Physical, Safety, and Environmental Data FOR REFRIGERANTS

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Manufacturers have commercialized more than 50 new refrigerants (including blends) in the last decade, and they are examining additional candidates. Users should expect a number of new introductions as the phaseout of R-22, now the most widely used refrigerant, approaches. A similar flurry of service fluids occurred with the phaseouts of R-12 and R-502; R-12 was the most widely used refrigerant until a few years ago.

This article provides two tables that summarize selected physical, safety, and environmental data for old and current refrigerants as well as leading candidates. The data in the two tables are the same, but they are presented in a different order.

Table 1 is sorted by refrigerant numbers. Table 2 contains the same information sorted by the normal boiling points (at atmospheric pressure) of the refrigerants. Table 1 lends itself to finding information on a specific refrigerant. Table 2 rearranges the refrigerants in coarse proximity for similar applications to facilitate comparisons.

The data in these tables are taken from the *ARTI Refrigerant Database*,[1] which is an information system on alternative refrigerants, associated lubricants, and their uses in air conditioning and refrigeration. The database consolidates and facilitates access to property, compatibility, safety, environmental, application, and other data.[2] It also provides an extensive bibliographic reference system.

REFRIGERANT DATA TABLES

The parameter descriptions that follow are in the same sequence as presented in Tables 1 and 2—reading from the left to the right columns.

Identifiers

◗ **Number** shown is the standard designation based on those assigned by or recommended for addition to ANSI/ASHRAE Standard 34-1997, *Designation and Safety Classification of Refrigerants*, and pending addenda thereto.[3] These familiar designations are used almost universally—usually preceded by "R-", "R", the word "refrigerant", composition-designating prefixes (for example CFC-, HCFC-, HFC-, or HC-), or manufacturer trade names.

◗ **Chemical formula** indicates the molecular makeup of single-compound refrigerants, namely those consisting of a single chemical substance.

◗ **Blend composition** is shown for refrigerant blends, namely those consisting of two or more chemicals that are mixed to obtain desired characteristics. The composition consists of two parts. The first identifies the components in order of increasing normal boiling points and are separated by slashes. The second part, which is enclosed in parentheses, indicates the mass fractions (as percentages) of those components in the same order.

◗ The tables also indicate the **common names** by which some refrigerants are frequently identified.

Physical properties

◗ **Molecular mass** is a calculated value based on the atomic weights recognized by the International Union of Pure and Applied Chemists (IUPAC).[4] It indicates the mass in grams of a mole of the refrigerant or, for blends, the mass-weighted average of a mole of the mixture.

◗ **Normal boiling point (NBP)** is the temperature at which liquid refrigerant will boil at standard atmospheric pres-

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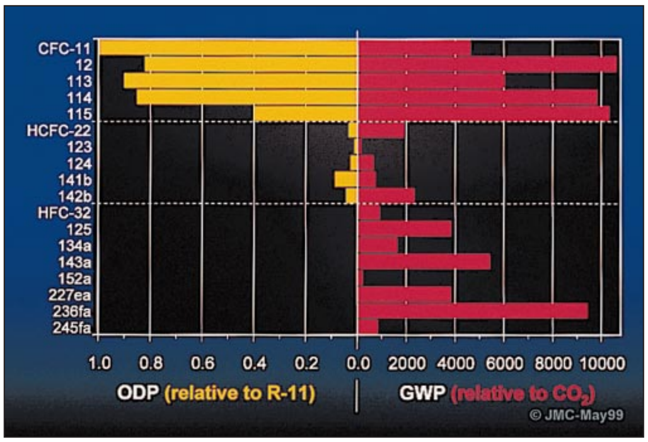
sure, namely 101.325 kPa (14.6959 psia). The NBP and most dimensional units in the tables are shown in both metric (SI) and in-lb units of measure. The bubble point (temperature at which a bubble first appears, hence the temperature at which boiling begins for a blend) is shown as the NBP for blends.

◗ **Critical temperature (T_c)** is the temperature at the critical point of the refrigerant. The T_c values shown for blends are the mass-weighted averages of the component T_cs, unless actual values have been determined.



Ozone depletion potential (ODP) contrasted to global warming (GWP) for key single-compound refrigerants, based on data from reference 6. CFCs generally have high ODP and GWP. HCFCs generally have much lower ODP and GWP. HFCs offer near-zero ODP, but some have comparatively high GWPs.

◗ **Critical pressure (P_c)** is the pressure at the critical point.

The NBP and critical properties suggest the application range for which an individual refrigerant might be suitable. Those with extremely low NBP lend themselves to ultra-low temperature refrigeration, for example, in cryogenic applications. Those with high NBPs are generally limited to high-temperature applications such as chillers. Both capacity and efficiency decline in a typical vapor-compression (reverse-Rankine) cycle—the one most commonly used—when condensing temperatures approach the T_c. The P_c will exceed the operating pressure except in transcritical cycles, which are uncommon except for R-744 (carbon dioxide). It is useful to compare relative operating pressures because practical cycles usually are designed to condense at 70 to 90 percent of the T_c (on an absolute basis) and, therefore, of the P_c.[5]

Safety data

◗ The first value is the occupational exposure limit, namely the **Threshold Limit Value-Time Weighted Average (TLV-TWA)** or a consistent measure. It is an indication of chronic (long-term, repeat exposure) toxicity of the refrigerant. Some of the consistent toxicity indices are the Workplace Environmental Exposure Level (WEEL) guides or the Permissible Exposure Limits (PEL). These measures indicate adopted limits for workplace exposures for trained personnel during typical workdays and work weeks.

◗ **Lower flammability limit (LFL)** is the lowest concentration at which the refrigerant will burn in air under prescribed test conditions. It is an indication of flammability.

◗ **Heat of combustion (HOC)** is an indicator of how much energy the refrigerant will release when it burns in air—assuming complete reaction to the most stable products in their vapor states. Negative values indicate endothermic reactions (those that require heat to proceed), while positive values indicate exothermic reactions (those that liberate heat).

◗ **ASHRAE Standard 34 safety group** is an assigned classification that is based on the TLV-TWA (or consistent measure), LFL, and HOC. It comprises a letter (A or B) that indicates relative toxicity followed by a number (1, 2, or 3) that indicates relative flammability. These classifications are widely used in mechanical and fire construction codes to determine requirements to promote safe use. Most of these code provisions are based on ASHRAE Standard 15, *Safety Code for Mechanical Refrigeration*. Some of the classifications are followed by lower-case letters:

"*d*"—signifies that the project committee responsible for ASHRAE Standard 34, SSPC 34, has recommended *deletion* of the classification, but final approval and/or publication is still pending

"*p*"—indicates that the classification was assigned on a *provisional* basis

"*r*"—signifies that SSPC 34 has recommended *revision or addition* of the classification as shown, but final approval and/or publication is still pending

Environmental data

◗ **Atmospheric lifetime (τ_{atm})** is an indication of the average persistence of the refrigerant—if it is released into the atmosphere or until it decomposes or reacts with other chemicals.

◗ **Ozone depletion potential (ODP)** is a normalized indicator, based on a value of 1.000 for CFC-11, of the ability of refrigerants (and other chemicals) to destroy stratospheric ozone molecules. The data shown are the modeled values adopted by the international scientific assessment.[6] The ODPs shown for blends are mass-weighted averages.

◗ **Global warming potential (GWP)** is a similar indicator of the potency to warm the planet by action as a greenhouse gas. The values shown are relative to carbon dioxide (CO_2) for an integration period of 100 years. Both the ODP and GWP are calculated from τ_{atm}, measured chemical properties, and other atmospheric data. The GWPs shown for blends are mass-weighted averages.

NEW DATA

The τ_{atm}, ODP, and GWP values in the tables are new data based on the latest editions of international scientific assessments.[6,7] The values indicated for blends were calculated for the nominal blend compositions.

Data definitions

The values shown for the refrigerant lives are composite, atmospheric lifetimes. The lifetimes can also be shown separately for the tropospheric (lower atmosphere where we live), stratospheric (next layer where global depletion of ozone is a concern), and higher layers because the atmospheric chemistry changes between layers.

The ODP values in the tables are *modeled* ODP values—the most indicative of environmental impacts. There are several other ways to express ODPs, including the *semi-empirical* ODP, *time-dependent* ODPs, and *regulatory* values such as those adopted in laws or in the Montreal Protocol.

The semi-empirical ODPs are calculated values that incorporate adjustments for observed atmospheric measurements. The concept is conceptually more accurate, but it is difficult to measure the data needed for representative adjustments accurately. The scientific consensus recommends use of the modeled values.[8]

The regulatory values generally are required for specific purposes, but they may not be updated with newer findings after adoption. The ODP values listed in the annexes to the Montreal Protocol, for example, have not been updated since 1987 for chlorofluorocarbons (CFCs) and 1992 for hydrochlorofluorocarbons (HCFCs). A note in the Protocol indicates that the values "are estimates based on existing knowledge and will be reviewed and revised periodically."[9]

Time-dependent ODPs use chemicals other than CFC-11 as the reference. By normalizing values to short-lived compounds, for example, short-term impacts are emphasized; long-term effects are discounted. Time-dependent ODPs are not often cited—particularly because the release of ozone-depleting substances already has peaked, and the stratospheric ozone layer will begin to recover in the next few years.

GWP values can be calculated for any desired integration period, commonly referred to as the integration time horizon (ITH). Short ITH periods emphasize immediate effects but overlook later impacts, while long ITH periods incorporate the later effects. The most common GWP values, including those cited herein, are for an ITH of 100 years.

Time frames

The values cited for τ_{atm}, ODP, and GWP change as understanding of atmospheric science expands and the chemical kinetics involved become better understood. They also change when newer measurements are made for both specific and reference chemicals and as modeling of atmospheric chemistry improves. These factors have driven periodic reviews and consensus assessments by the scientific community. The data shown in Tables 1 and 2 are based on the assessment published in February 1999 and consistent recalculations for the blends.

Differences in data

One reason readers may see diverging values for environmental data—beyond differences associated with parameter choices and whether the data are current—has to do with accuracy. Some manufacturers and authors round off the data, and errors propagate when rounded values are used for blend calculations. Halocarbon or absolute GWP (HGWP and AGWP, respectively) values sometimes are mislabeled as GWPs.

ACKNOWLEDGMENT

The database from which the summary data in Tables 1 and 2 were extracted is a part of the *HVACR Research for the 21st Century* initiative, a research program of the Air-Conditioning and Refrigeration Technology Institute. The program's primary objective is to enable marked improvements in energy efficiency through precompetitive research. The focal areas include:

- alternative equipment
- equipment energy efficiency
- indoor environmental quality (IEQ)
- system integration
- working fluids.

Innovative advancements in equipment will provide some of the energy and IEQ improvements. Others will stem from improved integration of air-conditioning and refrigeration processes into buildings and other applications. HPAC

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TABLE 1 — Summary Physical, Safety, and Environmental Data for Refrigerants (sorted by Standard 34 Designation)

refrigerant		physical data							safety data					environmental data		
number	chemical formula or blend composition – common name	molecular mass	NBP (°C)	NBP (°F)	Tc (°C)	Tc (°F)	Pc (MPa)	Pc (psia)	TLV-TWA (PPM)	LFL (%)	HOC MJ/kg	HOC Btu/lb	Std 34 safety group	atmospheric life (yr)	ODP	GWP 100 yr
11	CCl3F	137.37	23.7	74.7	198.0	388.4	4.41	640	C1000	none	0.9	387	A1	45	1.000	4600
12B1	CBrClF2 – halon 1211	165.36	-4.0	24.8	154.0	309.2	4.10	595	~~1000~~	none				11	5.100	1300
12B2	CBr2F2 – halon 1202	209.82	24.5	76.1	198.2	388.8			100	none					1.700	
12	CCl2F2	120.91	-29.8	-21.6	112.0	233.6	4.14	600	1000	none	-0.8	-344	A1	100	0.820	10600
13B1	CBrF3 – halon 1301	148.91	-57.7	-71.9	67.1	152.8	3.96	574	1000	none			A1	65	12.000	6900
13	CClF3	104.46	-81.3	-114.3	29.2	84.6	3.92	569	1000	none	-3.0	-1290	A1	640	1.000	10000
13I1	CF3I	195.91	-22.5	-8.5	122.0	251.6				none				<0.1	0.000	<1
14	CF4 – carbon tetrafluoride	88.00	-128.1	-198.6	-45.6	-50.1	3.75	544		none			A1	50000	0.000	5700
21	CHCl2F	102.92	8.9	48.0	178.3	352.9	5.18	751	10	none			B1	2.0	0.010	210
22	CHClF2	86.47	-40.8	-41.4	96.2	205.2	4.99	724	1000	none	2.2	946	A1	11.8	0.034	1900
23	CHF3 – fluoroform	70.01	-82.1	-115.8	25.9	78.6	4.84	702	1000	none	-12.5	-5374	A1	243	0.000	14800
30	CH2Cl2 – methylene chloride	84.93	40.2	104.4	237.0	458.6	6.08	882	50	14.6			B2	0.46	0.000	10
31	CH2ClF	68.48	-9.1	15.6					0.1						0.010	
32	CH2F2 – methylene fluoride	52.02	-51.7	-61.1	78.2	172.8	5.78	838	1000	13.3	9.4	4041	A2	5.6	0.000	880
40	CH3Cl – methyl chloride	50.49	-24.2	-11.6	143.1	289.6	6.67	967	50	8.1			B2	1.3	0.020	16
41	CH3F – methyl fluoride	34.03	-78.1	-108.6	44.1	111.4	5.90	856						3.7	0.000	140
50	CH4 – methane	16.04	-161.5	-258.7	-82.5	-116.5	4.64	673	1000	5			A3	12.2	0.000	24
113	CCl2FCClF2	187.37	47.6	117.7	214.1	417.4	3.39	492	1000	none	0.1	43	A1	85	0.900	6000
114	CClF2CClF2	170.92	3.6	38.5	145.7	294.3	3.26	473	1000	none	-3.1	-1333	A1	300	0.850	9800
115	CClF2CF3	154.47	-38.9	-38.0	80.0	176.0	3.12	453	1000	none	-2.1	-903	A1	1700	0.400	10300
116	CF3CF3 – perfluoroethane	138.01	-78.2	-108.8	19.9	67.8	3.04	441	1000	none			A1	10000	0.000	11400
123	CHCl2CF3	152.93	27.8	82.0	183.8	362.8	3.66	531	50	none	2.1	903	B1	1.4	0.012	120
124	CHClFCF3	136.48	-12.0	10.4	122.3	252.1	3.62	525	1000	none	0.9	387	A1	6.1	0.026	620
125	CHF2CF3	120.02	-48.1	-54.6	66.2	151.2	3.63	526	1000	none	-1.5	-645	A1	32.6	0.000	3800
E125	CHF2-O-CF3	136.02	-42.0	-43.6	81.3	178.3	3.35	486						165	0.000	15300
134	CHF2CHF2	102.03	-23.0	-9.4	119.0	246.2	4.62	670	1000	none	4.3	1849		10.6	0.000	1200
134a	CH2FCF3	102.03	-26.1	-15.0	101.1	214.0	4.06	589	1000	none	4.2	1806	A1	13.6	0.000	1600
E134	CHF2-O-CHF2	118.03	6.2	43.2	160.8	321.4	4.23	614		none				29.7	0.000	6900
141b	CH3CCl2F	116.95	32.0	89.6	204.2	399.6	4.25	616	500	6.4	8.6	3697		9.2	0.086	700
142b	CH3CClF2	100.49	-9.0	15.8	137.1	278.8	4.12	598	1000	6.9	9.8	4213	A2	18.5	0.043	2300
143	CH2FCHF2	84.04	5.0	41.0	156.7	314.1	5.24	760		5.8	10.9	4686		3.8	0.020	370
143a	CH3CF3	84.04	-47.2	-53.0	72.9	163.2	3.78	548	1000	7.1	10.3	4428	A2	53.5	0.000	5400
E143a	CH3-O-CF3	100.04	-24.1	-11.4	104.9	220.8	3.59	521						5.7	0.000	970
152a	CH3CHF2	66.05	-24.0	-11.2	113.3	235.9	4.52	656	1000	3.1	17.4	7481	A2	1.5	0.000	190
160	CH3CH2Cl – ethyl chloride	64.51	13.1	55.6	187.2	369.0	5.24	760	100	3.8	20.6	8856		<1	0.000	
161	CH3CH2F – ethyl fluoride	48.06	-37.1	-34.8	102.2	216.0	4.70	682		3.8				0.25	0.000	10
170	CH3CH3 – ethane	30.07	-88.6	-127.5	32.2	90.0	4.87	706	1000	3.2			A3		0.000	~20
E170	CH3-O-CH3 – dimethyl ether	46.07	-24.8	-12.6	128.8	263.8	5.32	772	1000	3.4				0.015	0.000	<1
218	CF3CF2CF3 – perfluoropropane	188.02	-36.6	-33.9	71.9	161.4	2.68	389	1000	none			A1	2600	0.000	8600
227ea	CF3CHFCF3	170.03	-15.6	3.9	102.8	217.0	2.98	432	1000	none	3.3	1419		36.5	0.000	3800
236fa	CF3CH2CF3	152.04	-1.4	29.5	124.9	256.8	3.20	464	1000	none			A1	226	0.000	9400
245ca	CH2FCF2CHF2	134.05	25.1	77.2	174.4	345.9	3.94	571		7.1	8.4	3611		6.6	0.000	720
245fa	CHF2CH2CF3	134.05	15.1	59.2	154.1	309.4	4.43	643	500 p	none	6.1	2623	A1p r	8.8	0.000	820
E245cb1	CH3-O-CF2-CF3	150.05	5.6	42.1	133.7	272.7	2.89	419		none				1.2	0.000	160
C270	-CH2-CH2-CH2- – cyclopropane	42.08	-33.5	-28.3	125.2	257.4	5.58	809		2.4					0.000	
290	CH3CH2CH3 – propane	44.10	-42.1	-43.8	96.7	206.1	4.25	616	2500	2.3	50.3	21625	A3		0.000	~20
C318	-CF2-CF2-CF2-CF2-	200.03	-6.0	21.2	115.2	239.4	2.78	403	1000	none			d	3200	0.000	11200
338mcc	CH2FCF2CF2CF3	202.05	27.8	82.0	158.8	317.8	2.73	396							0.000	
338mcf	CF3CH2CF2CF3	202.05	19.9	67.8	150.6	303.1	2.50	363		none					0.000	
E347mmy1	CF3-CF(OCH3)-CF3	200.05	29.4	84.9	160.2	320.4	2.55	370						3.5	0.000	340
400 -->	R-12/114 (50.0/50.0) – R-400(50/50)	141.63	-20.8	-5.4	128.9	264.0	3.92	569		none			A1/A1		0.835	10200
400 -->	R-12/114 (60.0/40.0) – R-400(60/40)	136.94	-23.2	-9.8	125.4	257.7	3.99	579		none			A1/A1		0.832	10280
401A	R-22/152a/124 (53.0/13.0/34.0) – MP39	94.44	-34.4	-29.9	105.3	221.5	4.61	669	1000	none			A1/A1		0.027	1240
401B	R-22/152a/124 (61.0/11.0/28.0) – MP66	92.84	-35.7	-32.3	103.5	218.3	4.68	679	1000	none	-2.7	-1161	A1/A1		0.028	1350
401C	R-22/152a/124 (33.0/15.0/52.0) – MP52	101.03	-30.5	-22.9	109.9	229.8	4.40	638		none			A1/A1		0.025	980
——	R-22/152a/124 (40.0/17.0/43.0) – MP33	96.61	-31.9	-25.4	108.3	226.9	4.50	653		none	-3.7	-1591			0.025	1060
402A	R-125/290/22 (60.0/2.0/38.0) – HP80	101.55	-49.2	-56.6	76.0	168.8	4.23	614		none	-1.4	-602	A1/A1		0.013	3000
402B	R-125/290/22 (38.0/2.0/60.0) – HP81	94.71	-47.2	-53.0	83.0	181.4	4.53	657		none	-1.6	-688	A1/A1		0.020	2580
403A	R-290/22/218 (5.0/75.0/20.0) – 69-S	91.99	-44.0	-47.2	91.2	196.2	4.69	680	1000	none			A1/A1		0.026	3150
403B	R-290/22/218 (5.0/56.0/39.0) – 69-L	103.26	-43.8	-46.8	88.7	191.7	4.40	638	1000	none			A1/A1		0.019	4420
404A	R-125/143a/134a (44.0/52.0/4.0) – HP62 and FX-70	97.60	-46.6	-51.9	72.1	161.8	3.74	542	1000	none	-6.6	-2837	A1/A1		0.000	4540
405A	R-22/152a/142b/C318 (45.0/7.0/5.5/42.5) – G2015	111.91	-32.9	-27.2	106.0	222.8	4.29	622	1000	none			d		0.018	5750
406A	R-22/600a/142b (55.0/4.0/41.0) – GHG	89.86	-32.7	-26.9	116.5	241.7	4.88	708		wff			A1/A2		0.036	1990
——	R-22/600a/142b (65.0/4.0/31.0) – GHG-HP	88.57	-35.0	-31.0	112.2	234.0	4.95	718		wff					0.035	1950
407A	R-32/125/134a (20.0/40.0/40.0) – Klea 60	90.11	-45.2	-49.4	81.9	179.4	4.49	651	1000	none	-3.6	-1548	A1/A1		0.000	2340
407B	R-32/125/134a (10.0/70.0/20.0) – Klea 61	102.94	-46.8	-52.2	74.4	165.9	4.08	592	1000	none	-1.8	-774	A1/A1		0.000	3070
407C	R-32/125/134a (23.0/25.0/52.0) – Klea 66; Suva 9000	86.20	-43.8	-46.8	87.3	189.1	4.63	672	1000	none	-4.9	-2107	A1/A1		0.000	1980
407D	R-32/125/134a (15.0/15.0/70.0)	90.96	-39.4	-38.9	91.6	196.9	4.48	650	1000	none	-4.3	-1849	A1/A1		0.000	1820
407E	R-32/125/134a (25.0/15.0/60.0)	83.78	-42.8	-45.0	88.8	191.8	4.73	686	1000	none	-4.8	-2064	A1/A1		0.000	1750
——	R-32/125/134a (30.0/10.0/60.0)	80.13	-43.4	-46.1	89.1	192.4	4.87	706		wff					0.000	1600
408A	R-125/143a/22 (7.0/46.0/47.0) – FX-10	87.01	-45.5	-49.9	83.3	181.9	4.42	641		none	5.7	2451	A1/A1		0.016	3640
409A	R-22/124/142b (60.0/25.0/15.0) – FX-56	97.43	-35.4	-31.7	106.9	224.4	4.69	680	1000	none	3.0	1290	A1/A1		0.039	1640
409B	R-22/124/142b (65.0/25.0/10.0) – FX-57	96.67	-36.5	-33.7	104.4	219.9	4.71	683		none			A1/A1		0.033	1620

continued on next page

TABLE 1 *(continued)*

refrigerant number	chemical formula or blend composition – common name	molecular mass (physical data)	NBP (°C)	NBP (°F)	Tc (°C)	Tc (°F)	Pc (MPa)	Pc (psia)	TLV-TWA (PPM) (safety data)	LFL (%)	HOC MJ/kg	HOC Btu/lb	Std 34 safety group	atmospheric life (yr) (environmental data)	ODP	GWP 100 yr
410A	R-32/125 (50.0/50.0) – Suva 9100; AZ-20	72.58	-51.6	-60.9	72.5	162.5	4.95	718	1000	none	-4.4	-1892	A1/A1		0.000	2340
410B	R-32/125 (45.0/55.0)	75.57	-51.5	-60.7	71.0	159.8	4.78	693		none			A1/A1		0.000	2490
—	R-32/125 (32.0/68.0) – FX-80	84.63	-51.1	-60.0	67.7	153.9	4.40	638							0.000	2870
411A	R-1270/22/152a (1.5/87.5/11.0)	82.36	-39.7	-39.5	99.1	210.4	4.95	718	1000	wff			A1/A2		0.030	1680
411B	R-1270/22/152a (3.0/94.0/3.0)	83.07	-41.6	-42.9	96.0	204.8	4.95	718	1000	wff	6.5	2794	A1/A2		0.032	1790
411C	R-1270/22/152a (3.0/95.5/1.5) – G2018C	83.44	-41.8	-43.2	95.5	203.9	4.95	718		none			A1/A1r		0.032	1820
412A	R-22/218/142b (70.0/5.0/25.0) – Arcton TP5R	92.17	-36.4	-33.5	107.5	225.5	4.88	708	1000	wff			A1/A2		0.035	2340
413A	R-218/134a/600a (9.0/88.0/3.0) – ISCEON 49	103.95	-29.3	-20.7	101.4	214.5	4.24	615		wff			A1/A2		0.000	2180
414A	R-22/124/600a/142b (51.0/28.5/4.0/16.5) – GHG-X4	96.93	-34.0	-29.2	110.7	231.3	4.70	682	1000		3.6	1548	A1/A1r		0.032	1530
414B	R-22/124/600a/142b (50.0/39.0/1.5/9.5) – HOT SHOT	101.59	-34.4	-29.9	108.0	226.4	4.59	666		none			A1/A1r		0.031	1410
—	R-23/22/152a (5.0/80.0/15.0) – NARM-22	81.72	-47.0	-52.6	97.2	207.0	5.04	731	1000	wff					0.027	2290
—	R-23/22/152a (5.0/90.0/5.0) – NARM-502	84.18	-48.4	-55.1	94.4	201.9	5.10	740	1000	none					0.031	2460
416A	R-134a/124/600 (59.0/39.5/1.5) – FR-12	111.92	-23.4	-10.1	108.2	226.8	4.02	583			7.8	3353	A1/A1r		0.010	1190
—	R-134a/124/600 (59.0/39.0/2.0) – DI-24	111.31	-23.4	-10.1	108.6	227.5	4.04	586		wff					0.010	1190
—	R-125/134a/600 (46.6/50.0/3.4) – Isceon 59	106.75	-38.0	-36.4	89.9	193.8	4.10	595		none					0.000	2570
—	R-125/143a/290/22 (42.0/6.0/2.0/50.0) – DI-44	95.70	-47.7	-53.9	81.0	177.8	4.45	645	1000	none					0.017	2870
—	R-134a/142b (80.0/20.0) – Freeze	101.71	-24.1	-11.4	107.5	225.5	4.12	598							0.010	1400
—	R-170/290 (6.0/94.0) – ER22/502	42.90	-50.0	-58.0	91.2	196.2	4.29	622		1.9					0.000	~21
—	R-22/12/142b (25.0/15.0/60.0) – R-176	98.99	-26.9	-16.4	129.4	264.9	5.10	740	1000	wff					0.157	3450
—	R-22/124/600 (50.0/47.0/3.0) – DI-36	102.64	-34.8	-30.6	102.6	216.7	4.56	661	900	none					0.029	1240
—	R-22/142b (40.0/60.0)	94.37	-27.9	-18.2	123.1	253.6	4.72	685		wff					0.039	2140
—	R-22/227ea/600a/142b (41.0/40.0/4.0/15.0 – GHG-X5	107.82	-32.4	-26.3	108.2	226.8	4.37	634							0.020	2640
—	R-23/125/143a (20.0/36.0/44.0) – ES20	90.16	-64.8	-84.6	67.3	153.1	4.03	585							0.000	6700
—	R-23/32/134a (4.5/21.5/74.0) – FX-220	83.14	-42.2	-44.0	89.0	192.2	4.90	711		none					0.000	2040
—	R-290/124/123 (3.0/40.0/57.0)	136.27	-15.3	4.5	151.1	304.0	3.99	579							0.017	320
—	R-290/600 (60.0/40.0 by liquid volume) – OZ-12	48.81													0.000	~20
—	R-290/600a (50.0/50.0)	50.15	-32.8	-27.0	114.8	238.6	4.04	586		2					0.000	~20
—	R-32/125/143a (10.0/45.0/45.0) – FX-40	90.69	-48.4	-55.1	72.0	161.6	4.05	587		none					0.000	4230
—	R-32/125/143a/134a (10.0/33.0/36.0/21.0) – HX4	90.80	-49.4	-56.9	77.5	171.5	4.01	582		none					0.000	3620
—	R-32/134a (25.0/75.0)	82.26	-40.3	-40.5	93.7	200.7	4.83	701		wff					0.000	1420
—	R-32/134a (30.0/70.0)	79.19	-41.8	-43.2	92.4	198.3	4.94	716	1000	wff					0.000	1380
—	R-600a/600 (50.0/50.0) – isobutane/butane	58.12	-6.5	20.3	143.6	290.5	3.73	541		1.8					0.000	~20
500	R-12/152a (73.8/26.2)	99.30	-33.6	-28.5	102.1	215.8	4.17	605	1000	none			A1		0.605	7870
501	R-22/12 (75.0/25.0)	93.10	-40.5	-40.9	96.2	205.2	4.76	690		none			A1		0.231	4080
502	R-22/115 (48.8/51.2)	111.63	-45.3	-49.5	80.7	177.3	4.02	583	1000	none			A1		0.221	6200
503	R-23/13 (40.1/59.9)	87.25	-87.5	-125.5	18.4	65.1	4.27	619	1000	none					0.599	14300
504	R-32/115 (48.2/51.8)	79.25	-57.7	-71.9	62.1	143.8	4.44	644		none					0.207	5760
505	R-12/31 (78.0/22.0)	103.48	-30.0	-22.0	117.8	244.0	4.73	686		none					0.642	
506	R-31/114 (55.1/44.9)	93.69	-12.3	9.9	142.2	288.0	5.16	748		none					0.387	
507A	R-125/143a (50.0/50.0) – AZ-50	98.86	-47.1	-52.8	70.9	159.6	3.79	550		none	-5.5	-2365	A1		0.000	4600
508A	R-23/116 (39.0/61.0) – Klea 5R3	100.10	-87.4	-125.3	11.0	51.8	3.70	537	1000	none			A1		0.000	12700
508B	R-23/116 (46.0/54.0) – Suva 95	95.39	-87.4	-125.3	14.0	57.2	3.93	570	1000	none			A1/A1		0.000	13000
509A	R-22/218 (44.0/56.0) – Arcton TP5R2	123.96	-40.4	-40.7	87.2	189.0	4.03	585	1000	none			A1		0.015	5650
—	R-134a/600a (80.0/20.0) – Electrolux RC	88.64	-29.5	-21.1	111.3	232.3	4.81	698		3.9					0.000	1280
600	CH3-CH2-CH2-CH3 – butane	58.12	-0.5	31.1	152.0	305.6	3.80	551	800	1.9	49.5	21281	A3		0.000	~20
600a	CH(CH3)2-CH3 – isobutane	58.12	-11.6	11.1	134.7	274.5	3.64	528	800	1.8	49.4	21238	A3		0.000	~20
601	CH3-CH2-CH2-CH2-CH3 – pentane	72.15	36.2	97.2	196.4	385.5	3.36	487	600	1.4				<<1	0.000	11
601a	(CH3)2CH-CH2-CH3 – isopentane	72.15	27.8	82.0	187.4	369.3	3.37	489	600	1.4					0.000	
601b	(CH3)4C – neopentane	72.15	9.5	49.1	160.6	321.1	3.20	464	600	1.4					0.000	
610	CH3-CH2-O-CH2-CH3 – ethyl ether	74.12	34.6	94.3	214.0	417.2	6.00	870	400	1.9					0.000	
611	HCOOCH3 – methyl formate	60.05	31.8	89.2	214.0	417.2	5.99	869	100	5.1			B2		0.000	
630	CH3(NH2) – methylamine	31.06	-6.7	19.9	156.9	314.4	7.46	1082	5	4.9					0.000	
631	CH3-CH2(NH2) – ethylamine	45.08	16.6	61.9	183.0	361.4	5.62	815	5	3.5					0.000	
704	He – helium	4.00	-268.9	-452.0	-267.9	-450.2	0.23	33		none			A1		0.000	
717	NH3 – ammonia	17.03	-33.3	-27.9	132.3	270.1	11.34	1645	25	14.8	22.5	9673	B2		0.000	<1
718	H2O – water	18.02	100.0	212.0	374.2	705.6	22.10	3205		none			A1		0.000	<1
729	air	28.97	-194.4	-317.9	-140.7	-221.3	3.77	547		none					0.000	0
744	CO2 – carbon dioxide	44.01	-78.4	-109.1	31.1	88.0	7.38	1070	5000	none			A1	>50	0.000	1
764	SO2 – sulfur dioxide	64.06	-10.0	14.0	157.5	315.5	7.88	1143	2	none			B1		0.000	
1130	CHCl=CHCl – dielene	96.94	47.8	118.0	243.3	469.9	5.48	795	200	5.6						
1150	CH2=CH2 – ethylene	28.05	-109.4	-164.9	9.3	48.7	5.11	741	1000	2.7			A3		0.000	
1270	CH3CH=CH2 – propylene	42.08	-47.7	-53.9	92.4	198.3	4.67	677	375	2.0			B3 r		0.000	

NBP = normal boiling point; Tc = critical temperature; Pc = critical pressure; TLV-TWA = ACGIH Threshold Limit Value - Time-Weighted Average, or consistent chronic exposure limit (e.g., OSHA Permissible Exposure Limit, PEL), unless preceded by "C" for TLV-Ceiling; LFL = lower flammability limit (% volume in air), "wff" signifies that the worst case of fractionation may become flammable; HOC = heat of combustion; ODP = ozone depletion potential (modeled); GWP = global warming potential (for 100 yr integration)

Suffixes to safety classifications indicate recommended changes that are not final yet ("d" for deletion and "r" for revision or addition) or classifications assigned as provisional ("p").

Data sources are identified in the Refrigerant Database; verify the data and associated limitations in those sources before use.

HPAC ENGINEERING

TABLE 2 — Summary Physical, Safety, and Environmental Data for Refrigerants (sorted by Boiling Point)

refrigerant: number	refrigerant: chemical formula or blend composition – common name	physical data: molecular mass	NBP (°C)	NBP (°F)	Tc (°C)	Tc (°F)	Pc (MPa)	Pc (psia)	safety data: TLV-TWA (PPM)	LFL (%)	HOC MJ/kg	HOC Btu/lb	Std 34 safety group	environmental data: atmospheric life (yr)	ODP	GWP 100 yr
704	He – helium	4.00	-268.9	-452.0	-267.9	-450.2	0.23	33		none			A1		0.000	
729	air	28.97	-194.4	-317.9	-140.7	-221.3	3.77	547		none					0.000	0
50	CH4 – methane	16.04	-161.5	-258.7	-82.5	-116.5	4.64	673	1000	5			A3	12.2	0.000	24
14	CF4 – carbon tetrafluoride	88.00	-128.1	-198.6	-45.6	-50.1	3.75	544		none			A1	50000	0.000	5700
1150	CH2=CH2 – ethylene	28.05	-109.4	-164.9	9.3	48.7	5.11	741	1000	2.7			A3		0.000	
170	CH3CH3 – ethane	30.07	-88.6	-127.5	32.2	90.0	4.87	706	1000	3.2			A3		0.000	~20
503	R-23/13 (40.1/59.9)	87.25	-87.5	-125.5	18.4	65.1	4.27	619	1000	none					0.599	14300
508A	R-23/116 (39.0/61.0) – Klea 5R3	100.10	-87.4	-125.3	11.0	51.8	3.70	537	1000	none			A1		0.000	12700
508B	R-23/116 (46.0/54.0) – Suva 95	95.39	-87.4	-125.3	14.0	57.2	3.93	570	1000	none			A1/A1		0.000	13000
23	CHF3 – fluoroform	70.01	-82.1	-115.8	25.9	78.6	4.84	702	1000	none	-12.5	-5374	A1	243	0.000	14800
13	CClF3	104.46	-81.3	-114.3	29.2	84.6	3.92	569	1000	none	-3.0	-1290	A1	640	1.000	10000
744	CO2 – carbon dioxide	44.01	-78.4	-109.1	31.1	88.0	7.38	1070	5000	none			A1	>50	0.000	1
116	CF3CF3 – perfluoroethane	138.01	-78.2	-108.8	19.9	67.8	3.04	441	1000	none			A1	10000	0.000	11400
41	CH3F – methyl fluoride	34.03	-78.1	-108.6	44.1	111.4	5.90	856						3.7	0.000	140
——	R-23/125/143a (20.0/36.0/44.0) – ES20	90.16	-64.8	-84.6	67.3	153.1	4.03	585							0.000	6700
13B1	CBrF3 – halon 1301	148.91	-57.7	-71.9	67.1	152.8	3.96	574	1000	none			A1	65	12.000	6900
504	R-32/115 (48.2/51.8)	79.25	-57.7	-71.9	62.1	143.8	4.44	644		none					0.207	5760
32	CH2F2 – methylene fluoride	52.02	-51.7	-61.1	78.2	172.8	5.78	838	1000	13.3	9.4	4041	A2	5.6	0.000	880
410A	R-32/125 (50.0/50.0) – Suva 9100; AZ-20	72.58	-51.6	-60.9	72.5	162.5	4.95	718	1000	none	-4.4	-1892	A1/A1		0.000	2340
410B	R-32/125 (45.0/55.0)	75.57	-51.5	-60.7	71.0	159.8	4.78	693		none			A1/A1		0.000	2490
——	R-32/125 (32.0/68.0) – FX-80	84.63	-51.1	-60.0	67.7	153.9	4.40	638							0.000	2870
——	R-170/290 (6.0/94.0) – ER22/502	42.90	-50.0	-58.0	91.2	196.2	4.29	622		1.9					0.000	~21
——	R-32/125/143a/134a (10.0/33.0/36.0/21.0) – HX4	90.80	-49.4	-56.9	77.5	171.5	4.01	582		none					0.000	3620
402A	R-125/290/22 (60.0/2.0/38.0) – HP80	101.55	-49.2	-56.6	76.0	168.8	4.23	614		none	-1.4	-602	A1/A1		0.013	3000
——	R-32/125/143a (10.0/45.0/45.0) – FX-40	90.69	-48.4	-55.1	72.0	161.6	4.05	587		none					0.000	4230
——	R-23/22/152a (5.0/90.0/5.0) – NARM-502	84.18	-48.4	-55.1	94.4	201.9	5.10	740	1000	none					0.031	2460
125	CHF2CF3	120.02	-48.1	-54.6	66.2	151.2	3.63	526	1000	none	-1.5	-645	A1	32.6	0.000	3800
1270	CH3CH=CH2 – propylene	42.08	-47.7	-53.9	92.4	198.3	4.67	677	375	2.0			B3 r		0.000	
——	R-125/143a/290/22 (42.0/6.0/2.0/50.0) – DI-44	95.70	-47.7	-53.9	81.0	177.8	4.45	645	1000	none					0.017	2870
143a	CH3CF3	84.04	-47.2	-53.0	72.9	163.2	3.78	548	1000	7.1	10.3	4428	A2	53.5	0.000	5400
402B	R-125/290/22 (38.0/2.0/60.0) – HP81	94.71	-47.2	-53.0	83.0	181.4	4.53	657		none	-1.6	-688	A1/A1		0.020	2580
507A	R-125/143a (50.0/50.0) – AZ-50	98.86	-47.1	-52.8	70.9	159.6	3.79	550		none	-5.5	-2365	A1		0.000	4600
——	R-23/22/152a (5.0/80.0/15.0) – NARM-22	81.72	-47.0	-52.6	97.2	207.0	5.04	731	1000	wff					0.027	2290
407B	R-32/125/134a (10.0/70.0/20.0) – Klea 61	102.94	-46.8	-52.2	74.4	165.9	4.08	592	1000	none	-1.8	-774	A1/A1		0.000	3070
404A	R-125/143a/134a (44.0/52.0/4.0) – HP62 and FX-70	97.60	-46.6	-51.9	72.1	161.8	3.74	542	1000	none	-6.6	-2837	A1/A1		0.000	4540
408A	R-125/143a/22 (7.0/46.0/47.0) – FX-10	87.01	-45.5	-49.9	83.3	181.9	4.42	641		none	5.7	2451	A1/A1		0.016	3640
502	R-22/115 (48.8/51.2)	111.63	-45.3	-49.5	80.7	177.3	4.02	583	1000	none			A1		0.221	6200
407A	R-32/125/134a (20.0/40.0/40.0) – Klea 60	90.11	-45.2	-49.4	81.9	179.4	4.49	651	1000	none	-3.6	-1548	A1/A1		0.000	2340
403A	R-290/22/218 (5.0/75.0/20.0) – 69-S	91.99	-44.0	-47.2	91.2	196.2	4.69	680	1000	none			A1/A1		0.026	3150
403B	R-290/22/218 (5.0/56.0/39.0) – 69-L	103.26	-43.8	-46.8	88.7	191.7	4.40	638	1000	none			A1/A1		0.019	4420
407C	R-32/125/134a (23.0/25.0/52.0) – Klea 66; Suva 9000	86.20	-43.8	-46.8	87.3	189.1	4.63	672	1000	none	-4.9	-2107	A1/A1		0.000	1980
——	R-32/125/134a (30.0/10.0/60.0)	80.13	-43.4	-46.1	89.1	192.4	4.87	706		wff					0.000	1600
407E	R-32/125/134a (25.0/15.0/60.0)	83.78	-42.8	-45.0	88.8	191.8	4.73	686	1000	none	-4.8	-2064	A1/A1		0.000	1750
——	R-23/32/134a (4.5/21.5/74.0) – FX-220	83.14	-42.2	-44.0	89.0	192.2	4.90	711		none					0.000	2040
290	CH3CH2CH3 – propane	44.10	-42.1	-43.8	96.7	206.1	4.25	616	2500	2.3	50.3	21625	A3		0.000	~20
E125	CHF2-O-CF3	136.02	-42.0	-43.6	81.3	178.3	3.35	486						165	0.000	15300
——	R-32/134a (30.0/70.0)	79.19	-41.8	-43.2	92.4	198.3	4.94	716	1000	wff					0.000	1380
411C	R-1270/22/152a (3.0/95.5/1.5) – G2018C	83.44	-41.8	-43.2	95.5	203.9	4.95	718		none			A1/A1r		0.032	1820
411B	R-1270/22/152a (3.0/94.0/3.0)	83.07	-41.6	-42.9	96.0	204.8	4.95	718	1000	wff	6.5	2794	A1/A2		0.032	1790
22	CHClF2	86.47	-40.8	-41.4	96.2	205.2	4.99	724	1000	none	2.2	946	A1	11.8	0.034	1900
501	R-22/12 (75.0/25.0)	93.10	-40.5	-40.9	96.2	205.2	4.76	690		none			A1		0.231	4080
509A	R-22/218 (44.0/56.0) – Arcton TP5R2	123.96	-40.4	-40.7	87.2	189.0	4.03	585	1000	none			A1		0.015	5650
——	R-32/134a (25.0/75.0)	82.26	-40.3	-40.5	93.7	200.7	4.83	701		wff					0.000	1420
411A	R-1270/22/152a (1.5/87.5/11.0)	82.36	-39.7	-39.5	99.1	210.4	4.95	718	1000	wff			A1/A2		0.030	1680
407D	R-32/125/134a (15.0/15.0/70.0)	90.96	-39.4	-38.9	91.6	196.9	4.48	650	1000	none	-4.3	-1849	A1/A1		0.000	1820
115	CClF2CF3	154.47	-38.9	-38.0	80.0	176.0	3.12	453	1000	none	-2.1	-903	A1	1700	0.400	10300
——	R-125/134a/600 (46.6/50.0/3.4) – Isceon 59	106.75	-38.0	-36.4	89.9	193.8	4.10	595		none					0.000	2570
161	CH3CH2F – ethyl fluoride	48.06	-37.1	-34.8	102.2	216.0	4.70	682		3.8				0.25	0.000	10
218	CF3CF2CF3 – perfluoropropane	188.02	-36.6	-33.9	71.9	161.4	2.68	389	1000	none			A1	2600	0.000	8600
409B	R-22/124/142b (65.0/25.0/10.0) – FX-57	96.67	-36.5	-33.7	104.4	219.9	4.71	683		none			A1/A1		0.033	1620
412A	R-22/218/142b (70.0/5.0/25.0) – Arcton TP5R	92.17	-36.4	-33.5	107.5	225.5	4.88	708	1000	wff			A1/A2		0.035	2340
401B	R-22/152a/124 (61.0/11.0/28.0) – MP66	92.84	-35.7	-32.3	103.5	218.3	4.68	679	1000	none	-2.7	-1161	A1/A1		0.028	1350
409A	R-22/124/142b (60.0/25.0/15.0) – FX-56	97.43	-35.4	-31.7	106.9	224.4	4.69	680	1000	none	3.0	1290	A1/A1		0.039	1640
——	R-22/600a/142b (65.0/4.0/31.0) – GHG-HP	88.57	-35.0	-31.0	112.2	234.0	4.95	718		wff					0.035	1950
——	R-22/124/600 (50.0/47.0/3.0) – DI-36	102.64	-34.8	-30.6	102.6	216.7	4.56	661	900	none					0.029	1240
401A	R-22/152a/124 (53.0/13.0/34.0) – MP39	94.44	-34.4	-29.9	105.3	221.5	4.61	669	1000	none			A1/A1		0.027	1240

continued on next page

TABLE 2 *(continued)*

refrigerant		physical data							safety data					environmental data		
			NBP		Tc		Pc				HOC					
number	chemical formula or blend composition – common name	molecular mass	(°C)	(°F)	(°C)	(°F)	(MPa)	(psia)	TLV-TWA (PPM)	LFL (%)	MJ/kg	Btu/lb	Std 34 safety group	atmospheric life (yr)	ODP	GWP 100 yr
414B	R-22/124/600a/142b (50.0/39.0/1.5/9.5) – HOT SHOT	101.59	-34.4	-29.9	108.0	226.4	4.59	666		none			A1/A1r		0.031	1410
414A	R-22/124/600a/142b (51.0/28.5/4.0/16.5) – GHG-X4	96.93	-34.0	-29.2	110.7	231.3	4.70	682	1000		3.6	1548	A1/A1r		0.032	1530
500	R-12/152a (73.8/26.2)	99.30	-33.6	-28.5	102.1	215.8	4.17	605	1000	none			A1		0.605	7870
C270	-CH2-CH2-CH2- – cyclopropane	42.08	-33.5	-28.3	125.2	257.4	5.58	809		2.4					0.000	
717	NH3 – ammonia	17.03	-33.3	-27.9	132.3	270.1	11.34	1645	25	14.8	22.5	9673	B2		0.000	<1
405A	R-22/152a/142b/C318 (45.0/7.0/5.5/42.5) – G2015	111.91	-32.9	-27.2	106.0	222.8	4.29	622	1000	none			d		0.018	5750
——	R-290/600a (50.0/50.0)	50.15	-32.8	-27.0	114.8	238.6	4.04	586		2					0.000	~20
406A	R-22/600a/142b (55.0/4.0/41.0) – GHG	89.86	-32.7	-26.9	116.5	241.7	4.88	708		wff			A1/A2		0.036	1990
——	R-22/227ea/600a/142b (41.0/40.0/4.0/15.0 – GHG-X5	107.82	-32.4	-26.3	108.2	226.8	4.37	634							0.020	2640
——	R-22/152a/124 (40.0/17.0/43.0) – MP33	96.61	-31.9	-25.4	108.3	226.9	4.50	653		none	-3.7	-1591			0.025	1060
401C	R-22/152a/124 (33.0/15.0/52.0) – MP52	101.03	-30.5	-22.9	109.9	229.8	4.40	638		none			A1/A1		0.025	980
505	R-12/31 (78.0/22.0)	103.48	-30.0	-22.0	117.8	244.0	4.73	686		none					0.642	
12	CCl2F2	120.91	-29.8	-21.6	112.0	233.6	4.14	600	1000	none	-0.8	-344	A1	100	0.820	10600
——	R-134a/600a (80.0/20.0) – Electrolux RC	88.64	-29.5	-21.1	111.3	232.3	4.81	698		3.9					0.000	1280
413A	R-218/134a/600a (9.0/88.0/3.0) – ISCEON 49	103.95	-29.3	-20.7	101.4	214.5	4.24	615		wff			A1/A2		0.000	2180
——	R-22/142b (40.0/60.0)	94.37	-27.9	-18.2	123.1	253.6	4.72	685		wff					0.039	2140
——	R-22/12/142b (25.0/15.0/60.0) – R-176	98.99	-26.9	-16.4	129.4	264.9	5.10	740	1000	wff					0.157	3450
134a	CH2FCF3	102.03	-26.1	-15.0	101.1	214.0	4.06	589	1000	none	4.2	1806	A1	13.6	0.000	1600
E170	CH3-O-CH3 – dimethyl ether	46.07	-24.8	-12.6	128.8	263.8	5.32	772	1000	3.4				0.015	0.000	<1
40	CH3Cl – methyl chloride	50.49	-24.2	-11.6	143.1	289.6	6.67	967	50	8.1			B2	1.3	0.020	16
E143a	CH3-O-CF3	100.04	-24.1	-11.4	104.9	220.8	3.59	521						5.7	0.000	970
——	R-134a/142b (80.0/20.0) – Freeze	101.71	-24.1	-11.4	107.5	225.5	4.12	598							0.010	1400
152a	CH3CHF2	66.05	-24.0	-11.2	113.3	235.9	4.52	656	1000	3.1	17.4	7481	A2	1.5	0.000	190
416A	R-134a/124/600 (59.0/39.5/1.5) – FR-12	111.92	-23.4	-10.1	108.2	226.8	4.02	583			7.8	3353	A1/A1r		0.010	1190
——	R-134a/124/600 (59.0/39.0/2.0) – DI-24	111.31	-23.4	-10.1	108.6	227.5	4.04	586		wff					0.010	1190
400 ->	R-12/114 (60.0/40.0) – R-400(60/40)	136.94	-23.2	-9.8	125.4	257.7	3.99	579		none			A1/A1		0.832	10280
134	CHF2CHF2	102.03	-23.0	-9.4	119.0	246.2	4.62	670	1000	none	4.3	1849		10.6	0.000	1200
13I1	CF3I	195.91	-22.5	-8.5	122.0	251.6				none				<0.1	0.000	<1
400 ->	R-12/114 (50.0/50.0) – R-400(50/50)	141.63	-20.8	-5.4	128.9	264.0	3.92	569		none			A1/A1		0.835	10200
227ea	CF3CHFCF3	170.03	-15.6	3.9	102.8	217.0	2.98	432	1000	none	3.3	1419		36.5	0.000	3800
——	R-290/124/123 (3.0/40.0/57.0)	136.27	-15.3	4.5	151.1	304.0	3.99	579							0.017	320
506	R-31/114 (55.1/44.9)	93.69	-12.3	9.9	142.2	288.0	5.16	748		none					0.387	
124	CHClFCF3	136.48	-12.0	10.4	122.3	252.1	3.62	525	1000	none	0.9	387	A1	6.1	0.026	620
600a	CH(CH3)2-CH3 – isobutane	58.12	-11.6	11.1	134.7	274.5	3.64	528	800	1.8	49.4	21238	A3		0.000	~20
764	SO2 – sulfur dioxide	64.06	-10.0	14.0	157.5	315.5	7.88	1143	2	none			B1		0.000	
31	CH2ClF	68.48	-9.1	15.6					0.1						0.010	
142b	CH3CClF2	100.49	-9.0	15.8	137.1	278.8	4.12	598	1000	6.9	9.8	4213	A2	18.5	0.043	2300
630	CH3(NH2) – methylamine	31.06	-6.7	19.9	156.9	314.4	7.46	1082	5	4.9					0.000	
——	R-600a/600 (50.0/50.0) – isobutane/butane	58.12	-6.5	20.3	143.6	290.5	3.73	541		1.8					0.000	~20
C318	-CF2-CF2-CF2-CF2-	200.03	-6.0	21.2	115.2	239.4	2.78	403	1000	none			d	3200	0.000	11200
12B1	CBrClF2 – halon 1211	165.36	-4.0	24.8	154.0	309.2	4.10	595	~~1000~~	none				11	5.100	1300
236fa	CF3CH2CF3	152.04	-1.4	29.5	124.9	256.8	3.20	464	1000	none			A1	226	0.000	9400
600	CH3-CH2-CH2-CH3 – butane	58.12	-0.5	31.1	152.0	305.6	3.80	551	800	1.9	49.5	21281	A3		0.000	~20
——	R-290/600 (60.0/40.0 by liquid volume) – OZ-12	48.81													0.000	~20
114	CClF2CClF2	170.92	3.6	38.5	145.7	294.3	3.26	473	1000	none	-3.1	-1333	A1	300	0.850	9800
143	CH2FCHF2	84.04	5.0	41.0	156.7	314.1	5.24	760		5.8	10.9	4686		3.8	0.020	370
E245cb1	CH3-O-CF2-CF3	150.05	5.6	42.1	133.7	272.7	2.89	419		none				1.2	0.000	160
E134	CHF2-O-CHF2	118.03	6.2	43.2	160.8	321.4	4.23	614		none				29.7	0.000	6900
21	CHCl2F	102.92	8.9	48.0	178.3	352.9	5.18	751	10	none			B1	2.0	0.010	210
601b	(CH3)4C – neopentane	72.15	9.5	49.1	160.6	321.1	3.20	464	600	1.4					0.000	
160	CH3CH2Cl – ethyl chloride	64.51	13.1	55.6	187.2	369.0	5.24	760	100	3.8	20.6	8856		<1	0.000	
245fa	CHF2CH2CF3	134.05	15.1	59.2	154.1	309.4	4.43	643	500 p	none	6.1	2623	A1p r	8.8	0.000	820
631	CH3-CH2(NH2) – ethylamine	45.08	16.6	61.9	183.0	361.4	5.62	815	5	3.5					0.000	
338mcf	CF3CH2CF2CF3	202.05	19.9	67.8	150.6	303.1	2.50	363		none					0.000	
11	CCl3F	137.37	23.7	74.7	198.0	388.4	4.41	640	C1000	none	0.9	387	A1	45	1.000	4600
12B2	CBr2F2 – halon 1202	209.82	24.5	76.1	198.2	388.8			100	none					1.700	
245ca	CH2FCF2CHF2	134.05	25.1	77.2	174.4	345.9	3.94	571		7.1	8.4	3611		6.6	0.000	720
123	CHCl2CF3	152.93	27.8	82.0	183.8	362.8	3.66	531	50	none	2.1	903	B1	1.4	0.012	120
338mcc	CH2FCF2CF2CF3	202.05	27.8	82.0	158.8	317.8	2.73	396							0.000	
601a	(CH3)2CH-CH2-CH3 – isopentane	72.15	27.8	82.0	187.4	369.3	3.37	489	600	1.4					0.000	
E347mmy1	CF3-CF(OCH3)-CF3	200.05	29.4	84.9	160.2	320.4	2.55	370						3.5	0.000	340
611	HCOOCH3 – methyl formate	60.05	31.8	89.2	214.0	417.2	5.99	869	100	5.1			B2		0.000	
141b	CH3CCl2F	116.95	32.0	89.6	204.2	399.6	4.25	616	500	6.4	8.6	3697		9.2	0.086	700
610	CH3-CH2-O-CH2-CH3 – ethyl ether	74.12	34.6	94.3	214.0	417.2	6.00	870	400	1.9					0.000	
601	CH3-CH2-CH2-CH2-CH3 – pentane	72.15	36.2	97.2	196.4	385.5	3.36	487	600	1.4				<<1	0.000	11
30	CH2Cl2 – methylene chloride	84.93	40.2	104.4	237.0	458.6	6.08	882	50	14.6			B2	0.46	0.000	10
113	CCl2FCClF2	187.37	47.6	117.7	214.1	417.4	3.39	492	1000	none	0.1	43	A1	85	0.900	6000
1130	CHCl=CHCl – dielene	96.94	47.8	118.0	243.3	469.9	5.48	795	200	5.6						
718	H2O – water	18.02	100.0	212.0	374.2	705.6	22.10	3205		none			A1		0.000	<1

NBP = normal boiling point; Tc = critical temperature; Pc = critical pressure; TLV-TWA = ACGIH Threshold Limit Value - Time-Weighted Average, or consistent chronic exposure limit (e.g., OSHA Permissible Exposure Limit, PEL), unless preceded by "C" for TLV-Ceiling; LFL = lower flammability limit (% volume in air), "wff" signifies that the worst case of fractionation may become flammable; HOC = heat of combustion; ODP = ozone depletion potential (modeled); GWP = global warming potential (for 100 yr integration)

Suffixes to safety classifications indicate recommended changes that are not final yet ("d" for deletion and "r" for revision or addition) or classifications assigned as provisional ("p").

Data sources are identified in the Refrigerant Database; verify the data and associated limitations in these sources before use.