Table 2 .... Physical Properties of Refrigerants*

(Arranged in Order of Increasing Boiling Point)

Refrigerant No.	Refrigerant Name	Chemical Formula	Molecular Weight	Boiling Point at 1 Atm, F	Freezing Point, F	Critical Temperature, F	Critical Pressure, psia	Critical Volume cu ft/lb	Surface Tension Dynes/cm	Refractive Index of Liquid
704	Helium	He	4.0026	−452.1	None	−450.2	33.21	.2311	0.1055	1.021(NBP)5461Å
702	Hydrogen (normal)	H_2	2.0159	−423.0	−434.5	−399.9	190.8	.5320	2.173	1.097(NBP)5791A
702	Hydrogen (para)	H_2	2.0159	−423.2	−434.8	−400.3	187.5	.5097	2.172	1.09(NBP)[k]
720	Neon	Ne	20.183	−410.9	−415.5	−379.8	384.9	.03316	4.786	...
728	Nitrogen	N_2	28.013	−320.4	−346.0	−232.4	492.9	.05092	8.981	1.205(83K)5893Å
729	Air	...	28.97	−317.8	...	−221.3	547.4	.04883	Plait Point	
						−221.1	546.3	.05007	Point of Contact	
740	Argon	A	39.948	−302.6	−308.8	−188.1	710.4	.02990	12.60	1.233(TP)5893Å
732	Oxygen	O_2	31.9988	−297.3	−361.8	−181.1	736.9	.04215	13.03	1.221(92K)5893Å
50	Methane	CH_4	16.03	−258.9	−297	−115.8	673	0.099		
14	Tetrafluoromethane	CF_4	88.01	−198.4	−299	− 49.9	542	0.025		
1150	Ethylene	C_2H_4	28.03	−155.0	−272	48.8	731.8	0.073[e]	16.5 (−155)[d]	1.363 (−148)[d]
170	Ethane	C_2H_6	30.04	−127.5	−278	90.1	708.3	0.076[e]		
744A	Nitrous Oxide	N_2O	44.02	−127.0	−152[e]	96.5	1050	0.036[e]		
13	Monochlorotrifluoromethane	$CClF_3$	104.47	−114.6	−294	83.9	561	0.0277		
744	Carbon Dioxide	CO_2	44.01	−109.3[e]	−69.9[f]	87.8	1071.1	0.035[e]	1.16 (68)[e]	1.195 (59)[e]
13B1	Monobromotrifluoromethane	$CBrF_3$	148.9	− 72.0	−270	152.6	575	0.0215	4.0 (77)	
1270	Propylene	C_3H_6	42.08	− 53.7	−301	196.5	667.2	0.069[d]		1.3640 (−58)[d]
502[j]	[j]		111.64	− 50.1		194.1	618.7	0.0286		
290	Propane	C_3H_8	44.06	− 44.2	−309.8	202	661.5			1.3397 (−43.2)[b]
22	Monochlorodifluoromethane	$CHClF_2$	86.48	− 41.36	−256	204.8	721.9	0.0305	9.0 (77)	1.252 (79.7)
115	Monochloropentafluoroethane	$CClF_2CF_3$	154.48	− 37.7	−159	175.9	453	0.0269		
717	Ammonia	NH_3	17.03	− 28.0	−107.9	271.4	1657	0.068[e]	23.4 (52)[e]	1.325 (61.7)[e]
500[g]	[g]	[g]	99.29	− 28.0	−254	221.1	631			
12	Dichlorodifluoromethane	CCl_2F_2	120.93	− 21.62	−252	233.6	596.9	0.0287	9.0 (77)	1.285 (79.7)
40	Methyl Chloride	CH_3Cl	50.48	− 10.8	−144	289.4	968.7	0.043	16.2 (68)[e]	
601	Isobutane	C_4H_{10}	58.12	10.3	−229	272.7	537			1.3514 (−13)[d]
764	Sulfur Dioxide	SO_2	64.06	14.0	−103.9	314.8	1141.5	0.031[e]		
630	Methyl Amine	CH_3NH_2	31.05	20.3	−134.5	314	1082		23 (−4)[e]	1.432 (63.5)[e]
600	Butane	C_4H_{10}	58.12	31.3	−211	306	550.1			1.3562 (5)[d]
114a[h]	Dichlorotetrafluoroethane	CCl_2FCF_2	170.9	37.6	− 76	294	478			
114	Dichlorotetrafluoroethane	$CClF_2CClF_2$	170.93	38.39	−137	294.3	474	0.0275	13 (77)	1.290 (79.7)
21	Dichloromonofluoromethane	$CHCl_2F$	102.93	48.06	−211	353.3	750	0.0307	19 (77)	1.361 (79.7)
160	Ethyl Chloride	C_2H_5Cl	64.52	54.0	−217.7	369	764	0.049[e]		
631	Ethyl Amine	$C_2H_5NH_2$	45.06	61.8	−115	362	815		20.4 (49.2)[e]	
11[h]	Trichloromonofluoromethane	CCl_3F	137.38	74.7	−168	388.4	635	0.0289	19 (77)	1.384 (79.7)
611	Methyl Formate	$C_2H_4O_2$	60.04	89.2	−147.5	418	607		25.08 (68)[e]	
610	Ethyl Ether	$C_4H_{10}O$	74.08	94.3	−177.3	522.1	380.8		17.01 (68)[e]	1.3497 (76.6)[e]
30	Methylene Chloride	CH_2Cl_2	84.94	103.6[i]	−142.1[i]	480	670		28.2 (68)[i]	1.4244 (68)[i]
113	Trichlorotrifluoroethane	CCl_2FCClF_2	187.39	117.63	− 31	417.4	495	0.0278	19 (77)	1.355 (79.7)
1130	Dichloroethylene	$CHCl{=}CHCl$	96.93	118	− 70	470	795			
1120	Trichloroethylene	$CHCl{=}CCl_2$	131.37[i]	188.4[i]	−123.5[i]	520	728		29 (86)[i]	1.4782 (68)[i]
718	Water	H_2O	18.02	212	32	706.1	3226	0.04[e]	71.97 (77)[e]	

* Data for the fluorocarbon refrigerants (except Refrigerant 11 and 500) are from E. I. duPont de Nemours & Co., Inc., Used by permission. Data for Refrigerant 500 are from Carrier Corp. Used by permission. Unless otherwise noted, data for the nonfluorinated refrigerants are from Reference 1.

[a] The temperature of measurement (Fahrenheit) is shown in parentheses.

[b] For the sodium D line.

[c] Data from References 2.

[d] Data from Reference 3.

[e] Sublimes.

[f] At 76.4 psia.

[g] Refrigerants 12 and 152a (73.8/26.2 percent by weight).

[h] Data from General Chemical Division, Allied Chemical Corporation.

[i] Data from Electrochemicals Department, E. I. du Pont de Nemours & Co., Inc.

[j] Refrigerants 22 and 115 (48.8/51.2 percent by weight).

[k] Dielectric constant data.

chanical compression systems but do not apply to systems using only a gas such as air. In applications such as the heat pump, the refrigerant can be used to add heat to the system.

The equipment in a refrigeration system serves only to provide the refrigerant in the liquid state at the place where the cooling is desired. Components of refrigeration systems should be designed and assembled to suit the special properties and peculiarities of the refrigerant to be used.

The object of this chapter is to give basic information on the characteristics of the various refrigerants used. More detailed thermodynamic properties will be found in Chapter 20, Refrigerant Tables and Charts. The ASHRAE standard designations of refrigerants by number are shown in Table 1. Complete information can be obtained from the manufacturer of any particular refrigerant.

The choice of the refrigerant for a particular application often depends on properties not directly related to its ability to remove heat. For example, flammability, toxicity, density, viscosity, availability, and other similar characteristics are often deciding factors.

As a rule, the selection of a refrigerant is a compromise between conflicting desirable properties. For example, the pressure in the evaporator should be as high as possible and, at the same time, a low condensing pressure is desirable. Low viscosity and low surface tension are desirable properties but, on the other hand, they make it difficult to provide dropwise condensation which would improve heat transfer. High capacity, accompanied by low power requirements, would also be desirable if possible. These and other conflicts must be resolved in selecting a refrigerant.

Since evaporation of the liquid is the only step in the refrigeration cycle which produces cooling, the latent heat of a refrigerant should be as large as possible. On a molar basis, the latent heat is about the same for materials having the same boiling point.

Since the compressor operates on volumes of gas, or mols refrigerants with similar boiling points will produce similar capacities in the same compressor. The weight of refrigerant

Table 3 .... Viscosity of Refrigerant Liquids at Saturation Pressure

(μ in centipoises)

Temp. F	Refrigerants 11*	12*	21*	22*	113*	114*	40 Methyl Chloride*	717 NH_3†	764 SO_2†	744 CO_2†
−40	0.980	0.423	0.629	0.351		0.879	0.349			
−20	0.801	0.371	0.547	0.316	1.566	0.711	0.321			
0	0.677	0.335	0.484	0.291	1.263	0.598	0.298			
+ 5								0.250	0.503	0.115
20	0.586	0.308	0.436	0.271	1.043	0.516	0.279	0.240	0.390	0.110
40	0.517	0.286	0.397	0.256	0.876	0.454	0.263	0.230	0.350	0.095
60	0.461	0.269	0.364	0.243	0.747	0.405	0.249			
80	0.417	0.255	0.337	0.232	0.646	0.366	0.237	0.210	0.290	0.064
100	0.380	0.242	0.314	0.223	0.564	0.334	0.226	0.200	0.260	
120	0.349	0.232	0.294	0.214	0.497	0.307	0.217			
140	0.323	0.222	0.277	0.207	0.442	0.284	0.208			
160	0.300	0.214	0.262	0.201	0.395		0.200			
180	0.281	0.207	0.248	0.195	0.356		0.193			
200	0.263	0.200	0.236		0.322		0.186			
220	0.248		0.225		0.293		0.180			
240	0.232		0.215		0.268		0.175			

* Data from Reference 4.

† Data from Reference 5. Recent Russian data (Reference 6) have lower values, for example, 0.127 cp at 100 F.

Table 4 .... Viscosity of Refrigerant Vapors at One Atmosphere Pressure‡

(μ in centipoises)

Temp. F	Refrigerants 11*	12*	21*	22*	113*	114*	40 Methyl chloride*	717 NH_3†	764 SO_2†	744 CO_2†
−40	0.0088	0.0106	0.0094	0.0105		0.0095	0.0086			
−20	0.0092	0.0109	0.0098	0.0109	0.0090	0.0098	0.0090			
0	0.0096	0.0113	0.0101	0.0113	0.0093	0.0102	0.0094			
+ 5								0.0085	0.0111	0.0132
20	0.0099	0.0116	0.0105	0.0118	0.0095	0.0106	0.0098	0.0088	0.0115	0.0135
40	0.0103	0.0119	0.0108	0.0122	0.0098	0.0109	0.0101	0.0093	0.0120	0.0140
60	0.0106	0.0123	0.0111	0.0126	0.0101	0.0112	0.0105			
80	0.0110	0.0126	0.0115	0.0130	0.0103	0.0116	0.0108			
100	0.0113	0.0129	0.0118	0.0133	0.0106	0.0119	0.0111	0.0105	0.0134	0.0155
120	0.0116	0.0132	0.0121	0.0137	0.0108	0.0122	0.0115			
140	0.0120	0.0135	0.0124	0.0141	0.0111	0.0125	0.0118			
150								0.0116	0.0144	0.0165
160	0.0123	0.0138	0.0127	0.0145	0.0113		0.0122			
180	0.0126	0.0140	0.0130	0.0148	0.0116		0.0125			
200	0.0129	0.0143	0.0133	0.0152	0.0118		0.0128			
220	0.0132	0.0146	0.0136	0.0156	0.0120		0.0131			
240	0.0135	0.0149	0.0139	0.0159	0.0123		0.0134			

* Data from Reference 4.

† Data from Reference 5. Recent Russian data (Reference 6) are in good agreement.

‡ 0.1 atm. for Refrigerant 113.