Errata to
Fundamentals of Refrigeration Self-Directed Learning Course, I-P Edition (2010)

May 23, 2019

Shaded items have been added since the previously published errata sheet dated September 21, 2018.

Page #	Location	
1	9 lines from bottom	Add the word "be" in the sentence that ends on this line, as in "means by which heat can be moved away."
9	18 lines from top	"The necessary low pressure is produced by the low pressure of the refrigerant maintained by the compressor" should read "The necessary low pressure is produced by **the expansion device."**
21	5 lines from top	Added "(Specific heat of air at constant pressure is 0.2359 Btu/lb)."
25	3 lines from bottom	h_g = 111.530 Btu/lb
25	2 lines from bottom	h_f = 34.859 Btu/lb
25	bottom line	$x = (88.414 - 34.859)/(111.530 - 34.859) = 0.700$
26	4 lines from top	ρ_f = 73.23 lb/ft^3
26	5 lines from top	$v_f = 1/73.23 = 0.01366$ ft^3/lb
26	6 lines from top	v_g = 0.3207 ft^3/lb
26	7 lines from top	$v = 0.01366 + (0.700)(0.3207 - 0.01366)$
26	8 lines from top	= 0.229 ft^3/lb
26	6 lines from bottom	h = 59.103 Btu/lb v = 1/40.66 = 0.02459 ft^3/lb
35		Update Figure 2-10 to the following:

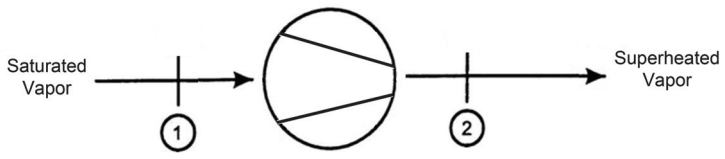
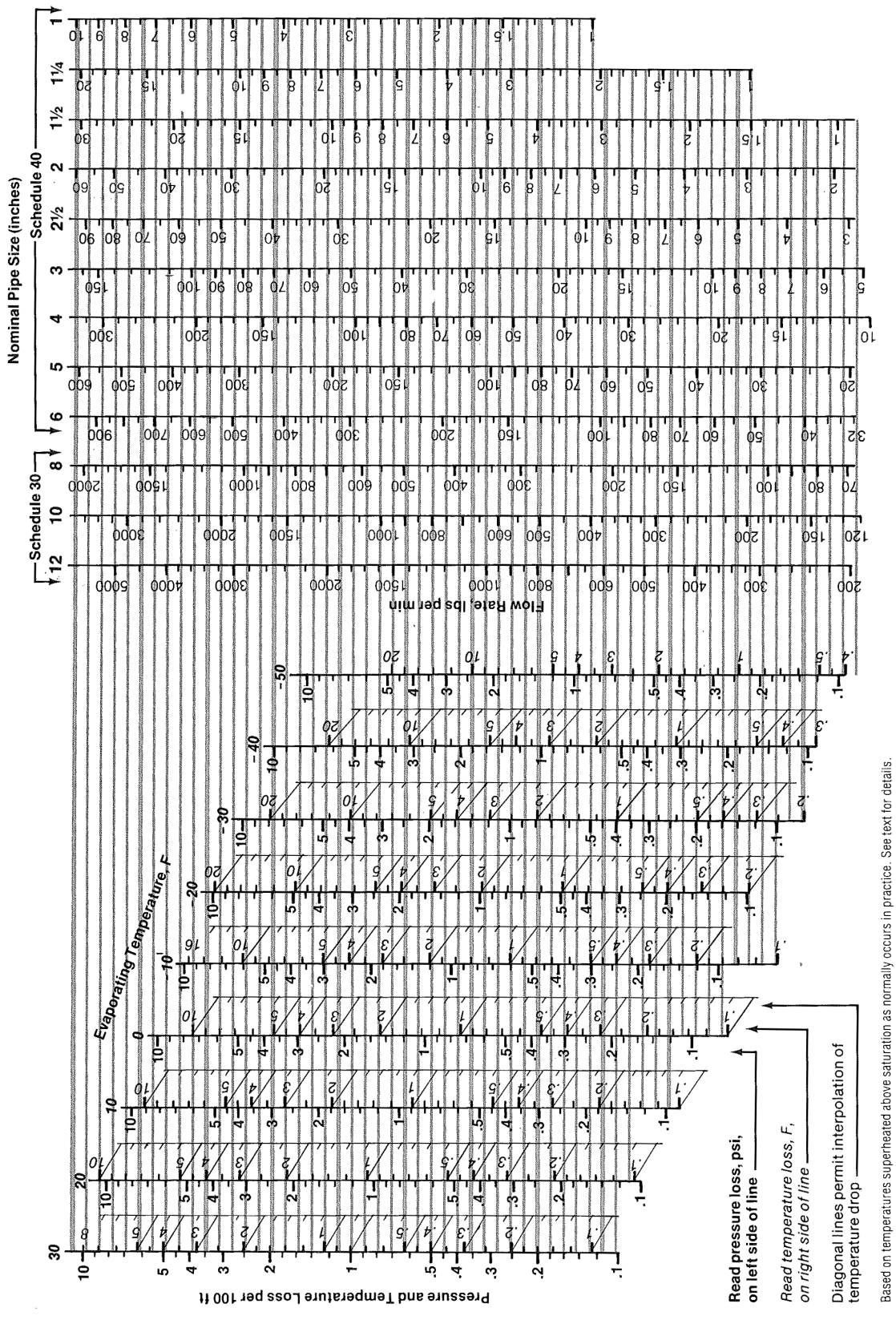


Figure 2-10 Ideal compressor.

35	Equation 2-17	$-\dot{W}_{out} = \dot{m}_2 h_2 - \dot{m}_1 h_1$
36	4 lines from top	h_1 = 107.471 Btu/lb $\quad s_1 = s_2$ = 0.22278 Btu/lb·°R
36	6 lines from top	0.22278 Btu/lb·°R
36	12 lines from top	$T = T_{sat}$ = 105.17°F
36	13 lines from top	s should be 0.22278
36	15 lines from top	$h_2 = 116.71 + \frac{(0.22278 - 0.21844)}{(0.22530 - 0.21844)}(120.64 - 116.71)$
36	16 lines from top	= 119.20 Btu/lb
36	8 lines from bottom	$\dot{W}_{in} = (2 \text{ lb/min})(1 \text{ min/60 s})[(119.20 - 107.471)]$ Btu/lb
36	7 lines from bottom	= 0.391 Btu/s = 1407 Btu/h

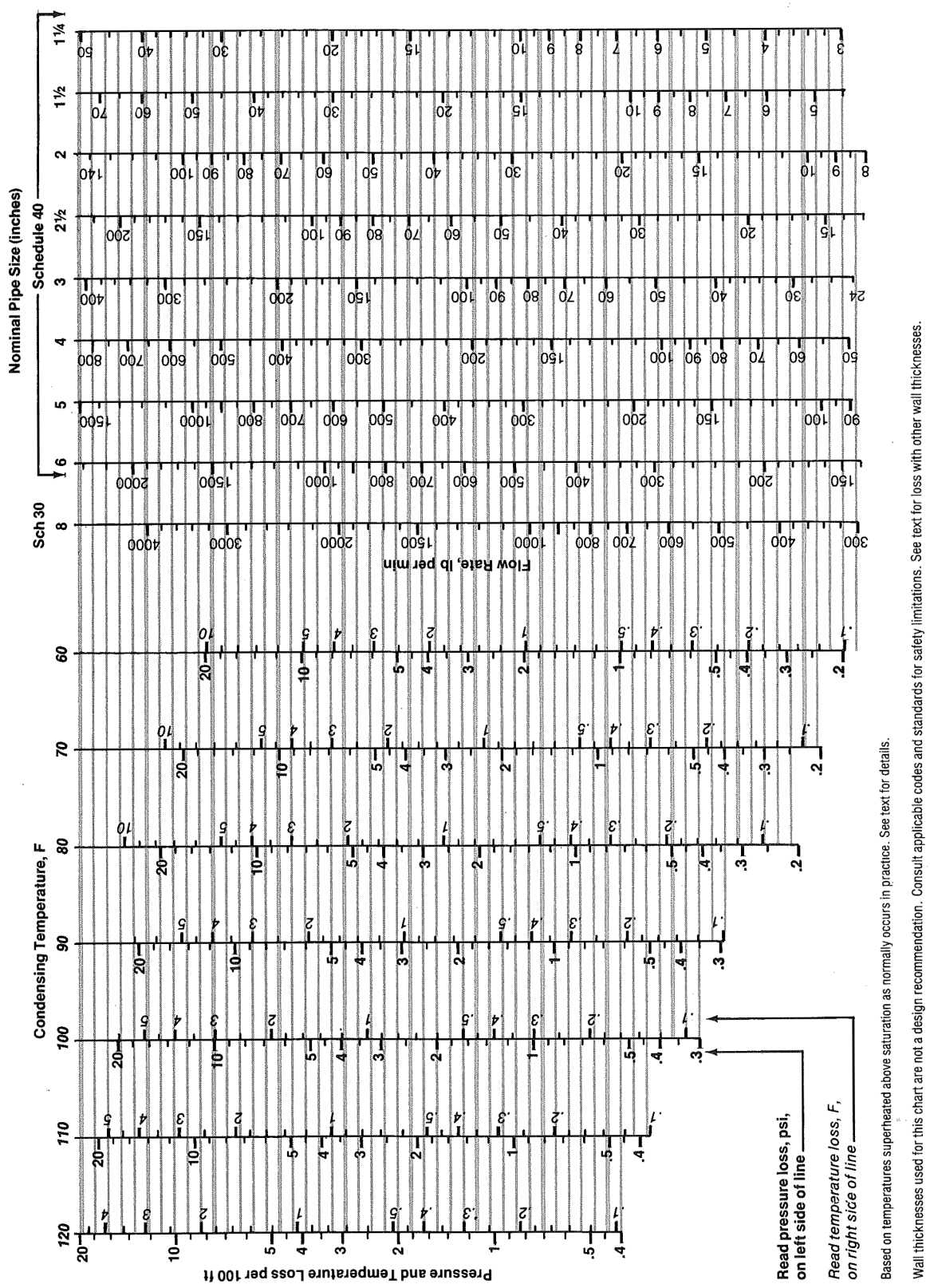
Page #	Location	
36	6 lines from bottom	$= (1407 \text{ Btu/h})\left(\frac{1}{2545 \text{ Btu/h}}\right) = 0.55 \text{ hp}$
37	Example 2-6	$h_2 = 24.72$ Btu/lb
38	15 lines from top	$p_2(sat.) = 5.778$ psia
38	18 lines from top	$h_1 = 30.671$ Btu/lb $= h_2$
39	2 lines from top	$h_{f2} = 18.570$ Btu/lb $\quad h_{g2} = 95.877$ Btu/lb
39	4 lines from top	$= \frac{30.671 - 18.570}{95.877 - 18.570}$
39	5 lines from top	$= 0.157$ or 15.7%
40	2 lines from top	$h_1 = 30.671$ Btu/lb $\quad h_2 = 95.877$ Btu/lb
40	4 lines from top	$= (5 \text{ lb/min})(95.877 - 30.671)$ Btu/lb
48	8 lines from top	$\dot{W}_{out}$ should read $\dot{W}_c$
55	12 lines from top	After the first sentence insert: "Thus the results shown in Figure 3-9 include the removal of flash gas."
55	13 lines from top	"temperature is observed to be approximately"
55	13 lines from top	30°F should be 22°F.
55	14 lines from top	70 psia should be 60.1 psia.
55	15 lines from top	55 psia should be 70.0 psia, and 18°F should be 30°F.
55	17 lines from top	2% should be 4%
62	Example 3-3 solution	$h_1 = 617.590$ Btu/lb and $s_1 = 1.29629$ Btu/lb·°R
82	15 and 16 lines from top	$\dot{Q} = \frac{kA}{x}(T_1 - T_2)$ where $\dot{Q}$ is the heat transfer rate... should read $\boldsymbol{Q} = \frac{kA}{x}(T_1 - T_2)$ where $\boldsymbol{\dot{Q}}$ is the heat transfer rate...
89	First line	Change "13.8 ft_3/lb dry air" to "13.8 ft^3/lb dry air".
89	Example 4-2 solution	Change the last sentence of Example 4-2 solution to: "Because the can's surface temperature is less than the surrounding air's dew point temperature, moisture must condense on the can surface."
110	Skill Dev Exercise 4-3	Change "copper siheets" to "copper sheets".
110	Skill Dev Exercise 4-5	Change last sentence to read "Assume that the refrigerant enters the coil as a saturated liquid and leaves as a saturated vapor at 35°F with no pressure drop."
122	3 lines from top	$\Delta h_{actual} = \frac{(\text{hp})42.4(\text{Btu/min·hp})}{\dot{m}_{actual}} = \frac{(9)(42.4)}{47.78} = 7.99$ Btu/lb
122	6 lines from top	Thus, $\eta_s = 6.69/7.99 = 0.84$ or $\eta_s = 84\%$.
144–45	In text	All occurrences of "impellor" should be spelled "impeller."
171	Skill Dev Exercise 6-4	Change "ft^3/lb" to "ft^3/min" or "cfm"
176	Table 7-1	Row two, column two, the roughness factor should be 0.000005.
177	Example 7-1	Viscosity = μ =0.0199 lb/ft·h (1 h/3600 s) = 0.00000553 = 5.53×10^{-6} lb/ft·s
178	Last line	$p_1 = 105$ psig + 14.7 psia $= 119.7$ psia
179	4 lines from top	$= 119.7 - \left(76.58\frac{\text{lb}}{\text{ft}^3}\right)(25 \text{ ft})\left(\frac{1 \text{ ft}^2}{144 \text{ in.}^2}\right)$
179	5 lines from top	$= 106.4$ psia
181–82	Figures 7-3 and 7-4	Replace Figures 7-3 and 7-4 with more legible graphics as shown on the following pages.



Based on temperatures superheated above saturation as normally occurs in practice. See text for details.

Wall thicknesses used for this chart are not a design recommendation. Consult applicable codes and standards for safety limitations. See text for loss with other wall thicknesses.

Figure 7-3 Pressure and temperature losses for ammonia in steel pipe suction lines.



Based on temperatures superheated above saturation as normally occurs in practice. See text for details.

Wall thicknesses used for this chart are not a design recommendation. Consult applicable codes and standards for safety limitations. See text for loss with other wall thicknesses.

Figure 7-4 Pressure and temperature losses for ammonia in steel pipe discharge lines.

Page #	Location	
189	2 lines from top	Change “diagram given in Figure B-5” to “diagram given in Figure B-6”.
198	Skill Dev Exercise 7-1	Add the word “steel” in the first sentence as shown: “Calculate the pressure drop for a 100 ft length of a 6 in. steel Schedule 40 ammonia suction line.”
198	Skill Dev Exercise 7-3	Add the word “steel” in the first sentence as shown: “A steel piping layout for an ammonia liquid line is shown in the figure below....”
200	Skill Dev Exercise 7-6	Add the word “steel” in the first sentence as shown: “A recirculation system that uses ammonia as the refrigerant has an insulated steel line delivering liquid to a cluster of evaporators.”
231	Figure 9-1	Revise Figure 9-1 as shown on the following pages.
234	Equation 9-2	$V_f = A_f L\left[\pi R^2\left(\frac{\theta}{180°}\right) - R(R - H_f)\sin\theta\right]$
248	Eight lines from bottom	Change 1.9 × 1.9 = 3.61 ft to (2)(1.9 ft) = 3.8 ft.
248	Seven lines from bottom	Change 3.6 ft 3.8 ft.
248	Three lines from bottom	Change 3.6 ft to 3.8 ft.
259	Figure 10-1	Revise Figure 10-1 as shown on the following pages.
265	Table 10-2	Seventh column, second row: 8.81 should be 10.36.
272	Last sentence	“The dominant code in the U.S. HVAC&R industry is ASHRAE Standard 15, which is continuously maintained by ASHRAE and consists of 13 sections and ten appendices.”
274	Example 10-1	$m = \frac{pV}{R_{\text{R-404A}}T}$ $= \frac{(14.7)(144)(69)}{(15.83)(70 + 460)}$ $= 17.4\frac{\text{lb R-404A}}{1000\ \text{ft}^3}$
275	Third line from top	“See that the maximum allowed quantity of refrigerant R-404A, according to Table 10-1, is 2227 lb, which in this situation is far greater than the 45 lb charge.”
276	7 lines from top	44 should be 144
291–92	Solution	Correct as follows:

Furthermore, we can write

$$\frac{M}{\Delta t} = \dot{m} \quad \text{and} \quad \frac{Q_{total}}{\Delta t} = \dot{Q}$$

where the dot above the quantity denotes a time rate of change or flow. Substituting $\dot{m}$ and $\dot{Q}$ into the above equation gives

$$\dot{Q} = \dot{m}c_{p,\,unfrozen}(T_{initial} - T_{freeze}) + \dot{m}h_L + \dot{m}c_{p,\,frozen}(T_{freeze} - T_{final})$$

For this example, $\dot{m}$ = 200 lb/min, and from Appendix C, Table C-2, for blueberries, we have

$c_{p,unfrozen}$ = 0.91 Btu/lb°F
$c_{p,frozen}$ = 0.49 Btu/lb°F
h_L = 122 Btu/lb
T_{freeze} = 29.1°F

So,

$$\dot{Q} = (200)(0.91)(80 - 29.1) + (200)(122) + (200)(0.49)[29.1 - (-5)]$$
$$= 9264 + 24{,}400 + 3342$$
$$= 37{,}010 \text{ Btu/min}$$

or that

$$\dot{Q} = \frac{37{,}010}{200} = 185 \text{ tons, refrigerating capacity}$$

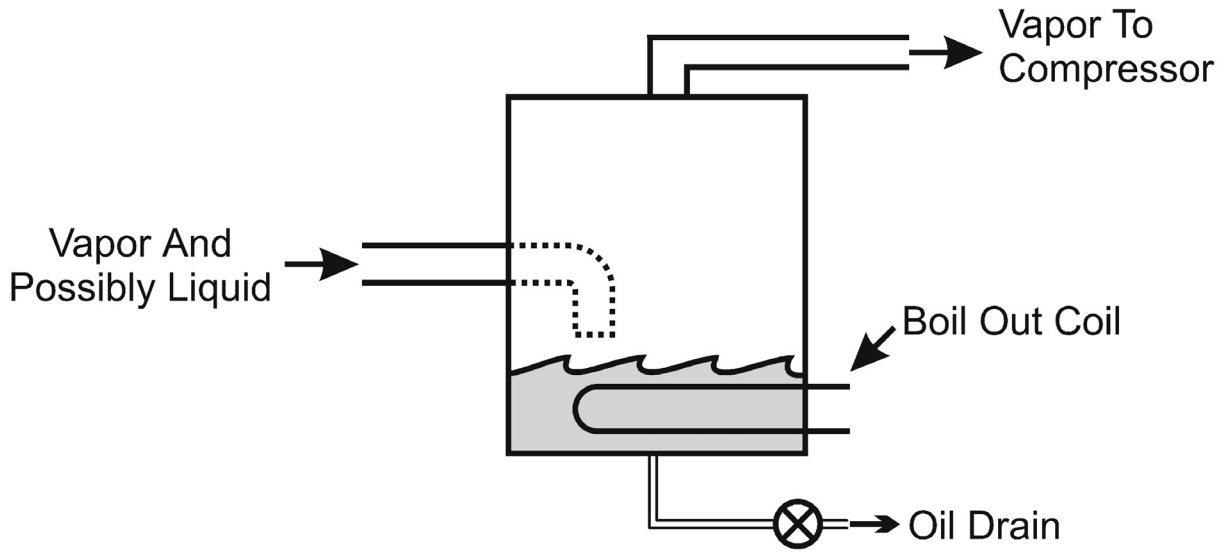


Figure 9-1 Suction line accumulator.

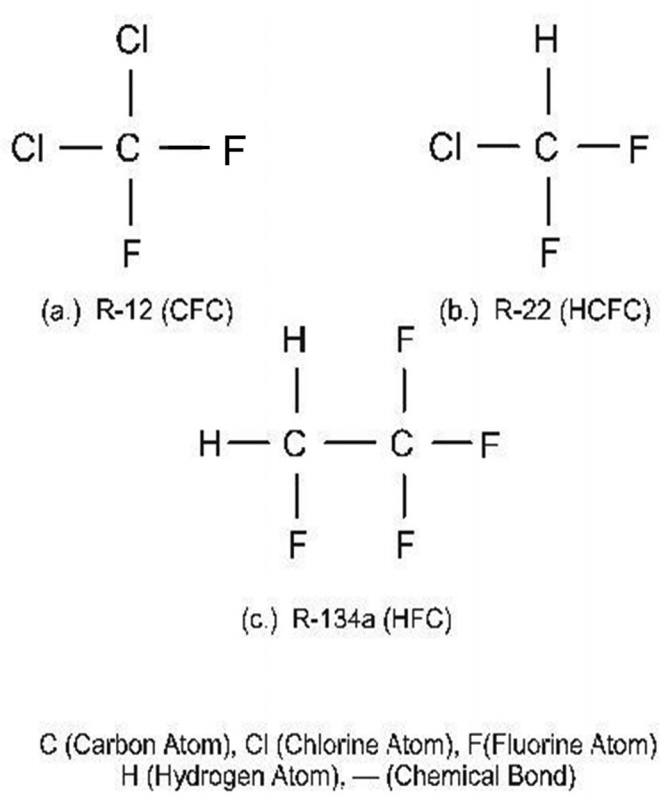


Figure 10-1 Molecular structures of select halocarbon refrigerants.

Page #	Location	
293	2 lines from bottom	$h_c = 0.19V^{0.6}$ (Btu/h·ft^{2}·°F)
298	17 lines from bottom	Replace last part of paragraph with "Figure 11-7d shows the airflow pattern as horizontal with no baffling. Other spiral freezer designs use baffles to split and direct the airflow in a manner to decrease freezing times. Additionally, the airflow pattern may be arranged such that the coldest air first contacts the coldest product. This is generally referred to as a parallel arrangement."
311	First three lines from top	$h_{am,\,in}(\text{sat. liq., } -20°\text{F}) = 21.253 \text{ Btu/lb}$ $h_{am,\,out}(\text{sat. vap., } -20°\text{F}) = 604.789 \text{ Btu/lb}$ $\dot{m}_{am} = \frac{(140 \text{ lb/min})(0.695 \text{ Btu/lb} \cdot °\text{F})[10°\text{F} - (-5°\text{F})]}{(604.789 - 21.253) \text{ Btu/lb}} = 2.50 \text{ lb/min}$
311	Last equation	Change the solution from "4050 Btu/lb·°F" to "4050 Btu/h·°F".
313	References and Bibliography	Add the following as the first entry: ASHRAE. 1997. *ASHRAE Handbook—Fundamentals*, Chapter 19. Atlanta: American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc.
314	Skill Dev Exercise 11-5	Change 20,000 lb to 60,000 lb.
351	Skill Dev Exercise 12-5	Modify last paragraph to read: "Assuming that each month contains 30 days, what is the average daily leak rate of R-123 for each month? Is there reason for concern? Use the Internet to access the U.S. EPA regulations concerning refrigerant leak rates and determine if there is cause for concern. Is there another reason for concern?"
353	First line	Change 2009 to 1997.
354		Replace Table A-1 with the R-22 table from 1997 *ASHRAE Handbook—Fundamentals*, Chapter 19, as shown on the following pages.
355		Replace Table A-2 with the R-23 table from 1997 *ASHRAE Handbook—Fundamentals*, Chapter 19, as shown on the following pages.
356		Replace Table A-3 with the R-123 table from 1997 *ASHRAE Handbook—Fundamentals*, Chapter 19, as shown on the following pages.
357		Replace Table A-4 with the R-134a table from 1997 *ASHRAE Handbook—Fundamentals*, Chapter 19, as shown on the following pages.
358–59		Replace Table A-5 with the R-134a table from 1997 *ASHRAE Handbook—Fundamentals*, Chapter 19, as shown on the following pages.
360		Replace Table A-6 with the R-404A table from 1997 *ASHRAE Handbook—Fundamentals*, Chapter 19, as shown on the following pages.
361		Replace Table A-7 with the R-717 table from 1997 *ASHRAE Handbook—Fundamentals*, Chapter 19, as shown on the following pages.
362		Replace Table A-8 with the R-744 table from 1997 *ASHRAE Handbook—Fundamentals*, Chapter 19, as shown on the following pages.
363	Second line	Change 2009 to 1997.
364		Replace Figure B-1 with the R-22 diagram from 1997 *ASHRAE Handbook—Fundamentals*, Chapter 19, as shown on the following pages.
365		Replace Figure B-2 with the R-23 diagram from 1997 *ASHRAE Handbook—Fundamentals*, Chapter 19, as shown on the following pages.
366		Replace Figure B-3 with the R-123 diagram from 1997 *ASHRAE Handbook—Fundamentals*, Chapter 19, as shown on the following pages.
367		Replace Figure B-4 with the R-134a diagram from 1997 *ASHRAE Handbook—Fundamentals*, Chapter 19, as shown on the following pages.
368		Replace Figure B-5 with the R-404A diagram from 1997 *ASHRAE Handbook—Fundamentals*, Chapter 19, as shown on the following pages.
369		Replace Figure B-6 with the R-717 diagram from 1997 *ASHRAE Handbook—Fundamentals*, Chapter 19, as shown on the following pages.
370		Replace Figure B-7 with the R-744 diagram from 1997 *ASHRAE Handbook—Fundamentals*, Chapter 19, as shown on the following pages.

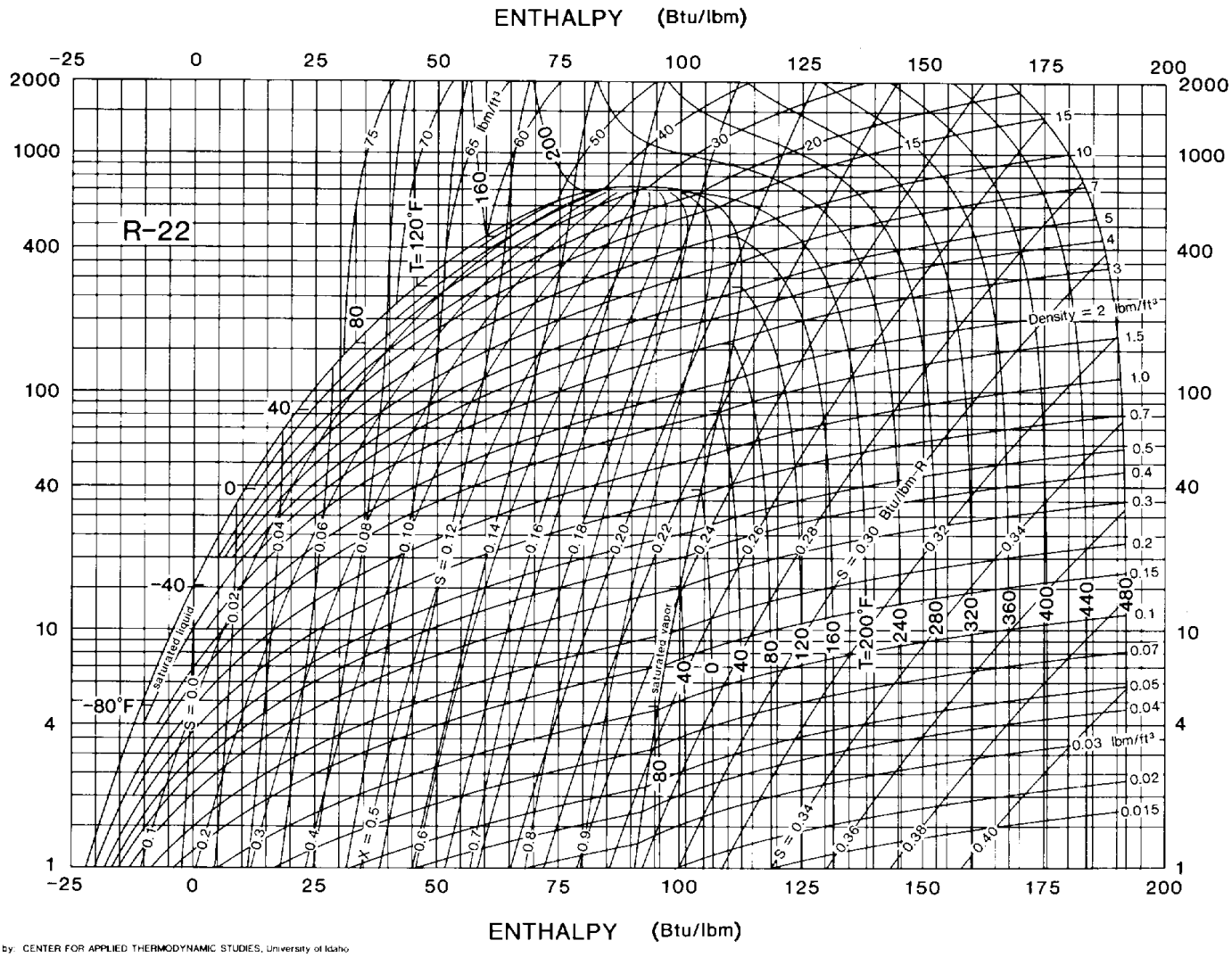


Fig. 4 Pressure-Enthalpy Diagram for Refrigerant 22

Refrigerant 22 (Chlorodifluoromethane) Properties of Saturated Liquid and Saturated Vapor

Temp,* °F	Pressure, psia	Density, lb/ft³ Liquid	Volume, ft³/lb Vapor	Enthalpy, Btu/lb Liquid	Enthalpy, Btu/lb Vapor	Entropy, Btu/lb·°F Liquid	Entropy, Btu/lb·°F Vapor	Specific Heat c_p, Btu/lb·°F Liquid	Specific Heat c_p, Btu/lb·°F Vapor	c_p/c_v Vapor	Velocity of Sound, ft/s Liquid	Velocity of Sound, ft/s Vapor	Viscosity, lb_m/ft·h Liquid	Viscosity, lb_m/ft·h Vapor	Thermal Cond, Btu/h·ft·°F Liquid	Thermal Cond, Btu/h·ft·°F Vapor	Surface Tension, dyne/cm	Temp,* °F
−250.00	—	107.37	—	−63.169	76.604	−0.21914	0.44952	—	0.1018	1.2914	—	395.	—	—	—	—	—	−250.00
−240.00	—	106.41	—	−56.462	77.629	−0.18786	0.42332	—	0.1033	1.2860	—	403.	—	—	—	—	—	−240.00
−230.00	—	105.48	—	−51.569	78.669	−0.16605	0.40101	—	0.1048	1.2807	—	411.	—	—	—	—	36.75	−230.00
−220.00	0.002	104.58	16805.	−47.705	79.724	−0.14958	0.38211	—	0.1064	1.2754	—	419.	—	—	—	—	35.70	−220.00
−210.00	0.004	103.70	6982.6	−44.426	80.796	−0.13616	0.36538	—	0.1080	1.2703	—	427.	—	—	—	—	34.67	−210.00
−200.00	0.010	102.81	3151.5	−41.474	81.882	−0.12457	0.35048	—	0.1096	1.2653	—	435.	—	—	—	—	33.63	−200.00
−190.00	0.022	101.92	1527.4	−38.706	82.984	−0.11411	0.33715	—	0.1113	1.2604	—	442.	—	—	—	—	32.61	−190.00
−180.00	0.044	101.03	787.79	−36.038	84.100	−0.10439	0.32518	—	0.1130	1.2558	—	449.	—	—	—	—	31.59	−180.00
−170.00	0.084	100.12	429.22	−33.424	85.230	−0.09521	0.31441	—	0.1147	1.2515	—	456.	—	—	—	—	30.58	−170.00
−160.00	0.151	99.22	245.51	−30.839	86.373	−0.08644	0.30470	—	0.1165	1.2474	—	463.	—	—	—	—	29.57	−160.00
−150.00	0.262	98.30	146.65	−28.269	87.528	−0.07800	0.29594	—	0.1183	1.2437	—	470.	—	—	—	—	28.57	−150.00
−140.00	0.435	97.38	91.059	−25.708	88.692	−0.06986	0.28801	—	0.1201	1.2403	—	476.	—	—	—	—	27.57	−140.00
−130.00	0.696	96.46	58.544	−23.150	89.864	−0.06198	0.28082	—	0.1221	1.2374	—	482.	—	—	—	—	26.59	−130.00
−120.00	1.080	95.53	38.833	−20.594	91.040	−0.05435	0.27430	0.2555	0.1241	1.2349	3483.	488.	—	—	—	—	25.61	−120.00
−110.00	1.626	94.60	26.494	−18.038	92.218	−0.04694	0.26838	0.2555	0.1262	1.2329	3384.	494.	—	—	0.0765	—	24.64	−110.00
−100.00	2.384	93.66	18.540	−15.481	93.397	−0.03973	0.26298	0.2557	0.1285	1.2315	3290.	500.	—	—	0.0749	—	23.67	−100.00
−90.00	3.413	92.71	13.275	−12.921	94.572	−0.03271	0.25807	0.2561	0.1308	1.2307	3198.	505.	—	—	0.0734	0.00292	22.71	−90.00
−80.00	4.778	91.75	9.7044	−10.355	95.741	−0.02587	0.25357	0.2567	0.1334	1.2305	3110.	510.	—	—	0.0718	0.00315	21.76	−80.00
−70.00	6.555	90.79	7.2285	−7.783	96.901	−0.01919	0.24945	0.2574	0.1361	1.2310	3023.	514.	—	—	0.0703	0.00338	20.82	−70.00
−60.00	8.830	89.81	5.4766	−5.201	98.049	−0.01266	0.24567	0.2584	0.1389	1.2323	2937.	519.	—	—	0.0688	0.00360	19.89	−60.00
−50.00	11.696	88.83	4.2138	−2.608	99.182	−0.00627	0.24220	0.2596	0.1420	1.2344	2852.	522.	—	—	0.0673	0.00382	18.96	−50.00
−45.00	13.383	88.33	3.7160	−1.306	99.742	−0.00312	0.24056	0.2604	0.1436	1.2358	2810.	524.	—	—	0.0665	0.00393	18.50	−45.00
−41.44b	14.696	87.97	3.4048	−0.377	100.138	−0.00090	0.23944	0.2609	0.1448	1.2369	2780.	525.	—	—	0.0660	0.00401	18.18	−41.44
−40.00	15.255	87.82	3.2880	0.000	100.296	0.00000	0.23899	0.2611	0.1453	1.2374	2768.	526.	—	—	0.0658	0.00404	18.05	−40.00
−35.00	17.329	87.32	2.9185	1.310	100.847	0.00309	0.23748	0.2620	0.1471	1.2393	2725.	527.	—	—	0.0651	0.00414	17.59	−35.00
−30.00	19.617	86.81	2.5984	2.624	101.391	0.00616	0.23602	0.2629	0.1489	1.2414	2683.	529.	—	—	0.0643	0.00425	17.14	−30.00
−25.00	22.136	86.29	2.3202	3.944	101.928	0.00920	0.23462	0.2638	0.1507	1.2437	2641.	530.	—	—	0.0636	0.00435	16.69	−25.00
−20.00	24.899	85.77	2.0774	5.268	102.461	0.01222	0.23327	0.2648	0.1527	1.2463	2599.	531.	—	—	0.0629	0.00445	16.24	−20.00
−15.00	27.924	85.25	1.8650	6.598	102.986	0.01521	0.23197	0.2659	0.1547	1.2493	2557.	532.	—	—	0.0622	0.00456	15.79	−15.00
−10.00	31.226	84.72	1.6784	7.934	103.503	0.01818	0.23071	0.2671	0.1567	1.2525	2515.	533.	—	—	0.0614	0.00466	—	−10.00
−5.00	34.821	84.18	1.5142	9.276	104.013	0.02113	0.22949	0.2684	0.1589	1.2560	2473.	534.	—	—	0.0607	0.00476	—	−5.00
0.00	38.726	83.64	1.3691	10.624	104.515	0.02406	0.22832	0.2697	0.1611	1.2599	2431.	535.	0.615	0.0268	0.0600	0.00486	—	0.00
5.00	42.960	83.09	1.2406	11.979	105.009	0.02697	0.22718	0.2710	0.1634	1.2641	2389.	535.	0.597	0.0271	0.0593	0.00496	—	5.00
10.00	47.538	82.54	1.1265	13.342	105.493	0.02987	0.22607	0.2725	0.1658	1.2687	2346.	535.	0.580	0.0274	0.0586	0.00506	—	10.00
15.00	52.480	81.98	1.0250	14.712	105.968	0.03275	0.22500	0.2740	0.1683	1.2737	2304.	536.	0.563	0.0276	0.0579	0.00516	—	15.00
20.00	57.803	81.41	0.9343	16.090	106.434	0.03561	0.22395	0.2756	0.1709	1.2792	2262.	536.	0.546	0.0279	0.0572	0.00526	—	20.00
25.00	63.526	80.84	0.8532	17.476	106.891	0.03846	0.22294	0.2773	0.1737	1.2851	2219.	536.	0.530	0.0282	0.0566	0.00536	—	25.00
30.00	69.667	80.26	0.7804	18.871	107.336	0.04129	0.22195	0.2791	0.1765	1.2915	2177.	536.	0.515	0.0284	0.0559	0.00546	—	30.00
35.00	76.245	79.67	0.7150	20.275	107.769	0.04411	0.22098	0.2809	0.1794	1.2984	2134.	535.	0.499	0.0287	0.0552	0.00555	—	35.00
40.00	83.280	79.07	0.6561	21.688	108.191	0.04692	0.22004	0.2829	0.1825	1.3059	2091.	535.	0.484	0.0290	0.0545	0.00565	—	40.00
45.00	90.791	78.46	0.6029	23.111	108.600	0.04972	0.21912	0.2849	0.1857	1.3141	2048.	534.	0.470	0.0292	0.0538	0.00575	—	45.00
50.00	98.799	77.84	0.5548	24.544	108.997	0.05251	0.21821	0.2870	0.1891	1.3229	2005.	533.	0.456	0.0295	0.0532	0.00584	—	50.00
55.00	107.32	77.22	0.5111	25.988	109.379	0.05529	0.21732	0.2893	0.1927	1.3324	1962.	532.	0.442	0.0298	0.0525	0.00594	—	55.00
60.00	116.38	76.58	0.4715	27.443	109.748	0.05806	0.21644	0.2916	0.1964	1.3428	1919.	531.	0.429	0.0301	0.0518	0.00604	—	60.00
65.00	126.00	75.93	0.4355	28.909	110.103	0.06082	0.21557	0.2941	0.2003	1.3540	1876.	530.	0.416	0.0303	0.0512	0.00613	—	65.00
70.00	136.19	75.27	0.4026	30.387	110.441	0.06358	0.21472	0.2967	0.2045	1.3663	1832.	528.	0.404	—	0.0505	0.00623	—	70.00
75.00	146.98	74.60	0.3726	31.877	110.761	0.06633	0.21387	0.2994	0.2089	1.3796	1788.	527.	0.392	—	0.0499	0.00632	—	75.00
80.00	158.40	73.92	0.3451	33.381	111.066	0.06907	0.21302	0.3024	0.2135	1.3941	1744.	525.	0.380	—	0.0492	0.00642	—	80.00
85.00	170.45	73.22	0.3199	34.898	111.350	0.07182	0.21218	0.3055	0.2185	1.4100	1700.	523.	0.369	—	0.0486	0.00652	—	85.00
90.00	183.17	72.51	0.2968	36.430	111.616	0.07456	0.21134	0.3088	0.2238	1.4275	1655.	520.	0.358	—	0.0479	0.00661	—	90.00
95.00	196.57	71.79	0.2756	37.977	111.859	0.07730	0.21050	0.3123	0.2295	1.4467	1611.	518.	0.348	—	0.0473	0.00671	—	95.00
100.00	210.69	71.05	0.2560	39.538	112.081	0.08003	0.20965	0.3162	0.2356	1.4678	1566.	515.	0.338	—	0.0466	0.00680	—	100.00
105.00	225.53	70.29	0.2379	41.119	112.278	0.08277	0.20879	0.3203	0.2422	1.4912	1520.	512.	—	—	0.0460	0.00690	—	105.00
110.00	241.14	69.51	0.2212	42.717	112.448	0.08552	0.20793	0.3248	0.2495	1.5173	1474.	509.	—	—	0.0454	0.00699	—	110.00
115.00	257.52	68.71	0.2058	44.334	112.591	0.08827	0.20705	0.3298	0.2573	1.5464	1428.	506.	—	—	0.0447	0.00709	—	115.00
120.00	274.71	67.89	0.1914	45.972	112.704	0.09103	0.20615	0.3353	0.2660	1.5791	1382.	502.	—	—	0.0441	0.00719	—	120.00
125.00	292.73	67.05	0.1781	47.633	112.783	0.09379	0.20522	0.3413	0.2756	1.6160	1334.	498.	—	—	—	—	—	125.00
130.00	311.61	66.17	0.1657	49.319	112.825	0.09657	0.20427	0.3482	0.2864	1.6581	1287.	494.	—	—	—	—	—	130.00
135.00	331.38	65.27	0.1542	51.032	112.826	0.09937	0.20329	0.3559	0.2985	1.7063	1238.	489.	—	—	—	—	—	135.00
140.00	352.07	64.33	0.1434	52.775	112.784	0.10220	0.20227	0.3648	0.3123	1.7621	1189.	485.	—	—	—	—	—	140.00
145.00	373.71	63.35	0.1332	54.553	112.692	0.10504	0.20119	0.3752	0.3282	1.8275	1139.	479.	—	—	—	—	—	145.00
150.00	396.32	62.33	0.1237	56.370	112.541	0.10793	0.20006	0.3873	0.3468	1.9050	1088.	474.	—	—	—	—	—	150.00
160.00	444.65	60.12	0.1063	60.145	112.035	0.11383	0.19757	0.4198	0.3957	2.1126	983.	462.	—	—	—	—	—	160.00
170.00	497.35	57.59	0.0907	64.175	111.165	0.12001	0.19464	0.4711	0.4716	2.4409	873.	448.	—	—	—	—	—	170.00
180.00	554.82	54.57	0.0763	68.597	109.753	0.12668	0.19102	0.5657	0.6073	3.0349	752.	433.	—	—	—	—	—	180.00
190.00	617.53	50.62	0.0625	73.742	107.398	0.13432	0.18613	0.7952	0.9222	4.4150	616.	415.	—	—	—	—	—	190.00
200.00	686.11	44.44	0.0478	80.558	102.809	0.14432	0.17805	—	—	—	—	—	—	—	—	—	—	200.00
205.06c	723.74	32.70	0.0306	91.052	91.052	0.15989	0.15989	∞	∞	∞	0.	0.	—	—	∞	∞	0.00	205.06

*temperatures are on the ITS−90 scale b = normal boiling point c = critical point

Refrigerant 23 (Trifluoromethane) Properties of Saturated Liquid and Saturated Vapor

Temp,* °F	Pressure, psia	Density, lb/ft³ Liquid	Volume, ft³/lb Vapor	Enthalpy, Btu/lb Liquid	Enthalpy, Btu/lb Vapor	Entropy, Btu/lb·°F Liquid	Entropy, Btu/lb·°F Vapor	Specific Heat c_p, Btu/lb·°F Liquid	Specific Heat c_p, Btu/lb·°F Vapor	c_p/c_v Vapor	Velocity of Sound, ft/s Liquid	Velocity of Sound, ft/s Vapor	Viscosity, lb_m/ft·h Liquid	Viscosity, lb_m/ft·h Vapor	Thermal Cond, Btu/h·ft·°F Liquid	Thermal Cond, Btu/h·ft·°F Vapor	Surface Tension, dyne/cm	Temp,* °F
−160.00	2.774	94.42	16.315	−35.171	75.195	−0.09766	0.27063	—	0.1363	1.2960	—	517.	—	—	—	—	—	−160.00
−155.00	3.442	93.95	13.334	−33.755	75.756	−0.09298	0.26646	—	0.1380	1.2969	—	521.	—	—	—	—	—	−155.00
−150.00	4.237	93.46	10.981	−32.354	76.309	−0.08842	0.26247	—	0.1399	1.2980	—	524.	—	—	—	—	—	−150.00
−145.00	5.177	92.97	9.1062	−30.964	76.853	−0.08398	0.25866	—	0.1419	1.2995	—	527.	—	—	—	—	—	−145.00
−140.00	6.279	92.46	7.6019	−29.581	77.388	−0.07962	0.25500	—	0.1441	1.3014	—	529.	—	—	—	—	—	−140.00
−135.00	7.566	91.95	6.3857	−28.201	77.913	−0.07535	0.25149	—	0.1464	1.3036	—	532.	—	—	—	—	—	−135.00
−130.00	9.058	91.42	5.3956	−26.822	78.427	−0.07114	0.24811	—	0.1488	1.3062	—	535.	—	—	—	—	—	−130.00
−125.00	10.778	90.88	4.5844	−25.440	78.930	−0.06699	0.24487	—	0.1514	1.3091	—	537.	—	—	—	—	—	−125.00
−120.00	12.751	90.32	3.9155	−24.052	79.421	−0.06289	0.24174	—	0.1542	1.3125	—	539.	—	—	—	—	—	−120.00
−115.64b	14.696	89.83	3.4267	−22.837	79.839	−0.05935	0.23911	—	0.1567	1.3157	—	541.	—	—	—	—	—	−115.64
−115.00	15.003	89.76	3.3607	−22.657	79.900	−0.05882	0.23873	—	0.1571	1.3162	—	541.	—	—	—	—	—	−115.00
−110.00	17.561	89.18	2.8981	−21.252	80.366	−0.05479	0.23582	—	0.1602	1.3204	—	543.	—	—	—	—	—	−110.00
−105.00	20.452	88.59	2.5102	−19.835	80.818	−0.05078	0.23301	—	0.1634	1.3251	—	545.	—	—	—	—	—	−105.00
−100.00	23.708	87.98	2.1834	−18.405	81.256	−0.04680	0.23029	—	0.1669	1.3302	—	546.	—	—	—	—	—	−100.00
−98.00	25.118	87.74	2.0672	−17.829	81.428	−0.04521	0.22923	—	0.1683	1.3324	—	547.	—	—	—	—	—	−98.00
−96.00	26.594	87.49	1.9584	−17.251	81.597	−0.04363	0.22818	—	0.1698	1.3346	—	547.	—	—	—	—	—	−96.00
−94.00	28.137	87.24	1.8565	−16.670	81.764	−0.04204	0.22714	—	0.1713	1.3370	—	548.	—	—	—	—	—	−94.00
−92.00	29.748	86.98	1.7609	−16.087	81.928	−0.04046	0.22612	—	0.1728	1.3394	—	548.	—	—	—	—	—	−92.00
−90.00	31.431	86.73	1.6712	−15.501	82.090	−0.03888	0.22511	—	0.1744	1.3419	—	549.	—	—	—	—	—	−90.00
−88.00	33.187	86.47	1.5871	−14.912	82.249	−0.03730	0.22411	—	0.1760	1.3445	—	549.	—	—	—	—	—	−88.00
−86.00	35.019	86.21	1.5079	−14.321	82.407	−0.03573	0.22313	—	0.1776	1.3472	—	550.	—	—	—	—	—	−86.00
−84.00	36.927	85.95	1.4336	−13.728	82.561	−0.03416	0.22216	—	0.1792	1.3500	—	550.	—	—	—	—	—	−84.00
−82.00	38.916	85.68	1.3636	−13.132	82.713	−0.03258	0.22119	—	0.1809	1.3529	—	550.	—	—	—	—	—	−82.00
−80.00	40.986	85.42	1.2977	−12.533	82.863	−0.03101	0.22025	—	0.1826	1.3559	—	551.	—	—	—	—	—	−80.00
−78.00	43.140	85.15	1.2356	−11.931	83.010	−0.02945	0.21930	—	0.1844	1.3589	—	551.	—	—	—	—	—	−78.00
−76.00	45.380	84.87	1.1771	−11.327	83.155	−0.02788	0.21838	—	0.1862	1.3621	—	551.	—	—	—	—	13.68	−76.00
−74.00	47.709	84.60	1.1219	−10.720	83.297	−0.02632	0.21746	—	0.1880	1.3654	—	551.	—	—	—	—	13.43	−74.00
−72.00	50.128	84.32	1.0698	−10.110	83.436	−0.02475	0.21655	—	0.1899	1.3688	—	551.	—	—	—	—	13.18	−72.00
−70.00	52.639	84.04	1.0207	−9.497	83.573	−0.02319	0.21565	—	0.1918	1.3722	—	551.	—	—	—	—	12.93	−70.00
−68.00	55.246	83.76	0.9742	−8.882	83.707	−0.02163	0.21477	—	0.1937	1.3758	—	552.	—	—	—	—	12.69	−68.00
−66.00	57.951	83.47	0.9302	−8.264	83.839	−0.02007	0.21389	—	0.1957	1.3796	—	552.	—	—	—	—	12.44	−66.00
−64.00	60.755	83.18	0.8887	−7.644	83.968	−0.01852	0.21302	—	0.1977	1.3834	—	552.	—	—	—	—	12.20	−64.00
−62.00	63.660	82.89	0.8493	−7.021	84.094	−0.01696	0.21216	—	0.1997	1.3874	—	552.	—	—	—	—	11.96	−62.00
−60.00	66.671	82.59	0.8121	−6.395	84.217	−0.01541	0.21131	—	0.2018	1.3915	—	552.	—	—	—	—	11.72	−60.00
−58.00	69.787	82.30	0.7768	−5.767	84.337	−0.01386	0.21047	—	0.2039	1.3957	—	551.	—	—	—	—	11.48	−58.00
−56.00	73.013	82.00	0.7433	−5.136	84.455	−0.01231	0.20963	—	0.2061	1.4000	—	551.	—	—	—	—	11.24	−56.00
−54.00	76.350	81.69	0.7116	−4.502	84.570	−0.01076	0.20881	—	0.2083	1.4045	—	551.	—	—	—	—	11.01	−54.00
−52.00	79.800	81.38	0.6814	−3.866	84.682	−0.00922	0.20799	—	0.2106	1.4092	—	551.	—	—	—	—	10.77	−52.00
−50.00	83.367	81.07	0.6528	−3.228	84.791	−0.00767	0.20718	—	0.2129	1.4140	—	551.	—	—	—	—	10.54	−50.00
−48.00	87.052	80.76	0.6257	−2.587	84.897	−0.00614	0.20637	—	0.2152	1.4190	—	550.	—	—	—	—	10.31	−48.00
−46.00	90.858	80.44	0.5998	−1.944	85.000	−0.00460	0.20558	—	0.2176	1.4241	—	550.	—	—	—	—	10.08	−46.00
−44.00	94.787	80.12	0.5753	−1.298	85.100	−0.00306	0.20479	—	0.2200	1.4294	—	550.	—	—	—	—	9.85	−44.00
−42.00	98.842	79.80	0.5519	−0.650	85.197	−0.00153	0.20401	—	0.2225	1.4349	—	549.	—	—	—	—	9.62	−42.00
−40.00	103.03	79.47	0.5296	0.000	85.291	0.00000	0.20323	—	0.2251	1.4405	738.	549.	0.396	—	0.0595	0.00654	9.40	−40.00
−38.00	107.34	79.14	0.5085	0.652	85.382	0.00153	0.20246	—	0.2277	1.4464	719.	548.	0.391	—	0.0590	0.00661	9.17	−38.00
−36.00	111.79	78.80	0.4883	1.307	85.469	0.00305	0.20170	—	0.2303	1.4525	701.	548.	0.386	—	0.0585	0.00668	8.95	−36.00
−34.00	116.37	78.47	0.4690	1.964	85.553	0.00457	0.20094	—	0.2330	1.4588	684.	547.	0.380	—	0.0581	0.00675	8.73	−34.00
−32.00	121.09	78.12	0.4507	2.623	85.634	0.00609	0.20019	—	0.2358	1.4653	667.	547.	0.375	—	0.0576	0.00683	8.51	−32.00
−30.00	125.95	77.78	0.4332	3.284	85.711	0.00761	0.19944	—	0.2386	1.4720	651.	546.	0.370	—	0.0572	0.00691	8.29	−30.00
−25.00	138.74	76.89	0.3928	4.947	85.888	0.01138	0.19760	—	0.2460	1.4901	613.	544.	0.357	—	0.0561	0.00711	7.76	−25.00
−20.00	152.46	75.98	0.3567	6.622	86.042	0.01514	0.19577	—	0.2538	1.5099	578.	542.	0.344	0.0299	0.0550	0.00732	7.23	−20.00
−15.00	167.17	75.04	0.3244	8.311	86.171	0.01888	0.19397	—	0.2622	1.5318	546.	540.	0.331	0.0304	0.0540	0.00755	6.72	−15.00
−10.00	182.90	74.07	0.2954	10.013	86.274	0.02260	0.19219	—	0.2711	1.5561	517.	537.	0.318	0.0309	0.0530	0.00778	6.22	−10.00
−5.00	199.70	73.07	0.2692	11.730	86.346	0.02630	0.19041	—	0.2808	1.5833	491.	534.	0.306	0.0314	0.0519	0.00803	—	−5.00
0.00	217.62	72.03	0.2457	13.462	86.387	0.02999	0.18863	—	0.2912	1.6138	466.	530.	0.293	0.0319	0.0508	0.00829	—	0.00
5.00	236.71	70.96	0.2243	15.213	86.392	0.03367	0.18685	—	0.3027	1.6484	444.	527.	0.281	0.0324	0.0497	0.00856	—	5.00
10.00	257.02	69.84	0.2049	16.985	86.358	0.03735	0.18505	—	0.3153	1.6879	423.	523.	0.269	0.0330	0.0484	0.00884	—	10.00
15.00	278.61	68.67	0.1872	18.783	86.278	0.04103	0.18323	—	0.3293	1.7334	403.	518.	—	0.0337	—	—	—	15.00
20.00	301.55	67.46	0.1710	20.611	86.148	0.04474	0.18136	—	0.3452	1.7866	385.	513.	—	0.0343	—	—	—	20.00
25.00	325.90	66.19	0.1562	22.479	85.959	0.04847	0.17944	—	0.3634	1.8495	367.	508.	—	0.0351	—	—	—	25.00
30.00	351.74	64.85	0.1426	24.396	85.701	0.05225	0.17745	—	0.3847	1.9250	349.	502.	—	0.0359	—	—	—	30.00
35.00	379.14	63.43	0.1300	26.375	85.361	0.05611	0.17536	—	0.4100	2.0176	332.	495.	—	0.0368	—	—	—	35.00
40.00	408.19	61.93	0.1183	28.434	84.923	0.06008	0.17314	—	0.4411	2.1338	314.	488.	—	0.0379	—	—	—	40.00
45.00	438.99	60.32	0.1074	30.598	84.365	0.06421	0.17074	—	0.4803	2.2840	296.	481.	—	0.0390	—	—	—	45.00
50.00	471.64	58.58	0.0971	32.901	83.654	0.06855	0.16813	—	0.5319	2.4859	277.	472.	—	0.0402	—	—	—	50.00
55.00	506.27	56.68	0.0874	35.389	82.745	0.07319	0.16520	—	0.6039	2.7721	257.	463.	—	0.0416	—	—	—	55.00
60.00	543.01	54.55	0.0780	38.138	81.561	0.07827	0.16182	—	0.7125	3.2100	236.	452.	—	—	—	—	—	60.00
65.00	581.99	52.08	0.0688	41.270	79.972	0.08400	0.15777	—	0.8981	3.9663	213.	441.	—	—	—	—	—	65.00
70.00	623.39	49.05	0.0594	45.032	77.695	0.09085	0.15252	—	1.2953	5.5959	—	—	—	—	—	—	—	70.00
75.00	667.39	44.71	0.0488	50.138	73.842	0.10012	0.14445	—	—	—	—	—	—	—	—	—	—	75.00
78.66c	701.40	32.78	0.0305	61.455	61.455	0.12090	0.12090	∞	∞	∞	0.	0.	—	—	∞	∞	0.00	78.66

*temperatures are on the IPTS−68 scale b = normal boiling point c = critical point

Refrigerant 123 (2,2-Dichloro-1,1,1-trifluoroethane) Properties of Saturated Liquid and Saturated Vapor

Temp.,* °F	Pressure, psia	Density, lb/ft³ Liquid	Volume, ft³/lb Vapor	Enthalpy, Btu/lb Liquid	Enthalpy, Btu/lb Vapor	Entropy, Btu/lb·°F Liquid	Entropy, Btu/lb·°F Vapor	Specific Heat c_p, Btu/lb·°F Liquid	Specific Heat c_p, Btu/lb·°F Vapor	c_p/c_v Vapor	Velocity of Sound, ft/s Liquid	Velocity of Sound, ft/s Vapor	Viscosity, lb_m/ft·h Liquid	Viscosity, lb_m/ft·h Vapor	Thermal Cond, Btu/h·ft·°F Liquid	Thermal Cond, Btu/h·ft·°F Vapor	Surface Tension, dyne/cm	Temp.,* °F
−40.00	0.548	100.71	53.445	0.000	81.340	0.00000	0.19382	—	0.1419	1.1064	—	386.	2.537	—	—	—	23.49	−40.00
−30.00	0.776	99.96	38.593	2.005	82.707	0.00472	0.19254	—	0.1442	1.1057	—	390.	2.303	—	—	—	22.78	−30.00
−20.00	1.080	99.20	28.345	3.923	84.085	0.00913	0.19146	—	0.1466	1.1052	—	394.	2.100	—	—	—	22.06	−20.00
−10.00	1.478	98.44	21.141	5.812	85.476	0.01338	0.19054	—	0.1490	1.1047	—	398.	1.922	—	—	—	21.35	−10.00
0.00	1.993	97.67	15.993	7.710	86.877	0.01755	0.18978	—	0.1514	1.1045	—	401.	1.766	—	0.0515	—	20.65	0.00
5.00	2.303	97.28	13.979	8.672	87.581	0.01963	0.18945	—	0.1526	1.1044	—	403.	1.695	—	0.0510	—	20.30	5.00
10.00	2.651	96.89	12.258	9.645	88.289	0.02171	0.18916	—	0.1539	1.1043	—	405.	1.629	—	0.0506	—	19.95	10.00
15.00	3.042	96.49	10.782	10.631	88.998	0.02380	0.18890	—	0.1551	1.1043	—	406.	1.566	—	0.0501	—	19.61	15.00
20.00	3.480	96.09	9.5110	11.632	89.710	0.02590	0.18867	—	0.1563	1.1043	—	408.	1.507	—	0.0496	—	19.26	20.00
25.00	3.969	95.69	8.4141	12.647	90.424	0.02800	0.18847	0.2046	0.1576	1.1043	2636.	409.	1.451	—	0.0492	—	18.92	25.00
30.00	4.513	95.29	7.4644	13.679	91.140	0.03012	0.18831	0.2079	0.1588	1.1044	2596.	411.	1.398	—	0.0487	—	18.57	30.00
35.00	5.116	94.88	6.6397	14.727	91.859	0.03224	0.18817	0.2111	0.1601	1.1046	2558.	412.	1.348	—	0.0482	—	18.23	35.00
40.00	5.785	94.47	5.9215	15.792	92.579	0.03438	0.18806	0.2144	0.1613	1.1047	2521.	414.	1.301	—	0.0478	—	17.89	40.00
45.00	6.522	94.06	5.2943	16.873	93.301	0.03653	0.18797	0.2177	0.1626	1.1050	2486.	415.	1.257	—	0.0473	—	17.55	45.00
50.00	7.334	93.64	4.7450	17.971	94.025	0.03869	0.18791	0.2209	0.1639	1.1052	2452.	416.	1.214	—	0.0468	—	17.21	50.00
55.00	8.226	93.22	4.2628	19.084	94.750	0.04086	0.18788	0.2240	0.1651	1.1056	2419.	417.	1.174	—	0.0464	—	16.87	55.00
60.00	9.203	92.80	3.8384	20.213	95.477	0.04304	0.18787	0.2271	0.1664	1.1059	2387.	418.	1.136	—	0.0459	—	16.53	60.00
65.00	10.271	92.38	3.4639	21.356	96.205	0.04523	0.18789	0.2300	0.1676	1.1063	2355.	419.	1.099	—	0.0454	—	16.20	65.00
70.00	11.436	91.95	3.1326	22.515	96.933	0.04742	0.18792	0.2329	0.1689	1.1068	2323.	420.	1.065	—	0.0450	0.00572	15.86	70.00
75.00	12.704	91.52	2.8389	23.687	97.663	0.04962	0.18798	0.2356	0.1701	1.1074	2292.	421.	1.032	—	0.0445	0.00583	15.53	75.00
80.00	14.080	91.08	2.5779	24.873	98.394	0.05182	0.18805	0.2382	0.1714	1.1080	2261.	422.	1.000	—	0.0440	0.00594	15.20	80.00
82.11b	14.696	90.89	2.4764	25.378	98.702	0.05275	0.18809	0.2392	0.1719	1.1083	2248.	422.	0.987	—	0.0438	0.00598	15.06	82.11
85.00	15.572	90.64	2.3454	26.072	99.124	0.05403	0.18815	0.2406	0.1726	1.1087	2231.	423.	0.970	—	0.0436	0.00605	14.87	85.00
90.00	17.185	90.20	2.1379	27.282	99.855	0.05623	0.18826	0.2430	0.1738	1.1095	2200.	423.	0.941	—	0.0431	0.00616	14.54	90.00
95.00	18.927	89.75	1.9522	28.504	100.586	0.05844	0.18839	0.2452	0.1751	1.1103	2169.	424.	0.913	—	0.0426	0.00627	14.21	95.00
100.00	20.803	89.30	1.7858	29.737	101.317	0.06065	0.18854	0.2473	0.1763	1.1113	2138.	425.	0.887	—	0.0422	0.00638	13.89	100.00
105.00	22.821	88.85	1.6363	30.980	102.047	0.06285	0.18871	0.2493	0.1775	1.1124	2107.	425.	0.861	—	0.0417	0.00649	13.56	105.00
110.00	24.988	88.39	1.5018	32.233	102.777	0.06505	0.18888	0.2511	0.1788	1.1135	2075.	425.	0.837	—	0.0412	0.00659	13.24	110.00
115.00	27.310	87.92	1.3804	33.495	103.505	0.06725	0.18907	0.2529	0.1800	1.1148	2044.	425.	0.813	—	0.0408	0.00670	12.92	115.00
120.00	29.796	87.46	1.2708	34.766	104.231	0.06944	0.18928	0.2545	0.1812	1.1162	2012.	426.	0.790	—	0.0403	0.00681	12.59	120.00
125.00	32.451	86.98	1.1716	36.044	104.956	0.07163	0.18949	0.2560	0.1825	1.1177	1980.	426.	0.768	0.0285	0.0398	0.00692	12.27	125.00
130.00	35.285	86.51	1.0816	37.330	105.679	0.07381	0.18972	0.2575	0.1837	1.1194	1948.	426.	0.747	0.0287	0.0394	0.00703	11.96	130.00
135.00	38.304	86.03	0.9999	38.623	106.399	0.07598	0.18995	0.2588	0.1850	1.1212	1915.	425.	0.727	0.0289	0.0389	0.00714	11.64	135.00
140.00	41.515	85.54	0.9255	39.922	107.116	0.07814	0.19019	0.2601	0.1862	1.1232	1882.	425.	0.707	0.0292	0.0384	0.00725	11.32	140.00
145.00	44.928	85.05	0.8577	41.228	107.830	0.08030	0.19044	0.2613	0.1875	1.1254	1849.	425.	0.687	0.0294	0.0380	0.00736	11.01	145.00
150.00	48.549	84.55	0.7958	42.540	108.540	0.08245	0.19070	0.2624	0.1888	1.1277	1816.	425.	0.669	0.0296	0.0375	0.00747	10.70	150.00
155.00	52.388	84.05	0.7393	43.857	109.246	0.08458	0.19097	0.2635	0.1901	1.1303	1782.	424.	0.651	0.0298	0.0370	0.00758	10.39	155.00
160.00	56.451	83.54	0.6874	45.179	109.948	0.08671	0.19123	0.2645	0.1914	1.1331	1749.	423.	0.633	0.0301	0.0366	0.00769	10.08	160.00
165.00	60.747	83.02	0.6399	46.506	110.645	0.08883	0.19151	0.2655	0.1927	1.1361	1715.	423.	0.616	0.0303	0.0361	0.00780	9.77	165.00
170.00	65.285	82.50	0.5963	47.838	111.337	0.09094	0.19178	0.2664	0.1941	1.1393	1681.	422.	0.599	0.0305	0.0356	0.00791	9.47	170.00
175.00	70.073	81.98	0.5561	49.174	112.022	0.09303	0.19206	0.2673	0.1955	1.1429	1646.	421.	0.583	0.0307	0.0352	0.00802	9.16	175.00
180.00	75.119	81.44	0.5191	50.515	112.702	0.09512	0.19234	0.2682	0.1969	1.1467	1612.	420.	—	0.0310	0.0347	0.00813	8.86	180.00
185.00	80.434	80.90	0.4850	51.860	113.374	0.09719	0.19261	0.2691	0.1984	1.1509	1578.	419.	—	0.0312	0.0342	0.00824	8.56	185.00
190.00	86.024	80.35	0.4535	53.209	114.039	0.09926	0.19289	0.2700	0.1999	1.1554	1543.	417.	—	0.0314	0.0338	0.00835	8.26	190.00
195.00	91.900	79.79	0.4244	54.562	114.697	0.10131	0.19317	0.2709	0.2015	1.1604	1509.	416.	—	0.0316	0.0333	0.00846	7.96	195.00
200.00	98.071	79.23	0.3974	55.920	115.346	0.10336	0.19344	0.2719	0.2032	1.1657	1474.	415.	—	0.0318	0.0328	—	7.67	200.00
205.00	104.55	78.65	0.3724	57.281	115.986	0.10539	0.19371	0.2728	0.2049	1.1715	1439.	413.	—	0.0321	0.0324	—	7.38	205.00
210.00	111.33	78.07	0.3492	58.647	116.617	0.10741	0.19398	0.2738	0.2067	1.1777	1405.	411.	—	0.0323	0.0319	—	7.09	210.00
215.00	118.44	77.48	0.3277	60.018	117.237	0.10943	0.19424	0.2749	0.2086	1.1846	1370.	409.	—	0.0325	—	—	6.80	215.00
220.00	125.89	76.88	0.3076	61.393	117.847	0.11143	0.19449	0.2760	0.2106	1.1920	1336.	407.	—	0.0327	—	—	6.51	220.00
225.00	133.67	76.26	0.2889	62.774	118.445	0.11343	0.19474	0.2772	0.2127	1.2001	1301.	405.	—	0.0329	—	—	6.23	225.00
230.00	141.81	75.64	0.2715	64.159	119.032	0.11542	0.19498	0.2786	0.2150	1.2089	1267.	403.	—	0.0332	—	—	5.94	230.00
235.00	150.31	75.00	0.2552	65.551	119.605	0.11740	0.19521	0.2800	0.2174	1.2185	1233.	401.	—	0.0334	—	—	5.67	235.00
240.00	159.19	74.35	0.2400	66.948	120.165	0.11937	0.19543	0.2816	0.2200	1.2291	1198.	398.	—	0.0336	—	—	5.39	240.00
245.00	168.44	73.69	0.2258	68.353	120.711	0.12134	0.19564	0.2834	0.2228	1.2407	1164.	396.	—	0.0338	—	—	5.11	245.00
250.00	178.10	73.01	0.2125	69.764	121.241	0.12330	0.19583	0.2853	0.2258	1.2534	1130.	393.	—	0.0340	—	—	4.84	250.00
260.00	198.63	71.61	0.1882	72.613	122.250	0.12721	0.19618	0.2899	0.2327	1.2831	1061.	387.	—	—	—	—	4.31	260.00
270.00	220.87	70.13	0.1668	75.501	123.184	0.13112	0.19646	0.2957	0.2411	1.3198	992.	380.	—	—	—	—	3.79	270.00
280.00	244.92	68.56	0.1478	78.437	124.031	0.13503	0.19667	0.3031	0.2515	1.3663	922.	372.	—	—	—	—	3.28	280.00
290.00	270.89	66.88	0.1308	81.434	124.773	0.13895	0.19676	0.3127	0.2649	1.4268	851.	363.	—	—	—	—	2.79	290.00
300.00	298.88	65.06	0.1154	84.507	125.389	0.14292	0.19674	0.3254	0.2829	1.5085	778.	353.	—	—	—	—	2.31	300.00
310.00	329.01	63.06	0.1015	87.677	125.845	0.14695	0.19654	0.3431	0.3083	1.6250	701.	342.	—	—	—	—	1.85	310.00
320.00	361.45	60.82	0.0887	90.977	126.088	0.15109	0.19612	0.3691	0.3471	1.8034	621.	329.	—	—	—	—	1.42	320.00
330.00	396.37	58.22	0.0768	94.457	126.025	0.15538	0.19536	0.4109	0.4137	2.1089	534.	315.	—	—	—	—	1.01	330.00
340.00	434.02	55.08	0.0652	98.209	125.478	0.15995	0.19405	0.4911	0.5508	2.7349	441.	300.	—	—	—	—	0.63	340.00
350.00	474.80	50.88	0.0534	102.454	124.000	0.16505	0.19166	—	—	—	—	—	—	—	—	—	0.29	350.00
360.00	519.44	43.25	0.0389	108.347	119.584	0.17206	0.18577	—	—	—	—	—	—	—	—	—	0.04	360.00
362.63c	532.00	34.34	0.0291	113.806	113.806	0.17788	0.17788	∞	∞	∞	0.	0.	—	—	∞	∞	0.00	362.63

*temperatures are on the ITS–90 scale b = normal boiling point c = critical point

Refrigerant 134a (1,1,1,2-Tetrafluoroethane) Properties of Saturated Liquid and Saturated Vapor

Temp.,* °F	Pressure, psia	Density, lb/ft³ Liquid	Volume, ft³/lb Vapor	Enthalpy, Btu/lb Liquid	Enthalpy, Btu/lb Vapor	Entropy, Btu/lb·°F Liquid	Entropy, Btu/lb·°F Vapor	Specific Heat c_p, Btu/lb·°F Liquid	Specific Heat c_p, Btu/lb·°F Vapor	c_p/c_v Vapor	Velocity of Sound, ft/s Liquid	Velocity of Sound, ft/s Vapor	Viscosity, lb_m/ft·h Liquid	Viscosity, lb_m/ft·h Vapor	Thermal Cond, Btu/h·ft·°F Liquid	Thermal Cond, Btu/h·ft·°F Vapor	Surface Tension, dyne/cm	Temp.,* °F
−153.94a	0.057	99.34	564.85	32.989	80.235	0.09154	0.27880	0.2740	0.1397	1.1628	3723.	416.	5.289	0.0160	—	—	28.15	−153.94
−150.00	0.072	98.95	449.29	31.902	80.783	0.08801	0.27588	0.2776	0.1409	1.1615	3670.	418.	4.913	0.0163	—	—	27.76	−150.00
−140.00	0.130	97.98	259.15	29.093	82.190	0.07908	0.26903	0.2837	0.1438	1.1583	3552.	424.	4.117	0.0168	—	—	26.78	−140.00
−130.00	0.222	97.01	155.69	26.238	83.618	0.07029	0.26294	0.2870	0.1467	1.1554	3448.	430.	3.497	0.0173	—	—	25.81	−130.00
−120.00	0.367	96.05	97.027	23.359	85.066	0.06169	0.25752	0.2886	0.1497	1.1528	3352.	436.	3.006	0.0179	—	—	24.86	−120.00
−110.00	0.586	95.09	62.509	20.467	86.531	0.05330	0.25270	0.2895	0.1527	1.1507	3261.	441.	2.613	0.0184	—	—	23.92	−110.00
−100.00	0.906	94.13	41.496	17.569	88.011	0.04513	0.24842	0.2900	0.1559	1.1489	3173.	446.	2.292	0.0190	—	—	22.99	−100.00
−90.00	1.363	93.17	28.303	14.665	89.504	0.03717	0.24462	0.2906	0.1591	1.1475	3087.	451.	2.028	0.0195	0.0721	—	22.08	−90.00
−80.00	1.997	92.21	19.783	11.755	91.005	0.02940	0.24125	0.2913	0.1624	1.1466	3001.	456.	1.808	0.0200	0.0706	—	21.17	−80.00
−75.00	2.396	91.73	16.680	10.297	91.759	0.02559	0.23972	0.2917	0.1641	1.1463	2959.	458.	1.712	0.0203	0.0699	—	20.73	−75.00
−70.00	2.859	91.25	14.138	8.837	92.514	0.02182	0.23827	0.2922	0.1658	1.1462	2916.	460.	1.623	0.0206	0.0691	—	20.28	−70.00
−65.00	3.393	90.77	12.045	7.374	93.270	0.01809	0.23691	0.2928	0.1676	1.1461	2874.	462.	1.542	0.0209	0.0684	—	19.84	−65.00
−60.00	4.006	90.28	10.310	5.907	94.026	0.01440	0.23563	0.2935	0.1694	1.1462	2832.	464.	1.466	0.0212	0.0677	0.00405	19.40	−60.00
−55.00	4.707	89.80	8.8656	4.437	94.783	0.01075	0.23443	0.2943	0.1712	1.1465	2790.	466.	1.396	0.0214	0.0669	0.00423	18.96	−55.00
−50.00	5.505	89.31	7.6569	2.963	95.539	0.00713	0.23331	0.2951	0.1731	1.1468	2747.	468.	1.331	0.0217	0.0662	0.00440	18.52	−50.00
−45.00	6.409	88.82	6.6405	1.484	96.295	0.00355	0.23225	0.2960	0.1750	1.1473	2705.	470.	1.271	0.0220	0.0654	0.00457	18.09	−45.00
−40.00	7.429	88.32	5.7819	0.000	97.050	0.00000	0.23125	0.2970	0.1769	1.1479	2663.	471.	1.215	0.0223	0.0647	0.00473	17.66	−40.00
−35.00	8.577	87.83	5.0533	1.489	97.804	0.00352	0.23032	0.2981	0.1789	1.1487	2621.	473.	1.163	0.0225	0.0639	0.00489	17.23	−35.00
−30.00	9.862	87.33	4.4325	2.984	98.556	0.00701	0.22945	0.2992	0.1810	1.1497	2579.	474.	1.113	0.0228	0.0632	0.00505	16.81	−30.00
−25.00	11.297	86.82	3.9014	4.484	99.306	0.01048	0.22863	0.3004	0.1831	1.1508	2536.	476.	1.068	0.0231	0.0625	0.00521	16.38	−25.00
−20.00	12.895	86.32	3.4452	5.991	100.054	0.01392	0.22786	0.3017	0.1852	1.1521	2494.	477.	1.024	0.0234	0.0617	0.00536	15.96	−20.00
−15.00	14.667	85.81	3.0519	7.505	100.799	0.01733	0.22714	0.3031	0.1874	1.1535	2452.	478.	0.984	0.0237	0.0610	0.00550	15.54	−15.00
−14.92b	14.696	85.80	3.0462	7.529	100.811	0.01739	0.22713	0.3031	0.1874	1.1535	2451.	478.	0.983	0.0237	0.0610	0.00551	15.54	−14.92
−10.00	16.626	85.29	2.7116	9.026	101.542	0.02073	0.22647	0.3045	0.1897	1.1552	2410.	479.	0.946	0.0240	0.0602	0.00565	15.13	−10.00
−5.00	18.787	84.77	2.4161	10.554	102.280	0.02409	0.22584	0.3060	0.1920	1.1570	2367.	480.	0.910	0.0243	0.0595	0.00579	14.71	−5.00
0.00	21.162	84.25	2.1587	12.090	103.015	0.02744	0.22525	0.3075	0.1943	1.1590	2325.	481.	0.876	0.0245	0.0588	0.00593	14.30	0.00
5.00	23.767	83.72	1.9337	13.634	103.745	0.03077	0.22470	0.3091	0.1968	1.1613	2283.	481.	0.843	0.0248	0.0580	0.00607	13.89	5.00
10.00	26.617	83.18	1.7365	15.187	104.471	0.03408	0.22418	0.3108	0.1993	1.1637	2240.	482.	0.813	0.0251	0.0573	0.00621	13.48	10.00
15.00	29.726	82.64	1.5630	16.748	105.192	0.03737	0.22370	0.3126	0.2018	1.1664	2198.	482.	0.784	0.0254	0.0565	0.00635	13.08	15.00
20.00	33.110	82.10	1.4101	18.318	105.907	0.04065	0.22325	0.3144	0.2045	1.1694	2155.	482.	0.756	0.0257	0.0558	0.00649	12.67	20.00
25.00	36.785	81.55	1.2749	19.897	106.617	0.04391	0.22283	0.3162	0.2072	1.1726	2113.	482.	0.730	0.0260	0.0550	0.00662	12.27	25.00
30.00	40.768	80.99	1.1550	21.486	107.320	0.04715	0.22244	0.3182	0.2100	1.1761	2070.	482.	0.705	0.0263	0.0543	0.00676	11.87	30.00
35.00	45.075	80.42	1.0484	23.085	108.016	0.05038	0.22207	0.3202	0.2129	1.1799	2027.	482.	0.681	0.0267	0.0536	0.00690	11.48	35.00
40.00	49.724	79.85	0.9534	24.694	108.705	0.05359	0.22172	0.3223	0.2159	1.1841	1985.	482.	0.658	0.0270	0.0528	0.00704	11.08	40.00
45.00	54.732	79.26	0.8685	26.314	109.386	0.05679	0.22140	0.3244	0.2190	1.1886	1942.	481.	0.636	0.0273	0.0521	0.00718	10.69	45.00
50.00	60.116	78.67	0.7925	27.944	110.058	0.05998	0.22110	0.3267	0.2222	1.1935	1899.	481.	0.615	0.0276	0.0513	0.00732	10.30	50.00
55.00	65.895	78.07	0.7243	29.586	110.722	0.06316	0.22081	0.3290	0.2255	1.1988	1856.	480.	0.595	0.0280	0.0506	0.00746	9.91	55.00
60.00	72.087	77.46	0.6630	31.239	111.376	0.06633	0.22054	0.3314	0.2289	1.2046	1813.	479.	0.576	0.0283	0.0499	0.00761	9.53	60.00
65.00	78.712	76.84	0.6077	32.905	112.019	0.06949	0.22028	0.3339	0.2325	1.2109	1770.	477.	0.557	0.0286	0.0491	0.00776	9.15	65.00
70.00	85.787	76.21	0.5577	34.583	112.652	0.07264	0.22003	0.3366	0.2363	1.2178	1726.	476.	0.539	0.0290	0.0484	0.00791	8.77	70.00
75.00	93.333	75.57	0.5125	36.274	113.272	0.07578	0.21979	0.3393	0.2402	1.2252	1683.	474.	0.522	0.0294	0.0476	0.00806	8.39	75.00
80.00	101.37	74.91	0.4715	37.978	113.880	0.07892	0.21957	0.3422	0.2444	1.2334	1640.	472.	0.505	0.0297	0.0469	0.00822	8.02	80.00
85.00	109.92	74.25	0.4343	39.697	114.475	0.08205	0.21934	0.3453	0.2487	1.2424	1596.	470.	0.489	0.0301	0.0462	0.00838	7.65	85.00
90.00	119.00	73.57	0.4004	41.430	115.055	0.08518	0.21912	0.3485	0.2533	1.2522	1552.	468.	0.473	0.0305	0.0454	0.00855	7.28	90.00
95.00	128.63	72.87	0.3694	43.179	115.619	0.08830	0.21890	0.3519	0.2582	1.2630	1509.	466.	0.458	0.0309	0.0447	0.00872	6.91	95.00
100.00	138.83	72.16	0.3411	44.943	116.166	0.09142	0.21868	0.3555	0.2633	1.2748	1465.	463.	0.443	0.0313	0.0439	0.00890	6.55	100.00
105.00	149.63	71.43	0.3153	46.725	116.694	0.09454	0.21845	0.3594	0.2689	1.2880	1421.	460.	0.428	0.0318	0.0432	0.00908	6.20	105.00
110.00	161.05	70.68	0.2915	48.524	117.203	0.09766	0.21822	0.3635	0.2748	1.3026	1376.	457.	0.414	0.0322	0.0425	0.00926	5.84	110.00
115.00	173.11	69.91	0.2697	50.343	117.690	0.10078	0.21797	0.3680	0.2812	1.3189	1332.	454.	0.400	0.0327	0.0417	0.00946	5.49	115.00
120.00	185.84	69.12	0.2497	52.181	118.153	0.10391	0.21772	0.3728	0.2881	1.3372	1288.	450.	0.387	0.0332	0.0410	0.00965	5.15	120.00
125.00	199.25	68.31	0.2312	54.040	118.591	0.10704	0.21744	0.3781	0.2957	1.3577	1243.	446.	0.374	0.0338	0.0403	0.00986	4.80	125.00
130.00	213.38	67.47	0.2141	55.923	119.000	0.11018	0.21715	0.3839	0.3040	1.3810	1198.	442.	0.361	0.0343	0.0395	0.01007	4.47	130.00
135.00	228.25	66.60	0.1983	57.830	119.377	0.11333	0.21683	0.3903	0.3133	1.4075	1153.	437.	0.348	0.0349	0.0388	0.01029	4.13	135.00
140.00	243.88	65.70	0.1836	59.764	119.720	0.11650	0.21648	0.3974	0.3236	1.4379	1108.	432.	0.335	0.0356	0.0380	0.01052	3.81	140.00
145.00	260.31	64.77	0.1700	61.727	120.024	0.11968	0.21609	0.4053	0.3353	1.4731	1062.	427.	0.323	0.0363	0.0373	0.01075	3.48	145.00
150.00	277.57	63.80	0.1574	63.722	120.284	0.12288	0.21566	0.4144	0.3486	1.5143	1017.	421.	0.311	0.0370	0.0366	0.01100	3.17	150.00
155.00	295.69	62.78	0.1455	65.752	120.495	0.12611	0.21517	0.4247	0.3640	1.5630	971.	416.	0.298	0.0378	0.0358	0.01125	2.86	155.00
160.00	314.69	61.72	0.1345	67.823	120.650	0.12938	0.21463	0.4368	0.3821	1.6213	924.	409.	0.286	0.0387	0.0351	0.01151	2.55	160.00
165.00	334.62	60.60	0.1241	69.939	120.739	0.13268	0.21400	0.4511	0.4036	1.6921	877.	403.	0.274	0.0397	0.0343	0.01178	2.26	165.00
170.00	355.51	59.42	0.1144	72.106	120.753	0.13603	0.21329	0.4683	0.4299	1.7798	829.	396.	0.262	0.0407	0.0336	0.01206	1.97	170.00
175.00	377.40	58.16	0.1052	74.335	120.677	0.13945	0.21247	0.4896	0.4627	1.8908	781.	388.	0.249	0.0420	0.0329	0.01235	1.69	175.00
180.00	400.34	56.80	0.0965	76.636	120.493	0.14295	0.21151	0.5168	0.5048	2.0354	731.	380.	0.237	0.0434	0.0321	0.01265	1.41	180.00
185.00	424.37	55.33	0.0881	79.027	120.175	0.14655	0.21037	0.5527	0.5612	2.2309	680.	372.	0.224	0.0450	0.0314	0.01296	1.15	185.00
190.00	449.55	53.70	0.0801	81.534	119.684	0.15029	0.20901	0.6031	0.6406	2.5087	627.	363.	0.211	0.0469	—	—	0.90	190.00
195.00	475.95	51.86	0.0723	84.196	118.963	0.15423	0.20733	0.6794	0.7612	2.9338	572.	353.	0.197	0.0493	—	—	0.67	195.00
200.00	503.64	49.70	0.0646	87.088	117.906	0.15847	0.20519	0.8100	0.9673	3.6640	514.	343.	0.182	0.0523	—	—	0.45	200.00
205.00	532.72	47.00	0.0566	90.368	116.289	0.16326	0.20226	1.0906	1.4042	5.2174	450.	331.	0.164	0.0566	—	—	0.25	205.00
210.00	563.34	43.03	0.0474	94.548	113.411	0.16933	0.19750	—	—	—	378.	316.	0.142	0.0639	—	—	0.09	210.00
213.85c	588.27	32.04	0.0312	103.775	103.775	0.18128	0.18128	∞	∞	∞	0.	0.	—	—	∞	∞	0.00	213.85

*temperatures are on the ITS−90 scale a = triple point b = normal boiling point c = critical point

Refrigerant 134a Properties of Superheated Vapor

Pressure = 14.696 psia
Saturation temperature = −14.92°F

Temp,* °F	Density, lb/ft³	Enthalpy, Btu/lb	Entropy, Btu/lb·°F	Vel. Sound, ft/s
Saturated				
Liquid	85.7972	7.53	0.01739	2451.2
Vapor	0.3283	100.81	0.22713	478.0
0.00	0.3158	103.62	0.23335	487.2
20.00	0.3008	107.45	0.24149	499.0
40.00	0.2874	111.34	0.24944	510.2
60.00	0.2753	115.31	0.25723	521.0
80.00	0.2642	119.35	0.26486	531.5
100.00	0.2541	123.47	0.27236	541.6
120.00	0.2448	127.68	0.27974	551.4
140.00	0.2362	131.96	0.28700	561.0
160.00	0.2282	136.32	0.29416	570.4
180.00	0.2208	140.77	0.30122	579.5
200.00	0.2139	145.30	0.30819	588.5
220.00	0.2074	149.90	0.31507	597.3
240.00	0.2013	154.59	0.32187	606.0
260.00	0.1955	159.36	0.32858	614.5
280.00	0.1901	164.20	0.33522	622.8
300.00	0.1850	169.12	0.34178	631.1

Pressure = 25.00 psia
Saturation temperature = 7.22°F

Temp,* °F	Density, lb/ft³	Enthalpy, Btu/lb	Entropy, Btu/lb·°F	Vel. Sound, ft/s
Saturated				
Liquid	83.4823	14.32	0.03224	2263.9
Vapor	0.5426	104.07	0.22446	481.5
20.00	0.5245	106.60	0.22982	489.9
40.00	0.4991	110.61	0.23800	502.4
60.00	0.4765	114.66	0.24596	514.1
80.00	0.4563	118.78	0.25373	525.4
100.00	0.4379	122.96	0.26135	536.2
120.00	0.4212	127.22	0.26881	546.6
140.00	0.4058	131.55	0.27615	556.7
160.00	0.3916	135.95	0.28337	566.5
180.00	0.3786	140.43	0.29048	576.0
200.00	0.3663	144.98	0.29750	585.3
220.00	0.3549	149.61	0.30441	594.4
240.00	0.3443	154.32	0.31124	603.3
260.00	0.3343	159.10	0.31798	612.0
280.00	0.3248	163.96	0.32464	620.6
300.00	0.3160	168.90	0.33122	629.0

Pressure = 50.00 psia
Saturation temperature = 40.29°F

Temp,* °F	Density, lb/ft³	Enthalpy, Btu/lb	Entropy, Btu/lb·°F	Vel. Sound, ft/s
Saturated				
Liquid	79.8125	24.79	0.05377	1982.3
Vapor	1.0545	108.74	0.22170	481.7
60.00	0.9982	113.00	0.23005	496.2
80.00	0.9489	117.32	0.23822	509.8
100.00	0.9055	121.68	0.24614	522.5
120.00	0.8670	126.07	0.25385	534.5
140.00	0.8322	130.51	0.26139	545.8
160.00	0.8008	135.01	0.26877	556.7
180.00	0.7718	139.57	0.27601	567.2
200.00	0.7454	144.20	0.28313	577.4
220.00	0.7208	148.89	0.29014	587.2
240.00	0.6980	153.65	0.29704	596.8
260.00	0.6768	158.48	0.30385	606.1
280.00	0.6569	163.38	0.31056	615.2
300.00	0.6383	168.35	0.31719	624.1

Pressure = 75.00 psia
Saturation temperature = 62.24°F

Temp,* °F	Density, lb/ft³	Enthalpy, Btu/lb	Entropy, Btu/lb·°F	Vel. Sound, ft/s
Saturated				
Liquid	77.1862	31.98	0.06775	1793.6
Vapor	1.5686	111.67	0.22042	478.1
80.00	1.4873	115.74	0.22809	492.7
100.00	1.4092	120.30	0.23639	507.7
120.00	1.3416	124.85	0.24439	521.6
140.00	1.2822	129.43	0.25215	534.5
160.00	1.2294	134.04	0.25971	546.6
180.00	1.1817	138.69	0.26710	558.2
200.00	1.1383	143.39	0.27434	569.2
220.00	1.0984	148.15	0.28145	579.8
240.00	1.0620	152.97	0.28843	590.1
260.00	1.0280	157.85	0.29531	600.0
280.00	0.9966	162.79	0.30208	609.7
300.00	0.9671	167.80	0.30876	619.0
320.00	0.9398	172.87	0.31535	628.2
340.00	0.9138	178.01	0.32186	637.1
360.00	0.8895	183.21	0.32828	645.9
380.00	0.8665	188.48	0.33463	654.5
400.00	0.8448	193.82	0.34091	662.9

Pressure = 100.00 psia
Saturation temperature = 79.17°F

Temp,* °F	Density, lb/ft³	Enthalpy, Btu/lb	Entropy, Btu/lb·°F	Vel. Sound, ft/s
Saturated				
Liquid	75.0245	37.69	0.07840	1646.8
Vapor	2.0917	113.78	0.21960	472.8
80.00	2.0858	113.98	0.21998	473.6
100.00	1.9576	118.80	0.22874	491.6
120.00	1.8509	123.55	0.23709	507.8
140.00	1.7597	128.29	0.24512	522.4
160.00	1.6800	133.02	0.25288	536.0
180.00	1.6094	137.78	0.26044	548.8
200.00	1.5463	142.57	0.26781	560.8
220.00	1.4891	147.40	0.27502	572.3
240.00	1.4368	152.27	0.28210	583.3
260.00	1.3886	157.21	0.28905	593.9
280.00	1.3444	162.19	0.29588	604.1
300.00	1.3031	167.24	0.30261	614.0
320.00	1.2647	172.35	0.30925	623.6
340.00	1.2287	177.52	0.31579	632.9
360.00	1.1950	182.75	0.32225	642.1
380.00	1.1633	188.04	0.32863	651.0
400.00	1.1334	193.39	0.33494	659.8

Pressure = 125.00 psia
Saturation temperature = 93.15°F

Temp,* °F	Density, lb/ft³	Enthalpy, Btu/lb	Entropy, Btu/lb·°F	Vel. Sound, ft/s
Saturated				
Liquid	73.1279	42.53	0.08715	1524.7
Vapor	2.6279	115.41	0.21898	466.7
100.00	2.5638	117.16	0.22212	473.9
120.00	2.4025	122.16	0.23090	492.9
140.00	2.2694	127.08	0.23924	509.7
160.00	2.1561	131.96	0.24725	525.0
180.00	2.0577	136.83	0.25498	539.0
200.00	1.9710	141.71	0.26250	552.2
220.00	1.8935	146.62	0.26983	564.6
240.00	1.8233	151.56	0.27700	576.4
260.00	1.7592	156.55	0.28402	587.6
280.00	1.7006	161.59	0.29093	598.4
300.00	1.6463	166.67	0.29771	608.8
320.00	1.5959	171.82	0.30440	618.9
340.00	1.5492	177.02	0.31098	628.7
360.00	1.5055	182.27	0.31747	638.2
380.00	1.4644	187.59	0.32388	647.5
400.00	1.4258	192.97	0.33021	656.6

Pressure = 150.00 psia
Saturation temperature = 105.17°F

Temp,* °F	Density, lb/ft³	Enthalpy, Btu/lb	Entropy, Btu/lb·°F	Vel. Sound, ft/s
Saturated				
Liquid	71.4013	46.78	0.09464	1419.1
Vapor	3.1801	116.71	0.21844	460.0
120.00	3.0077	120.64	0.22530	476.6
140.00	2.8181	125.78	0.23403	496.0
160.00	2.6620	130.83	0.24231	513.3
180.00	2.5295	135.83	0.25026	528.9
200.00	2.4146	140.82	0.25794	543.3
220.00	2.3132	145.82	0.26539	556.7
240.00	2.2223	150.83	0.27267	569.3
260.00	2.1401	155.88	0.27978	581.3
280.00	2.0658	160.97	0.28675	592.7
300.00	1.9971	166.10	0.29360	603.7
320.00	1.9338	171.28	0.30033	614.2
340.00	1.8751	176.51	0.30696	624.5
360.00	1.8208	181.80	0.31349	634.4
380.00	1.7695	187.14	0.31993	644.0
400.00	1.7216	192.54	0.32628	653.4
420.00	1.6766	198.00	0.33256	662.6
440.00	1.6341	203.51	0.33876	671.6
460.00	1.5940	209.08	0.34488	680.4
480.00	1.5558	214.71	0.35094	689.0
500.00	1.5197	220.40	0.35692	697.4

Pressure = 175.00 psia
Saturation temperature = 115.76°F

Temp,* °F	Density, lb/ft³	Enthalpy, Btu/lb	Entropy, Btu/lb·°F	Vel. Sound, ft/s
Saturated				
Liquid	69.7902	50.62	0.10126	1325.3
Vapor	3.7511	117.76	0.21794	453.0
120.00	3.6836	118.95	0.21999	458.4
140.00	3.4148	124.38	0.22921	481.3
160.00	3.2025	129.64	0.23783	500.9
180.00	3.0271	134.79	0.24602	518.3
200.00	2.8785	139.90	0.25388	534.0
220.00	2.7494	144.99	0.26148	548.5
240.00	2.6349	150.08	0.26887	562.1
260.00	2.5328	155.19	0.27607	574.8
280.00	2.4403	160.34	0.28312	586.9
300.00	2.3558	165.51	0.29003	598.5
320.00	2.2785	170.73	0.29681	609.5
340.00	2.2071	176.00	0.30348	620.2
360.00	2.1411	181.32	0.31004	630.5
380.00	2.0795	186.69	0.31651	640.5
400.00	2.0216	192.11	0.32290	650.3
420.00	1.9675	197.59	0.32920	659.7
440.00	1.9164	203.12	0.33542	669.0
460.00	1.8683	208.71	0.34156	678.0
480.00	1.8228	214.36	0.34763	686.9
500.00	1.7797	220.05	0.35363	695.6

Pressure = 200.00 psia
Saturation temperature = 125.27°F

Temp,* °F	Density, lb/ft³	Enthalpy, Btu/lb	Entropy, Btu/lb·°F	Vel. Sound, ft/s
Saturated				
Liquid	68.2602	54.14	0.10721	1240.5
Vapor	4.3437	118.61	0.21743	445.6
140.00	4.0726	122.86	0.22460	465.2
160.00	3.7850	128.36	0.23363	487.8
180.00	3.5561	133.70	0.24210	507.2
200.00	3.3656	138.94	0.25018	524.5
220.00	3.2036	144.14	0.25793	540.2
240.00	3.0623	149.31	0.26544	554.7
260.00	2.9371	154.50	0.27274	568.3
280.00	2.8247	159.69	0.27987	581.1
300.00	2.7234	164.92	0.28684	593.2
320.00	2.6305	170.18	0.29368	604.8
340.00	2.5455	175.49	0.30039	615.9
360.00	2.4668	180.83	0.30700	626.7
380.00	2.3934	186.23	0.31350	637.0
400.00	2.3254	191.68	0.31991	647.1
420.00	2.2614	197.18	0.32624	656.9
440.00	2.2017	202.73	0.33248	666.4
460.00	2.1453	208.34	0.33864	675.7
480.00	2.0920	214.00	0.34473	684.8
500.00	2.0417	219.71	0.35075	693.7

*temperatures are on the ITS−90 scale

Refrigerant 134a Properties of Superheated Vapor (*Concluded*)

Pressure = 225.00 psia
Saturation temperature = 133.93°F

Temp,* °F	Density, lb/ft³	Enthalpy, Btu/lb	Entropy, Btu/lb·°F	Vel. Sound, ft/s
Saturated				
Liquid	66.7870	57.42	0.11266	1162.8
Vapor	4.9609	119.30	0.21690	438.1
140.00	4.8123	121.16	0.22002	447.3
160.00	4.4191	126.99	0.22959	473.6
180.00	4.1206	132.54	0.23840	495.5
200.00	3.8796	137.94	0.24671	514.6
220.00	3.6784	143.25	0.25465	531.6
240.00	3.5058	148.52	0.26229	547.2
260.00	3.3542	153.78	0.26970	561.6
280.00	3.2202	159.04	0.27691	575.1
300.00	3.0995	164.32	0.28395	587.9
320.00	2.9899	169.62	0.29084	600.0
340.00	2.8897	174.97	0.29761	611.7
360.00	2.7978	180.35	0.30425	622.8
380.00	2.7122	185.77	0.31079	633.6
400.00	2.6330	191.24	0.31723	644.0
420.00	2.5592	196.77	0.32358	654.0
440.00	2.4900	202.34	0.32984	663.9
460.00	2.4249	207.96	0.33603	673.4
480.00	2.3636	213.64	0.34213	682.8
500.00	2.3057	219.36	0.34816	691.9

Pressure = 250.00 psia
Saturation temperature = 141.89°F

Temp,* °F	Density, lb/ft³	Enthalpy, Btu/lb	Entropy, Btu/lb·°F	Vel. Sound, ft/s
Saturated				
Liquid	65.3526	60.50	0.11770	1090.7
Vapor	5.6060	119.84	0.21634	430.3
160.00	5.1189	125.49	0.22560	458.2
180.00	4.7275	131.31	0.23484	483.1
200.00	4.4239	136.89	0.24343	504.2
220.00	4.1756	142.34	0.25156	522.8
240.00	3.9664	147.71	0.25935	539.5
260.00	3.7854	153.05	0.26688	554.9
280.00	3.6265	158.37	0.27418	569.2
300.00	3.4847	163.71	0.28129	582.6
320.00	3.3571	169.06	0.28824	595.3
340.00	3.2408	174.44	0.29506	607.4
360.00	3.1342	179.85	0.30175	618.9
380.00	3.0359	185.31	0.30832	630.1
400.00	2.9451	190.81	0.31479	640.8
420.00	2.8604	196.35	0.32117	651.2
440.00	2.7813	201.94	0.32745	661.3
460.00	2.7072	207.58	0.33365	671.1
480.00	2.6374	213.27	0.33977	680.7
500.00	2.5717	219.02	0.34582	690.1

Pressure = 275.00 psia
Saturation temperature = 149.27°F

Temp,* °F	Density, lb/ft³	Enthalpy, Btu/lb	Entropy, Btu/lb·°F	Vel. Sound, ft/s
Saturated				
Liquid	63.9423	63.43	0.12241	1023.4
Vapor	6.2831	120.25	0.21572	422.3
160.00	5.9060	123.82	0.22155	441.2
180.00	5.3869	129.98	0.23133	469.9
200.00	5.0031	135.78	0.24026	493.4
220.00	4.6978	141.38	0.24862	513.7
240.00	4.4465	146.87	0.25658	531.7
260.00	4.2314	152.30	0.26423	548.0
280.00	4.0446	157.69	0.27162	563.1
300.00	3.8803	163.08	0.27881	577.2
320.00	3.7317	168.49	0.28583	590.5
340.00	3.5987	173.91	0.29270	603.1
360.00	3.4764	179.36	0.29943	615.1
380.00	3.3646	184.84	0.30604	626.6
400.00	3.2612	190.37	0.31254	637.7
420.00	3.1653	195.93	0.31894	648.4
440.00	3.0758	201.55	0.32525	658.8
460.00	2.9922	207.20	0.33147	668.9
480.00	2.9136	212.91	0.33761	678.7
500.00	2.8397	218.67	0.34368	688.3

Pressure = 300.00 psia
Saturation temperature = 156.16°F

Temp,* °F	Density, lb/ft³	Enthalpy, Btu/lb	Entropy, Btu/lb·°F	Vel. Sound, ft/s
Saturated				
Liquid	62.5436	66.23	0.12686	959.8
Vapor	6.9967	120.54	0.21505	414.2
160.00	6.8168	121.92	0.21730	422.0
180.00	6.1118	128.55	0.22782	455.8
200.00	5.6239	134.61	0.23715	482.1
220.00	5.2494	140.39	0.24578	504.3
240.00	4.9472	146.00	0.25393	523.7
260.00	4.6939	151.52	0.26171	541.1
280.00	4.4758	157.00	0.26921	557.0
300.00	4.2852	162.45	0.27649	571.8
320.00	4.1160	167.90	0.28357	585.7
340.00	3.9631	173.37	0.29049	598.8
360.00	3.8247	178.85	0.29727	611.2
380.00	3.6981	184.37	0.30392	623.1
400.00	3.5816	189.92	0.31045	634.6
420.00	3.4737	195.51	0.31688	645.6
440.00	3.3735	201.15	0.32321	656.3
460.00	3.2799	206.83	0.32945	666.6
480.00	3.1922	212.55	0.33561	676.7
500.00	3.1098	218.32	0.34169	686.5

Pressure = 325.00 psia
Saturation temperature = 162.62°F

Temp,* °F	Density, lb/ft³	Enthalpy, Btu/lb	Entropy, Btu/lb·°F	Vel. Sound, ft/s
Saturated				
Liquid	61.1446	68.92	0.13110	899.5
Vapor	7.7526	120.71	0.21431	405.9
180.00	6.9220	126.96	0.22423	440.3
200.00	6.2928	133.36	0.23408	470.2
220.00	5.8341	139.34	0.24301	494.5
240.00	5.4723	145.10	0.25136	515.5
260.00	5.1741	150.73	0.25930	534.0
280.00	4.9208	156.29	0.26692	550.9
300.00	4.7017	161.81	0.27428	566.4
320.00	4.5082	167.31	0.28144	580.9
340.00	4.3352	172.82	0.28841	594.5
360.00	4.1790	178.35	0.29524	607.4
380.00	4.0368	183.90	0.30193	619.7
400.00	3.9063	189.48	0.30849	631.5
420.00	3.7859	195.09	0.31495	642.8
440.00	3.6743	200.75	0.32131	653.8
460.00	3.5703	206.44	0.32757	664.4
480.00	3.4731	212.19	0.33375	674.7
500.00	3.3819	217.97	0.33984	684.7

Pressure = 350.00 psia
Saturation temperature = 168.71°F

Temp,* °F	Density, lb/ft³	Enthalpy, Btu/lb	Entropy, Btu/lb·°F	Vel. Sound, ft/s
Saturated				
Liquid	59.7334	71.54	0.13516	841.7
Vapor	8.5577	120.76	0.21349	397.5
180.00	7.8491	125.18	0.22046	423.2
200.00	7.0242	132.01	0.23098	457.6
220.00	6.4561	138.24	0.24029	484.4
240.00	6.0219	144.17	0.24888	507.1
260.00	5.6728	149.91	0.25698	526.9
280.00	5.3805	155.56	0.26472	544.7
300.00	5.1295	161.15	0.27218	561.0
320.00	4.9098	166.72	0.27941	576.1
340.00	4.7148	172.27	0.28644	590.2
360.00	4.5396	177.84	0.29332	603.6
380.00	4.3807	183.42	0.30005	616.3
400.00	4.2355	189.03	0.30665	628.4
420.00	4.1019	194.67	0.31313	640.1
440.00	3.9784	200.35	0.31952	651.4
460.00	3.8636	206.06	0.32580	662.2
480.00	3.7564	211.82	0.33199	672.8
500.00	3.6561	217.62	0.33811	683.0

Pressure = 375.00 psia
Saturation temperature= 174.46°F

Temp,* °F	Density, lb/ft³	Enthalpy, Btu/lb	Entropy, Btu/lb·°F	Vel. Sound, ft/s
Saturated				
Liquid	58.2974	74.09	0.13908	785.9
Vapor	9.4209	120.69	0.21256	389.0
180.00	8.9498	123.10	0.21634	403.8
200.00	7.8311	130.54	0.22781	444.1
220.00	7.1211	137.08	0.23758	474.0
240.00	6.6028	143.19	0.24644	498.5
260.00	6.1926	149.07	0.25473	519.6
280.00	5.8555	154.82	0.26260	538.4
300.00	5.5694	160.49	0.27016	555.5
320.00	5.3212	166.11	0.27747	571.3
340.00	5.1022	171.72	0.28457	586.0
360.00	4.9066	177.32	0.29149	599.8
380.00	4.7300	182.94	0.29826	612.9
400.00	4.5692	188.58	0.30490	625.4
420.00	4.4217	194.24	0.31141	637.4
440.00	4.2857	199.94	0.31782	648.9
460.00	4.1596	205.68	0.32413	660.1
480.00	4.0421	211.46	0.33034	670.8
500.00	3.9323	217.28	0.33647	681.3

Pressure = 400.00 psia
Saturation temperature = 197.93°F

Temp,* °F	Density, lb/ft³	Enthalpy, Btu/lb	Entropy, Btu/lb·°F	Vel. Sound, ft/s
Saturated				
Liquid	56.8213	76.60	0.14289	731.8
Vapor	10.3541	120.50	0.21152	380.4
180.00	10.3454	120.53	0.21158	380.6
200.00	8.7370	128.93	0.22451	429.5
220.00	7.8399	135.85	0.23484	463.0
240.00	7.2145	142.18	0.24403	489.7
260.00	6.7351	148.21	0.25252	512.3
280.00	6.3472	154.06	0.26055	532.1
300.00	6.0221	159.81	0.26821	550.0
320.00	5.7425	165.49	0.27560	566.5
340.00	5.4977	171.15	0.28277	581.7
360.00	5.2802	176.80	0.28975	596.0
380.00	5.0848	182.45	0.29656	609.5
400.00	4.9075	188.12	0.30323	622.4
420.00	4.7454	193.82	0.30978	634.7
440.00	4.5964	199.54	0.31621	646.5
460.00	4.4584	205.30	0.32254	657.9
480.00	4.3303	211.09	0.32878	669.0
500.00	4.2107	216.93	0.33492	679.6

Pressure = 600.00 psia
Saturation temperature = n/a (supercritical)

Temp,* °F	Density, lb/ft³	Enthalpy, Btu/lb	Entropy, Btu/lb·°F	Vel. Sound, ft/s
220.00	19.6784	118.27	0.20421	340.3
240.00	14.2159	131.50	0.22343	409.1
260.00	12.2674	139.92	0.23530	449.7
280.00	11.0672	147.15	0.24522	480.8
300.00	10.2049	153.83	0.25413	506.7
320.00	9.5351	160.21	0.26241	529.2
340.00	8.9895	166.39	0.27024	549.2
360.00	8.5305	172.45	0.27774	567.5
380.00	8.1351	178.45	0.28496	584.4
400.00	7.7885	184.40	0.29197	600.1
420.00	7.4804	190.34	0.29879	615.0
440.00	7.2035	196.26	0.30546	629.0
460.00	6.9523	202.20	0.31198	642.4
480.00	6.7229	208.15	0.31838	655.3
500.00	6.5118	214.12	0.32467	667.6

*temperatures are on the ITS-90 scale

Refrigerant 404A [R-125/143a/134a (44/52/4)] Properties of Liquid on the Bubble Line and Vapor on the Dew Line

Pressure,	Temperature*, °F		Density, lb/ft³	Volume, ft³/lb	Enthalpy, Btu/lb		Entropy, Btu/lb·°F		Specific Heat c_p, Btu/lb·°F		c_p/c_v	Velocity of Sound, ft/s		Pressure,
psia	Bubble	Dew	Liquid	Vapor	Liquid	Vapor	Liquid	Vapor	Liquid	Vapor	Vapor	Liquid	Vapor	psia
1.00	−130.49	−128.46	89.51	36.17	−25.81	71.15	−0.06905	0.22497	0.2733	0.1535	1.160	3217.	439.5	1.00
1.50	−120.93	−119.01	88.60	24.74	−23.19	72.53	−0.06119	0.22089	0.2756	0.1568	1.159	3113.	444.4	1.50
2.00	−113.74	−111.89	87.91	18.90	−21.20	73.57	−0.05539	0.21811	0.2774	0.1593	1.158	3037.	447.9	2.00
2.50	−107.91	−106.11	87.35	15.34	−19.58	74.42	−0.05074	0.21604	0.2788	0.1614	1.158	2978.	450.6	2.50
3.00	−102.97	−101.22	86.86	12.94	−18.20	75.14	−0.04685	0.21440	0.2801	0.1633	1.158	2928.	452.8	3.00
4.00	−94.84	−93.16	86.06	9.888	−15.91	76.32	−0.04051	0.21192	0.2821	0.1664	1.158	2848.	456.3	4.00
5.00	−88.22	−86.59	85.41	8.027	−14.04	77.29	−0.03543	0.21008	0.2838	0.1690	1.158	2785.	458.9	5.00
6.00	−82.60	−81.02	84.84	6.768	−12.44	78.11	−0.03116	0.20863	0.2853	0.1712	1.159	2731.	461.0	6.00
7.00	−77.69	−76.15	84.35	5.859	−11.03	78.83	−0.02746	0.20746	0.2867	0.1733	1.159	2685.	462.7	7.00
8.00	−73.32	−71.80	83.90	5.171	−9.77	79.46	−0.02419	0.20647	0.2879	0.1751	1.160	2643.	464.1	8.00
10.00	−65.74	−64.28	83.12	4.195	−7.58	80.56	−0.01858	0.20488	0.2901	0.1784	1.161	2573.	466.4	10.00
12.00	−59.29	−57.86	82.45	3.535	−5.70	81.50	−0.01386	0.20365	0.2921	0.1813	1.163	2513.	468.1	12.00
14.00	−53.64	−52.25	81.86	3.059	−4.04	82.31	−0.00976	0.20266	0.2938	0.1839	1.165	2461.	469.5	14.00
14.696b	−51.82	−50.44	81.67	2.922	−3.51	82.57	−0.00845	0.20235	0.2944	0.1848	1.165	2445.	469.9	14.70
16.00	−48.59	−47.23	81.32	2.697	−2.55	83.03	−0.00613	0.20183	0.2954	0.1864	1.166	2415.	470.5	16.00
18.00	−44.02	−42.69	80.84	2.414	−1.20	83.69	−0.00286	0.20113	0.2969	0.1886	1.168	2373.	471.4	18.00
20.00	−39.83	−38.52	80.38	2.185	0.05	84.28	0.00012	0.20052	0.2983	0.1907	1.170	2335.	472.0	20.00
22.00	−35.95	−34.66	79.96	1.997	1.21	84.83	0.00286	0.19999	0.2997	0.1927	1.172	2300.	472.6	22.00
24.00	−32.34	−31.07	79.57	1.839	2.30	85.34	0.00541	0.19951	0.3009	0.1945	1.174	2267.	473.0	24.00
26.00	−28.95	−27.71	79.19	1.704	3.32	85.81	0.00778	0.19909	0.3022	0.1963	1.175	2237.	473.3	26.00
28.00	−25.77	−24.54	78.84	1.588	4.29	86.26	0.01001	0.19871	0.3033	0.1981	1.177	2208.	473.5	28.00
30.00	−22.75	−21.54	78.50	1.487	5.21	86.68	0.01210	0.19837	0.3045	0.1997	1.179	2181.	473.7	30.00
32.00	−19.88	−18.68	78.18	1.398	6.08	87.07	0.01409	0.19805	0.3056	0.2013	1.181	2155.	473.8	32.00
34.00	−17.15	−15.97	77.87	1.319	6.92	87.45	0.01598	0.19776	0.3066	0.2029	1.183	2130.	473.8	34.00
36.00	−14.54	−13.37	77.57	1.249	7.72	87.80	0.01778	0.19750	0.3077	0.2044	1.185	2106.	473.8	36.00
38.00	−12.04	−10.88	77.28	1.186	8.50	88.14	0.01950	0.19725	0.3087	0.2059	1.187	2084.	473.8	38.00
40.00	−9.64	−8.49	77.00	1.129	9.24	88.47	0.02115	0.19702	0.3097	0.2073	1.188	2062.	473.7	40.00
42.00	−7.33	−6.19	76.73	1.077	9.96	88.78	0.02273	0.19681	0.3106	0.2087	1.190	2041.	473.5	42.00
44.00	−5.10	−3.97	76.47	1.030	10.65	89.08	0.02425	0.19661	0.3116	0.2101	1.192	2021.	473.4	44.00
46.00	−2.94	−1.83	76.22	0.9864	11.33	89.37	0.02572	0.19642	0.3125	0.2115	1.194	2002.	473.2	46.00
48.00	−0.86	0.24	75.97	0.9465	11.98	89.64	0.02713	0.19624	0.3134	0.2128	1.196	1983.	473.0	48.00
50.00	1.16	2.25	75.73	0.9098	12.62	89.91	0.02850	0.19607	0.3143	0.2141	1.198	1965.	472.8	50.00
55.00	5.94	7.01	75.16	0.8292	14.13	90.53	0.03174	0.19569	0.3166	0.2172	1.203	1921.	472.1	55.00
60.00	10.41	11.46	74.61	0.7616	15.55	91.11	0.03476	0.19535	0.3187	0.2203	1.208	1881.	471.3	60.00
65.00	14.61	15.64	74.09	0.7040	16.89	91.65	0.03758	0.19505	0.3208	0.2233	1.213	1843.	470.5	65.00
70.00	18.57	19.58	73.60	0.6543	18.17	92.14	0.04023	0.19478	0.3229	0.2262	1.218	1807.	469.5	70.00
75.00	22.32	23.31	73.12	0.6111	19.39	92.61	0.04274	0.19453	0.3249	0.2290	1.223	1773.	468.5	75.00
80.00	25.88	26.86	72.66	0.5731	20.55	93.05	0.04511	0.19430	0.3269	0.2318	1.228	1740.	467.4	80.00
85.00	29.28	30.25	72.22	0.5393	21.67	93.46	0.04738	0.19409	0.3288	0.2345	1.233	1709.	466.3	85.00
90.00	32.54	33.49	71.79	0.5092	22.74	93.85	0.04954	0.19389	0.3308	0.2372	1.239	1679.	465.1	90.00
95.00	35.66	36.59	71.37	0.4822	23.78	94.21	0.05162	0.19370	0.3327	0.2399	1.244	1651.	463.9	95.00
100.00	38.66	39.58	70.97	0.4577	24.78	94.56	0.05361	0.19353	0.3347	0.2426	1.250	1623.	462.7	100.00
110.00	44.34	45.24	70.19	0.4152	26.69	95.20	0.05737	0.19320	0.3385	0.2479	1.261	1571.	460.1	110.00
120.00	49.65	50.52	69.44	0.3796	28.50	95.79	0.06088	0.19290	0.3424	0.2531	1.273	1521.	457.4	120.00
130.00	54.63	55.48	68.72	0.3492	30.21	96.31	0.06417	0.19262	0.3463	0.2584	1.285	1475.	454.6	130.00
140.00	59.34	60.17	68.02	0.3230	31.84	96.80	0.06728	0.19235	0.3502	0.2638	1.298	1431.	451.7	140.00
150.00	63.80	64.61	67.35	0.3001	33.41	97.24	0.07023	0.19209	0.3542	0.2692	1.312	1389.	448.8	150.00
160.00	68.05	68.83	66.69	0.2800	34.91	97.64	0.07304	0.19184	0.3583	0.2747	1.326	1349.	445.7	160.00
170.00	72.10	72.87	66.05	0.2622	36.36	98.01	0.07573	0.19159	0.3624	0.2803	1.341	1311.	442.7	170.00
180.00	75.97	76.73	65.41	0.2462	37.76	98.35	0.07830	0.19134	0.3667	0.2861	1.357	1274.	439.6	180.00
190.00	79.69	80.43	64.79	0.2319	39.12	98.66	0.08077	0.19109	0.3711	0.2921	1.374	1238.	436.4	190.00
200.00	83.27	83.99	64.18	0.2189	40.44	98.94	0.08316	0.19084	0.3757	0.2982	1.391	1203.	433.2	200.00
220.00	90.04	90.72	62.99	0.1963	42.98	99.42	0.08769	0.19032	0.3853	0.3113	1.430	1138.	426.7	220.00
240.00	96.36	97.01	61.81	0.1772	45.39	99.82	0.09196	0.18978	0.3957	0.3256	1.474	1076.	420.1	240.00
260.00	102.29	102.92	60.64	0.1610	47.71	100.12	0.09600	0.18921	0.4072	0.3414	1.524	1016.	413.3	260.00
280.00	107.90	108.49	59.48	0.1468	49.95	100.35	0.09985	0.18860	0.4200	0.3592	1.582	960.	406.4	280.00
300.00	113.20	113.77	58.32	0.1344	52.12	100.49	0.10355	0.18794	0.4345	0.3796	1.650	906.	399.4	300.00
320.00	118.24	118.78	57.15	0.1234	54.24	100.55	0.10712	0.18722	0.4511	0.4032	1.730	853.	392.2	320.00
340.00	123.04	123.56	55.96	0.1136	56.31	100.53	0.11058	0.18643	0.4705	0.4310	1.827	803.	385.0	340.00
360.00	127.63	128.12	54.75	0.1047	58.35	100.43	0.11395	0.18557	0.4937	0.4646	1.945	753.	377.7	360.00
380.00	132.02	132.49	53.49	0.0965	60.37	100.23	0.11726	0.18461	0.5220	0.5061	2.092	705.	370.2	380.00
400.00	136.24	136.67	52.19	0.0890	62.38	99.94	0.12053	0.18353	0.5579	0.5588	2.282	657.	362.6	400.00
450.00	146.06	146.42	48.56	0.0722	67.49	98.62	0.12873	0.18011	0.7133	0.7888	3.120	541.	343.1	450.00
500.00	154.99	155.25	43.76	0.0565	73.20	95.88	0.13774	0.17463	1.2479	1.5641	5.974	422.	322.1	500.00
548.18c	162.50	162.50	35.84	0.0279	80.83	80.83	0.14972	0.14972	∞	∞	∞	0.	0.0	548.18

*temperatures are on the ITS−90 scale b = one standard atmosphere c = critical point

Refrigerant 717 (Ammonia) Properties of Saturated Liquid and Saturated Vapor

Temp,* °F	Pressure, psia	Density, lb/ft³ Liquid	Volume, ft³/lb Vapor	Enthalpy, Btu/lb Liquid	Enthalpy, Btu/lb Vapor	Entropy, Btu/lb·°F Liquid	Entropy, Btu/lb·°F Vapor	Specific Heat c_p, Btu/lb·°F Liquid	Specific Heat c_p, Btu/lb·°F Vapor	c_p/c_v Vapor	Velocity of Sound, ft/s Liquid	Velocity of Sound, ft/s Vapor	Viscosity, lb_m/ft·h Liquid	Viscosity, lb_m/ft·h Vapor	Thermal Cond, Btu/h·ft·°F Liquid	Thermal Cond, Btu/h·ft·°F Vapor	Surface Tension, dyne/cm	Temp,* °F
−107.78a	0.876	45.81	252.01	−71.827	569.276	−0.18678	1.63586	—	0.4752	1.3352	—	1167.	1.224	0.0166	—	0.00742	—	−107.78
−100.00	1.230	45.51	183.31	−63.032	572.742	−0.16206	1.60621	—	0.4777	1.3362	—	1179.	1.167	0.0169	—	0.00769	—	−100.00
−90.00	1.856	45.13	124.64	−52.230	577.125	−0.13244	1.57049	—	0.4817	1.3379	—	1194.	1.076	0.0172	—	0.00802	41.94	−90.00
−80.00	2.733	44.73	86.784	−41.713	581.419	−0.10437	1.53719	—	0.4869	1.3399	—	1208.	0.983	0.0176	—	0.00836	40.67	−80.00
−70.00	3.931	44.32	61.753	−31.305	585.612	−0.07732	1.50607	—	0.4932	1.3423	—	1222.	0.897	0.0180	—	0.00869	39.41	−70.00
−60.00	5.539	43.91	44.818	−20.912	589.693	−0.05100	1.47691	—	0.5007	1.3450	—	1235.	0.820	0.0183	—	0.00902	38.16	−60.00
−50.00	7.656	43.49	33.121	−10.484	593.653	−0.02526	1.44953	—	0.5097	1.3481	—	1247.	0.753	0.0187	0.3543	0.00936	36.90	−50.00
−45.00	8.941	43.28	28.652	−5.250	595.584	−0.01257	1.43646	—	0.5146	1.3499	—	1253.	0.723	0.0189	0.3510	0.00953	36.28	−45.00
−40.00	10.396	43.07	24.885	0.000	597.482	0.00000	1.42376	1.0508	0.5200	1.3518	5046.	1259.	0.694	0.0191	0.3477	0.00971	35.65	−40.00
−35.00	12.040	42.85	21.694	5.267	599.344	0.01246	1.41144	1.0541	0.5256	1.3538	5025.	1264.	0.668	0.0193	0.3444	0.00987	35.03	−35.00
−30.00	13.890	42.64	18.981	10.551	601.171	0.02481	1.39946	1.0575	0.5317	1.3559	5006.	1269.	0.643	0.0195	0.3411	0.01004	34.41	−30.00
−27.99b	14.696	42.55	18.006	12.682	601.896	0.02975	1.39473	1.0589	0.5342	1.3568	4999.	1272.	0.634	0.0196	0.3398	0.01011	34.16	−27.99
−25.00	15.964	42.42	16.665	15.854	602.962	0.03706	1.38781	1.0609	0.5380	1.3582	4988.	1275.	0.620	0.0197	0.3379	0.01021	33.78	−25.00
−20.00	18.281	42.21	14.680	21.174	604.714	0.04921	1.37648	1.0644	0.5448	1.3607	4971.	1279.	0.598	0.0199	0.3346	0.01038	33.16	−20.00
−15.00	20.861	41.99	12.973	26.511	606.428	0.06125	1.36545	1.0679	0.5518	1.3633	4954.	1284.	0.577	0.0201	0.3313	0.01055	32.54	−15.00
−10.00	23.727	41.77	11.500	31.867	608.102	0.07320	1.35471	1.0714	0.5593	1.3661	4936.	1288.	0.558	0.0203	0.3281	0.01073	31.92	−10.00
−5.00	26.900	41.55	10.223	37.242	609.736	0.08506	1.34424	1.0750	0.5671	1.3692	4916.	1293.	0.539	0.0205	0.3248	0.01092	31.31	−5.00
0.00	30.402	41.33	9.1135	42.635	611.327	0.09682	1.33403	1.0786	0.5752	1.3724	4894.	1297.	0.521	0.0207	0.3216	0.01112	30.69	0.00
5.00	34.258	41.11	8.1464	48.046	612.876	0.10849	1.32408	1.0822	0.5837	1.3759	4870.	1300.	0.504	0.0209	0.3183	0.01133	30.07	5.00
10.00	38.492	40.88	7.3005	53.477	614.382	0.12008	1.31437	1.0860	0.5925	1.3797	4844.	1304.	0.488	0.0211	0.3151	0.01155	29.46	10.00
15.00	43.131	40.65	6.5585	58.928	615.842	0.13158	1.30488	1.0898	0.6017	1.3838	4816.	1307.	0.473	0.0213	0.3119	0.01178	28.84	15.00
20.00	48.199	40.43	5.9059	64.398	617.256	0.14299	1.29561	1.0937	0.6113	1.3881	4785.	1310.	0.458	0.0215	0.3086	0.01202	28.23	20.00
25.00	53.724	40.20	5.3303	69.888	618.623	0.15432	1.28654	1.0977	0.6212	1.3928	4751.	1313.	0.444	0.0217	0.3053	0.01227	27.62	25.00
30.00	59.734	39.96	4.8211	75.400	619.941	0.16558	1.27767	1.1018	0.6315	1.3979	4716.	1316.	0.431	0.0219	0.3021	0.01252	27.01	30.00
35.00	66.258	39.73	4.3695	80.933	621.208	0.17676	1.26898	1.1060	0.6422	1.4033	4677.	1318.	0.417	0.0221	0.2988	0.01278	26.40	35.00
40.00	73.324	39.49	3.9682	86.488	622.424	0.18787	1.26047	1.1103	0.6533	1.4092	4637.	1320.	0.405	0.0223	0.2956	0.01305	25.79	40.00
45.00	80.962	39.25	3.6105	92.066	623.585	0.19891	1.25213	1.1148	0.6648	1.4155	4594.	1322.	0.393	0.0225	0.2923	0.01333	25.18	45.00
50.00	89.204	39.01	3.2910	97.666	624.692	0.20987	1.24394	1.1194	0.6767	1.4222	4549.	1323.	0.381	0.0227	0.2890	0.01361	24.57	50.00
55.00	98.081	38.76	3.0050	103.291	625.741	0.22077	1.23590	1.1241	0.6890	1.4295	4502.	1325.	0.370	0.0229	0.2857	0.01390	23.97	55.00
60.00	107.62	38.51	2.7484	108.941	626.731	0.23161	1.22800	1.1290	0.7018	1.4374	4452.	1326.	0.359	0.0231	0.2824	0.01419	23.36	60.00
65.00	117.87	38.26	2.5177	114.615	627.659	0.24238	1.22022	1.1341	0.7152	1.4458	4401.	1327.	0.349	0.0234	0.2791	0.01449	22.76	65.00
70.00	128.84	38.00	2.3098	120.315	628.523	0.25309	1.21257	1.1393	0.7290	1.4549	4348.	1327.	0.339	0.0236	0.2757	0.01479	22.16	70.00
75.00	140.58	37.75	2.1222	126.041	629.321	0.26374	1.20503	1.1448	0.7434	1.4647	4293.	1327.	0.329	0.0238	0.2724	0.01510	21.56	75.00
80.00	153.12	37.49	1.9525	131.795	630.051	0.27434	1.19759	1.1504	0.7584	1.4752	4236.	1327.	0.320	0.0240	0.2690	0.01541	20.96	80.00
85.00	166.50	37.22	1.7987	137.577	630.709	0.28488	1.19024	1.1563	0.7740	1.4865	4178.	1327.	0.310	0.0242	0.2657	0.01572	20.36	85.00
90.00	180.74	36.95	1.6591	143.389	631.292	0.29537	1.18298	1.1625	0.7903	1.4987	4118.	1327.	0.302	0.0244	0.2623	0.01604	19.76	90.00
95.00	195.90	36.68	1.5321	149.232	631.799	0.30581	1.17580	1.1689	0.8074	1.5117	4057.	1326.	0.293	0.0246	0.2589	0.01636	19.17	95.00
100.00	211.99	36.40	1.4165	155.106	632.224	0.31621	1.16868	1.1757	0.8253	1.5258	3994.	1325.	0.285	0.0249	0.2555	0.01669	18.57	100.00
105.00	229.07	36.12	1.3109	161.013	632.567	0.32656	1.16163	1.1829	0.8441	1.5410	3931.	1324.	0.277	0.0251	0.2520	0.01703	17.98	105.00
110.00	247.17	35.84	1.2144	166.955	632.821	0.33687	1.15462	1.1905	0.8639	1.5574	3865.	1322.	0.270	0.0253	0.2486	0.01738	17.39	110.00
115.00	266.32	35.55	1.1261	172.933	632.985	0.34715	1.14766	1.1986	0.8847	1.5750	3799.	1320.	0.262	0.0256	0.2451	0.01773	16.80	115.00
120.00	286.57	35.26	1.0451	178.950	633.053	0.35739	1.14073	1.2072	0.9067	1.5941	3731.	1318.	0.255	0.0258	0.2417	0.01809	16.22	120.00
125.00	307.96	34.96	0.9708	185.007	633.023	0.36760	1.13383	1.2165	0.9299	1.6146	3663.	1315.	0.248	0.0260	0.2382	0.01846	15.63	125.00
130.00	330.52	34.66	0.9024	191.107	632.888	0.37778	1.12694	1.2264	0.9546	1.6368	3593.	1312.	0.241	0.0263	0.2347	0.01885	15.05	130.00
135.00	354.30	34.35	0.8394	197.253	632.646	0.38795	1.12006	1.2372	0.9808	1.6609	3523.	1309.	0.235	0.0265	0.2311	0.01925	14.46	135.00
140.00	379.34	34.03	0.7813	203.447	632.289	0.39809	1.11318	1.2489	1.0088	1.6869	3451.	1306.	0.229	0.0268	0.2276	0.01966	13.88	140.00
145.00	405.67	33.71	0.7277	209.694	631.813	0.40823	1.10628	1.2616	1.0387	1.7152	3378.	1302.	0.222	0.0271	0.2240	0.02009	13.31	145.00
150.00	433.35	33.39	0.6781	215.997	631.213	0.41836	1.09937	1.2754	1.0707	1.7460	3305.	1298.	0.216	0.0274	0.2204	0.02054	12.73	150.00
155.00	462.42	33.05	0.6322	222.361	630.480	0.42849	1.09241	1.2907	1.1051	1.7796	3230.	1293.	0.211	0.0276	0.2167	0.02102	12.16	155.00
160.00	492.92	32.71	0.5896	228.792	629.609	0.43863	1.08541	1.3074	1.1423	1.8162	3154.	1288.	0.205	0.0279	0.2130	0.02151	11.58	160.00
165.00	524.91	32.36	0.5500	235.294	628.590	0.44878	1.07836	1.3259	1.1826	1.8564	3078.	1283.	0.199	0.0282	0.2093	0.02204	11.01	165.00
170.00	558.42	32.01	0.5133	241.874	627.416	0.45897	1.07123	1.3464	1.2264	1.9007	3000.	1277.	0.194	0.0286	0.2056	0.02259	10.45	170.00
175.00	593.51	31.64	0.4790	248.540	626.075	0.46919	1.06401	1.3692	1.2743	1.9495	2922.	1271.	0.189	0.0289	0.2018	0.02318	9.88	175.00
180.00	630.22	31.26	0.4471	255.298	624.558	0.47946	1.05669	1.3946	1.3268	2.0037	2842.	1264.	0.184	0.0293	0.1979	0.02380	9.32	180.00
185.00	668.61	30.87	0.4173	262.159	622.851	0.48978	1.04925	1.4232	1.3848	2.0640	2761.	1257.	0.178	0.0296	0.1940	0.02446	8.76	185.00
190.00	708.73	30.47	0.3894	269.133	620.938	0.50018	1.04167	1.4555	1.4493	2.1317	2679.	1249.	0.173	0.0300	0.1900	0.02517	8.20	190.00
195.00	750.64	30.06	0.3632	276.232	618.804	0.51067	1.03393	1.4921	1.5214	2.2081	2595.	1240.	0.168	0.0305	0.1860	0.02593	7.65	195.00
200.00	794.38	29.63	0.3387	283.469	616.428	0.52127	1.02599	1.5339	1.6028	2.2950	2511.	1231.	0.163	0.0309	0.1819	0.02674	7.10	200.00
205.00	840.03	29.18	0.3157	290.862	613.785	0.53200	1.01782	1.5821	1.6955	2.3947	2424.	1222.	0.159	0.0314	0.1777	0.02762	6.55	205.00
210.00	887.64	28.71	0.2940	298.429	610.846	0.54289	1.00939	1.6382	1.8022	2.5104	2336.	1211.	0.154	0.0320	0.1734	0.02857	6.00	210.00
215.00	937.28	28.23	0.2735	306.194	607.577	0.55396	1.00065	1.7041	1.9265	2.6462	2247.	1200.	0.149	0.0326	0.1689	0.02960	5.46	215.00
220.00	989.03	27.71	0.2541	314.185	603.934	0.56525	0.99154	1.7826	2.0737	2.8080	2155.	1188.	0.144	0.0332	0.1644	0.03073	4.93	220.00
225.00	1043.0	27.17	0.2357	322.439	599.861	0.57682	0.98199	1.8778	2.2509	3.0042	2061.	1175.	0.139	0.0339	0.1597	0.03196	4.40	225.00
230.00	1099.1	26.59	0.2182	330.998	595.287	0.58871	0.97190	1.9956	2.4691	3.2471	1966.	1162.	0.134	0.0348	—	—	3.87	230.00
235.00	1157.7	25.98	0.2015	339.924	590.119	0.60101	0.96115	2.1451	2.7450	3.5558	1867.	1147.	0.129	0.0357	—	—	3.35	235.00
240.00	1218.6	25.31	0.1854	349.296	584.228	0.61382	0.94957	2.3415	3.1056	3.9616	1766.	1130.	0.124	0.0368	—	—	2.84	240.00
245.00	1282.1	24.58	0.1698	359.229	577.434	0.62729	0.93692	2.6113	3.5985	4.5184	1662.	1113.	0.119	0.0381	—	—	2.33	245.00
250.00	1348.3	23.76	0.1545	369.899	569.465	0.64166	0.92285	3.0058	4.3134	5.3293	1555.	1094.	0.114	0.0396	—	—	1.83	250.00
255.00	1417.3	22.83	0.1393	381.593	559.887	0.65731	0.90677	3.6381	5.4427	6.6150	1443.	1073.	0.108	0.0416	—	—	1.34	255.00
260.00	1489.4	21.73	0.1239	394.854	547.928	0.67496	0.88765	4.8147	7.4812	8.9443	1327.	1049.	0.101	0.0443	—	—	0.87	260.00
269.99c	1643.7	14.67	0.0682	467.152	467.152	0.77240	0.77240	∞	∞	∞	0.	0.	—	—	∞	∞	0.00	269.99

*temperatures have been converted from the IPTS-68 scale of the original formulation to the ITS-90 scale a = triple point b = normal boiling point c = critical point

Refrigerant 744 (Carbon Dioxide) Properties of Saturated Liquid and Saturated Vapor

Temp.,* °F	Pressure, psia	Density, lb/ft³ Liquid	Volume, ft³/lb Vapor	Enthalpy, Btu/lb Liquid	Enthalpy, Btu/lb Vapor	Entropy, Btu/lb·°F Liquid	Entropy, Btu/lb·°F Vapor	Specific Heat c_p, Btu/lb·°F Liquid	Specific Heat c_p, Btu/lb·°F Vapor	c_p/c_v Vapor	Velocity of Sound, ft/s Liquid	Velocity of Sound, ft/s Vapor	Viscosity, lb_m/ft·h Liquid	Viscosity, lb_m/ft·h Vapor	Thermal Cond, Btu/h·ft·°F Liquid	Thermal Cond, Btu/h·ft·°F Vapor	Surface Tension, dyne/cm	Temp.,* °F
−69.83a	75.138	73.56	1.1640	−14.225	136.515	−0.03471	0.35196	0.4764	0.2052	1.4669	3224.	737.	0.625	0.0267	0.1044	0.00654	17.09	−69.83
−65.00	84.296	72.95	1.0427	−11.922	136.902	−0.02890	0.34819	0.4751	0.2106	1.4750	3164.	737.	0.597	0.0271	0.1024	0.00667	16.41	−65.00
−60.00	94.643	72.30	0.9328	−9.541	137.274	−0.02297	0.34437	0.4745	0.2166	1.4845	3101.	738.	0.571	0.0274	0.1004	0.00681	15.72	−60.00
−55.00	105.91	71.65	0.8368	−7.161	137.616	−0.01712	0.34065	0.4745	0.2228	1.4951	3037.	738.	0.545	0.0277	0.0984	0.00694	15.03	−55.00
−50.00	118.16	70.99	0.7525	−4.780	137.927	−0.01135	0.33699	0.4752	0.2293	1.5069	2972.	738.	0.521	0.0281	0.0963	0.00708	14.35	−50.00
−48.00	123.34	70.73	0.7216	−3.826	138.041	−0.00906	0.33555	0.4757	0.2321	1.5121	2946.	737.	0.512	0.0282	0.0955	0.00714	14.08	−48.00
−46.00	128.69	70.46	0.6923	−2.871	138.151	−0.00678	0.33412	0.4762	0.2348	1.5174	2920.	737.	0.503	0.0283	0.0947	0.00719	13.81	−46.00
−44.00	134.21	70.20	0.6644	−1.915	138.255	−0.00451	0.33270	0.4769	0.2377	1.5230	2893.	737.	0.494	0.0285	0.0939	0.00725	13.54	−44.00
−42.00	139.90	69.93	0.6379	−0.958	138.353	−0.00225	0.33129	0.4776	0.2406	1.5288	2867.	737.	0.485	0.0286	0.0931	0.00731	13.28	−42.00
−40.00	145.77	69.65	0.6126	0.000	138.445	0.00000	0.32989	0.4784	0.2436	1.5349	2840.	737.	0.477	0.0287	0.0923	0.00737	13.01	−40.00
−38.00	151.82	69.38	0.5885	0.961	138.532	0.00224	0.32850	0.4794	0.2466	1.5413	2814.	736.	0.469	0.0289	0.0915	0.00743	12.75	−38.00
−36.00	158.06	69.11	0.5655	1.923	138.612	0.00448	0.32711	0.4804	0.2498	1.5479	2787.	736.	0.460	0.0290	0.0907	0.00749	12.48	−36.00
−34.00	164.48	68.83	0.5436	2.887	138.686	0.00671	0.32574	0.4816	0.2530	1.5549	2760.	735.	0.453	0.0291	0.0899	0.00756	12.22	−34.00
−32.00	171.09	68.55	0.5227	3.853	138.754	0.00893	0.32437	0.4828	0.2563	1.5621	2732.	735.	0.445	0.0293	0.0891	0.00762	11.96	−32.00
−30.00	177.90	68.27	0.5027	4.822	138.816	0.01115	0.32300	0.4841	0.2596	1.5697	2705.	734.	0.437	0.0294	0.0883	0.00769	11.70	−30.00
−28.00	184.90	67.99	0.4836	5.793	138.871	0.01336	0.32165	0.4856	0.2631	1.5776	2678.	734.	0.430	0.0295	0.0875	0.00776	11.45	−28.00
−26.00	192.11	67.71	0.4654	6.767	138.919	0.01557	0.32030	0.4871	0.2667	1.5859	2650.	733.	0.422	0.0297	0.0867	0.00783	11.19	−26.00
−24.00	199.52	67.42	0.4480	7.743	138.960	0.01777	0.31895	0.4888	0.2703	1.5945	2622.	733.	0.415	0.0298	0.0859	0.00790	10.93	−24.00
−22.00	207.14	67.13	0.4313	8.723	138.995	0.01996	0.31761	0.4905	0.2741	1.6036	2594.	732.	0.408	0.0300	0.0851	0.00797	10.68	−22.00
−20.00	214.97	66.84	0.4154	9.706	139.021	0.02215	0.31627	0.4924	0.2779	1.6130	2566.	731.	0.401	0.0301	0.0843	0.00805	10.43	−20.00
−18.00	223.02	66.54	0.4001	10.693	139.041	0.02434	0.31494	0.4944	0.2819	1.6229	2538.	730.	0.394	0.0302	0.0835	0.00813	10.18	−18.00
−16.00	231.29	66.25	0.3855	11.683	139.053	0.02653	0.31361	0.4965	0.2860	1.6333	2509.	730.	0.388	0.0304	0.0827	0.00822	9.93	−16.00
−14.00	239.78	65.95	0.3714	12.677	139.056	0.02871	0.31228	0.4987	0.2903	1.6441	2481.	729.	0.381	0.0305	0.0819	0.00830	9.68	−14.00
−12.00	248.49	65.65	0.3580	13.675	139.052	0.03089	0.31095	0.5011	0.2947	1.6554	2452.	728.	0.375	0.0307	0.0811	0.00839	9.43	−12.00
−10.00	257.44	65.34	0.3451	14.677	139.040	0.03307	0.30963	0.5036	0.2992	1.6673	2423.	727.	0.368	0.0309	0.0804	0.00849	9.19	−10.00
−8.00	266.62	65.03	0.3328	15.683	139.019	0.03524	0.30831	0.5062	0.3039	1.6798	2394.	726.	0.362	0.0310	0.0796	0.00858	8.95	−8.00
−6.00	276.04	64.72	0.3209	16.694	138.989	0.03741	0.30698	0.5090	0.3088	1.6929	2364.	725.	0.356	0.0312	0.0788	0.00869	8.70	−6.00
−4.00	285.70	64.41	0.3095	17.710	138.950	0.03959	0.30566	0.5119	0.3138	1.7067	2335.	724.	0.350	0.0314	0.0780	0.00879	8.46	−4.00
−2.00	295.60	64.09	0.2986	18.732	138.901	0.04176	0.30433	0.5150	0.3190	1.7211	2305.	722.	0.344	0.0316	0.0772	0.00890	8.22	−2.00
0.00	305.76	63.76	0.2880	19.758	138.843	0.04394	0.30300	0.5183	0.3245	1.7363	2275.	721.	0.338	0.0317	0.0764	0.00902	7.99	0.00
2.00	316.17	63.44	0.2779	20.790	138.775	0.04611	0.30167	0.5218	0.3301	1.7523	2245.	720.	0.333	0.0319	0.0756	0.00914	7.75	2.00
4.00	326.83	63.11	0.2682	21.828	138.697	0.04829	0.30034	0.5254	0.3360	1.7691	2215.	719.	0.327	0.0321	0.0749	0.00927	7.52	4.00
6.00	337.76	62.77	0.2589	22.872	138.608	0.05046	0.29900	0.5292	0.3422	1.7868	2185.	717.	0.322	0.0323	0.0741	0.00940	7.29	6.00
8.00	348.95	62.43	0.2498	23.923	138.508	0.05264	0.29766	0.5333	0.3486	1.8055	2154.	716.	0.316	0.0325	0.0733	0.00954	7.05	8.00
10.00	360.41	62.09	0.2412	24.980	138.397	0.05483	0.29631	0.5376	0.3553	1.8253	2123.	714.	0.311	0.0327	0.0725	0.00968	6.83	10.00
12.00	372.14	61.74	0.2328	26.044	138.273	0.05702	0.29495	0.5421	0.3624	1.8461	2092.	713.	0.305	0.0330	0.0718	0.00984	6.60	12.00
14.00	384.15	61.39	0.2248	27.116	138.138	0.05920	0.29359	0.5469	0.3698	1.8682	2061.	711.	0.300	0.0332	0.0710	0.01000	6.37	14.00
16.00	396.44	61.03	0.2170	28.195	137.990	0.06140	0.29222	0.5519	0.3776	1.8917	2029.	709.	0.295	0.0334	0.0702	0.01016	6.15	16.00
18.00	409.02	60.67	0.2095	29.283	137.828	0.06360	0.29084	0.5573	0.3857	1.9165	1997.	708.	0.290	0.0337	0.0694	0.01034	5.93	18.00
20.00	421.89	60.30	0.2023	30.379	137.653	0.06581	0.28945	0.5630	0.3944	1.9429	1966.	706.	0.284	0.0339	0.0687	0.01052	5.71	20.00
22.00	435.05	59.92	0.1953	31.484	137.463	0.06802	0.28805	0.5690	0.4035	1.9710	1933.	704.	0.279	0.0342	0.0679	0.01072	5.49	22.00
24.00	448.52	59.54	0.1886	32.598	137.258	0.07025	0.28663	0.5755	0.4131	2.0009	1901.	702.	0.274	0.0345	0.0671	0.01092	5.28	24.00
26.00	462.28	59.15	0.1821	33.722	137.037	0.07248	0.28520	0.5823	0.4234	2.0329	1869.	700.	0.269	0.0347	0.0663	0.01114	5.06	26.00
28.00	476.36	58.75	0.1758	34.857	136.800	0.07472	0.28376	0.5896	0.4342	2.0670	1836.	698.	0.264	0.0350	0.0656	0.01136	4.85	28.00
30.00	490.74	58.35	0.1697	36.002	136.545	0.07697	0.28230	0.5974	0.4458	2.1037	1803.	696.	0.259	0.0353	0.0648	0.01160	4.64	30.00
32.00	505.45	57.94	0.1638	37.159	136.273	0.07923	0.28082	0.6057	0.4582	2.1430	1770.	694.	0.254	0.0356	0.0640	0.01185	4.43	32.00
34.00	520.47	57.52	0.1581	38.328	135.981	0.08151	0.27932	0.6146	0.4715	2.1853	1736.	692.	0.249	0.0360	0.0633	0.01211	4.23	34.00
36.00	535.83	57.09	0.1526	39.511	135.669	0.08380	0.27779	0.6242	0.4858	2.2310	1702.	689.	0.244	0.0363	0.0625	0.01239	4.03	36.00
38.00	551.51	56.65	0.1473	40.706	135.336	0.08610	0.27625	0.6345	0.5011	2.2804	1668.	687.	0.239	0.0366	0.0617	0.01268	3.82	38.00
40.00	567.54	56.20	0.1421	41.917	134.980	0.08842	0.27467	0.6457	0.5177	2.3339	1634.	684.	0.235	0.0370	0.0610	0.01299	3.63	40.00
42.00	583.91	55.74	0.1371	43.143	134.600	0.09076	0.27307	0.6577	0.5358	2.3923	1599.	682.	0.230	0.0374	0.0602	0.01332	3.43	42.00
44.00	600.62	55.27	0.1322	44.385	134.195	0.09312	0.27144	0.6708	0.5554	2.4559	1565.	679.	0.225	0.0378	0.0595	0.01366	3.24	44.00
46.00	617.69	54.79	0.1274	45.645	133.763	0.09551	0.26977	0.6851	0.5769	2.5257	1529.	677.	0.220	0.0382	0.0587	0.01402	3.05	46.00
48.00	635.13	54.29	0.1228	46.924	133.302	0.09791	0.26806	0.7007	0.6005	2.6025	1494.	674.	0.215	0.0386	0.0579	0.01441	2.86	48.00
50.00	652.92	53.78	0.1183	48.223	132.809	0.10035	0.26631	0.7179	0.6265	2.6875	1458.	671.	0.210	0.0390	0.0572	0.01481	2.67	50.00
52.00	671.09	53.25	0.1140	49.544	132.283	0.10281	0.26451	0.7369	0.6554	2.7818	1421.	668.	0.205	0.0395	0.0564	0.01525	2.49	52.00
54.00	689.64	52.71	0.1097	50.888	131.720	0.10531	0.26267	0.7580	0.6877	2.8873	1384.	665.	0.200	0.0400	0.0557	0.01570	2.31	54.00
56.00	708.58	52.15	0.1056	52.259	131.117	0.10784	0.26077	0.7815	0.7240	3.0059	1347.	662.	0.194	0.0404	0.0549	0.01618	2.14	56.00
58.00	727.91	51.57	0.1015	53.657	130.471	0.11041	0.25880	0.8081	0.7652	3.1402	1309.	658.	0.189	0.0410	0.0542	0.01669	1.96	58.00
60.00	747.64	50.97	0.0975	55.087	129.777	0.11303	0.25676	0.8383	0.8122	3.2935	1270.	655.	0.184	0.0415	0.0534	0.01724	1.80	60.00
62.00	767.78	50.34	0.0937	56.551	129.029	0.11570	0.25464	0.8729	0.8665	3.4703	1230.	652.	0.179	0.0420	0.0526	0.01781	1.63	62.00
64.00	788.33	49.68	0.0899	58.054	128.222	0.11843	0.25243	0.9132	0.9299	3.6763	1189.	648.	0.173	0.0426	0.0519	0.01842	1.47	64.00
66.00	809.32	49.00	0.0861	59.600	127.348	0.12123	0.25011	0.9605	1.0050	3.9194	1148.	644.	0.168	0.0432	0.0511	0.01907	1.31	66.00
68.00	830.74	48.28	0.0824	61.197	126.396	0.12411	0.24767	1.0173	1.0952	4.2107	1105.	640.	0.163	0.0438	0.0504	0.01977	1.16	68.00
70.00	852.61	47.51	0.0788	62.851	125.355	0.12708	0.24508	1.0866	1.2057	4.5663	1060.	636.	0.157	0.0445	0.0496	0.02050	1.01	70.00
75.00	909.34	45.36	0.0697	67.321	122.243	0.13505	0.23777	1.3554	1.6345	5.9316	941.	625.	0.143	—	—	—	0.66	75.00
80.00	969.22	42.64	0.0604	72.565	117.967	0.14434	0.22847	1.9829	2.6237	9.0199	809.	610.	0.128	—	—	—	0.35	80.00
85.00	1032.7	38.47	0.0494	79.825	110.771	0.15720	0.21401	—	—	—	—	—	—	—	—	—	0.10	85.00
87.76c	1069.6	29.20	0.0342	94.234	94.234	0.18320	0.18320	∞	∞	∞	0.	0.	—	—	∞	∞	0.00	87.76

*temperatures are on the IPTS−68 scale a = triple point c = critical point

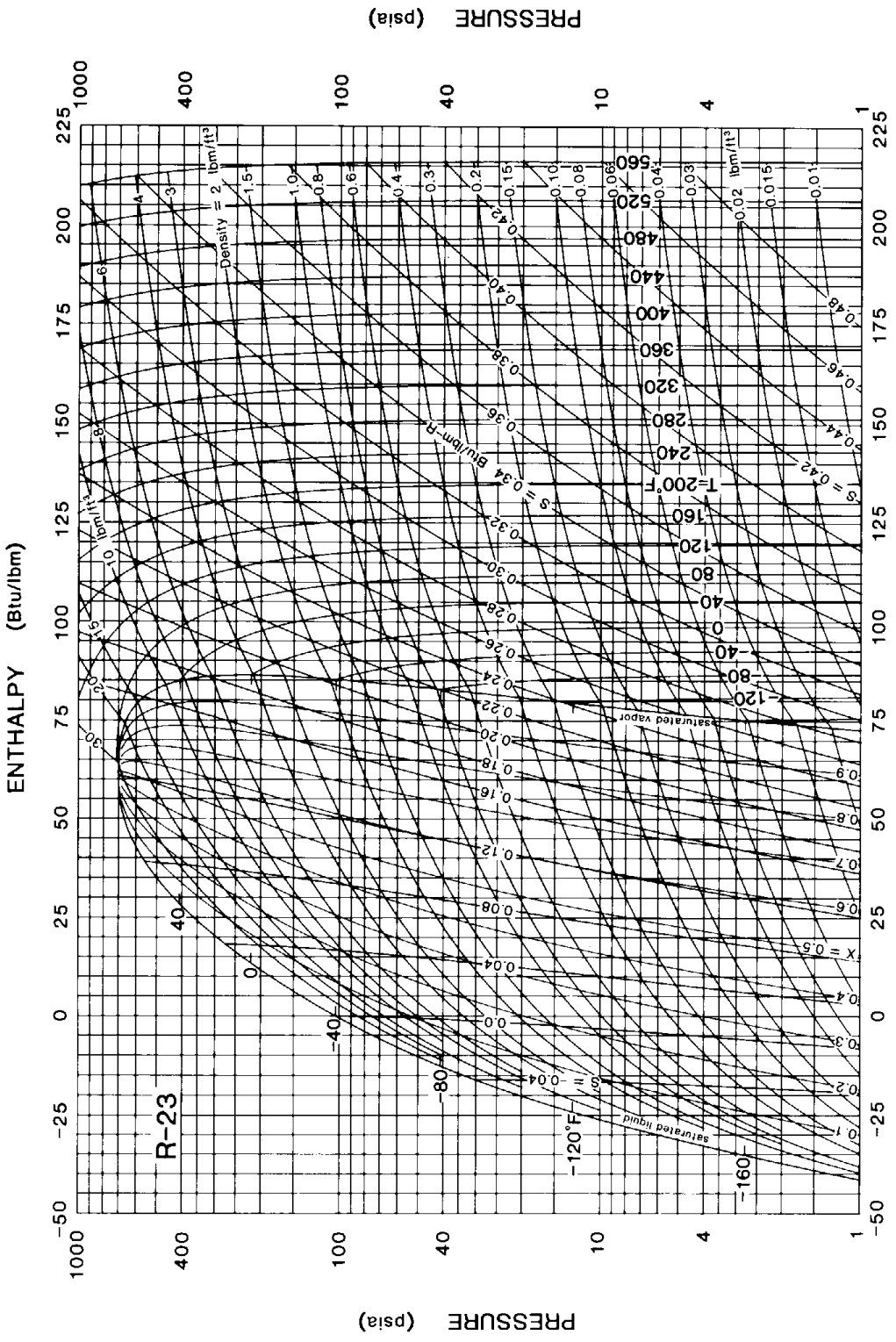


Fig. 5 Pressure-Enthalpy Diagram for Refrigerant 23

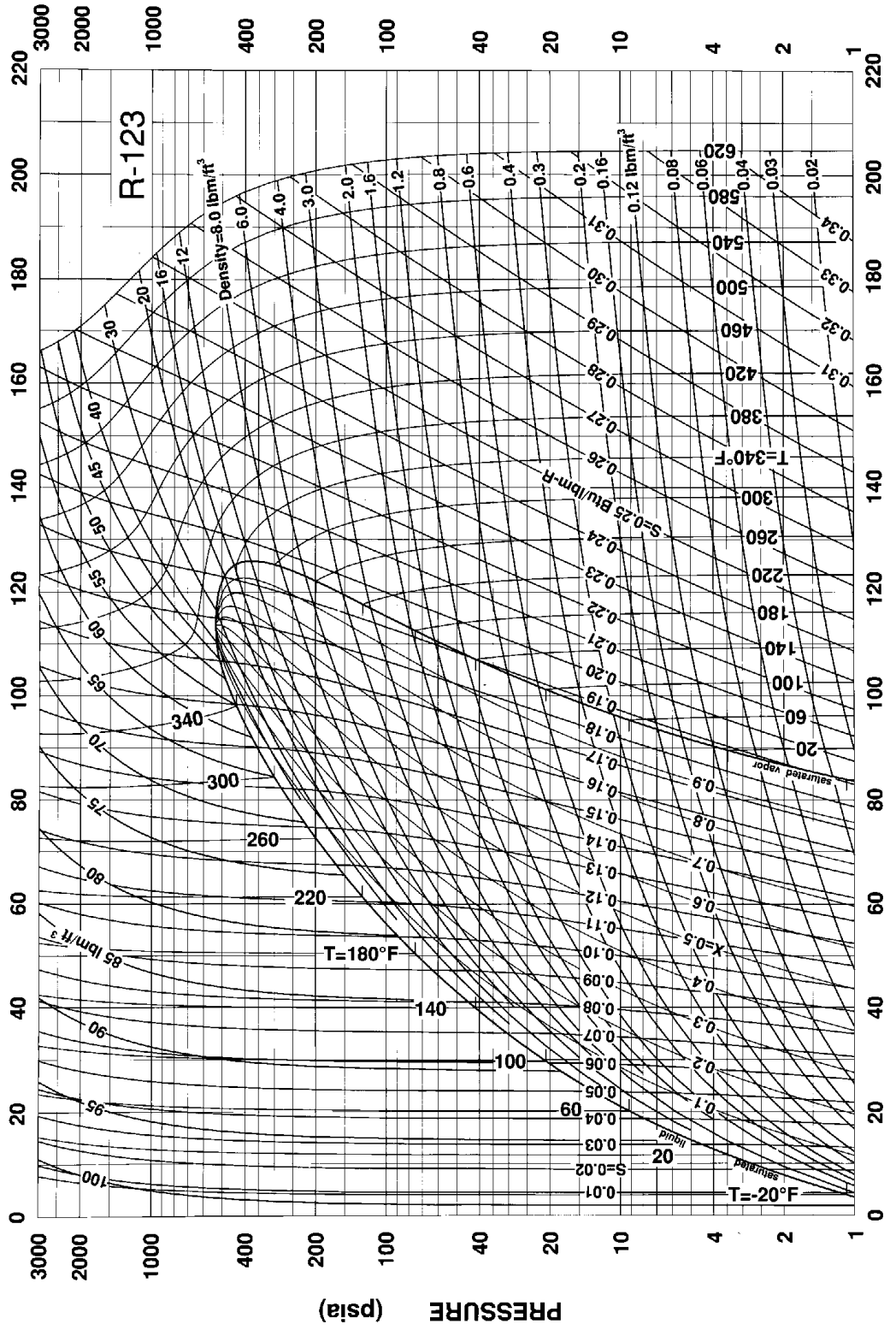


Fig. 9 Pressure-Enthalpy Diagram for Refrigerant 123

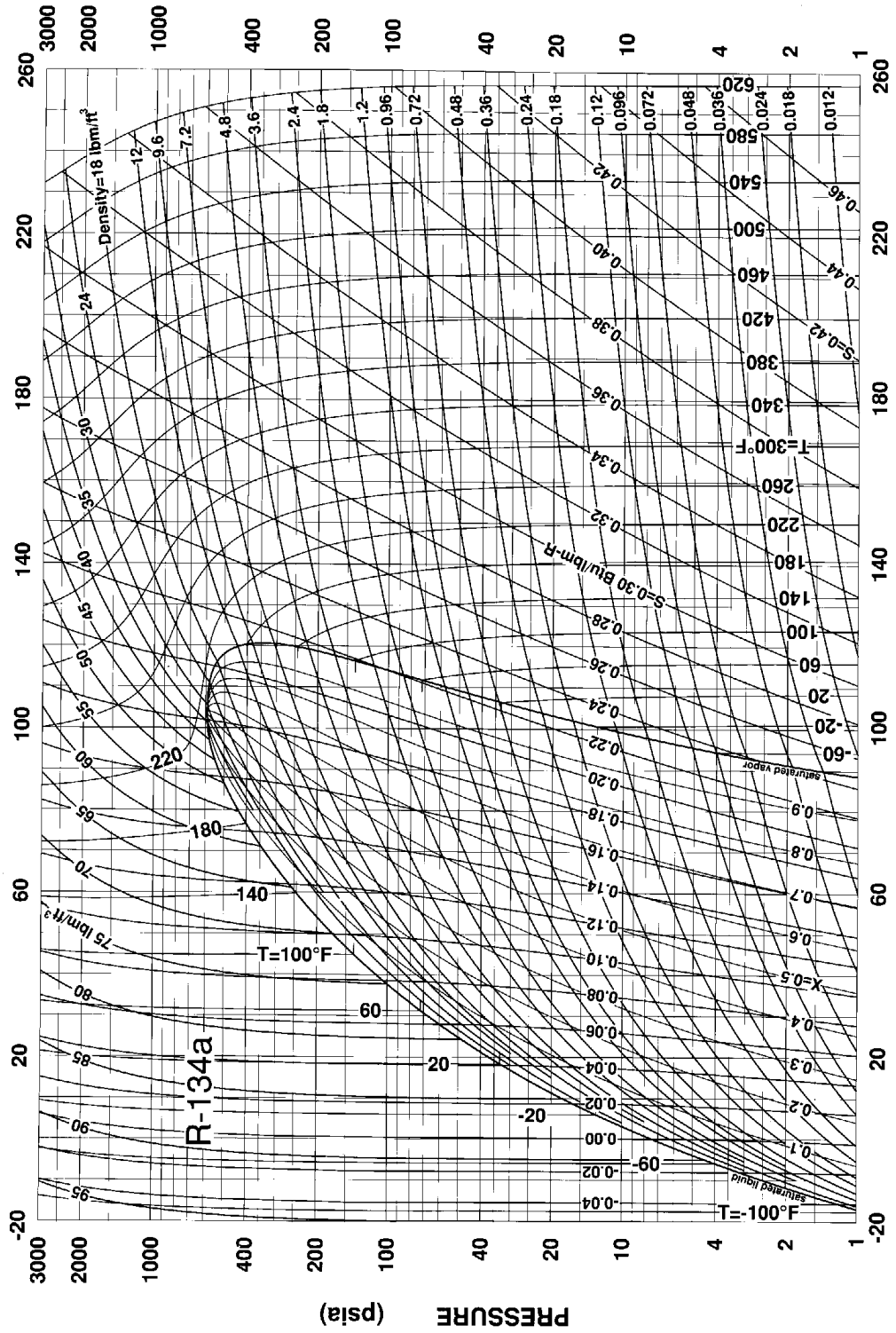


Fig. 12 Pressure–Enthalpy Diagram for Refrigerant 134a

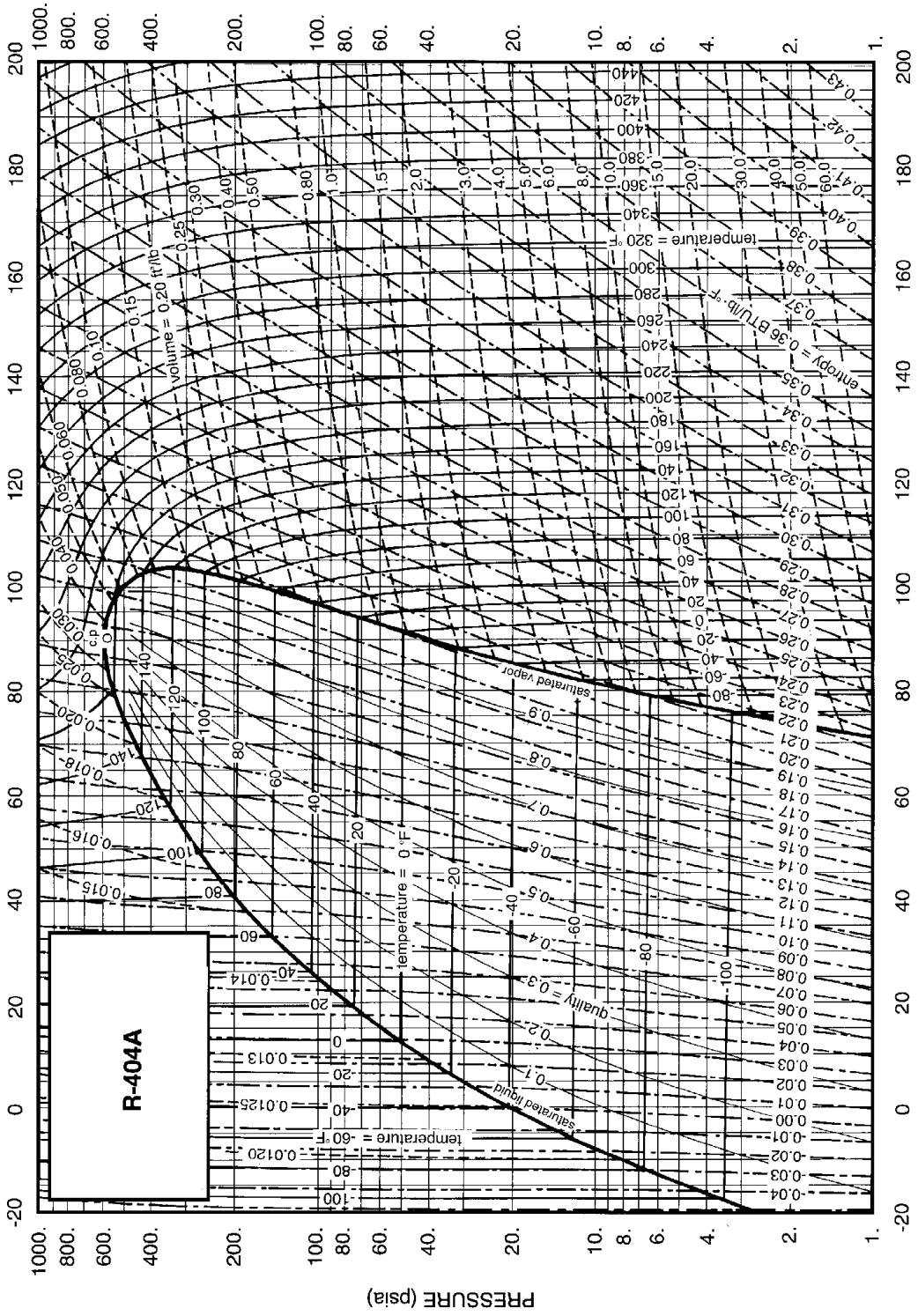


Fig. 16 Pressure–Enthalpy Diagram for Refrigerant 404A
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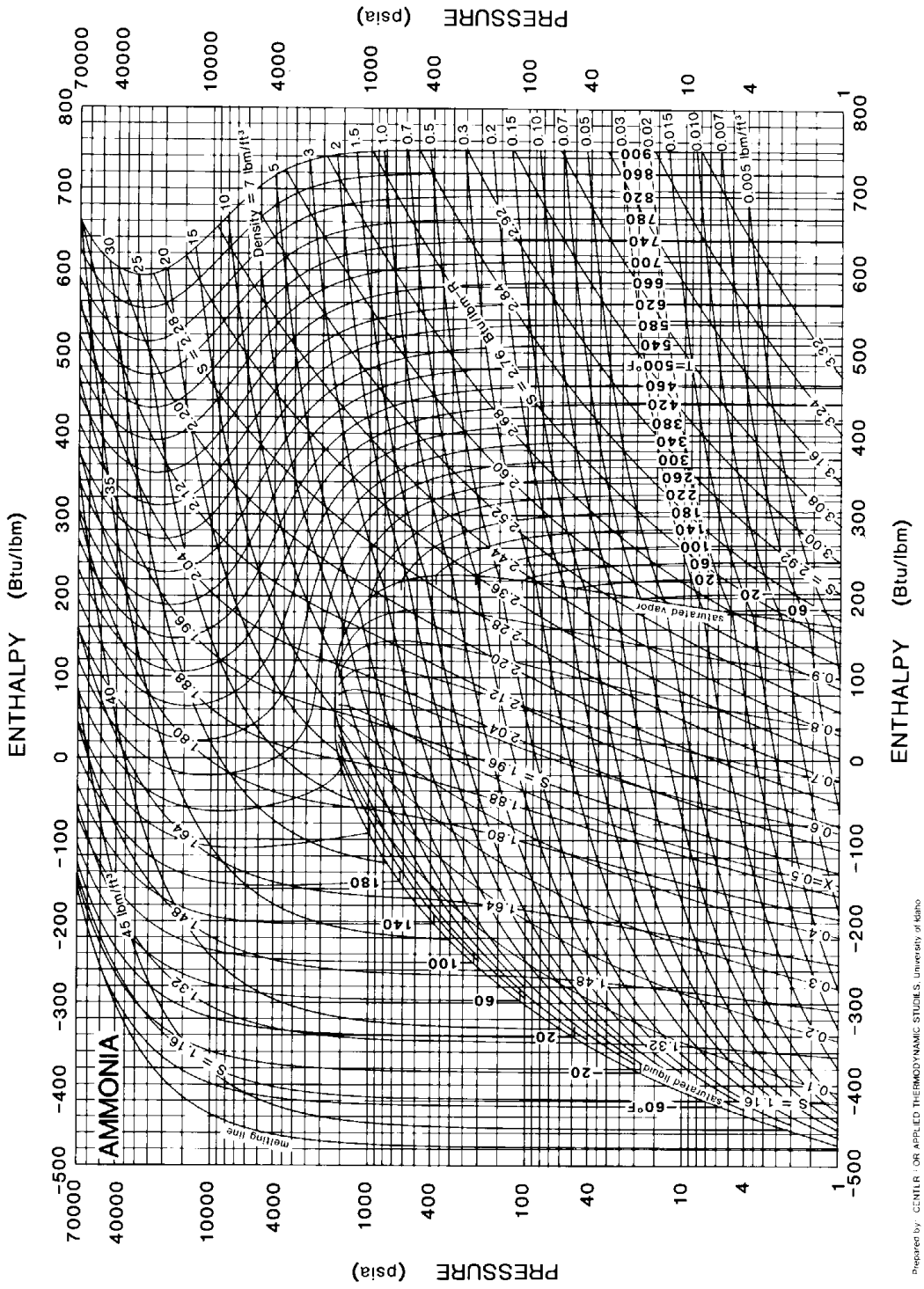

Fig. 21 Pressure–Enthalpy Diagram for Refrigerant 717 (Ammonia)
Note: The reference states for enthalpy and entropy differ from those in the table.

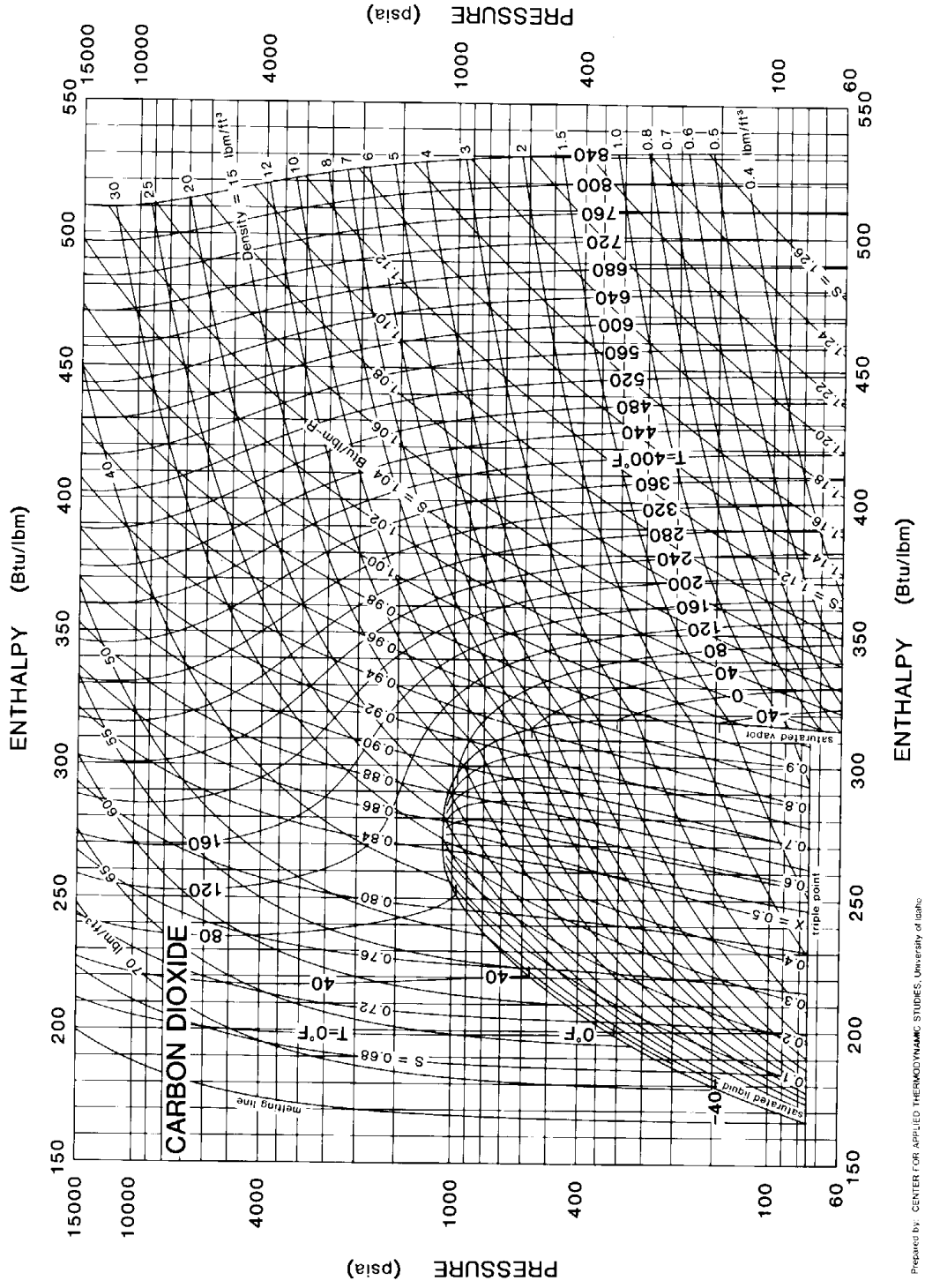

Fig. 23 Pressure–Enthalpy Diagram for Refrigerant 744 (Carbon Dioxide)
Note: The reference states for enthalpy and entropy differ from those in the table.