736 Tables in SI Units

TABLE A-10 Properties of Saturated Refrigerant 134a (Liquid–Vapor): Temperature Table

		Specific m ³ /			Energy /kg	Enthalpy kJ/kg			Enti kJ/k		
Temp. °C	Press. bar	Sat. Liquid $v_{\rm f} \times 10^3$	Sat. Vapor $v_{ m g}$	Sat. Liquid u _f	Sat. Vapor u _g	Sat. Liquid h_{f}	Evap. h_{fg}	Sat. Vapor h _g	Sat. Liquid $s_{ m f}$	Sat. Vapor	Temp.
-40	0.5164	0.7055	0.3569	-0.04	204.45	0.00	222.88	222.88	0.0000	0.9560	-40
-36	0.6332	0.7113	0.2947	4.68	206.73	4.73	220.67	225.40	0.0201	0.9506	-36
-32	0.7704	0.7172	0.2451	9.47	209.01	9.52	218.37	227.90	0.0401	0.9456	-32
-28 -26 -24	0.9305 1.0199 1.1160	0.7233 0.7265 0.7296	0.2052 0.1882 0.1728	14.31 16.75 19.21	211.29 212.43 213.57	14.37 16.82 19.29	216.01 214.80 213.57	230.38 231.62 232.85	0.0600 0.0699 0.0798	0.9411 0.9390 0.9370	$ \begin{array}{r} -28 \\ -26 \\ \end{array} $
-22 -20 -18	1.2192 1.3299 1.4483	0.7328 0.7361 0.7395	0.1590 0.1464 0.1350	21.68 24.17 26.67	214.70 215.84 216.97	21.77 24.26 26.77	212.32 211.05 209.76	234.08 235.31 236.53	0.0897 0.0996 0.1094	0.9351 0.9332 0.9315	$ \begin{array}{c c} -22 \\ -20 \\ -18 \end{array} $
-16	1.5748	0.7428	0.1247	29.18	218.10	29.30	208.45	237.74	0.1192	0.9298	-16
-12	1.8540	0.7498	0.1068	34.25	220.36	34.39	205.77	240.15	0.1388	0.9267	-12
-8	2.1704	0.7569	0.0919	39.38	222.60	39.54	203.00	242.54	0.1583	0.9239	-8
-8 -4 0 4	2.5274 2.9282 3.3765	0.7644 0.7721 0.7801	0.0794 0.0689 0.0600	44.56 49.79 55.08	224.84 227.06 229.27	44.75 50.02 55.35	200.15 197.21 194.19	244.90 247.23 249.53	0.1383 0.1777 0.1970 0.2162	0.9239 0.9213 0.9190 0.9169	-8 -4 0 4
8	3.8756	0.7884	0.0525	60.43	231.46	60.73	191.07	251.80	0.2354	0.9150	8
12	4.4294	0.7971	0.0460	65.83	233.63	66.18	187.85	254.03	0.2545	0.9132	12
16	5.0416	0.8062	0.0405	71.29	235.78	71.69	184.52	256.22	0.2735	0.9116	16
20	5.7160	0.8157	0.0358	76.80	237.91	77.26	181.09	258.36	0.2924	0.9102	20
24	6.4566	0.8257	0.0317	82.37	240.01	82.90	177.55	260.45	0.3113	0.9089	24
26	6.8530	0.8309	0.0298	85.18	241.05	85.75	175.73	261.48	0.3208	0.9082	26
28	7.2675	0.8362	0.0281	88.00	242.08	88.61	173.89	262.50	0.3302	0.9076	28
30	7.7006	0.8417	0.0265	90.84	243.10	91.49	172.00	263.50	0.3396	0.9070	30
32	8.1528	0.8473	0.0250	93.70	244.12	94.39	170.09	264.48	0.3490	0.9064	32
34	8.6247	0.8530	0.0236	96.58	245.12	97.31	168.14	265.45	0.3584	0.9058	34
36	9.1168	0.8590	0.0223	99.47	246.11	100.25	166.15	266.40	0.3678	0.9053	36
38	9.6298	0.8651	0.0210	102.38	247.09	103.21	164.12	267.33	0.3772	0.9047	38
40	10.164	0.8714	0.0199	105.30	248.06	106.19	162.05	268.24	0.3866	0.9041	40
42	10.720	0.8780	0.0188	108.25	249.02	109.19	159.94	269.14	0.3960	0.9035	42
44	11.299	0.8847	0.0177	111.22	249.96	112.22	157.79	270.01	0.4054	0.9030	44
48	12.526	0.8989	0.0159	117.22	251.79	118.35	153.33	271.68	0.4243	0.9017	48
52	13.851	0.9142	0.0142	123.31	253.55	124.58	148.66	273.24	0.4432	0.9004	52
56	15.278	0.9308	0.0127	129.51	255.23	130.93	143.75	274.68	0.4622	0.8990	56
60	16.813	0.9488	0.0114	135.82	256.81	137.42	138.57	275.99	0.4814	0.8973	60
70	21.162	1.0027	0.0086	152.22	260.15	154.34	124.08	278.43	0.5302	0.8918	70
80	26.324	1.0766	0.0064	169.88	262.14	172.71	106.41	279.12	0.5814	0.8827	80
90	32.435	1.1949	0.0046	189.82	261.34	193.69	82.63	276.32	0.6380	0.8655	90
100	39.742	1.5443	0.0027	218.60	248.49	224.74	34.40	259.13	0.7196	0.8117	100

Source: Tables A-10 through A-12 are calculated based on equations from D. P. Wilson and R. S. Basu, "Thermodynamic Properties of a New Stratospherically Safe Working Fluid—Refrigerant 134a," ASHRAE Trans., Vol. 94, Pt. 2, 1988, pp. 2095–2118.

TABLE A-11 Properties of Saturated Refrigerant 134a (Liquid–Vapor): Pressure Table

		Specific Volume m ³ /kg		Internal Energy kJ/kg			Enthalpy kJ/kg		Enti kJ/k		
		Sat.	Sat.	Sat.	Sat.	Sat.		Sat.	Sat.	Sat.	
Press.	Temp.	Liquid	Vapor	Liquid	Vapor	Liquid	Evap.	Vapor	Liquid	Vapor	Press.
bar	°C	$v_{\rm f} imes 10^3$	v_{g}	$u_{ m f}$	$u_{\rm g}$	$h_{ m f}$	$h_{ m fg}$	$h_{ m g}$	$s_{ m f}$	$s_{\rm g}$	bar
0.6	-37.07	0.7097	0.3100	3.41	206.12	3.46	221.27	224.72	0.0147	0.9520	0.6
0.8	-31.21	0.7184	0.2366	10.41	209.46	10.47	217.92	228.39	0.0440	0.9447	0.8
1.0	-26.43	0.7258	0.1917	16.22	212.18	16.29	215.06	231.35	0.0678	0.9395	1.0
1.2	-22.36	0.7323	0.1614	21.23	214.50	21.32	212.54	233.86	0.0879	0.9354	1.2
1.4	-18.80	0.7381	0.1395	25.66	216.52	25.77	210.27	236.04	0.1055	0.9322	1.4
1.6	-15.62	0.7435	0.1229	29.66	218.32	29.78	208.19	237.97	0.1211	0.9295	1.6
1.8	-12.73	0.7485	0.1098	33.31	219.94	33.45	206.26	239.71	0.1352	0.9273	1.8
2.0	-10.09	0.7532	0.0993	36.69	221.43	36.84	204.46	241.30	0.1481	0.9253	2.0
2.4	-5.37	0.7618	0.0834	42.77	224.07	42.95	201.14	244.09	0.1710	0.9222	2.4
2.8	-1.23	0.7697	0.0719	48.18	226.38	48.39	198.13	246.52	0.1911	0.9197	2.8
3.2	2.48	0.7770	0.0632	53.06	228.43	53.31	195.35	248.66	0.2089	0.9177	3.2
3.6	5.84	0.7839	0.0564	57.54	230.28	57.82	192.76	250.58	0.2251	0.9160	3.6
4.0	8.93	0.7904	0.0509	61.69	231.97	62.00	190.32	252.32	0.2399	0.9145	4.0
5.0	15.74	0.8056	0.0409	70.93	235.64	71.33	184.74	256.07	0.2723	0.9117	5.0
6.0	21.58	0.8196	0.0341	78.99	238.74	79.48	179.71	259.19	0.2999	0.9097	6.0
7.0	26.72	0.8328	0.0292	86.19	241.42	86.78	175.07	261.85	0.3242	0.9080	7.0
8.0	31.33	0.8454	0.0255	92.75	243.78	93.42	170.73	264.15	0.3459	0.9066	8.0
9.0	35.53	0.8576	0.0226	98.79	245.88	99.56	166.62	266.18	0.3656	0.9054	9.0
10.0	39.39	0.8695	0.0202	104.42	247.77	105.29	162.68	267.97	0.3838	0.9043	10.0
12.0	46.32	0.8928	0.0166	114.69	251.03	115.76	155.23	270.99	0.4164	0.9023	12.0
14.0	52.43	0.9159	0.0140	123.98	253.74	125.26	148.14	273.40	0.4453	0.9003	14.0
16.0	57.92	0.9392	0.0121	132.52	256.00	134.02	141.31	275.33	0.4714	0.8982	16.0
18.0	62.91	0.9631	0.0105	140.49	257.88	142.22	134.60	276.83	0.4954	0.8959	18.0
20.0	67.49	0.9878	0.0093	148.02	259.41	149.99	127.95	277.94	0.5178	0.8934	20.0
25.0	77.59	1.0562	0.0069	165.48	261.84	168.12	111.06	279.17	0.5687	0.8854	25.0
30.0	86.22	1.1416	0.0053	181.88	262.16	185.30	92.71	278.01	0.6156	0.8735	30.0

TABLE A-12 Properties of Superheated Refrigerant 134a Vapor

		· r			,	T			
°C	v m³/kg	и kJ/kg	<i>h</i> kJ/kg	s kJ/kg · K		v m³/kg	и kJ/kg	<i>h</i> kJ/kg	s kJ/kg · K
		0.6 bar = 0.6 bar = 0.6 bar		' a			$1.0 \text{ bar} = T_{\text{sat}} = -26$	0.10 MPa 5.43°C)	
Sat20 -10	0.31003 0.33536 0.34992	206.12 217.86 224.97	224.72 237.98 245.96	0.9520 1.0062 1.0371		0.19170 0.19770 0.20686	212.18 216.77 224.01	231.35 236.54 244.70	0.9395 0.9602 0.9918
0 10 20	0.36433 0.37861 0.39279	232.24 239.69 247.32	254.10 262.41 270.89	1.0675 1.0973 1.1267		0.21587 0.22473 0.23349	231.41 238.96 246.67	252.99 261.43 270.02	1.0227 1.0531 1.0829
30 40 50	0.40688 0.42091 0.43487	255.12 263.10 271.25	279.53 288.35 297.34	1.1557 1.1844 1.2126		0.24216 0.25076 0.25930	254.54 262.58 270.79	278.76 287.66 296.72	1.1122 1.1411 1.1696
60 70 80 90	0.44879 0.46266 0.47650 0.49031	279.58 288.08 296.75 305.58	306.51 315.84 325.34 335.00	1.2405 1.2681 1.2954 1.3224		0.26779 0.27623 0.28464 0.29302	279.16 287.70 296.40 305.27	305.94 315.32 324.87 334.57	1.1977 1.2254 1.2528 1.2799
	p = 1.4 bar = 0.14 MPa $(T_{\text{sat}} = -18.80^{\circ}\text{C})$						$1.8 \text{ bar} = T_{\text{sat}} = -12$	0.18 MPa 2.73°C)	
Sat10 0	0.13945 0.14549 0.15219	216.52 223.03 230.55	236.04 243.40 251.86	0.9322 0.9606 0.9922		0.10983 0.11135 0.11678	219.94 222.02 229.67	239.71 242.06 250.69	0.9273 0.9362 0.9684
10 20 30	0.15875 0.16520 0.17155	238.21 246.01 253.96	260.43 269.13 277.97	1.0230 1.0532 1.0828		0.12207 0.12723 0.13230	237.44 245.33 253.36	259.41 268.23 277.17	0.9998 1.0304 1.0604
40 50 60	0.17783 0.18404 0.19020	262.06 270.32 278.74	286.96 296.09 305.37	1.1120 1.1407 1.1690		0.13730 0.14222 0.14710	261.53 269.85 278.31	286.24 295.45 304.79	1.0898 1.1187 1.1472
70 80 90 100	0.19633 0.20241 0.20846 0.21449	287.32 296.06 304.95 314.01	314.80 324.39 334.14 344.04	1.1969 1.2244 1.2516 1.2785		0.15193 0.15672 0.16148 0.16622	286.93 295.71 304.63 313.72	314.28 323.92 333.70 343.63	1.1753 1.2030 1.2303 1.2573
								•	
		$2.0 \text{ bar} = (T_{\text{sat}} = -1)$		P a			$\begin{array}{c} 2.4 \text{ bar} = \\ T_{\text{sat}} = -5 \end{array}$	0.24 MPa .37°C)	
Sat10 0	0.09933 0.09938 0.10438	221.43 221.50 229.23	241.30 241.38 250.10	0.9253 0.9256 0.9582		0.08343	224.07 228.31	244.09 248.89	0.9222 0.9399
10 20 30	0.10922 0.11394 0.11856	237.05 244.99 253.06	258.89 267.78 276.77	0.9898 1.0206 1.0508		0.08993 0.09399 0.09794	236.26 244.30 252.45	257.84 266.85 275.95	0.9721 1.0034 1.0339
40 50 60	0.12311 0.12758 0.13201	261.26 269.61 278.10	285.88 295.12 304.50	1.0804 1.1094 1.1380		0.10181 0.10562 0.10937	260.72 269.12 277.67	285.16 294.47 303.91	1.0637 1.0930 1.1218
70 80 90 100	0.13639 0.14073 0.14504 0.14932	286.74 295.53 304.47 313.57	314.02 323.68 333.48 343.43	1.1661 1.1939 1.2212 1.2483		0.11307 0.11674 0.12037 0.12398	286.35 295.18 304.15 313.27	313.49 323.19 333.04 343.03	1.1501 1.1780 1.2055 1.2326

 TABLE A-12 (Continued)

	(Сопиниса									
°C	$\frac{v}{m^3/kg}$	u kJ/kg	<i>h</i> kJ/kg	s kJ/kg · K	$\frac{v}{\mathrm{m}^3/\mathrm{k}}$	cg	и kJ/kg	<i>h</i> kJ/kg	s kJ/kg · K		
	<i>p</i> =	= 2.8 bar = $= (T_{\text{sat}} = -$		a	i	p = 3.2 bar = 0.32 MPa $(T_{\text{sat}} = 2.48^{\circ}\text{C})$					
Sat.	0.07193 0.07240	226.38 227.37	246.52 247.64	0.9197 0.9238	0.063	22 2	228.43	248.66	0.9177		
10	0.07613	235.44	256.76	0.9566	0.065	76 2	234.61	255.65	0.9427		
20	0.07972	243.59	265.91	0.9883	0.069		242.87	264.95	0.9749		
30 40	0.08320 0.08660	251.83 260.17	275.12 284.42	1.0192 1.0494	0.072 0.075		251.19 259.61	274.28 283.67	1.0062 1.0367		
50	0.08000	268.64	293.81	1.0789	0.073		268.14	293.15	1.0665		
60	0.08992	277.23	303.32	1.10789	0.078		276.79	302.72	1.0003		
70	0.09641	285.96	312.95	1.1364	0.083		285.56	312.41	1.1243		
80	0.09960	294.82	322.71	1.1644	0.086		294.46	322.22	1.1525		
90	0.10275	303.83	332.60	1.1920	0.089		303.50	332.15	1.1802		
100	0.10587	312.98	342.62	1.2193	0.092		312.68	342.21	1.2076		
110 120	0.10897 0.11205	322.27 331.71	352.78 363.08	1.2461 1.2727	0.095 0.097		322.00 331.45	352.40 362.73	1.2345 1.2611		
		4.0 bar =		Pa		p = 5.0) bar =	0.50 MPa			
		$(T_{\rm sat}=8$.93°C)			$(T_{\rm s}$	$_{\rm sat} = 15.$	74°C)			
Sat.	0.05089	231.97	252.32	0.9145	0.040	086 2	235.64	256.07	0.9117		
10	0.05119	232.87	253.35	0.9182	0.041	00	20.40	260.24	0.0264		
20	0.05397	241.37	262.96	0.9515	0.041		239.40	260.34	0.9264		
30 40	0.05662 0.05917	249.89 258.47	272.54 282.14	0.9837 1.0148	0.044 0.046		248.20 256.99	270.28 280.16	0.9597 0.9918		
50	0.06164	267.13	291.79	1.0452	0.048		265.83	290.04	1.0229		
60	0.06405	275.89	301.51	1.0748	0.050)43 2	274.73	299.95	1.0531		
70	0.06641	284.75	311.32	1.1038	0.052		283.72	309.92	1.0825		
80	0.06873	293.73	321.23	1.1322	0.054		292.80	319.96	1.1114		
90 100	0.07102 0.07327	302.84 312.07	331.25 341.38	1.1602 1.1878	0.056 0.058		302.00 311.31	330.10 340.33	1.1397 1.1675		
110	0.07550	321.44	351.64	1.1676	0.059		320.74	350.68	1.1073		
120	0.07771	330.94	362.03	1.2417	0.061		330.30	361.14	1.2218		
130	0.07991	340.58	372.54	1.2681	0.063	347 3	339.98	371.72	1.2484		
140	0.08208	350.35	383.18	1.2941	0.065	524 3	349.79	382.42	1.2746		
	p =	6.0 bar =	= 0.60 MF	Pa		p = 7.0) bar =	0.70 MPa			
		$(T_{\rm sat}=2)$	1.58°C)			$(T_{\rm s}$	$_{\rm at} = 26.$.72°C)			
Sat.	0.03408	238.74	259.19	0.9097	0.029		241.42	261.85	0.9080		
30	0.03581	246.41	267.89	0.9388	0.029		244.51	265.37	0.9197		
40	0.03774	255.45	278.09	0.9719	0.031		253.83	275.93	0.9539		
50 60	0.03958 0.04134	264.48 273.54	288.23 298.35	1.0037 1.0346	0.033 0.034		263.08 272.31	286.35 296.69	0.9867 1.0182		
70	0.04304	282.66	308.48	1.0645	0.036		281.57	307.01	1.0487		
80	0.04469	291.86	318.67	1.0938	0.037		290.88	317.35	1.0784		
90	0.04631	301.14	328.93	1.1225	0.039	24 3	300.27	327.74	1.1074		
100	0.04790	310.53	339.27	1.1505	0.040		309.74	338.19	1.1358		
110	0.04946	320.03	349.70	1.1781	0.042		319.31	348.71	1.1637		
120 130	0.05099 0.05251	329.64 339.38	360.24 370.88	1.2053 1.2320	0.043 0.044		328.98 338.76	359.33 370.04	1.1910 1.2179		
140	0.05402	349.23	381.64	1.2584	0.045		348.66	380.86	1.2444		
150	0.05550	359.21	392.52	1.2844	0.043		358.68	391.79	1.2706		
160	0.05698	369.32	403.51	1.3100	0.048		368.82	402.82	1.2963		

TABLE A-12 (Continued)

			,								
$^{T}_{^{\circ}\mathrm{C}}$	$\frac{v}{m^3/kg}$	и kJ/kg	<i>h</i> kJ/kg	s kJ/kg · K		v /kg	<i>u</i> kJ/kg	<i>h</i> kJ/kg	s kJ/kg · K		
	<i>p</i> =	$8.0 \text{ bar} = (T_{\text{sat}} = 3)$		Pa		p = 9.0 bar = 0.90 MPa $(T_{\text{sat}} = 35.53^{\circ}\text{C})$					
Sat. 40 50	0.02547 0.02691 0.02846	243.78 252.13 261.62	264.15 273.66 284.39	0.9066 0.9374 0.9711	0.02	2255 2325 2472	245.88 250.32 260.09	266.18 271.25 282.34	0.9054 0.9217 0.9566		
60 70 80	0.02992 0.03131 0.03264	271.04 280.45 289.89	294.98 305.50 316.00	1.0034 1.0345 1.0647	0.02	2609 2738 2861	269.72 279.30 288.87	293.21 303.94 314.62	0.9897 1.0214 1.0521		
90 100 110	0.03393 0.03519 0.03642	299.37 308.93 318.57	326.52 337.08 347.71	1.0940 1.1227 1.1508	0.02 0.03	2980 3095 3207	298.46 308.11 317.82	325.28 335.96 346.68	1.0819 1.1109 1.1392		
120 130 140	0.03762 0.03881 0.03997	328.31 338.14 348.09	358.40 369.19 380.07	1.1784 1.2055 1.2321	0.03 0.03	3316 3423 3529	327.62 337.52 347.51	357.47 368.33 379.27	1.1670 1.1943 1.2211		
150 160 170 180	0.04113 0.04227 0.04340 0.04452	358.15 368.32 378.61 389.02	391.05 402.14 413.33 424.63	1.2584 1.2843 1.3098 1.3351	0.03 0.03 0.03	3633 3736 3838 3939	357.61 367.82 378.14 388.57	390.31 401.44 412.68 424.02	1.2475 1.2735 1.2992 1.3245		
p = 10.0 bar = 1.00 MPa $(T_{\text{sat}} = 39.39^{\circ}\text{C})$							2.0 bar = $T_{\text{sat}} = 46$.	: 1.20 MPa 32°C)	a		
Sat. 40 50	0.02020 0.02029 0.02171	247.77 248.39 258.48	267.97 268.68 280.19	0.9043 0.9066 0.9428		1663 1712	251.03 254.98	270.99 275.52	0.9023 0.9164		
60 70 80	0.02171 0.02301 0.02423 0.02538	268.35 278.11 287.82	291.36 302.34 313.20	0.9428 0.9768 1.0093 1.0405	0.01	1835 1947	265.42 275.59 285.62	287.44 298.96 310.24	0.9104 0.9527 0.9868 1.0192		
90 100 110	0.02649 0.02755 0.02858	297.53 307.27 317.06	324.01 334.82 345.65	1.0707 1.1000 1.1286	0.02	2150 2244 2335	295.59 305.54 315.50	321.39 332.47 343.52	1.0503 1.0804 1.1096		
120 130 140	0.02959 0.03058 0.03154	326.93 336.88 346.92	356.52 367.46 378.46	1.1567 1.1841 1.2111	0.02	2423 2508 2592	325.51 335.58 345.73	354.58 365.68 376.83	1.1381 1.1660 1.1933		
150 160 170 180	0.03250 0.03344 0.03436 0.03528	357.06 367.31 377.66 388.12	389.56 400.74 412.02 423.40	1.2376 1.2638 1.2895 1.3149	0.02 0.02	2674 2754 2834 2912	355.95 366.27 376.69 387.21	388.04 399.33 410.70 422.16	1.2201 1.2465 1.2724 1.2980		
	<i>p</i> =	14.0 bar $(T_{\text{sat}} = 52)$	= 1.40 MI 2.43°C)	Pa		p = 16.0 bar = 1.60 MPa $(T_{\text{sat}} = 57.92^{\circ}\text{C})$					
Sat. 60 70	0.01405 0.01495 0.01603	253.74 262.17 272.87	273.40 283.10 295.31	0.9003 0.9297 0.9658	0.01	1208 1233 1340	256.00 258.48 269.89	275.33 278.20 291.33	0.8982 0.9069 0.9457		
80 90 100	0.01701 0.01792 0.01878	283.29 293.55 303.73	307.10 318.63 330.02	0.9997 1.0319 1.0628		1435 1521 1601	280.78 291.39 301.84	303.74 315.72 327.46	0.9813 1.0148 1.0467		
110 120 130	0.01960 0.02039 0.02115	313.88 324.05 334.25	341.32 352.59 363.86	1.0927 1.1218 1.1501	0.01 0.01	1677 1750 1820	312.20 322.53 332.87	339.04 350.53 361.99	1.0773 1.1069 1.1357		
140 150 160	0.02189 0.02262 0.02333	344.50 354.82 365.22	375.15 386.49 397.89	1.1777 1.2048 1.2315	0.01 0.02	1887 1953 2017	343.24 353.66 364.15	373.44 384.91 396.43	1.1638 1.1912 1.2181		
170 180 190 200	0.02403 0.02472 0.02541 0.02608	375.71 386.29 396.96 407.73	409.36 420.90 432.53 444.24	1.2576 1.2834 1.3088 1.3338	0.02 0.02	2080 2142 2203 2263	374.71 385.35 396.08 406.90	407.99 419.62 431.33 443.11	1.2445 1.2704 1.2960 1.3212		