Table 11 .... Latent Heat of Vaporization versus Boiling Point

Refrigerant No.	Refrigerant Name	Latent Heat at Boiling Point, Btu/Mol	Trouton Constant[a]	Reference
630	Methyl Amine	11,172	23.28	1
717	Ammonia	10,036	23.25	1
764	Sulfur Dioxide	10,697	22.58	1
631	Ethyl Amine	11,733	22.50	1
611	Methyl Formate	12,290	22.39	1
744A	Nitrous Oxide	7,144	21.47	1
21	Dichloromonofluoromethane	10,720	21.11	*
30	Methylene Chloride	11,781	20.92	1
22	Monochlorodifluoromethane	8,687	20.76	*
40	Methyl Chloride	9,304	20.73	1
113	Trichlorotrifluoroethane	11,828	20.49	*
500	...	8,786	20.35	1
114	Dichlorotetrafluoroethane	10,085	20.25	*
11	Trichloromonofluoromethane	10,765	20.14	*
14	Tetrafluoromethane	5,161	19.75	*
13B1	Monobromotrifluoromethane	7,606	19.62	*
12	Dichlorodifluoromethane	8,591	19.61	*
601	Isobutane	9,206	19.59	1
600	Butane	9,613	19.58	1
13	Monochlorotrifluoromethane	6,670	19.33	*
290	Propane	8,006	19.27	1
170	Ethane	6,354	19.13	1
1150	Ethylene	5,791	19.01	1

[a] Latent heat/Boiling point in Rankine degrees.
* Data for Refrigerant 11 from General Chemical Division, Allied Chemical Corp. Data on other refrigerants from E. I. duPont de Nemours & Co., Inc. Used by permission.

VELOCITY OF SOUND

Examples of the velocity of sound in the vapor phase of several fluorinated refrigerants are shown in Table 14. The velocity increases when the temperature is increased and decreases when the pressure is increased. The velocity of sound can be calculated from the following equations:

$$V_s = \sqrt{g_c \left(\frac{dP}{d\rho}\right)_S} = \sqrt{g_c \gamma \left(\frac{dP}{d\rho}\right)_T} \quad (1)$$

where

V_s = velocity of sound, feet per second.
g_c = 32.1740 (pound) (feet) per (pound) (second) (second).
P = pressure, pounds per square foot, absolute.
ρ = density, pounds per cubic foot.
$\gamma = c_p/c_v$ = ratio of specific heats.
S = entropy, Btu per (pound) (Rankine degree).
T = temperature, Rankine degrees.

The velocity of sound can be estimated from the tables of thermodynamic properties. The change in pressure with respect to a change in density ($dP/d\rho$) can be estimated either at constant entropy or at constant temperature. It is simpler to make this estimation at constant temperature but, in this case, the heat capacity ratio must also be known as shown above. The practical velocity of a gas in piping or through openings is limited by the velocity of sound in the gas.

Table 12 .... Electrical Properties of Liquid Refrigerants

Refrigerant No.	Refrigerant Name	Temperature, F	Dielectric Constant	Volume Resistivity $\times 10^{-8}$ Megohm-Centimeters[a]	Reference
11	Trichloromonofluoromethane	84 * 77	2.28 1.92	 6368 9	** 12 13
12	Dichlorodifluoromethane	84 * 77	2.13 1.74	 5390 >12	** 12 13
13	Monochlorotrifluoromethane	−22	2.3	12	13
21	Dichloromonofluoromethane	82 * 77	5.34 4.88	 0.894 3	** 12 13
22	Monochlorodifluoromethane	86 * 77	2.44 1.68	 4549 >12	** 12 13
113	Trichlorotrifluoromethane	86 * 77	2.44 1.68	 4549 >12	** 12 13
114	Dichlorotetrafluoroethane	88 * 77	2.17 1.83	 6647 > 7	** 12 13
30	Methylene Chloride	77	9.1	0.1	13
290	Propane	*	1.27	7384	12
500	...[b]	*	1.80	5575	12
717	Ammonia	69	15.5		2
744	Carbon Dioxide	32	1.59		2
744A	Nitrous Oxide	32	1.61		2
764	Sulfur Dioxide	32	15.6		2

[a] To obtain actual numerical values, multiply values in this column by 10^9.
[b] Azeotrope of Refrigerants 12 and 152a (73.8/26.2 percent by weight).
* Ambient Temperature.
** Data for Refrigerant 11 from General Chemical Division, Allied Chemical Corp. Data on other refrigerants from E. I. duPont de Nemours & Co., Inc. Used by permission.

REFRIGERANT PERFORMANCE

Tables of thermodynamic properties for the various refrigerants and methods of calculating refrigerant performance are shown in Chapters 1 and 20.

The theoretical calculated performance of a number of refrigerants for the standard cycle of 5 F evaporation and 86 F condensation is shown in Table 15. Calculated data for other conditions are given in Table 16. In both tables the calculations have been made on the basis of one ton of refrigeration. The tables can be used to compare the properties of different refrigerants, but actual operating conditions will be somewhat different from the calculated data. In most cases, it is assumed that the suction vapor is saturated. It is also assumed that the compression is adiabatic or at constant entropy. For Refrigerants 113 and 114, these assumptions would lead to some liquid in the discharge vapor. In these cases, it is assumed that the discharge vapor is saturated and the suction vapor is slightly superheated. In Section F of Table 16, it is assumed that the temperature of the suction gas is 65 F. Comparison with Section E illustrates the effect of suction gas superheating on the refrigerant properties.

The comparisons shown in Tables 17 and 18 are based on constant compressor displacement. They illustrate the effect of different evaporating and condensing temperatures on theoretical capacity and horsepower of compression.

Table 13 .... Electrical Properties of Refrigerant Vapors

Refrigerant No.	Refrigerant Name	Pressure, Atm.	Temperature, F	Dielectric Constant	Relative Dielectric Strength (Nitrogen = 1)	Volume Resistivity, Megohm-Centimeters	Reference
11	Trichloromonofluoromethane	0.5 * 1.0	79 ** 73	1.0019 1.009	 3.1	7435×10³	14 12 15
12	Dichlorodifluoromethane	0.5 * 1.0	84 ** 73	1.0016 1.012	452† 2.4	7277×10³	14 12 15
13	Monochlorotrifluoromethane	0.5 1.0	84 73	1.0013	1.4		14 15
14	Tetrafluoromethane	0.5 1.0	76 73	1.0006	1.0		14 15
21	Dichloromonofluoromethane	0.5 * 1.0	86 ** 73	1.0035 1.021	 1.3	3658×10³	14 12 15
22	Monochlorodifluoromethane	0.5 * 1.0	78 ** 73	1.0035 1.004	460† 1.3	2113×10⁶	14 12 15
113	Trichlorotrifluoroethane	* 0.4	** 73	1.010	440† 2.6	9418×10³	12 15
114	Dichlorotetrafluoroethane	0.5 * 1.0	80 ** 73	1.0021 1.002	295† 2.8	14,830×10³	14 12 15
30	Methylene Chloride	1.0 1.0	212 73	1.0065	1.11		2 15
40	Methyl Chloride	1.0 1.0	73 73	1.00094	1.06		2 15
170	Ethane	1.0	32	1.0015			2
290	Propane	*	**	1.009	440†	10,530×10³	12
500	...[a]	*	**	1.024	470†	7645×10³	12
717	Ammonia	1.0 *	32 **	1.0072	0.82		2 15
729	Air	1.0	32	1.00059			2
744	Carbon Dioxide	1.0 1.0	32 **	1.00099	0.88		2 15
744A	Nitrous Oxide	1.0 1.0	32 73	1.00113	1.14		2 15
764	Sulfur Dioxide	1.0 1.0	73 73	1.00075	1.9		2 15
1150	Ethylene	1.0 1.0	32 73	1.00144	1.21		2 15

* Saturation vapor pressure.
** Ambient temperature.
† Measured breakdown voltage, volts/mil.
[a] Azeotrope of Refrigerants 12 and 152a (73.8/26.2 percent by weight).

Table 14 .... Velocity of Sound in Refrigerant Vapors[a]

(Feet per Second)

Refrigerant	Pressure, psia	Temperature, F 50	100	150
11	10	*	469	490
12	10	480	503	525
22	10	583	610	635
113	10	*	390	409
114	10	391	411	430

Refrigerant	Pressure, psia	Temperature, F 50	100	150
12	100	*	457	490
22	100	*	574	607
12	200	*	*	442
22	200	*	523	572

[a] Data from E. I. duPont de Nemours & Co., Inc. Used by permission.
* Below saturation temperature.