PROPERTY TABLES FOR THERMAL FLUIDS ENGINEERING

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FOR THERMAL FLUIDS ENGINEERING

SI AND U.S. CUSTOMARY UNITS

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Preface

The tables in the booklet complement the property tables in the appendices to *Thermodynamics: Concepts and Applications* and *Thermal-Fluid Science: An Integrated Approach* by Stephen R. Turns. In addition to duplicating the SI tables in these books in both SI and US Customary units, the present booklet contains property data for the refrigerant R-134a and properties of the atmosphere at high altitudes.

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Thermodynamic Properties of Refrigerant-134a

Table A.1 Saturation Properties of Refrigerant R-134a: Temperature Increments

Temp., °C	Press., P_{sat}, MPa	Specific Volume, m^3/kg		Internal Energy, kJ/kg		Enthalpy, kJ/kg			Entropy, kJ/kg·K	
		Sat. Liquid, v_f	Sat. Vapor, v_g	Sat. Liquid, u_f	Sat. Vapor, u_g	Sat. Liquid, h_f	Evap., h_{fg}	Sat. Vapor, h_g	Sat. Liquid, s_f	Sat. Vapor, s_g
−40	0.051209	0.00070537	0.36108	148.11	355.51	148.14	225.86	374.00	0.79561	1.7643
−36	0.062908	0.00071120	0.29771	153.14	357.81	153.18	223.36	376.54	0.81700	1.7588
−32	0.076658	0.00071719	0.24727	158.19	360.11	158.25	220.81	379.06	0.83814	1.7538
−28	0.092703	0.00072336	0.20680	163.28	362.40	163.34	218.23	381.57	0.85906	1.7492
−24	0.11130	0.00072970	0.17407	168.39	364.70	168.47	215.60	384.07	0.87975	1.7451
−22	0.12165	0.00073294	0.16006	170.96	365.84	171.05	214.27	385.32	0.89002	1.7432
−20	0.13273	0.00073623	0.14739	173.54	366.99	173.64	212.91	386.55	0.90025	1.7413
−18	0.14460	0.00073958	0.13592	176.12	368.13	176.23	211.56	387.79	0.91042	1.7396
−16	0.15728	0.00074297	0.12551	178.72	369.28	178.83	210.19	389.02	0.92054	1.7379
−12	0.18524	0.00074994	0.10744	183.93	371.55	184.07	207.39	391.46	0.94066	1.7348
−8	0.21693	0.00075714	0.092422	189.17	373.82	189.34	204.53	393.87	0.96060	1.7320
−4	0.25268	0.00076460	0.079866	194.45	376.07	194.65	201.60	396.25	0.98037	1.7294
0	0.29280	0.00077233	0.069309	199.77	378.31	200.00	198.60	398.60	1.0000	1.7271
2	0.31462	0.00077631	0.064663	202.45	379.42	202.69	197.08	399.77	1.0098	1.7260
4	0.33766	0.00078037	0.060385	205.13	380.53	205.40	195.52	400.92	1.0195	1.7250
6	0.36198	0.00078451	0.056443	207.83	381.63	208.11	193.95	402.06	1.0292	1.7240
8	0.38761	0.00078873	0.052804	210.53	382.73	210.84	192.36	403.20	1.0388	1.7230
10	0.41461	0.00079305	0.049442	213.25	383.82	213.58	190.74	404.32	1.0485	1.7221
12	0.44301	0.00079745	0.046332	215.98	384.90	216.33	189.10	405.43	1.0581	1.7212
14	0.47288	0.00080196	0.043451	218.71	385.98	219.09	187.44	406.53	1.0677	1.7204
16	0.50425	0.00080657	0.040780	221.46	387.05	221.87	185.74	407.61	1.0772	1.7196
18	0.53718	0.00081128	0.038301	224.23	388.11	224.66	184.03	408.69	1.0867	1.7188
20	0.57171	0.00081610	0.035997	227.00	389.17	227.47	182.28	409.75	1.0962	1.7180
22	0.60789	0.00082105	0.033854	229.79	390.21	230.29	180.50	410.79	1.1057	1.7173
24	0.64578	0.00082612	0.031858	232.59	391.25	233.12	178.70	411.82	1.1152	1.7166
26	0.68543	0.00083131	0.029998	235.40	392.28	235.97	176.87	412.84	1.1246	1.7159
28	0.72688	0.00083665	0.028263	238.23	393.29	238.84	175.00	413.84	1.1341	1.7152

30	0.77020	0.00084213	0.026642	241.07	394.30	241.72	173.10	414.82	1.1435	1.7145
32	0.81543	0.00084777	0.025126	243.93	395.29	244.62	171.16	415.78	1.1529	1.7138
34	0.86263	0.00085357	0.023708	246.80	396.27	247.54	169.18	416.72	1.1623	1.7131
36	0.91185	0.00085954	0.022380	249.69	397.24	250.48	167.17	417.65	1.1717	1.7124
38	0.96315	0.00086569	0.021135	252.60	398.19	253.43	165.12	418.55	1.1811	1.7118
40	1.0166	0.00087204	0.019966	255.52	399.13	256.41	163.02	419.43	1.1905	1.7111
42	1.0722	0.00087859	0.018868	258.46	400.05	259.41	160.87	420.28	1.1999	1.7103
44	1.1301	0.00088537	0.017837	261.42	400.96	262.43	158.68	421.11	1.2092	1.7096
48	1.2529	0.00089965	0.015951	267.41	402.71	268.53	154.16	422.69	1.2280	1.7081
52	1.3854	0.00091502	0.014276	273.47	404.37	274.74	149.41	424.15	1.2469	1.7064
56	1.5282	0.00093166	0.012782	279.64	405.94	281.06	144.41	425.47	1.2658	1.7045
60	1.6818	0.00094979	0.011444	285.91	407.38	287.50	139.13	426.63	1.2848	1.7024
70	2.1168	0.0010038	0.0086527	302.16	410.33	304.28	124.37	428.65	1.3332	1.6956
80	2.6332	0.0010773	0.0064483	319.55	411.83	322.39	106.42	428.81	1.3836	1.6850
90	3.2442	0.0011936	0.0046134	339.06	410.45	342.93	82.490	425.42	1.4390	1.6662
100	3.9724	0.0015357	0.0026809	367.20	397.03	373.30	34.380	407.68	1.5188	1.6109

Table A.2 Saturation Properties of Refrigerant R-134a: Pressure Increments

Press., MPa	Temp., T_{sat}, °C	Specific Volume, m^3/kg		Internal Energy, kJ/kg		Enthalpy, kJ/kg			Entropy, kJ/kg·K	
		Sat. Liquid, v_f	Sat. Vapor, v_g	Sat. Liquid, u_f	Sat. Vapor, u_g	Sat. Liquid, h_f	Evap., h_{fg}	Sat. Vapor, h_g	Sat. Liquid, s_f	Sat. Vapor, s_g
0.06	−36.935	0.00070982	0.31123	151.96	357.27	152.00	223.94	375.94	0.81202	1.7601
0.08	−31.115	0.00071854	0.23755	159.31	360.61	159.37	220.25	379.62	0.84278	1.7528
0.1	−26.361	0.00072593	0.19256	165.37	363.34	165.44	217.16	382.60	0.86756	1.7475
0.12	−22.310	0.00073244	0.16214	170.56	365.67	170.65	214.47	385.12	0.88844	1.7435
0.14	−18.760	0.00073830	0.14015	175.14	367.70	175.24	212.08	387.32	0.90656	1.7402
0.16	−15.588	0.00074368	0.12349	179.25	369.51	179.37	209.90	389.27	0.92262	1.7376
0.18	−12.712	0.00074868	0.11042	183.00	371.15	183.13	207.89	391.02	0.93709	1.7353
0.2	−10.076	0.00075337	0.099877	186.45	372.64	186.60	206.02	392.62	0.95027	1.7334
0.24	−5.3653	0.00076202	0.083906	192.65	375.30	192.83	202.61	395.44	0.97364	1.7303
0.28	−1.2277	0.00076993	0.072360	198.14	377.62	198.35	199.54	397.89	0.99399	1.7278
0.32	2.4768	0.00077727	0.063611	203.09	379.69	203.34	196.70	400.04	1.0121	1.7257
0.36	5.8412	0.00078418	0.056744	207.61	381.54	207.90	194.07	401.97	1.0284	1.7240
0.4	8.9306	0.00079073	0.051207	211.79	383.24	212.11	191.61	403.72	1.0433	1.7226
0.5	15.735	0.00080595	0.041123	221.10	386.91	221.50	185.97	407.47	1.0759	1.7197
0.6	21.572	0.00081998	0.034300	229.19	389.99	229.68	180.89	410.57	1.1037	1.7175
0.7	26.713	0.00083320	0.029365	236.41	392.64	236.99	176.21	413.20	1.1280	1.7156
0.8	31.327	0.00084585	0.025625	242.97	394.96	243.65	171.81	415.46	1.1497	1.7140
0.9	35.526	0.00085811	0.022687	249.01	397.01	249.78	167.65	417.43	1.1695	1.7126
1	39.388	0.00087007	0.020316	254.63	398.85	255.50	163.66	419.16	1.1876	1.7113
1.2	46.315	0.00089351	0.016718	264.88	401.98	265.95	156.09	422.04	1.2201	1.7087
1.4	52.422	0.00091671	0.014110	274.12	404.54	275.40	148.90	424.30	1.2489	1.7062
1.6	57.906	0.00094010	0.012126	282.61	406.64	284.11	141.93	426.04	1.2748	1.7036
1.8	62.895	0.00096400	0.010562	290.52	408.35	292.26	135.10	427.36	1.2987	1.7007
2	67.481	0.00098877	0.0092915	297.98	409.70	299.95	128.33	428.28	1.3209	1.6976
2.5	77.577	0.0010569	0.0069403	315.20	411.65	317.84	111.17	429.01	1.3711	1.6881
3	86.203	0.0011413	0.0052813	331.28	411.49	334.70	92.640	427.34	1.4171	1.6748

Table A.3 Superheated Vapor

Table A.3A $P = 0.06$ MPa ($T_{sat} = -36.935°C$)

T, °C	v, m³/kg	u, kJ/kg	h, kJ/kg	s, kJ/kg·K
Sat.	0.311230	357.27	375.94	1.7601
−20	0.336080	368.74	388.91	1.8131
−10	0.350490	375.70	396.73	1.8434
0	0.364760	382.80	404.69	1.8730
10	0.378930	390.07	412.81	1.9022
20	0.39303	397.50	421.08	1.9310
30	0.40705	405.10	429.52	1.9593
40	0.42102	412.86	438.12	1.9872
50	0.43495	420.79	446.88	2.0147
60	0.44884	428.88	455.81	2.0419
70	0.46269	437.14	464.90	2.0688
80	0.47652	445.56	474.15	2.0954
90	0.49032	454.14	483.56	2.1217

Table A.3B $P = 0.10$ MPa ($T_{sat} = -26.361°C$)

T, °C	v, m³/kg	u, kJ/kg	h, kJ/kg	s, kJ/kg·K
Sat.	0.192560	363.34	382.60	1.7475
−20	0.198410	367.81	387.65	1.7677
−10	0.207430	374.89	395.64	1.7986
0	0.216300	382.10	403.73	1.8288
10	0.225060	389.45	411.95	1.8584
20	0.23373	396.94	420.31	1.8874
30	0.24233	404.59	428.82	1.9160
40	0.25088	412.40	437.49	1.9441
50	0.25938	420.37	446.30	1.9718
60	0.26784	428.49	455.28	1.9991
70	0.27626	436.78	464.41	2.0261
80	0.28466	445.23	473.70	2.0528
90	0.29303	453.84	483.14	2.0792

Table A.3C $P = 0.14$ MPa ($T_{sat} = -18.760°C$)

T, °C	v, m³/kg	u, kJ/kg	h, kJ/kg	s, kJ/kg·K
Sat.	0.140150	367.70	387.32	1.7402
−10	0.146060	374.05	394.50	1.7680
0	0.152630	381.37	402.74	1.7987
10	0.159080	388.81	411.08	1.8287
20	0.165440	396.37	419.53	1.8580
30	0.17172	404.08	428.12	1.8868
40	0.17795	411.93	436.84	1.9151
50	0.18412	419.94	445.72	1.9430
60	0.19025	428.10	454.74	1.9705
70	0.19635	436.42	463.91	1.9977
80	0.20243	444.90	473.24	2.0244
90	0.20847	453.53	482.72	2.0509
100	0.21450	462.32	492.35	2.0771

Table A.3D $P = 0.18$ MPa ($T_{sat} = -12.712$°C)

T, °C	v, m³/kg	u, kJ/kg	h, kJ/kg	s, kJ/kg·K
Sat.	0.110420	371.15	391.02	1.7353
−10	0.111900	373.17	393.31	1.7441
0	0.117220	380.62	401.72	1.7754
10	0.122400	388.15	410.18	1.8059
20	0.127480	395.79	418.73	1.8355
30	0.13248	403.55	427.40	1.8646
40	0.13742	411.46	436.19	1.8931
50	0.14230	419.51	445.13	1.9212
60	0.14715	427.71	454.20	1.9489
70	0.15196	436.06	463.41	1.9761
80	0.15674	444.56	472.78	2.0030
90	0.16149	453.22	482.29	2.0296
100	0.16622	462.03	491.95	2.0558

Table A.3E $P = 0.20$ MPa ($T_{sat} = -10.076$°C)

T, °C	v, m³/kg	u, kJ/kg	h, kJ/kg	s, kJ/kg·K
Sat.	0.099877	372.64	392.62	1.7334
−10	0.099915	372.70	392.68	1.7337
0	0.104810	380.23	401.20	1.7654
10	0.109550	387.82	409.73	1.7961
20	0.114190	395.49	418.33	1.8259
30	0.11874	403.29	427.04	1.8551
40	0.12323	411.22	435.87	1.8838
50	0.12766	419.29	444.83	1.9120
60	0.13206	427.51	453.92	1.9397
70	0.13642	435.88	463.16	1.9670
80	0.14074	444.39	472.54	1.9939
90	0.14505	453.06	482.07	2.0206
100	0.14933	461.88	491.75	2.0468

Table A.3F $P = 0.24$ MPa ($T_{sat} = -5.3653$°C)

T, °C	v, m³/kg	u, kJ/kg	h, kJ/kg	s, kJ/kg·K
Sat.	0.083906	375.30	395.44	1.7303
0	0.086170	379.43	400.11	1.7475
10	0.090262	387.13	408.79	1.7787
20	0.094233	394.89	417.51	1.8090
30	0.098118	402.75	426.30	1.8385
40	0.10193	410.74	435.20	1.8674
50	0.10570	418.86	444.22	1.8957
60	0.10942	427.11	453.37	1.9236
70	0.11310	435.51	462.65	1.9511
80	0.11675	444.06	472.08	1.9781
90	0.12038	452.75	481.64	2.0048
100	0.12398	461.59	491.35	2.0312