856.0	5.8712	0.019861	2610.4	2809.1	5.7568				
350	0.02580	2724.4	2956.6	6.0361	0.02242	2699.2	2923.4	5.9443	0.016126	2624.6	2826.2	5.7118
400	0.02993	2848.4	3117.8	6.2854	0.02641	2832.4	3096.5	6.2120	0.02000	2789.3	3039.3	6.0417
450	0.03350	2955.2	3256.6	6.4844	0.02975	2943.4	3240.9	6.4190	0.02299	2912.5	3199.8	6.2719
500	0.03677	3055.2	3386.1	6.6576	0.03279	3045.8	3373.7	6.5966	0.02560	3021.7	3341.8	6.4618
550	0.03987	3152.2	3511.0	6.8142	0.03564	3144.6	3500.9	6.7561	0.02801	3125.0	3475.2	6.6290
600	0.04285	3248.1	3633.7	6.9589	0.03837	3241.7	3625.3	6.9029	0.03029	3225.4	3604.0	6.7810
650	0.04574	3343.6	3755.3	7.0943	0.04101	3338.2	3748.2	7.0398	0.03248	3324.4	3730.4	6.9218
700	0.04857	3439.3	3876.5	7.2221	0.04358	3434.7	3870.5	7.1687	0.03460	3422.9	3855.3	7.0536
800	0.05409	3632.5	4119.3	7.4596	0.04859	3628.9	4114.8	7.4077	0.03869	3620.0	4103.6	7.2965
900	0.05950	3829.2	4364.8	7.6783	0.05349	3826.3	4361.2	7.6272	0.04267	3819.1	4352.5	7.5182
1000	0.06485	4030.3	4614.0	7.8821	0.05832	4027.8	4611.0	7.8315	0.04658	4021.6	4603.8	7.7237
1100	0.07016	4236.3	4867.7	8.0740	0.06312	4234.0	4865.1	8.0237	0.05045	4228.2	4858.8	7.9165
1200	0.07544	4447.2	5126.2	8.2556	0.06789	4444.9	5123.8	8.2055	0.05430	4439.3	5118.0	8.0937
1300	0.08072	4662.7	5389.2	8.4284	0.07265	4460.5	5387.0	8.3783	0.05813	4654.8	5381.4	8.2717

$P=15.0\text{ MPa } (T_{\text{sat}}=342.24\text{ }^{\circ}\text{C})$					$P=17.5\text{ MPa } (T_{\text{sat}}=354.75\text{ }^{\circ}\text{C})$				$P=20.0\text{ MPa } (T_{\text{sat}}=365.81\text{ }^{\circ}\text{C})$			
$T, \text{ }^{\circ}\text{C}$	$v, \text{ m}^3/\text{kg}$	$u, \text{ kJ/kg}$	$h, \text{ kJ/kg}$	$s, \text{ kJ/kgK}$	$v, \text{ m}^3/\text{kg}$	$u, \text{ kJ/kg}$	$h, \text{ kJ/kg}$	$s, \text{ kJ/kgK}$	$v, \text{ m}^3/\text{kg}$	$u, \text{ kJ/kg}$	$h, \text{ kJ/kg}$	$s, \text{ kJ/kgK}$
$T_{\text{sat}}$	0.010337	2455.5	2610.5	5.3098	0.007920	2390.2	2528.8	5.1419	0.005834	2293.0	2409.7	4.9269
350	0.011470	2520.4	2692.4	5.4421								
400	0.015649	2740.7	2975.5	5.8811	0.012447	2685.0	2902.9	5.7213	0.009942	2619.3	2818.1	5.5540
450	0.018445	2879.5	3156.2	6.1404	0.015174	2844.2	3109.7	6.0184	0.012695	2806.2	3060.1	5.9017

(continued)

(continued)

$P = 15.0 \text{ MPa } (T_{\text{sat}} = 342.24 \text{ }^{\circ}\text{C})$					$P = 17.5 \text{ MPa } (T_{\text{sat}} = 354.75 \text{ }^{\circ}\text{C})$				$P = 20.0 \text{ MPa } (T_{\text{sat}} = 365.81 \text{ }^{\circ}\text{C})$			
$T, \text{ }^{\circ}\text{C}$	$v, \text{ m}^3/\text{kg}$	$u, \text{ kJ/kg}$	$h, \text{ kJ/kg}$	$s, \text{ kJ/kgK}$	$v, \text{ m}^3/\text{kg}$	$u, \text{ kJ/kg}$	$h, \text{ kJ/kg}$	$s, \text{ kJ/kgK}$	$v, \text{ m}^3/\text{kg}$	$u, \text{ kJ/kg}$	$h, \text{ kJ/kg}$	$s, \text{ kJ/kgK}$
500	0.02080	2996.6	3308.6	6.3443	0.017358	2970.3	3274.1	6.2383	0.014768	2942.9	3238.2	6.1401
550	0.02293	3104.7	3448.6	6.5199	0.019288	3083.9	3421.4	6.4230	0.016555	3062.4	3393.5	6.3348
600	0.02491	3208.6	3582.3	6.6776	0.02106	3191.5	3560.1	6.5866	0.018178	3174.0	3537.6	6.5048
650	0.02680	3310.3	3712.3	6.8224	0.02274	3296.0	3693.9	6.7357	0.019693	3281.4	3675.3	6.6582
700	0.02861	3410.9	3840.1	6.9572	0.02434	3398.7	3824.6	6.8736	0.02113	3386.4	3809.0	6.7993
800	0.03210	3610.9	4092.4	7.2040	0.02738	3601.8	4081.1	7.1244	0.02385	3592.7	4069.7	7.0544
900	0.03546	3811.9	4343.8	7.4279	0.03031	3804.7	4335.1	7.3507	0.02645	3797.5	4326.4	7.2830
1000	0.03875	4015.4	4596.6	7.6348	0.03316	4009.3	4589.5	7.5589	0.02897	4003.1	4582.5	7.4925
1100	0.04200	4222.6	4852.6	7.8283	0.03597	4216.9	4846.4	7.7531	0.03145	4211.3	4840.2	7.6874
1200	0.04523	4433.8	5112.3	8.0108	0.03876	4428.3	5106.6	7.9360	0.03391	4422.8	5101.0	7.8707
1300	0.04845	4649.1	5376.0	8.1840	0.04154	4643.5	5370.5	8.1093	0.03636	4638.0	5365.1	8.0442

$P = 25.0 \text{ MPa}$					$P = 30.0 \text{ MPa}$				$P = 35.0 \text{ MPa}$			
$T, \text{ }^{\circ}\text{C}$	$v, \text{ m}^3/\text{kg}$	$u, \text{ kJ/kg}$	$h, \text{ kJ/kg}$	$s, \text{ kJ/kgK}$	$v, \text{ m}^3/\text{kg}$	$u, \text{ kJ/kg}$	$h, \text{ kJ/kg}$	$s, \text{ kJ/kgK}$	$v, \text{ m}^3/\text{kg}$	$u, \text{ kJ/kg}$	$h, \text{ kJ/kg}$	$s, \text{ kJ/kgK}$
375	0.0019731	1798.7	1848.0	4.0320	0.0017892	1737.8	1791.5	3.9305	0.0017003	1702.9	1762.4	3.8722
400	0.006004	2430.1	2580.2	5.1418	0.002790	2067.4	2151.1	4.4728	0.002100	1914.1	1987.6	4.2126
425	0.007881	2609.2	2806.3	5.4723	0.005303	2455.1	2614.2	5.1504	0.003428	2253.4	2373.4	4.7747
450	0.009162	2720.7	2949.7	5.6744	0.006735	2619.3	2821.4	5.4424	0.004961	2498.7	2672.4	5.1962
500	0.011123	2884.3	3162.4	5.9592	0.008678	2820.7	3081.1	5.7905	0.006927	2751.9	2994.4	5.6282
550	0.012724	3017.5	3335.6	6.1765	0.010168	2970.3	3275.4	6.0342	0.008345	2921.0	3213.0	5.9026
600	0.014137	3137.9	3491.4	6.3602	0.011446	3100.5	3443.9	6.2331	0.009527	3062.0	3395.5	6.1179
650	0.015433	3251.6	3637.4	6.5229	0.012596	3221.0	3598.9	6.4058	0.010575	3189.8	3559.9	6.3010
700	0.016646	3361.3	3777.5	6.6707	0.013661	3335.8	3745.6	6.5606	0.011533	3309.8	3713.5	6.4631
800	0.018912	3574.3	4047.1	6.9345	0.015623	3555.5	4024.2	6.8332	0.013278	3536.7	4001.5	6.7450
900	0.021045	3783.0	4309.1	7.1680	0.017448	3768.5	4291.9	7.0718	0.014883	3754.0	4274.9	6.9386
1000	0.02310	3990.9	4568.5	7.3802	0.019196	3978.8	4554.7	7.2867	0.016410	3966.7	4541.1	7.2064
1100	0.02512	4200.2	4828.2	7.5765	0.020903	4189.2	4816.3	7.4845	0.017895	4178.3	4804.6	7.4037
1200	0.02711	4412.0	5089.9	7.7605	0.022589	4401.3	5079.0	7.6692	0.019360	4390.7	5068.3	7.5910
1300	0.02910	4626.9	5354.4	7.9342	0.024266	4616.0	5344.0	7.8432	0.020815	4605.1	5333.6	7.7653

$P=40.0\text{ MPa}$					$P=50.0\text{ MPa}$				$P=60.0\text{ MPa}$			
$T, ^\circ\text{C}$	$v, \text{m}^3/\text{kg}$	$u, \text{kJ/kg}$	$h, \text{kJ/kg}$	$s, \text{kJ/kgK}$	$v, \text{m}^3/\text{kg}$	$u, \text{kJ/kg}$	$h, \text{kJ/kg}$	$s, \text{kJ/kgK}$	$v, \text{m}^3/\text{kg}$	$u, \text{kJ/kg}$	$h, \text{kJ/kg}$	$s, \text{kJ/kgK}$
375	0.0016407	1677.1	1742.8	3.8290	0.0015594	1638.6	1716.6	3.7639	0.0015028	1609.4	1699.5	3.7141
400	0.0019077	1854.6	1930.9	4.1135	0.0017309	1788.1	1874.6	4.0031	0.0016335	1745.4	1843.4	3.9318
425	0.002532	2096.9	2198.1	4.5029	0.002007	1959.7	2060.0	4.2734	0.0018165	1892.7	2001.7	4.1626
450	0.003693	2365.1	2512.8	4.9459	0.002486	2159.6	2284.0	4.5884	0.002085	2053.9	2179.0	4.4121
500	0.005622	2678.4	2903.3	5.4700	0.003892	2525.5	2720.1	5.1726	0.002956	2390.6	2567.9	4.9321
550	0.006984	2869.7	3149.1	5.7785	0.005118	2763.6	3019.5	5.5485	0.003956	2658.8	2896.2	5.3441
600	0.008094	3022.6	3346.4	6.0144	0.006112	2942.0	3247.6	5.8178	0.004834	2861.1	3151.2	5.6452
650	0.009063	3158.0	3520.6	6.2054	0.006966	3093.5	3441.8	6.0342	0.005595	3028.8	3364.5	5.8829
700	0.009941	3283.6	3681.2	6.3750	0.007727	3230.5	3616.8	6.2189	0.006272	3177.2	3553.5	6.0824
800	0.011523	3517.8	3978.7	6.6662	0.009076	3479.8	3933.6	6.5290	0.007459	3441.5	3889.1	6.4109
900	0.012962	3739.4	4257.9	6.9150	0.010283	3710.3	4224.4	6.7882	0.008505	3681.0	4191.5	6.6805
1000	0.014324	3954.6	4527.6	7.1356	0.011411	3930.5	4501.1	7.0146	0.009480	3906.4	4475.2	6.9127
1100	0.015642	4167.4	4793.1	7.3364	0.012496	4145.7	4770.5	7.2184	0.010409	4124.1	4748.6	7.1195
1200	0.016940	4380.1	5057.7	7.5224	0.013561	4359.1	5037.2	7.4058	0.011317	4338.2	5017.2	7.3083
1300	0.018229	4594.3	5323.5	7.6969	0.014616	4572.8	5303.6	7.5808	0.012215	4551.4	5284.3	7.483

## Appendix 8d: Properties of Subcooled Water

$P=5.0\text{ MPa } (T_{\text{sat}}=263.99^\circ\text{C})$					$P=10.0\text{ MPa } (T_{\text{sat}}=311.06^\circ\text{C})$				$P=15.0\text{ MPa } (T_{\text{sat}}=342.24^\circ\text{C})$			
$T, ^\circ\text{C}$	$v, \text{m}^3/\text{kg}$	$u, \text{kJ/kg}$	$h, \text{kJ/kg}$	$s, \text{kJ/kgK}$	$v, \text{m}^3/\text{kg}$	$u, \text{kJ/kg}$	$h, \text{kJ/kg}$	$s, \text{kJ/kgK}$	$v, \text{m}^3/\text{kg}$	$u, \text{kJ/kg}$	$h, \text{kJ/kg}$	$s, \text{kJ/kgK}$
Sat.	0.0012859	1147.8	1154.2	2.9202	0.0014524	1393.0	1407.6	3.3596	0.0016581	1585.60	1610.5	3.6848
0	0.0009977	0.0	5.0	0.0001	0.0009952	0.1	10.0	0.0002	0.0009928	0.15	15.1	0.0004
20	0.0009995	83.7	88.7	0.2956	0.0009972	83.4	93.3	0.2945	0.0009950	83.06	98.0	0.2934
40	0.0010056	167.0	172.0	0.5705	0.0010034	166.4	176.4	0.5686	0.0010013	165.76	180.8	0.5666
60	0.0010149	250.2	255.3	0.8285	0.0010127	249.4	259.5	0.8258	0.0010105	248.51	263.7	0.8232
80	0.0010268	333.7	338.9	1.0720	0.0010245	332.6	342.8	1.0688	0.0010222	331.48	346.8	1.0656
100	0.0010410	417.5	422.7	1.3030	0.0010385	416.1	426.5	1.2992	0.0010361	414.74	430.3	1.2955
120	0.0010576	501.8	507.1	1.5233	0.0010549	500.1	510.6	1.5189	0.0010522	498.40	514.2	1.5145
140	0.0010768	586.8	592.2	1.7343	0.0010737	584.7	595.4	1.7292	0.0010707	582.66	598.7	1.7242
160	0.0010988	672.6	678.1	1.9375	0.0010953	670.1	681.1	1.9317	0.0010918	667.71	684.1	1.9260
180	0.0011240	759.6	765.3	2.1341	0.0011199	756.7	767.8	2.1275	0.0011159	753.76	770.5	2.1210
200	0.0011530	848.1	853.9	2.3255	0.0011480	844.5	856.0	2.3178	0.0011433	841.00	858.2	2.3104

(Continued)

(continued)

$P=5.0\text{ MPa}$ ( $T_{\text{sat}}=263.99\text{ }^{\circ}\text{C}$ )					$P=10.0\text{ MPa}$ ( $T_{\text{sat}}=311.06\text{ }^{\circ}\text{C}$ )				$P=15.0\text{ MPa}$ ( $T_{\text{sat}}=342.24\text{ }^{\circ}\text{C}$ )			
$T, \text{ }^{\circ}\text{C}$	$v, \text{ m}^3/\text{kg}$	$u, \text{ kJ/kg}$	$h, \text{ kJ/kg}$	$s, \text{ kJ/kgK}$	$v, \text{ m}^3/\text{kg}$	$u, \text{ kJ/kg}$	$h, \text{ kJ/kg}$	$s, \text{ kJ/kgK}$	$v, \text{ m}^3/\text{kg}$	$u, \text{ kJ/kg}$	$h, \text{ kJ/kg}$	$s, \text{ kJ/kgK}$
220	0.0011866	938.4	944.4	2.5128	0.0011805	934.1	945.9	2.5039	0.0011748	929.90	947.5	2.4953
240	0.0012264	1031.4	1037.5	2.6979	0.0012187	1026.0	1038.1	2.6872	0.0012114	1020.80	1039.0	2.6771
260	0.0012749	1127.9	1134.3	2.8830	0.0012645	1121.1	1133.7	2.8699	0.0012550	1114.60	1133.4	2.8576
280					0.0013216	1220.9	1234.1	3.0548	0.0013084	1212.50	1232.1	3.0393
300					0.0013972	1328.4	1342.3	3.2469	0.0013770	1316.60	1337.3	3.2260
320									0.0014724	1431.10	1453.2	3.4247
340									0.0016311	1567.50	1591.9	3.6546

$P=20.0\text{ MPa}$ ( $T_{\text{sat}}=365.81\text{ }^{\circ}\text{C}$ )					$P=30.0\text{ MPa}$				$P=50.0\text{ MPa}$			
$T, \text{ }^{\circ}\text{C}$	$v, \text{ m}^3/\text{kg}$	$u, \text{ kJ/kg}$	$h, \text{ kJ/kg}$	$s, \text{ kJ/kgK}$	$v, \text{ m}^3/\text{kg}$	$u, \text{ kJ/kg}$	$h, \text{ kJ/kg}$	$s, \text{ kJ/kgK}$	$v, \text{ m}^3/\text{kg}$	$u, \text{ kJ/kg}$	$h, \text{ kJ/kg}$	$s, \text{ kJ/kgK}$
Sat.	0.002036	1785.6	1826.3	4.0139								
0	0.0009904	0.2	20.0	0.0004	0.0009856	0.3	29.8	0.0001	0.0009766	0.20	49.0	0.0014
20	0.0009928	82.8	102.6	0.2923	0.0009886	82.2	111.8	0.2899	0.0009804	81.00	130.0	0.2848
40	0.0009992	165.2	185.2	0.5646	0.0009951	164.0	193.9	0.5607	0.0009872	161.86	211.2	0.5527
60	0.0010084	247.7	267.9	0.8206	0.0010042	246.1	276.2	0.8154	0.0009962	242.98	292.8	0.8052
80	0.0010199	330.4	350.8	1.0624	0.0010156	328.3	358.8	1.0561	0.0010073	324.34	374.7	1.0440
100	0.0010337	413.4	434.1	1.2917	0.0010290	410.8	441.7	1.2844	0.0010201	405.88	456.9	1.2703
120	0.0010496	496.8	517.8	1.5102	0.0010445	493.6	524.9	1.5018	0.0010348	487.65	539.4	1.4857
140	0.0010678	580.7	602.0	1.7193	0.0010621	576.9	608.8	1.7098	0.0010515	569.77	622.4	1.6915
160	0.0010885	665.4	687.1	1.9204	0.0010821	660.8	693.3	1.9096	0.0010703	652.41	705.9	1.8891
180	0.0011120	751.0	773.2	2.1147	0.0011047	745.6	778.7	2.1024	0.0010912	735.69	790.3	2.0794
200	0.0011388	837.7	860.5	2.3031	0.0011302	831.4	865.3	2.2893	0.0011146	819.70	875.5	2.2634
220	0.0011695	925.9	949.3	2.4870	0.0011590	918.3	953.1	2.4711	0.0011408	904.70	961.7	2.4419
240	0.0012046	1016.0	1040.0	2.6674	0.0011920	1006.9	1042.6	2.6490	0.0011702	990.70	1049.2	2.6158
260	0.0012462	1108.6	1133.5	2.8459	0.0012303	1097.4	1134.3	2.8243	0.0012034	1078.10	1138.2	2.7860
280	0.0012965	1204.7	1230.6	3.0248	0.0012755	1190.7	1229.0	2.9986	0.0012415	1167.20	1229.3	2.9537
300	0.0013596	1306.1	1333.3	3.2071	0.0013307	1287.9	1327.8	3.1741	0.0012860	1258.70	1323.0	3.1200
320	0.0014437	1415.7	1444.6	3.3979	0.0013997	1390.7	1432.7	3.3539	0.0013388	1353.30	1420.2	3.2868
340	0.0015684	1539.7	1571.0	3.6075	0.0014920	1501.7	1546.5	3.5426	0.0014032	1452.00	1522.1	3.4557
360	0.0018226	1702.8	1739.3	3.8772	0.0016265	1626.6	1675.4	3.7494	0.0014838	1556.00	1630.2	3.6291
380					0.0018691	1781.4	1837.5	4.0012	0.0015884	1667.20	1746.6	3.8101

# Appendix 9: Properties of R-134a

**Appendix 9a: Properties of Saturated R-134a (Temperature Table)**

Temp., °C	Pressure, MPa	Specific volume, m <sup>3</sup> /kg		Internal energy, kJ/kg		Enthalpy, kJ/kg		Entropy, kJ/ kgK	
$T_{\text{sat}}$	$P$	$v_f$	$v_g$	$u_f$	$u_g$	$h_f$	$h_g$	$s_f$	$s_g$
−24	0.11160	0.0007296	0.1728	19.21	213.57	19.29	232.85	0.0798	0.9370
−22	0.12192	0.0007328	0.1590	21.68	214.70	21.77	234.08	0.0897	0.9351
−20	0.13299	0.0007361	0.1464	24.17	215.84	24.26	235.31	0.0996	0.9332
−18	0.14483	0.0007395	0.1350	26.67	216.97	26.77	236.53	0.1094	0.9315
−16	0.15748	0.0007428	0.1247	29.18	218.10	29.30	237.74	0.1192	0.9298
−12	0.18540	0.0007498	0.1068	34.25	220.36	34.39	240.15	0.1388	0.9267
−8	0.21704	0.0007569	0.0919	39.38	222.60	39.54	242.54	0.1583	0.9239
−4	0.25274	0.0007644	0.0794	44.56	224.84	44.75	244.90	0.1777	0.9213
0	0.29282	0.0007721	0.0689	49.79	227.06	50.02	247.23	0.1970	0.9190
4	0.33765	0.0007801	0.0600	55.08	229.27	55.35	249.53	0.2162	0.9169
8	0.38756	0.0007884	0.0525	60.43	231.46	60.73	251.80	0.2354	0.9150
12	0.44294	0.0007971	0.0460	65.83	233.63	66.18	254.03	0.2545	0.9132
16	0.50416	0.0008062	0.0405	71.29	235.78	71.69	256.22	0.2735	0.9116
20	0.57160	0.0008157	0.0358	76.80	237.91	77.26	258.35	0.2924	0.9102
24	0.64566	0.0008257	0.0317	82.37	240.01	82.90	260.45	0.3113	0.9089
26	0.68530	0.0008309	0.0298	85.18	241.05	85.75	261.48	0.3208	0.9082
28	0.72675	0.0008362	0.0281	88.00	242.08	88.61	262.50	0.3302	0.9076
30	0.77006	0.0008417	0.0265	90.84	243.10	91.49	263.50	0.3396	0.9070
32	0.81528	0.0008473	0.0250	93.70	244.12	94.39	264.48	0.3490	0.9064
34	0.86247	0.0008530	0.0236	96.58	245.12	97.31	265.45	0.3584	0.9058
36	0.91168	0.0008590	0.0223	99.47	246.11	100.25	266.40	0.3678	0.9053
38	0.96298	0.0008651	0.0210	102.38	247.09	103.21	267.33	0.3772	0.9047
40	1.0164	0.0008714	0.0199	105.30	248.06	106.19	268.24	0.3866	0.9041
42	1.0720	0.0008780	0.0188	108.25	249.02	109.19	269.14	0.3960	0.9035
44	1.1299	0.0008847	0.0177	111.22	249.96	112.22	270.01	0.4054	0.9030
48	1.2526	0.0008989	0.0159	117.22	251.79	118.35	271.68	0.4243	0.9017
52	1.3851	0.0009142	0.0142	123.31	253.55	124.58	273.24	0.4432	0.9004
56	1.5278	0.0009308	0.0127	129.51	255.23	130.93	274.68	0.4622	0.8990
60	1.6813	0.0009488	0.0114	135.82	256.81	137.42	275.99	0.4814	0.8973
70	2.1162	0.0010027	0.0086	152.22	260.15	154.34	278.43	0.5302	0.8918
80	2.6324	0.0010766	0.0064	169.88	262.14	172.71	279.12	0.5814	0.8827
90	3.2435	0.0011949	0.0046	189.82	261.34	193.69	276.32	0.6380	0.8655
100	3.9742	0.0015443	0.0027	218.60	248.49	224.74	259.13	0.7196	0.8117

Appendix 9b: Properties of Saturated R-134a (Pressure Table)

Pressure, MPa	Temp., °C	Specific volume, m <sup>3</sup> /kg		Internal energy, kJ/kg		Enthalpy, kJ/kg		Entropy, kJ/ kgK	
<i>P</i>	<i>T<sub>sat</sub></i>	<i>v<sub>f</sub></i>	<i>v<sub>g</sub></i>	<i>u<sub>f</sub></i>	<i>u<sub>g</sub></i>	<i>h<sub>f</sub></i>	<i>h<sub>g</sub></i>	<i>s<sub>f</sub></i>	<i>s<sub>g</sub></i>
0.06	−37.07	0.000710	0.3100	3.41	206.12	3.46	224.72	0.0147	0.9520
0.08	−31.21	0.000718	0.2366	10.41	209.46	10.47	228.39	0.044	0.9447
0.10	−26.43	0.000726	0.1917	16.22	212.18	16.29	231.35	0.0678	0.9395
0.12	−22.36	0.000732	0.1614	21.23	214.50	21.32	233.86	0.0879	0.9354
0.14	−18.80	0.000738	0.1395	25.66	216.52	25.77	236.04	0.1055	0.9322
0.16	−15.62	0.000744	0.1229	29.66	218.32	29.78	237.97	0.1211	0.9295
0.18	−12.73	0.000749	0.1098	33.31	219.94	33.45	239.71	0.1352	0.9273
0.20	−10.09	0.000753	0.0993	36.69	221.43	36.84	241.30	0.1481	0.9253
0.24	−5.37	0.000762	0.0834	42.77	224.07	42.95	244.09	0.171	0.9222
0.28	−1.23	0.000770	0.0719	48.18	226.38	48.39	246.52	0.1911	0.9197
0.32	2.48	0.000777	0.0632	53.06	228.43	53.31	248.66	0.2089	0.9177
0.36	5.84	0.000784	0.0564	57.54	230.28	57.82	250.58	0.2251	0.9160
0.40	8.93	0.000790	0.0509	61.69	231.97	62.00	252.32	0.2399	0.9145
0.50	15.74	0.000806	0.0409	70.93	235.64	71.33	256.07	0.2723	0.9117
0.60	21.58	0.000820	0.0341	78.99	238.74	79.48	259.19	0.2999	0.9097
0.70	26.72	0.000833	0.0292	86.19	241.42	86.78	261.85	0.3242	0.9080
0.80	31.33	0.000845	0.0255	92.75	243.78	93.42	264.15	0.3459	0.9066
0.90	35.53	0.000858	0.0226	98.79	245.88	99.56	266.18	0.3656	0.9054
1.00	39.39	0.000870	0.0202	104.42	247.77	105.29	267.97	0.3838	0.9043
1.20	46.32	0.000893	0.0166	114.69	251.03	115.76	270.99	0.4164	0.9023
1.40	52.43	0.000916	0.0140	123.98	253.74	125.26	273.40	0.4453	0.9003
1.60	57.92	0.000939	0.0121	132.52	256.00	134.02	275.33	0.4714	0.8982
1.80	62.91	0.000963	0.0105	140.49	257.88	142.22	276.83	0.4954	0.8959
2.00	67.49	0.000988	0.0093	148.02	259.41	149.99	277.94	0.5178	0.8934
2.50	77.59	0.001056	0.0069	165.48	261.84	168.12	279.17	0.5687	0.8854
3.00	86.22	0.001142	0.0053	181.88	262.16	185.30	278.01	0.6156	0.8735



Appendix 9c: Properties of Superheated R-134a

<i>P</i> = 0.06 MPa ( <i>T</i> <sub>sat</sub> = −37.07 °C)					<i>P</i> = 0.10 MPa ( <i>T</i> <sub>sat</sub> = −26.43 °C)				<i>P</i> = 0.14 MPa ( <i>T</i> <sub>sat</sub> = −18.08 °C)			
<i>T</i> , °C	<i>v</i> , m <sup>3</sup> /kg	<i>u</i> , kJ/kg	<i>h</i> , kJ/kg	<i>s</i> , kJ/kgK	<i>v</i> , m <sup>3</sup> /kg	<i>u</i> , kJ/kg	<i>h</i> , kJ/kg	<i>s</i> , kJ/kgK	<i>v</i> , m <sup>3</sup> /kg	<i>u</i> , kJ/kg	<i>h</i> , kJ/kg	<i>s</i> , kJ/kgK
<i>T</i> <sub>sat</sub>	0.31003	206.12	224.72	0.9520	0.19170	212.18	231.35	0.9395	0.13945	216.52	236.04	0.9322
−20	0.33536	217.86	237.98	1.0062	0.19770	216.77	236.54	0.9602				
−10	0.34992	224.97	245.96	1.0371	0.20686	224.01	244.70	0.9918	0.14549	223.03	243.40	0.9606
0	0.36433	232.24	254.10	1.0675	0.21587	231.41	252.99	1.0227	0.15219	230.55	251.86	0.9922
10	0.37861	239.69	262.41	1.0973	0.22473	238.96	261.43	1.0531	0.15875	238.21	260.43	1.0230
20	0.39279	247.32	270.89	1.1267	0.23349	246.67	270.02	1.0829	0.16520	246.01	269.13	1.0532
30	0.40688	255.12	279.53	1.1557	0.24216	254.54	278.76	1.1122	0.17155	253.96	277.97	1.0828
40	0.42091	263.10	288.35	1.1844	0.25076	262.58	287.66	1.1411	0.17783	262.06	286.96	1.1120
50	0.43487	271.25	297.34	1.2126	0.25930	270.79	296.72	1.1696	0.18404	270.32	296.09	1.1407
60	0.44879	279.58	306.51	1.2405	0.26779	279.16	305.94	1.1977	0.19020	278.74	305.37	1.1690
70	0.46266	288.08	315.84	1.2681	0.27623	287.70	315.32	1.2254	0.19633	287.32	314.80	1.1969
80	0.47650	296.75	325.34	1.2954	0.28464	296.40	324.87	1.2528	0.20241	296.06	324.39	1.2244
90	0.49031	305.58	335.00	1.3224	0.29302	305.27	334.57	1.2799	0.20846	304.95	334.14	1.2516
100									0.21449	314.01	344.04	1.2785

<i>P</i> = 0.18 MPa ( <i>T</i> <sub>sat</sub> = −12.73 °C)					<i>P</i> = 0.20 MPa ( <i>T</i> <sub>sat</sub> = −10.09 °C)				<i>P</i> = 0.24 MPa ( <i>T</i> <sub>sat</sub> = −5.37 °C)			
<i>T</i> , °C	<i>v</i> , m <sup>3</sup> /kg	<i>u</i> , kJ/kg	<i>h</i> , kJ/kg	<i>s</i> , kJ/kgK	<i>v</i> , m <sup>3</sup> /kg	<i>u</i> , kJ/kg	<i>h</i> , kJ/kg	<i>s</i> , kJ/kgK	<i>v</i> , m <sup>3</sup> /kg	<i>u</i> , kJ/kg	<i>h</i> , kJ/kg	<i>s</i> , kJ/kgK
<i>T</i> <sub>sat</sub>	0.10983	219.94	239.71	0.9273	0.09933	221.43	241.30	0.9253	0.08343	224.07	244.09	0.9222
−10	0.11135	222.02	242.06	0.9362	0.09938	221.50	241.38	0.9256				
0	0.11678	229.67	250.69	0.9684	0.10438	229.23	250.10	0.9582	0.08574	228.31	248.89	0.9399
10	0.12207	237.44	259.41	0.9998	0.10922	237.05	258.89	0.9898	0.08993	236.26	257.84	0.9721
20	0.12723	245.33	268.23	1.0304	0.11394	244.99	267.78	1.0206	0.09339	244.30	266.85	1.0034
30	0.13230	253.36	277.17	1.0604	0.11856	253.06	276.77	1.0508	0.09794	252.45	275.95	1.0339
40	0.13730	261.53	286.24	1.0898	0.12311	261.26	285.88	1.0804	0.10181	260.72	285.16	1.0637
50	0.14222	269.85	295.45	1.1187	0.12758	269.61	295.12	1.1094	0.10562	269.12	294.47	1.0930

(continued)

(continued)

$P=0.18\text{ MPa } (T_{\text{sat}}=-12.73\text{ }^{\circ}\text{C})$					$P=0.20\text{ MPa } (T_{\text{sat}}=-10.09\text{ }^{\circ}\text{C})$				$P=0.24\text{ MPa } (T_{\text{sat}}=-5.37\text{ }^{\circ}\text{C})$			
$T, \text{ }^{\circ}\text{C}$	$v, \text{ m}^3/\text{kg}$	$u, \text{ kJ/kg}$	$h, \text{ kJ/kg}$	$s, \text{ kJ/kgK}$	$v, \text{ m}^3/\text{kg}$	$u, \text{ kJ/kg}$	$h, \text{ kJ/kg}$	$s, \text{ kJ/kgK}$	$v, \text{ m}^3/\text{kg}$	$u, \text{ kJ/kg}$	$h, \text{ kJ/kg}$	$s, \text{ kJ/kgK}$
60	0.14710	278.31	304.79	1.1472	0.13201	278.10	304.50	1.1380	0.10937	277.67	303.91	1.1218
70	0.15193	286.93	314.28	1.1753	0.13639	286.74	314.02	1.1661	0.11307	286.35	313.49	1.1501
80	0.15672	295.71	323.92	1.2030	0.14073	295.53	323.68	1.1939	0.11674	295.18	323.19	1.1780
90	0.16148	304.63	333.70	1.2303	0.14504	304.47	333.48	1.2212	0.12037	304.15	333.04	1.2055
100	0.16622	313.72	343.63	1.2573	0.14932	313.57	343.43	1.2483	0.12398	313.27	343.03	1.2326

$P=0.28\text{ MPa } (T_{\text{sat}}=-1.23\text{ }^{\circ}\text{C})$					$P=0.32\text{ MPa } (T_{\text{sat}}=2.48\text{ }^{\circ}\text{C})$				$P=0.40\text{ MPa } (T_{\text{sat}}=8.93\text{ }^{\circ}\text{C})$			
$T, \text{ }^{\circ}\text{C}$	$v, \text{ m}^3/\text{kg}$	$u, \text{ kJ/kg}$	$h, \text{ kJ/kg}$	$s, \text{ kJ/kgK}$	$v, \text{ m}^3/\text{kg}$	$u, \text{ kJ/kg}$	$h, \text{ kJ/kg}$	$s, \text{ kJ/kgK}$	$v, \text{ m}^3/\text{kg}$	$u, \text{ kJ/kg}$	$h, \text{ kJ/kg}$	$s, \text{ kJ/kgK}$
$T_{\text{sat}}$	0.07193	226.38	246.52	0.9197	0.06322	228.43	248.66	0.9177	0.05089	231.97	252.32	0.9145
0	0.07240	227.37	247.64	0.9238								
10	0.07613	235.44	256.76	0.9566	0.06576	234.61	255.65	0.9427	0.05119	232.87	253.35	0.9182
20	0.07972	243.59	265.91	0.9883	0.06901	242.87	264.95	0.9749	0.05397	241.37	262.96	0.9515
30	0.08320	251.83	275.12	1.0192	0.07214	251.19	274.28	1.0062	0.05662	249.89	272.54	0.9837
40	0.08660	260.17	284.42	1.0494	0.07518	259.61	283.67	1.0367	0.05917	258.47	282.14	1.0148
50	0.08992	268.64	293.81	1.0789	0.07815	268.14	293.15	1.0665	0.06164	267.13	291.79	1.0452
60	0.09319	277.23	303.32	1.1079	0.08106	276.79	302.72	1.0957	0.06405	275.89	301.51	1.0748
70	0.09641	285.96	312.95	1.1364	0.08392	285.56	312.41	1.1243	0.06641	284.75	311.32	1.1038
80	0.09960	294.82	322.71	1.1644	0.08674	294.46	322.22	1.1525	0.06873	293.73	321.23	1.1322
90	0.10275	303.83	332.60	1.1920	0.08953	303.50	332.15	1.1802	0.07102	302.84	331.25	1.1602
100	0.10587	312.98	342.62	1.2193	0.09229	312.68	342.21	1.1076	0.07327	312.07	341.38	1.1878
110	0.10897	322.27	352.78	1.2461	0.09503	322.00	352.40	1.2345	0.07550	321.44	351.64	1.2149
120	0.11205	331.71	363.08	1.2727	0.09774	331.45	362.73	1.2611	0.07771	330.94	362.03	1.2417
130									0.07991	340.58	372.54	1.2681
140									0.08208	350.35	383.18	1.2941

$P=0.50\text{ MPa } (T_{\text{sat}}=15.74\text{ }^{\circ}\text{C})$					$P=0.60\text{ MPa } (T_{\text{sat}}=21.58\text{ }^{\circ}\text{C})$				$P=0.70\text{ MPa } (T_{\text{sat}}=26.72\text{ }^{\circ}\text{C})$			
$T, \text{ }^{\circ}\text{C}$	$v, \text{ m}^3/\text{kg}$	$u, \text{ kJ/kg}$	$h, \text{ kJ/kg}$	$s, \text{ kJ/kgK}$	$v, \text{ m}^3/\text{kg}$	$u, \text{ kJ/kg}$	$h, \text{ kJ/kg}$	$s, \text{ kJ/kgK}$	$v, \text{ m}^3/\text{kg}$	$u, \text{ kJ/kg}$	$h, \text{ kJ/kg}$	$s, \text{ kJ/kgK}$
$T_{\text{sat}}$	0.04086	235.64	256.07	0.9117	0.03408	238.74	259.19	0.9097	0.02918	241.42	261.85	0.9080
20	0.04188	239.40	260.34	0.9264								
30	0.04416	248.20	270.28	0.9597	0.03581	246.41	267.89	0.9388	0.02979	244.51	265.37	0.9197
40	0.04633	256.99	280.16	0.9918	0.03774	255.45	278.09	0.9719	0.03157	253.83	275.93	0.9539
50	0.04842	265.83	290.04	1.0229	0.03958	264.48	288.23	1.0037	0.03324	263.08	286.35	0.9867
60	0.05043	274.73	299.95	1.0531	0.04134	273.54	298.35	1.0346	0.03482	272.31	296.69	1.0182
70	0.05240	283.72	309.92	1.0825	0.04304	282.66	308.48	1.0645	0.03634	281.57	307.01	1.0487
80	0.05432	292.80	319.96	1.1114	0.04469	291.86	318.67	1.0938	0.03781	290.88	317.35	1.0784
90	0.05620	302.00	330.10	1.1397	0.04631	301.14	328.93	1.1225	0.03924	300.27	327.74	1.1074
100	0.05805	311.31	340.33	1.1675	0.04790	310.53	339.27	1.1505	0.04064	309.74	338.19	1.1358
110	0.05988	320.74	350.68	1.1949	0.04946	320.03	349.70	1.1781	0.04201	319.31	348.71	1.1637
120	0.06168	330.30	361.14	1.2218	0.05099	329.64	360.24	1.2053	0.04335	328.98	359.33	1.1910
130	0.06347	339.98	371.72	1.2484	0.05251	339.38	370.88	1.2320	0.04468	338.76	370.04	1.2179
140	0.06524	349.79	382.42	1.2746	0.05402	349.23	381.64	1.2584	0.04599	348.66	380.86	1.2444
150					0.05550	359.21	392.52	1.2844	0.04729	358.68	391.79	1.2706
160					0.05698	369.32	403.51	1.3100	0.04857	368.82	402.82	1.2963

$P=0.80\text{ MPa } (T_{\text{sat}}=31.33\text{ }^{\circ}\text{C})$					$P=0.90\text{ MPa } (T_{\text{sat}}=35.53\text{ }^{\circ}\text{C})$				$P=1.00\text{ MPa } (T_{\text{sat}}=39.33\text{ }^{\circ}\text{C})$			
$T, \text{ }^{\circ}\text{C}$	$v, \text{ m}^3/\text{kg}$	$u, \text{ kJ/kg}$	$h, \text{ kJ/kg}$	$s, \text{ kJ/kgK}$	$v, \text{ m}^3/\text{kg}$	$u, \text{ kJ/kg}$	$h, \text{ kJ/kg}$	$s, \text{ kJ/kgK}$	$v, \text{ m}^3/\text{kg}$	$u, \text{ kJ/kg}$	$h, \text{ kJ/kg}$	$s, \text{ kJ/kgK}$
$T_{\text{sat}}$	0.02547	243.78	264.15	0.9066	0.02255	245.88	266.18	0.9054	0.02020	247.77	267.97	0.9043
40	0.02691	252.13	273.66	0.9374	0.02325	250.32	271.25	0.9217	0.02029	248.39	268.68	0.9066
50	0.02846	261.62	284.39	0.9711	0.02472	260.09	282.34	0.9566	0.02171	258.48	280.19	0.9428
60	0.02992	271.04	294.98	1.0034	0.02609	269.72	293.21	0.9897	0.02301	268.35	291.36	0.9768
70	0.03131	280.45	305.50	1.0345	0.02738	279.30	303.94	1.0214	0.02423	278.11	302.34	1.0093
80	0.03264	289.89	316.00	1.0647	0.02861	288.87	314.62	1.0521	0.02538	287.82	313.20	1.0405
90	0.03393	299.37	326.52	1.0940	0.02980	298.46	325.28	1.0819	0.02649	297.53	324.01	1.0707
100	0.03519	308.93	337.08	1.1227	0.03095	308.11	335.96	1.1109	0.02755	307.27	334.82	1.1000

(continued)

(continued)

$P=0.80\text{ MPa } (T_{\text{sat}}=31.33\text{ }^{\circ}\text{C})$					$P=0.90\text{ MPa } (T_{\text{sat}}=35.53\text{ }^{\circ}\text{C})$				$P=1.00\text{ MPa } (T_{\text{sat}}=39.33\text{ }^{\circ}\text{C})$			
$T, ^{\circ}\text{C}$	$v, \text{ m}^3/\text{kg}$	$u, \text{ kJ/kg}$	$h, \text{ kJ/kg}$	$s, \text{ kJ/kgK}$	$v, \text{ m}^3/\text{kg}$	$u, \text{ kJ/kg}$	$h, \text{ kJ/kg}$	$s, \text{ kJ/kgK}$	$v, \text{ m}^3/\text{kg}$	$u, \text{ kJ/kg}$	$h, \text{ kJ/kg}$	$s, \text{ kJ/kgK}$
110	0.03642	318.57	347.71	1.1508	0.03207	317.82	346.68	1.1392	0.02858	317.06	345.65	1.1286
120	0.03762	328.31	358.40	1.1784	0.03316	327.62	357.47	1.1670	0.02959	326.93	356.52	1.1567
130	0.03881	338.14	369.19	1.2055	0.03423	337.52	368.33	1.1943	0.03058	336.88	367.46	1.1841
140	0.03997	348.09	380.07	1.2321	0.03529	347.51	379.27	1.2211	0.03154	346.92	378.46	1.2111
150	0.04113	358.15	391.05	1.2584	0.03633	357.61	390.31	1.2475	0.03250	357.06	389.56	1.2376
160	0.04227	368.32	402.14	1.2843	0.03736	367.82	401.44	1.2735	0.03344	367.31	400.74	1.2638
170	0.04340	378.61	413.33	1.3098	0.03838	378.14	412.68	1.2992	0.03436	377.66	412.02	1.2895
180	0.04452	389.02	424.63	1.3351	0.03939	388.57	424.02	1.3245	0.03528	388.12	423.40	1.3149

$P=1.20\text{ MPa } (T_{\text{sat}}=46.32\text{ }^{\circ}\text{C})$					$P=1.40\text{ MPa } (T_{\text{sat}}=52.43\text{ }^{\circ}\text{C})$				$P=1.60\text{ MPa } (T_{\text{sat}}=57.92\text{ }^{\circ}\text{C})$			
$T, ^{\circ}\text{C}$	$v, \text{ m}^3/\text{kg}$	$u, \text{ kJ/kg}$	$h, \text{ kJ/kg}$	$s, \text{ kJ/kgK}$	$v, \text{ m}^3/\text{kg}$	$u, \text{ kJ/kg}$	$h, \text{ kJ/kg}$	$s, \text{ kJ/kgK}$	$v, \text{ m}^3/\text{kg}$	$u, \text{ kJ/kg}$	$h, \text{ kJ/kg}$	$s, \text{ kJ/kgK}$
$T_{\text{sat}}$	0.01663	251.03	270.99	0.9023	0.01405	253.74	273.40	0.9003	0.01208	256.00	275.33	0.8982
50	0.01712	254.98	275.52	0.9164								
60	0.01835	265.42	287.44	0.9527	0.01495	262.17	283.10	0.9297	0.01233	258.48	278.20	0.9069
70	0.01947	275.59	298.96	0.9868	0.01603	272.87	295.31	0.9658	0.01340	269.89	291.33	0.9457
80	0.02051	285.62	310.24	1.0192	0.01701	283.29	307.10	0.9997	0.01435	280.78	303.74	0.9813
90	0.02150	295.59	321.39	1.0503	0.01792	293.55	318.63	1.0319	0.01521	291.39	315.72	1.0148
100	0.02244	305.54	332.47	1.0804	0.01878	303.73	330.02	1.0628	0.01601	301.84	327.46	1.0467
110	0.02335	315.50	343.52	1.1096	0.01960	313.88	341.32	1.0927	0.01677	312.20	339.04	1.0773
120	0.02423	325.51	354.58	1.1381	0.02039	324.05	352.59	1.1218	0.01750	322.53	350.53	1.1069
130	0.02508	335.58	365.68	1.1660	0.02115	334.25	363.86	1.1501	0.01820	332.87	361.99	1.1357
140	0.02592	345.73	376.83	1.1933	0.02189	344.50	375.15	1.1777	0.01887	343.24	373.44	1.1638
150	0.02674	355.95	388.04	1.2201	0.02262	354.82	386.49	1.2048	0.01953	353.66	384.91	1.1912
160	0.02754	366.27	399.33	1.2465	0.02333	365.22	397.89	1.2315	0.02017	364.15	396.43	1.2181
180	0.02834	376.69	410.70	1.2724	0.02403	375.71	409.36	1.2576	0.02080	374.71	407.99	1.2445
180	0.02912	387.21	422.16	1.2980	0.02472	386.29	420.90	1.2834	0.02142	385.35	419.62	1.2704
190					0.02541	396.96	432.53	1.3088	0.02203	396.08	431.33	1.2960
200					0.02608	407.73	444.24	1.3338	0.02263	406.90	443.11	1.3212

# Appendix 10: Generalised Compressibility

## Appendix 10a: Generalised Compressibility Chart $0 < P_r < 1$

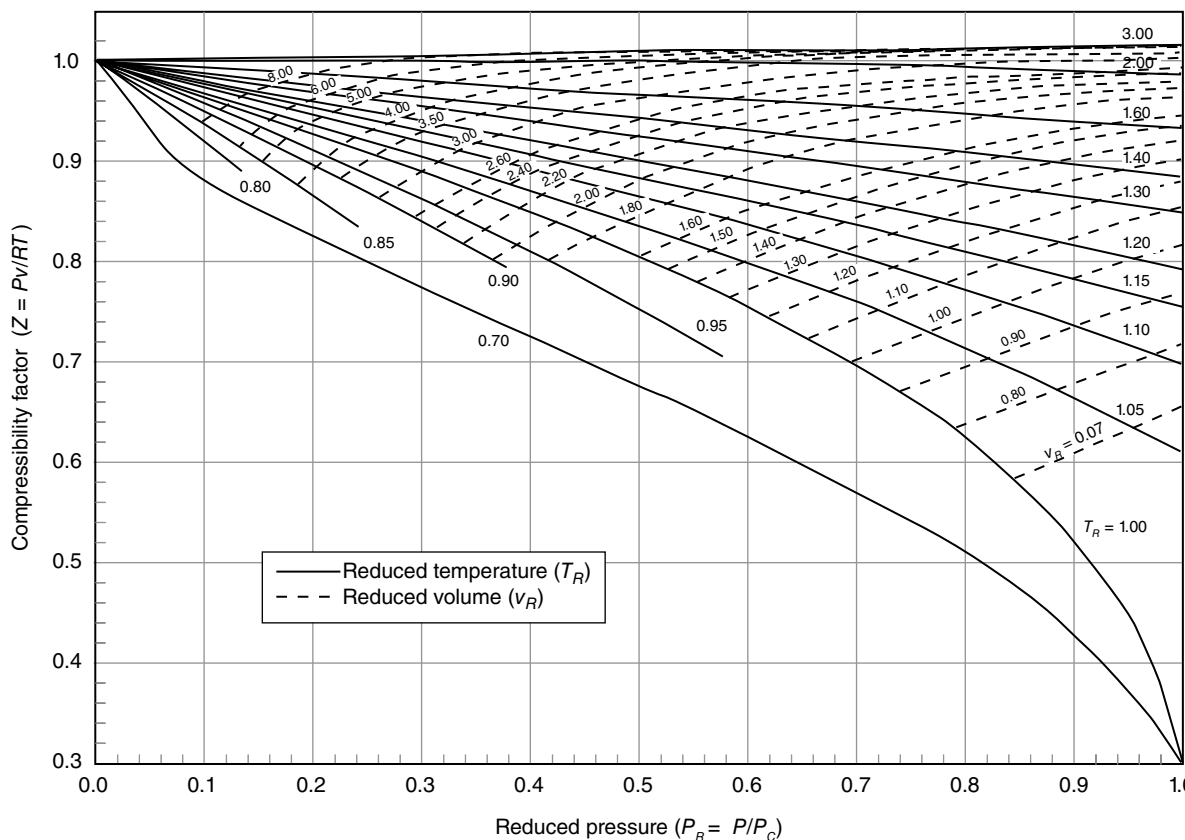


Figure A10.1

Appendix 10b: Generalised Compressibility Chart  $0 < P_r < 7$

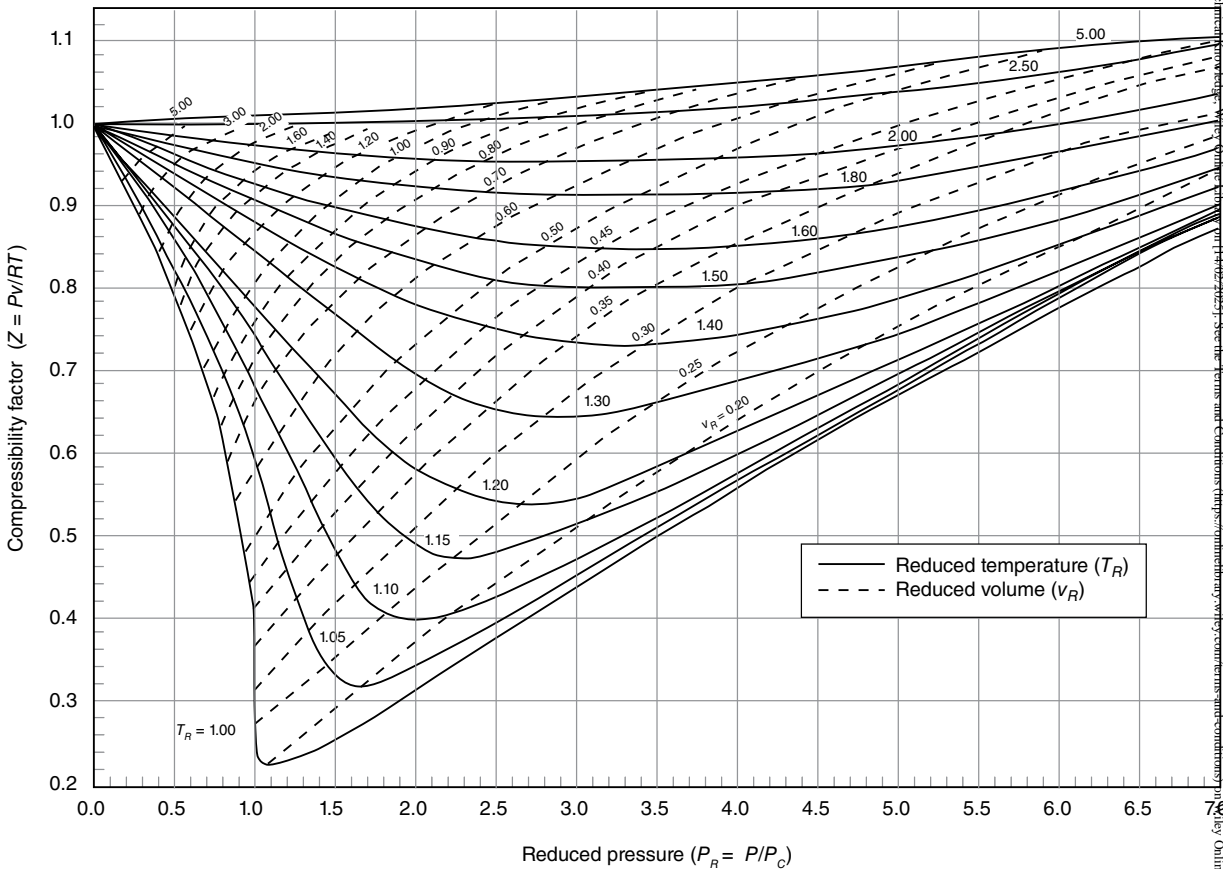


Figure A10.2