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UNDERSTANDING REFRIGERANT TABLES

INTRODUCTION

A *Mollier diagram* is a graphical representation of the properties of a refrigerant, generally in terms of enthalpy and entropy. A familiarity with these diagrams will make this chapter easier. An understanding of the pressure-temperature relationship of refrigerants as they pass through the refrigeration compression cycle also will help you as you study this chapter on refrigerant tables.

Part of this chapter deals with a refrigerant (R-22) that will soon be phased out of production. However, as a service technician you may continue to come across it for years to come. Be prepared—remember that good troubleshooting requires a thorough understanding of the basics.

Table 1, on pages 4 and 5, shows the properties of R-22 at saturation. It will be used in the examples that follow. R-22 will soon be phased out, so you will not see it as much as you do other refrigerants in the future. However, all other refrigerant tables work essentially the same way as the R-22 example.

This chapter will review the older refrigerant (R-22) first, and then refer to one of the newer replacement refrigerants (R-410A). As you study their characteristics, known problems, limitations, etc., remember that this is a field of rapid change. It is *your* responsibility to keep current. This can be done only by constant review of the latest technical material.

USING TABLES TO DETERMINE PROPERTIES AT SATURATION

Refrigerant tables have many practical uses for the competent service technician. Like gauges, test instruments, and thermometers, they are valuable tools. Some of the things that you can determine by using refrigerant tables include:

- setting of controls
- checking temperature according to pressure
- computing correct head pressure for a specific set of operating conditions
- setting expansion valve superheat
- noting pressure drop
- evaluating refrigerant capacities of cylinders and receivers
- estimating compressor capacity
- estimating normal discharge temperature, etc.

The table at the end of this chapter shows the properties at saturation of R-410A. (Trade names are not used.) The data contained in these tables are taken from the best available sources, and are as accurate as possible. Note that temperature steps are in small increments. Thus, you can use them with a close degree of accuracy. The values listed in Table 1 for R-22 are used for the example calculations. The figures are arranged in columns, each with an appropriate heading. Each column is discussed in the following sections.

COLUMN 1: TEMPERATURE

The saturation temperatures start with the lowest temperature at which the subject refrigerant might be used. They continue in small increments through the ranges in which accuracy is most essential. They go up to the highest temperature for which properties at saturation are known and available.

All saturation properties are based on saturation temperatures. Therefore, the temperatures that you see listed in Column 1 are the reference points in most uses of refrigerant tables. *Saturated* refers to the condition of a liquid at its boiling temperature, and of a vapor at its condensing temperature.

COLUMNS 2 AND 3: PRESSURE

Column 2 lists the absolute pressures (psia) and Column 3 lists the gauge pressures (psig) of the saturated refrigerant at the corresponding Fahrenheit temperature. An asterisk (*) indicates inches of mercury (in. Hg) vacuum. This unit of measurement is used up to atmospheric pressure, or zero pounds of gauge pressure. Pressures above 0 psig are shown in psig.

To convert gauge pressures *above* 0 psig to absolute pressures (psia), simply add 14.7. To convert pressures *below* 0 psig (that is, those values preceded by an asterisk) to absolute pressures, you must subtract the (in. Hg) vacuum from 29.921. Then multiply the result by 0.491, or roughly 50%. The vacuum and pressure values in Columns 2 and 3 are those at saturation that correspond to the temperatures in Column 1.

For example, assume that the temperature of boiling R-22 in an evaporator is –50°F. Then the evaporator pressure is 6.154 in. Hg vacuum, or 11.674 psia (29.921 – 6.154 = 23.767 $\times$ 0.491 = 11.67). This is also the *low-side pressure*, assuming there is no pressure drop. If there is a 2-psig pressure drop (about 4.5 in. Hg), the *suction pressure* will be about 14 in. Hg, or 7.0 psia.

You can also use Column 3 to find the *saturation temperature* that corresponds to a gauge reading. For example, a compound gauge at the evaporator may read 68.5 psig. Then the temperature of the boiling refrigerant is 40°F. This is usually considered the evaporator temperature. *Caution:* If the gauge is located at the compressor, make an allowance for pressure drop in the suction line.

You can also check *condenser* pressure-temperature values by using Column 3. A discharge pressure of 226 psig with R-22, for example, means that the normal condensing temperature is 110°F. Note, however, that the condensing temperature should *not* be confused with:

- entering and leaving air temperatures of an air-cooled condenser
- inlet and outlet water temperatures of a water-cooled condenser
- the temperature of the liquid refrigerant leaving the condenser.

Saturation temperatures and corresponding pressures are always the same for a particular refrigerant. Thus, data in Columns 1 and 3 can be used to set low-pressure controls, high-pressure cut-outs, thermostats, and similar control devices. You can use a thermometer to determine pressure. You can use a pressure gauge to determine temperature. But remember—*this only works if the refrigerant is at saturation*. It will *not* hold true if the liquid is subcooled below the saturation temperature shown in the appropriate table. The same thing applies to a vapor superheated above the saturation temperature shown in the same table.

COLUMN 4: LIQUID DENSITY

Liquids vary in their density (weight per cubic foot). Most refrigerants in liquid form have higher densities than water (that is, they have specific gravities above 1.0). The densities of refrigerants also vary with their temperatures. As a rule, liquids expand as they become warmer. Thus, liquid densities at higher temperatures are less than at lower temperatures.

If you know the internal volume of a refrigerant container, such as a cylinder or receiver, you can easily find how much liquid refrigerant it will hold. Simply multiply the internal volume of the container in cubic feet (ft^3) by the density of the liquid refrigerant at a selected temperature. The answer is the number of pounds of liquid that the given container will hold (completely liquid-full) at that temperature.

There is another way to find the same answer. Instead of multiplying by the density, divide by the specific volume at the same temperature. For example, say that a receiver has an internal volume of 1.7 ft^3. Multiply 1.7 by 75.469 (the density of R-22 at 70°F). The answer is a total liquid capacity of 128.30 lb of R-22 at 70°F. You get the same answer if you divide by the specific volume of liquid For R-22 at 70°F, the specific volume is 0.01325 ft^3/lb. And 1.7 divided by 0.01325 equals 128.30 lb.

Caution: Liquid-full components of a refrigeration system will build up hydrostatic pressure with an increase in temperature. They can burst or explode, the same as a liquid-full cylinder.

COLUMN 5: VAPOR VOLUME

The values listed in Column 4 are "specific" volumes. They are the *reciprocals* of the density values. A good example is the liquid density of R-22 at 40°F. Column 4 shows it to be 79.255 lb/ft^3. Divide 1 by 79.255 to get the reciprocal, 0.0126175. This is the *specific volume* of liquid R-22 at 40°F. The same is true of saturated vapor at 40°F. The density is 1.52 lb/ft^3. The specific volume is 0.6575 ft^3/lb (1 ÷ 0.6575 = 1.52).

Thus, the volume value in Column 5 is the reciprocal of the density value of the saturated vapor. But if volume and density are reciprocals of each other, why show both in the tables? To find the amount of liquid in a space of known volume, you use the density values. If you know the amount of refrigerant and you need to find the size of the container, you use the specific volume values. In both cases, you must apply mathematics to find the answer.

Vapor density values have another practical use. Assume that a 125-lb cylinder of R-22 (at 70°F) is waiting to be charged into a system. The cylinder has an internal volume of 1.967 ft^3. Charging is done into the high side in liquid form. After the liquid is charged into the high side, the cylinder is secured with its cap on, ready for return. Actually, it still contains 1.967 ft^3 of saturated vapor at 70°F. The volume of saturated vapor at 70°F is 0.4037 ft^3/lb. This means that the cylinder still holds 4.87 lb (1.967 divided by 0.4037) of R-22. If you return the cylinder without recovering it, 4.87 lb of R-22 is lost. *Note:* EPA rules require the recovery of the vapor from disposable cylinders prior to disposal.

COLUMNS 6, 7, AND 8: ENTHALPY

Enthalpy means the same thing as "heat content." Both terms refer to heat content in Btu per pound (Btu/lb). The term *enthalpy* is now more common than "heat content."

Columns 6 and 8 show the enthalpy values for liquid and vapor at Column 1 temperatures above –40°F. Vapor heat content values, however, include the *latent* heat value shown in Column 7. This will be discussed shortly. The heat content of liquid is *sensible* heat. In low-temperature areas, it amounts to about 0.25 Btu per pound per degree Fahrenheit (Btu/lb/°F) for R-22. It gradually increases until at liquid-line temperatures it is about 0.31 Btu/lb/°F.

The heat content shown in Column 6 is the amount of heat (in Btu) in a pound of saturated liquid. Values are based on the assumption that the saturated liquid at –40°F has no sensible heat, which is not completely true, of course. Even liquid at –100°F still has some heat in it. To be completely accurate, these values would have to be based on absolute zero. This, however, is not really necessary. The purpose of the table is simply to find out how much heat is required to warm a pound of liquid refrigerant from one temperature to a higher temperature.

For example, Column 6 shows the heat content of saturated liquid at 80°F is 33.109 Btu/lb. At 20°F, it is 15.837 Btu/lb. Therefore, to cool 1 lb of R-22 saturated liquid from 80°F to 20°F requires removing 17.272 Btu/lb (33.109 – 15.837). This difference is about the same whether heat content is based on 0°F, 40°F, –100°F, or even absolute zero.

In Table 1, the values in Column 6 for saturated liquids below –40°F are negative (note the minus signs). This does not mean that saturated liquid R-22 at –60°F has 4.987 Btu less than no heat at all. That is impossible. Rather, the minus sign means that at –60°F, R-22 has 4.987 Btu/lb less heat content than it does at –40°F.

Look at Table 1 again. You can see from Column 6 that warming 1 lb of R-22 from –60°F to –55°F requires 1.233 Btu (4.987 – 3.754 = 1.233). Divide 1.233 by 5 (which is the temperature difference in degrees Fahrenheit), and you find that the heat content is about 0.2466 Btu/lb/°F in the –60°F range (1.233 ÷ 5 = 0.2466).

Column 7 shows the latent heat of vaporization of the refrigerant at the saturation temperature in Column 1. Note that the latent heat decreases as saturation temperature increases.

1	2	3	4	5	6	7	8	9	10
Temp (°F)	Pressure		Density (lb/ft^3)	Volume (ft^3/lb)	Enthalpy** (Btu/lb)			Entropy** (Btu/lb/°R)	
	(psia)	(psig)	Liquid	Vapor	Liquid	Latent	Vapor	Liquid	Vapor
–100	2.398	*25.038	93.770	18.4330	–14.564	107.935	93.371	–0.0373	0.2627
–90	3.422	*22.952	92.843	13.2350	–12.216	106.759	94.544	–0.0309	0.2578
–80	4.782	*20.184	91.905	9.6949	–9.838	105.548	95.710	–0.0245	0.2534
–70	6.552	*16.580	90.952	7.2318	–7.429	104.297	96.868	–0.0183	0.2493
-60	8.818	*11.967	89.986	5.4844	–4.987	103.001	98.014	–0.0121	0.2455
–55	10.166	*9.223	89.497	4.8036	–3.754	102.335	98.581	–0.0090	0.2437
–50	11.674	*6.154	89.004	4.2224	–2.511	101.656	99.144	–0.0060	0.2420
–45	13.354	*2.732	88.507	3.7243	–1.260	100.963	99.703	–0.0030	0.2404
–40	15.222	0.526	88.006	3.2957	0.000	100.257	100.257	0.0000	0.2388
–35	17.290	2.594	87.501	2.9256	1.269	99.536	100.805	0.0030	0.2373
–30	19.573	4.877	86.991	2.6049	2.547	98.801	101.348	0.0059	0.2359
–28	20.549	5.853	86.785	2.4887	3.061	98.503	101.564	0.0071	0.2353
–26	21.564	6.868	86.579	2.3787	3.576	98.202	101.778	0.0083	0.2347
–24	22.617	7.921	86.372	2.2746	4.093	97.899	101.992	0.0095	0.2342
–22	23.711	9.015	86.165	2.1760	4.611	97.593	102.204	0.0107	0.2336
–20	24.845	10.149	85.956	2.0826	5.131	97.285	102.415	0.0118	0.2331
–18	26.020	11.324	85.747	1.9940	5.652	96.974	102.626	0.0130	0.2326
–16	27.239	12.543	85.537	1.9099	6.175	96.660	102.835	0.0142	0.2321
–14	28.501	13.805	85.326	1.8302	6.699	96.344	103.043	0.0154	0.2315
–12	29.809	15.113	85.114	1.7544	7.224	96.025	103.250	0.0165	0.2310
–10	31.162	16.466	84.901	1.6825	7.751	95.704	103.455	0.0177	0.2305
–8	32.563	17.867	84.688	1.6141	8.280	95.380	103.660	0.0189	0.2300
–6	34.011	19.315	84.473	1.5491	8.810	95.053	103.863	0.0200	0.2296
–4	35.509	20.813	84.258	1.4872	9.341	94.724	104.065	0.0212	0.2291
–2	37.057	22.361	84.042	1.4283	9.874	94.391	104.266	0.0224	0.2286
0	38.657	23.961	83.825	1.3723	10.409	94.056	104.465	0.0235	0.2281
2	40.309	25.613	83.606	1.3189	10.945	93.718	104.663	0.0247	0.2277
4	42.014	27.318	83.387	1.2680	11.483	93.378	104.860	0.0258	0.2272
6	43.775	29.079	83.167	1.2195	12.022	93.034	105.056	0.0270	0.2268
8	45.591	30.895	82.946	1.1732	12.562	92.688	105.250	0.0281	0.2263
10	47.464	32.768	82.724	1.1290	13.104	92.338	105.442	0.0293	0.2259
12	49.396	34.700	82.501	1.0869	13.648	91.986	105.633	0.0304	0.2254
14	51.387	36.691	82.276	1.0466	14.193	91.630	105.823	0.0316	0.2250
16	53.438	38.742	82.051	1.0082	14.739	91.272	106.011	0.0327	0.2246
18	55.551	40.855	81.825	0.9714	15.288	90.910	106.198	0.0338	0.2242
20	57.727	43.031	81.597	0.9363	15.837	90.545	106.383	0.0350	0.2237
22	59.967	45.271	81.368	0.9027	16.389	90.178	106.566	0.0361	0.2233
24	62.272	47.576	81.138	0.8705	16.942	89.807	106.748	0.0373	0.2229
26	64.644	49.948	80.907	0.8397	17.496	89.433	106.928	0.0384	0.2225
28	67.083	52.387	80.675	0.8103	18.052	89.055	107.107	0.0395	0.2221
30	69.591	54.895	80.441	0.7820	18.609	88.674	107.284	0.0407	0.2217
32	72.169	57.473	80.207	0.7550	19.169	88.290	107.459	0.0418	0.2213
34	74.818	60.122	79.971	0.7291	19.729	87.903	107.632	0.0429	0.2210
36	77.540	62.844	79.733	0.7042	20.292	87.512	107.804	0.0440	0.2206
38	80.336	65.640	79.495	0.6804	20.856	87.118	107.974	0.0452	0.2202
40	83.206	68.510	79.255	0.6575	21.422	86.720	108.142	0.0463	0.2198
42	86.153	71.457	79.013	0.6355	21.989	86.319	108.308	0.0474	0.2194
44	89.177	74.481	78.770	0.6144	22.558	85.914	108.472	0.0485	0.2191
46	92.280	77.584	78.526	0.5942	23.129	85.506	108.634	0.0496	0.2187
48	95.463	80.767	78.280	0.5747	23.701	85.094	108.795	0.0507	0.2183

*Inches of mercury vacuum

**Based on 0 for the saturated liquid at –40°F

Table 1. Properties of R-22 at saturation

Temp (°F)	Pressure (psia)	Pressure (psig)	Density (lb/ft^3) Liquid	Volume (ft^3/lb) Vapor	Enthalpy** (Btu/lb) Liquid	Enthalpy** (Btu/lb) Latent	Enthalpy** (Btu/lb) Vapor	Entropy** (Btu/lb/°R) Liquid	Entropy** (Btu/lb/°R) Vapor
50	98.72	84.03	78.033	0.5560	24.275	84.678	108.953	0.0519	0.2180
52	102.07	87.38	77.784	0.5380	24.851	84.258	109.109	0.0530	0.2176
54	105.50	90.81	77.534	0.5207	25.429	83.834	109.263	0.0541	0.2173
56	109.02	94.32	77.282	0.5041	26.008	83.407	109.415	0.0552	0.2169
58	112.62	97.93	77.028	0.4881	26.589	82.975	109.564	0.0563	0.2166
60	116.31	101.62	76.773	0.4727	27.172	82.540	109.712	0.0574	0.2162
62	120.09	105.39	76.515	0.4578	27.757	82.100	109.857	0.0585	0.2159
64	123.96	109.26	76.257	0.4435	28.344	81.656	110.000	0.0596	0.2155
66	127.92	113.22	75.996	0.4298	28.932	81.208	110.140	0.0607	0.2152
68	131.97	117.28	75.733	0.4165	29.523	80.755	110.278	0.0618	0.2149
70	136.12	121.43	75.469	0.4037	30.116	80.298	110.414	0.0629	0.2145
72	140.37	125.67	75.202	0.3913	30.710	79.836	110.547	0.0640	0.2142
74	144.71	130.01	74.934	0.3794	31.307	79.370	110.677	0.0651	0.2138
76	149.15	134.45	74.664	0.3680	31.906	78.899	110.805	0.0662	0.2135
78	153.69	138.99	74.391	0.3569	32.506	78.423	110.930	0.0673	0.2132
80	158.33	143.63	74.116	0.3462	33.109	77.943	111.052	0.0684	0.2128
82	163.07	148.37	73.839	0.3358	33.714	77.457	111.171	0.0695	0.2125
84	167.92	153.22	73.560	0.3258	34.322	76.966	111.288	0.0706	0.2122
86	172.87	158.17	73.278	0.3162	34.931	76.470	111.401	0.0717	0.2118
88	177.93	163.23	72.994	0.3069	35.543	75.968	111.512	0.0728	0.2115
90	183.09	168.40	72.708	0.2978	36.158	75.461	111.619	0.0739	0.2112
92	188.37	173.67	72.419	0.2891	36.774	74.949	111.723	0.0750	0.2108
94	193.76	179.06	72.127	0.2807	37.394	74.430	111.824	0.0761	0.2105
96	199.26	184.56	71.833	0.2725	38.016	73.905	111.921	0.0772	0.2102
98	204.87	190.18	71.536	0.2646	38.640	73.375	112.015	0.0783	0.2098
100	210.60	195.91	71.236	0.2570	39.267	72.838	112.105	0.0794	0.2095
102	216.45	201.76	70.933	0.2496	39.897	72.294	112.192	0.0805	0.2092
104	222.42	207.72	70.626	0.2424	40.530	71.744	112.274	0.0816	0.2088
106	228.50	213.81	70.317	0.2354	41.166	71.187	112.353	0.0827	0.2085
108	234.71	220.02	70.005	0.2287	41.804	70.623	112.427	0.0838	0.2082
110	241.04	226.35	69.689	0.2222	42.446	70.052	112.498	0.0849	0.2078
112	247.50	232.80	69.369	0.2158	43.091	69.473	112.564	0.0860	0.2075
114	254.08	239.38	69.046	0.2097	43.739	68.886	112.626	0.0871	0.2071
116	260.79	246.10	68.719	0.2037	44.391	68.291	112.682	0.0882	0.2068
118	267.63	252.94	68.388	0.1980	45.046	67.688	112.735	0.0893	0.2064
120	274.60	259.91	68.054	0.1923	45.705	67.077	112.782	0.0904	0.2061
122	281.71	267.01	67.714	0.1869	46.368	66.456	112.824	0.0915	0.2057
124	288.95	274.25	67.371	0.1816	47.034	65.826	112.860	0.0926	0.2054
126	296.33	281.63	67.023	0.1764	47.705	65.186	112.891	0.0937	0.2050
128	303.84	289.14	66.670	0.1714	48.380	64.537	112.917	0.0948	0.2046
130	311.50	296.80	66.312	0.1666	49.059	63.877	112.936	0.0959	0.2043
132	319.29	304.60	65.949	0.1618	49.743	63.206	112.949	0.0971	0.2039
135	331.26	316.56	65.394	0.1550	50.778	62.178	112.956	0.0987	0.2033
140	351.94	337.25	64.440	0.1441	52.528	60.403	112.931	0.1016	0.2023
145	373.58	358.88	63.445	0.1340	54.315	58.543	112.858	0.1044	0.2013
150	396.19	381.50	62.402	0.1244	56.143	56.585	112.728	0.1073	0.2002
160	444.53	429.83	60.145	0.1070	59.948	52.316	112.263	0.1133	0.1977
170	497.26	482.56	57.581	0.0912	64.019	47.419	111.438	0.1195	0.1949
180	554.78	540.09	54.549	0.0767	68.498	41.570	110.068	0.1263	0.1913
190	617.59	602.89	50.677	0.0628	73.711	34.023	107.734	0.1340	0.1864
200	686.36	671.66	44.571	0.0474	80.862	21.990	102.853	0.1446	0.1779

Table 1. Properties of R-22 at saturation (continued)

The values in Column 8, subtitled "Vapor," are always the sum of the heat content of the saturated liquid refrigerant and the latent heat of vaporization. Before a liquid boils, it possesses *sensible* heat, as shown in Column 6. When the liquid boils, it acquires *latent* heat in addition to the sensible heat. The total heat of the resulting saturated vapor must equal the heat of the liquid plus the acquired latent heat. Some tables refer to the heat content of the vapor as "total" heat. This condition is more clearly defined in the following example.

Assume that liquid R-22 is boiling (evaporating) in an evaporator at 40°F. The saturated vapor produced has a heat content (from Column 8) of 108.142 Btu/lb. This consists of 21.422 Btu/lb from Column 6 (sensible heat of the liquid), and 86.720 Btu/lb from Column 7 (latent heat of vaporization).

When Column 6 values are added to Column 7 values, the result shown in Column 8 represents the total heat content of the saturated vapor in the evaporator. This is before it is superheated or warmed to a temperature above the evaporator temperature.

Note that if the evaporator temperature is below –40°F, the values in Column 6 are negative. They must be *subtracted* from the values in Column 7 to find the heat of the vapor. For example, the heat of vapor for R-22 at –60°F is 98.014 Btu/lb. You calculate this by subtracting 4.987 Btu/lb liquid heat from 103.001 Btu/lb latent heat.

NET COOLING EFFECT

The *net cooling effect* is another value that you can find by using refrigerant tables. For example, assume that an R-22 system with a 40°F evaporator has liquid entering the metering device at 80°F. The liquid must be cooled 40°F before it can start to boil in the evaporator at 40°F.

The heat of the R-22 liquid at 80°F is 33.109 Btu/lb, as shown in Table 1. At 40°F, it is 21.422 Btu/lb. Therefore, 11.687 Btu/lb (33.109 – 21.422) must be removed in order to cool the 80°F liquid to 40°F. It then boils in the evaporator and absorbs its latent heat of 86.720 Btu/lb (that is, it cools at the rate of 86.720 Btu/lb). However, the *net cooling effect* (actual useful cooling) is somewhat less than 86.720 Btu/lb. This is because 11.687 Btu/lb was used in cooling the liquid from 80°F to 40°F, which leaves only 75.033 Btu/lb (86.720 – 11.687) as the net cooling effect. In this system, each pound of R-22 would produce 75.033 Btu/lb of useful cooling instead of the full latent heat of vaporization of 86.720 Btu/lb.

There is a faster method of finding the net cooling effect. Simply subtract the heat of the liquid at the inlet to the metering device from the heat of the vapor at its evaporator boiling temperature. The result is the same as with the more informative equation.

Now, assume that the liquid entering the evaporator is subcooled. You can use the actual temperature of the liquid to find its heat content, instead of the saturation temperature corresponding to head pressure. In the preceding example, assume that the liquid is subcooled from 80°F to 60°F in the liquid line. Now you can use 27.172 Btu/lb instead of 33.109 Btu/lb as the heat of liquid. The result is a net cooling effect of 81.070 Btu/lb (75.133 + 5.937). This is a gain of almost 8%, just by subcooling the liquid from 80°F to 60°F. This can be done by means of a liquid subcooler.

You will find that there are many other uses for the heat content values in Columns 6, 7, and 8.

COLUMNS 9 AND 10: ENTROPY

Entropy is a ratio that describes the relative energy in a refrigerant. It is found by dividing the amount of heat in the liquid or vapor refrigerant by its temperature in degrees absolute. Entropy is not of particular interest or importance to the service technician. It will not be discussed further here. Note, however, that entropy values are useful with a Mollier diagram to estimate compressor discharge temperature.

CONCLUSION

Table 1, used as an example in this chapter, is for R-22. R-22 will soon be phased out and will no longer be manufactured in the U.S. However, thousands of systems using R-22 are still operating. They will continue to do so as long as R-22 is available, or until they are retrofitted for a replacement refrigerant. With a thorough understanding of the use of refrigerant tables and the examples given in this chapter, you can use such tables for any refrigerant, including the newer replacement refrigerants.

The table included on pages 8 and 9 (for R-410A) is very similar in format to the table for R-22 that you have studied as an example. There may be slight variations in some refrigerant tables, but for the most part you should be able to find the same information and make the same kinds of calculations. You also may find the conversion methods on page 10 helpful. If you need tables for refrigerants that are not included in this chapter, you can get them from any refrigerant manufacturer through your refrigerant wholesaler.

Temp (°F)	Pressure (psia)	Pressure (psig)	Density (lb/ft^3) Liquid	Volume (ft^3/lb) Vapor	Enthalpy** (Btu/lb) Liquid	Enthalpy** (Btu/lb) Latent	Enthalpy** (Btu/lb) Vapor	Entropy** (Btu/lb/°R) Liquid	Entropy** (Btu/lb/°R) Vapor
–20.00	41.58	26.88	79.79	1.4354	4.99	105.57	110.56	0.0116	0.2517
–10.00	51.53	36.83	78.60	1.1693	7.64	104.06	111.70	0.0175	0.2489
0.00	63.27	48.57	77.38	0.9594	10.41	102.37	112.78	0.0235	0.2462
10.00	77.03	62.33	76.12	0.7925	13.29	100.52	113.81	0.0296	0.2437
12.00	80.05	65.35	75.87	0.7633	13.88	100.13	114.01	0.0309	0.2432
14.00	83.15	68.45	75.61	0.7354	14.47	99.74	114.21	0.0321	0.2427
16.00	86.35	71.65	75.35	0.7087	15.08	99.32	114.40	0.0334	0.2422
18.00	89.64	74.94	75.09	0.6830	15.68	98.91	114.59	0.0346	0.2417
20.00	93.03	78.33	74.83	0.6585	16.29	98.49	114.78	0.0359	0.2412
22.00	96.52	81.82	74.57	0.6350	16.91	98.05	114.96	0.0372	0.2407
24.00	100.11	85.41	74.30	0.6124	17.53	97.61	115.14	0.0384	0.2402
26.00	103.81	89.11	74.03	0.5908	18.16	97.16	115.32	0.0397	0.2398
28.00	107.60	92.90	73.76	0.5700	18.79	96.71	115.50	0.0410	0.2393
30.00	111.51	96.81	73.49	0.5501	19.43	96.24	115.67	0.0423	0.2388
32.00	115.52	100.82	73.22	0.5310	20.08	95.77	115.85	0.0436	0.2384
34.00	119.65	104.95	72.94	0.5126	20.73	95.28	116.01	0.0449	0.2379
36.00	123.89	109.19	72.67	0.4949	21.38	94.80	116.18	0.0462	0.2374
38.00	128.24	113.54	72.39	0.4780	22.05	94.29	116.34	0.0475	0.2370
40.00	132.71	118.01	72.11	0.4617	22.71	93.79	116.50	0.0488	0.2365
42.00	137.30	122.60	71.82	0.4460	23.39	93.26	116.65	0.0501	0.2360
44.00	142.01	127.31	71.54	0.4310	24.07	92.73	116.80	0.0515	0.2356
46.00	146.85	132.15	71.25	0.4165	24.76	92.19	116.95	0.0528	0.2351
48.00	151.81	137.11	70.96	0.4025	25.45	91.64	117.09	0.0541	0.2347
50.00	156.89	142.19	70.66	0.3891	26.15	91.08	117.23	0.0555	0.2342
52.00	162.11	147.41	70.37	0.3762	26.85	90.52	117.37	0.0568	0.2337
54.00	167.46	152.76	70.07	0.3637	27.57	89.93	117.50	0.0582	0.2333
56.00	172.94	158.24	69.76	0.3517	28.28	89.35	117.63	0.0596	0.2328
58.00	178.56	163.86	69.46	0.3402	29.01	88.75	117.76	0.0609	0.2324
60.00	184.32	169.62	69.15	0.3290	29.74	88.14	117.88	0.0623	0.2319
62.00	190.21	175.51	68.84	0.3183	30.48	87.52	118.00	0.0637	0.2315
64.00	196.25	181.55	68.52	0.3080	31.23	86.88	118.11	0.0651	0.2310
66.00	202.44	187.74	68.20	0.2980	31.99	86.23	118.22	0.0665	0.2306
68.00	208.77	194.07	67.88	0.2883	32.75	85.57	118.32	0.0679	0.2301
70.00	215.25	200.55	67.56	0.2790	33.52	84.90	118.42	0.0694	0.2297
72.00	221.88	207.18	67.23	0.2701	34.30	84.22	118.52	0.0708	0.2292
74.00	228.67	213.97	66.89	0.2614	35.09	83.52	118.61	0.0722	0.2287
76.00	235.61	220.91	66.56	0.2530	35.88	82.81	118.69	0.0737	0.2283
78.00	242.71	228.01	66.21	0.2449	36.68	82.09	118.77	0.0752	0.2278
80.00	249.97	235.27	65.87	0.2371	37.50	81.35	118.85	0.0766	0.2274
82.00	257.39	242.69	65.51	0.2296	38.32	80.60	118.92	0.0781	0.2269
84.00	264.98	250.28	65.16	0.2222	39.15	79.83	118.98	0.0796	0.2264
86.00	272.74	258.04	64.80	0.2152	39.99	70.05	119.04	0.0811	0.2260
88.00	280.66	265.96	64.43	0.2083	40.84	78.26	119.10	0.0826	0.2255
90.00	288.76	274.06	64.06	0.2017	41.70	77.44	119.14	0.0841	0.2250
92.00	297.03	282.33	63.68	0.1953	42.57	76.62	119.19	0.0857	0.2246
94.00	305.47	290.77	63.29	0.1891	43.45	75.77	119.22	0.0872	0.2241
96.00	314.10	299.40	62.90	0.1831	44.34	74.91	119.25	0.0888	0.2236
98.00	322.90	308.20	62.50	0.1773	45.24	74.03	119.27	0.0903	0.2231
100.00	331.89	317.19	62.10	0.1716	46.15	73.14	119.29	0.0919	0.2226
102.00	341.06	326.36	61.69	0.1662	47.08	72.21	119.29	0.0935	0.2221

**Based on 0 for the saturated liquid at –40°F

Table 2. Properties of R-410A at saturation

Temp (°F)	Pressure (psia)	Pressure (psig)	Density (lb/ft³) Liquid	Volume (ft³/lb) Vapor	Enthalpy** (Btu/lb) Liquid	Enthalpy** (Btu/lb) Latent	Enthalpy** (Btu/lb) Vapor	Entropy** (Btu/lb/°R) Liquid	Entropy** (Btu/lb/°R) Vapor
104.00	350.43	335.73	61.27	0.1608	48.02	71.28	119.30	0.0952	0.2216
106.00	359.98	345.28	60.84	0.1557	48.98	70.31	119.29	0.0968	0.2211
108.00	369.72	355.02	60.40	0.1507	49.94	69.33	119.27	0.0985	0.2206
110.00	379.66	364.96	59.59	0.1458	50.93	68.32	119.25	0.1001	0.2201
112.00	389.79	375.09	59.49	0.1411	51.92	67.30	119.22	0.1018	0.2195
114.00	400.13	385.43	59.02	0.1365	52.94	66.24	119.18	0.1035	0.2190
116.00	410.66	395.96	58.54	0.1321	53.97	65.16	119.13	0.1053	0.2185
118.00	421.40	406.70	58.05	0.1277	55.02	64.05	119.07	0.1070	0.2179
120.00	432.35	417.65	57.54	0.1235	56.09	62.91	119.00	0.1088	0.2174
122.00	443.50	428.80	57.02	0.1194	57.18	61.74	118.92	0.1106	0.2168
124.00	454.87	440.17	56.49	0.1154	58.30	60.52	118.82	0.1125	0.2162
126.00	466.44	451.74	55.93	0.1115	59.44	59.28	118.72	0.1144	0.2156
128.00	478.24	463.54	55.36	0.1077	60.60	58.00	118.60	0.1163	0.2150
130.00	490.25	475.55	54.77	0.1040	61.80	56.67	118.47	0.1183	0.2144
132.00	502.48	487.78	54.16	0.1003	63.02	55.30	118.32	0.1203	0.2137
134.00	514.93	500.23	53.52	0.0967	64.29	53.87	118.16	0.1223	0.2131
136.00	527.61	512.91	52.85	0.0932	65.59	52.38	117.97	0.1244	0.2124
138.00	540.51	525.81	52.16	0.0898	66.93	50.84	117.77	0.1266	0.2117
140.00	553.64	538.94	51.43	0.0864	68.33	49.22	117.55	0.1289	0.2110
142.00	567.01	552.31	50.66	0.0831	69.78	47.52	117.30	0.1312	0.2102
144.00	580.61	565.91	49.84	0.0797	71.31	45.71	117.02	0.1337	0.2094
146.00	594.44	579.74	48.97	0.0764	72.91	43.80	116.71	0.1362	0.2085
148.00	608.52	593.82	48.03	0.0731	74.61	41.76	116.37	0.1389	0.2077
150.00	622.83	608.13	47.02	0.0698	76.43	39.54	115.97	0.1418	0.2067
152.00	637.39	622.69	45.91	0.0665	78.40	37.12	115.52	0.1450	0.2056
154.00	652.19	637.49	44.66	0.0630	80.58	34.41	114.99	0.1484	0.2045
156.00	667.24	652.54	43.23	0.0593	83.06	31.29	114.35	0.1524	0.2032
158.00	682.54	667.84	41.51	0.0553	86.01	27.53	113.54	0.1570	0.2016
160.00	698.09	683.39	39.28	0.0505	89.87	22.84	112.41	0.1632	0.1995

Table 2. Properties of R-410A at saturation (continued)

To convert measurements

From	To	Multiply by
Cubic feet	Cubic inches	1,728.0
Cubic inches	Cubic feet	0.00058
Cubic feet	Gallons	7.480
Gallons	Cubic feet	0.1337
Liters	Gallons	0.2642
Gallons	Liters	3.7854

To convert pressure (at 32°F)

From	To	Multiply by
Inches of water	Pounds per square inch	0.03612
Pounds per square inch	Inches of water	27.686
Inches of mercury	Pounds per square inch	0.4912
Pounds per square inch	Inches of mercury	2.036

To convert energy, heat, and power

From	To	Multiply by
Horsepower	Foot-pounds per minute	33,000.0
Horsepower	Kilowatts	0.746
Kilowatts	Horsepower	1.3404
British thermal units	Foot-pounds	778.177
Foot-pounds	British thermal units	0.001285
Horsepower	Watts	745.7
British thermal units per hour	Watts	0.29288

To convert temperatures

From	To	Do this
Degrees Celsius	Degrees Fahrenheit	Multiply by 1.8 and add 32
Degrees Rankine	Degrees Fahrenheit	Subtract 459.69

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