

INTERNATIONAL STANDARD

ISO 817

Second edition
2005-01-15

Refrigerants — Designation system

Fluides frigorigènes — Système de désignation

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Reference number
ISO 817:2005(E)

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Published in Switzerland

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 817 was prepared by Technical Committee ISO/TC 86, *Refrigeration and air-conditioning*, Subcommittee SC 8, *Refrigerants and refrigeration lubricants*.

This second edition cancels and replaces the first edition (ISO 817:1974), which has been technically revised.

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Refrigerants — Designation system

1 Scope

This International Standard provides an unambiguous system for numbering and assigning composition-designating prefixes to refrigerants. Tables listing the refrigerant designations are included. It is intended to be used with other relevant safety standards such as ISO 5149, IEC 60335-2-24 and IEC 60335-2-40.

2 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

2.1

azeotrope

blend composed of two or more refrigerants whose equilibrium vapor and liquid phase compositions are the same at a given pressure, but may be different at other conditions

2.2

blends

mixtures composed of two or more refrigerants

2.3

compound

substance composed of two or more atoms chemically bonded in definite proportions

2.4

cyclic compound

organic compound whose structure is characterized by a closed ring of atoms

2.5

isomers

two or more compounds having the same chemical composition with differing molecular configurations

NOTE Isomers will have different physical properties.

EXAMPLE R-600 ($\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$), with a boiling point of 0 °C and R-600a ($\text{CH}(\text{CH}_3)_2\text{CH}_3$) with a boiling point of -12 °C. Both of these compounds contain 4 carbon and 10 hydrogen atoms.

2.6

nominal composition

liquid phase composition of refrigerant blends

NOTE For the refrigerant blends, see Tables 2 and 3.

2.7

refrigerant

fluid used for heat transfer in a mechanical refrigerating system, which absorbs heat at a low temperature and a low pressure of the fluid and rejects it at a higher temperature and a higher pressure of the fluid, usually involving changes of the phase of the fluid

- 2.8**
relative molar mass
mass numerically equal to the molecular mass expressed in grams per mol, except that it is dimensionless
- 2.9**
unsaturated organic compound
organic (carbon-containing) compound containing at least one double or triple bond between carbon atoms
- 2.10**
saturated organic compound
organic (carbon-containing) compound that has only single bonds between carbon atoms
- 2.11**
zeotrope
blend composed of two or more refrigerants whose equilibrium vapour and liquid phase compositions are not the same at any point

3 Numbering of refrigerants

- 3.1** An identifying number of 2 to 4 digits shall be assigned to each refrigerant, as follows.
- 3.2** The identifying numbers assigned to the hydrocarbons, halocarbons and ethers of the methane, ethane, propane, and cyclobutane series are such that the chemical composition of the compounds can be explicitly determined from the refrigerant numbers, and vice versa, without ambiguity. The molecular structure can be similarly determined for the methane, ethane, and most of the propane series.
- 3.2.1** The first digit on the right is the number of fluorine (F) atoms in the compound.
- 3.2.2** The second digit from the right is one more than the number of hydrogen (H) atoms in the compound.
- 3.2.3** The third digit from the right is one less than the number of carbon (C) atoms in the compound. When this digit is zero, it is omitted from the number.
- 3.2.4** The fourth digit from the right is equal to the number of carbon-carbon double bonds in the compound. When this digit is zero, it is omitted from the number.
- 3.2.5** In those instances where bromine (Br) or iodine (I) is present, the same rules apply, except that the upper case letter B or I after the designation for the chlorofluoro compound shows the presence of bromine or iodine. The number following the letter B or I shows the number of bromine or iodine atoms present.
- 3.2.6** The number of chlorine (Cl) atoms in the compound is found by subtracting the sum of fluorine (F), bromine (Br), iodine (I) and hydrogen (H) atoms from the total number of atoms that can be connected to the carbon (C) atoms. For saturated organic compounds, this number is $2n + 2$, where n is the number of carbon atoms. The number is $2n$ for compounds with one double bond and saturated cyclic compounds.
- 3.2.7** The carbon atoms shall be numbered sequentially, in order of appearance, with the number 1 assigned to the end carbon with the greatest number of hydrogen substituents. In the case where both end carbons contain the same number of (but different) halogen atoms, the number 1 shall be assigned to the first end carbon, defined as having the largest number of bromine then chlorine then fluorine, and then iodine atoms.
- 3.2.8** For cyclic compounds, the letter C is used before the identifying refrigerant numbers.

EXAMPLE R-C318, PFC-C318.

3.2.9 In the case of isomers in the ethane series, each has the same number, with the most symmetrical one indicated by the number alone. As the isomers become more and more unsymmetrical, successive lower case letters (i.e., a, b, or c) are appended. Symmetry is determined by first summing the atomic mass of the halogen and hydrogen atoms attached to each carbon atom. One sum is subtracted from the other; the smaller the absolute value of the difference, the more symmetrical the isomer.

3.2.10 In the case of isomers in the propane series, each has the same number, with the isomers distinguished by two appended lower case letters. The first appended letter indicates the substitution on the central carbon atom (C2):

-CCl ₂ -	a
-CClF-	b
-CF ₂ -	c
-CClH-	d
-CFH-	e
-CH ₂ -	f

For halogenated derivatives of cyclopropane, the carbon atom with the largest sum of attached atomic masses shall be considered the central carbon atom; for these compounds, the first appended letter is omitted. The second appended letter indicates the relative symmetry of the substituents on the end carbon atoms (C1 and C3). Symmetry is determined by first summing the atomic masses of the halogen and hydrogen atoms attached to the C1 and C3 carbon atoms. One sum is subtracted from the other; the smaller the absolute value of this difference, the more symmetrical the isomer. In contrast to the ethane series, however, the most symmetrical isomer has a second appended letter of "a" (as opposed to no appended letter for ethane isomers); increasingly asymmetrical isomers are assigned successive letters. Appended letters are omitted when no isomers are possible, and the number alone represents the molecular structure unequivocally; for example, CF₃CF₂CF₃ is designated R-218, not R218ca. An example of this system is given in Annex A. Bromine containing propane series isomers are not covered by the appended letters tabulated above because no such refrigerants have been identified.

3.3 Ether-based refrigerants shall be designated with the prefix "E" (for "ethers") immediately preceding the number. Except for the following differences, the basic number designations for the hydrocarbon atoms shall be determined according to the current standard for hydrocarbon nomenclature (see 3.2).

3.3.1 Two-carbon, dimethyl ethers (e.g. R-E125, CHF₂-O-CF₃) require no suffixes other than those specified in 3.2.9, as the presence of the "E" prefix provides an unambiguous description.

3.3.2 For straight-chain, three carbon ethers, the carbon atoms shall be numbered sequentially, in order of appearance, with the number 1 assigned to the end carbon with the highest number of halogens. In the case where both end carbons contain the same number of (but different) halogen atoms, the number 1 shall be assigned to the first end carbon, defined as having the largest number of bromine, then chlorine, then fluorine and then iodine atoms.

3.3.2.1 An additional integer identifying the first carbon to which the ether oxygen is attached shall be appended to the suffix letters (e.g. R-E236ea2, CHF₂-O-CHF-CF₃).

3.3.2.2 In the case of otherwise symmetric hydrocarbon structures, the ether oxygen shall be assigned to the carbon which has the leading position in the formula.

3.3.2.3 In those cases where only a single isomer exists for the hydrocarbon portion of the ether structure, such as CF₃-O-CF₂-CF₃, the suffix letters described in 3.2.9 shall be omitted. In this cited example, the correct designation shall be R-E218.

3.3.2.4 Structures containing two oxygen atoms, di-ethers, shall be designated with two suffix integers to designate the positions of the ether oxygen atoms.

3.3.3 For cyclic ethers carrying both the "C" and "E" prefixes, the "C" shall precede the "E," as "CE," to designate "cyclic ethers." For four-membered cyclic ethers, including three carbon and one ether oxygen atom, the basic number designations for the hydrocarbon atoms shall be constructed according to the current standard for hydrocarbon nomenclature (subsection 3.2).

3.4 Blends are assigned a refrigerant number in the 400 or 500 series.

3.4.1 Zeotropes shall be serially assigned an identifying number in the 400 series. In order to differentiate among the different zeotropes having the same refrigerants but a different composition, a capital letter (A, B, C...) is added after the number.

3.4.2 Azeotropes shall be serially assigned an identifying number in the 500 series. In order to differentiate among the different azeotropes having the same refrigerants but a different composition, a capital letter (A, B, C...) is added after the number.

3.5 Miscellaneous organic compounds shall be serially assigned an identifying number in the 600 series.

3.6 Inorganic compounds shall be assigned identifying numbers in the 700 series and 7 000 series.

3.6.1 For compounds with molecular masses less than 100, the number shall be the sum of 700 and the relative molar mass, rounded to the nearest integer.

3.6.2 For compounds with molar masses equal to or greater than 100, the identifying number shall be the sum of 7 000 and the relative molar mass, rounded to the nearest integer.

3.6.3 When two or more inorganic refrigerants have the same molar masses, capital letters (i.e., A, B, C, etc.) shall be added in serial order of designation to distinguish among them.

4 Designation prefixes

4.1 General prefixes

The identifying number, as determined according to Clause 3, may be preceded by the letter R or the word "Refrigerant" ("Refrigerants" if more than one).

EXAMPLE R134a, Refrigerant 134a, R 134a, R-134a.

4.2 Composition-designating prefixes

For the fluorocarbon and the hydrocarbon families, the identifying number, as determined according to Clause 3, may be prefixed by a letter sequence which designates the elements which constitute the specific compound. The composition-designating prefix shall consist of the first letter of elements contained in the compound. The first element listed shall be "H" for hydrogen if present and the last shall be "C" for carbon. The intermediate letters shall represent the halogens listed in the following order: "I" for iodine, "B" for bromine, "C" for chlorine and "F" for fluorine. The compositional designating prefixes for ethers shall substitute an "E" for "C" (carbon), such that HFE, HCFE, and CFE refer to hydrofluoroether, hydrochlorofluoroether, and chlorofluoroether, respectively. In addition, when a refrigerant compound is fully fluorinated, the notation PFC shall be used.

EXAMPLE 1	Chlorofluorocarbon 12	CCl_2F_2	CFC-12
EXAMPLE 2	Hydrochlorofluorocarbon 22	CHClF_2	HCFC-22
EXAMPLE 3	Hydrofluorocarbon 134a	CH_2FCF_3	HFC-134a
EXAMPLE 4	Perfluorocarbon 116	CF_3CF_3	PFC-116
EXAMPLE 5	Hydrocarbon 600a	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$	HC-600a
EXAMPLE 6	Perfluorocarbon C318	$\text{CF}_2\text{CF}_2\text{CF}_2\text{CF}_2$	PFC-C318

Blends with assigned numbers may be identified by linking the appropriate composition-designating prefixes of individual components.

EXAMPLE 7 (CFC/HFC-500).

Blends without assigned numbers may be identified using appropriate composition-designating prefixes for each component.

EXAMPLE 8 HCFC-22/HFC-152a/CFC-114 [36/24/40].

5 Refrigerant and refrigerant blend designations

See Tables 1 to 3.

Table 1 — Refrigerant designations

Refrigerant number	Composition designating prefix	Chemical name ^b	Chemical formula	Molar mass ^a g/mole	Normal boiling point ^a °C
Methane series					
R-11	CFC	trichlorofluoromethane	CCl ₃ F	137,4	24
R-12	CFC	dichlorodifluoromethane	CCl ₂ F ₂	120,9	-30
R-12B1	BCFC	bromochlorodifluoromethane	CBrClF ₂	165,4	-4
R-13	CFC	chlorotrifluoromethane	CClF ₃	104,5	-81
R-13B1	BFC	bromotrifluoromethane	CBrF ₃	148,9	-58
R-14	PFC	tetrafluoromethane (carbon tetrafluoride)	CF ₄	88,0	-128
R-21	HCFC	dichlorofluoromethane	CHCl ₂ F	102,9	9
R-22	HCFC	chlorodifluoromethane	CHClF ₂	86,5	-41
R-23	HFC	trifluoromethane	CHF ₃	70,0	-82
R-30	HCC	dichloromethane (methylene chloride)	CH ₂ Cl ₂	84,9	40
R-31	HCFC	chlorofluoromethane	CH ₂ ClF	68,5	-9
R-32	HFC	difluoromethane (methylene fluoride)	CH ₂ F ₂	52,0	-52
R-40	HCC	chloromethane (methyl chloride)	CH ₃ Cl	50,5	-24
R-41	HFC	fluoromethane (methyl fluoride)	CH ₃ F	34,0	-78
R-50	HC	methane	CH ₄	16,0	-161
Ethane series					
R-113	CFC	1,1,2-trichloro-1,2,2-trifluoroethane	CCl ₂ CClF ₂	187,4	48
R-114	CFC	1,2-dichloro-1,1,2,2-tetrafluoroethane	CClF ₂ CClF ₂	170,9	4
R-115	CFC	chloropentafluoroethane	CClF ₂ CF ₃	154,5	-39
R-116	PFC	hexafluoroethane	CF ₃ CF ₃	138,0	-78
R-123	HCFC	2,2-dichloro-1,1,1-trifluoroethane	CHCl ₂ CF ₃	153,0	27
R-124	HCFC	2-chloro-1,1,1,2-tetrafluoroethane	CHClCF ₃	136,5	-12
R-125	HFC	pentafluoroethane	CHF ₂ CF ₃	120,0	-49
R-134a	HFC	1,1,1,2-tetrafluoroethane	CH ₂ FCF ₃	102,0	-26
R-141b	HCFC	1,1-dichloro-1-fluoroethane	CH ₃ CCl ₂ F	117,0	32
R-142b	HCFC	1-chloro-1,1-difluoroethane	CH ₃ CClF ₂	100,5	-10
R-143a	HFC	1,1,1-trifluoroethane	CH ₃ CF ₃	84,0	-47
R-152a	HFC	1,1-difluoroethane	CH ₃ CHF ₂	66,0	-25
R-170	HC	ethane	CH ₃ CH ₃	30,0	-89

Table 1 (Continued)

Refrigerant number	Composition designating prefix	Chemical name ^b	Chemical formula	Molar mass ^a g/mole	Normal boiling point ^a °C
Propane series					
R-218	PFC	octafluoropropane	CF ₃ CF ₂ CF ₃	188,0	-37
R-225ea	HCFC	1,3-dichloro-1,1,2,3,3-pentafluoropropane	CClF ₂ CHFCClF ₂	202,9	
R-227ea	HFC	1,1,1,2,3,3,3-heptafluoropropane	CF ₃ CFHCF ₃	170,0	-16
R-236fa	HFC	1,1,1,3,3,3-hexafluoropropane	CF ₃ CH ₂ CF ₃	152,0	-1
R-245fa	HFC	1,1,1,3,3-pentafluoropropane	CHF ₂ CH ₂ CF ₃	134,0	15
R-290	HC	Propane	CH ₃ CH ₂ CH ₃	44,0	-42
Cyclic organic compound					
R-C318	PFC	octafluorocyclobutane	$\left[\text{CF}_2\text{CF}_2\text{CF}_2\text{CF}_2 \right]$	200,0	-6
Misc. organic compounds/Hydrocarbons					
R-600	HC	butane	CH ₃ CH ₂ CH ₂ CH ₃	58,1	0
R-600a	HC	2-methyl propane (isobutane)	CH(CH ₃) ₂ CH ₃	58,1	-12
Oxygen compounds					
R-610		ethyl ether	CH ₃ CH ₂ OCH ₂ CH ₃	74,1	35
R-611		methyl formate	HCOOCH ₃	60,0	32
Sulfur compounds					
R-620		d	d	d	d
Nitrogen compounds					
R-630		methyl amine	CH ₃ NH ₂	31,1	-7
R-631		ethyl amine	CH ₃ CH ₂ (NH ₂)	45,1	17
Inorganic compounds					
R-702		hydrogen	H ₂	2,0	-253
R-704		helium	He	4,0	-269
R-717		ammonia	NH ₃	17,0	-33
R-718		water	H ₂ O	18,0	100
R-720		neon	Ne	20,2	-246
R-728		nitrogen	N ₂	28,1	-196
R-732		oxygen	O ₂	32,0	-183
R-740		argon	Ar	39,9	-186
R-744		carbon dioxide	CO ₂	44,0	-78 ^c
R-744A		nitrous oxide	N ₂ O	44,0	-90
R-764		sulfur dioxide	SO ₂	64,1	-10
Unsaturated organic compounds					
R-1132a	HFC	1,1-difluoroethene (vinylidene fluoride)	CH ₂ = CF ₂	64,0	-82
R-1150	HC	ethene (ethylene)	CH ₂ = CH ₂	28,1	-104
R-1270	HC	propene (propylene)	CH ₃ CH = CH ₂	42,1	-48
^a The molecular mass and normal boiling point are not part of this International Standard. The normal boiling point is the temperature at which a liquid substance boils at standard atmospheric pressure (101,3 kPa). ^b The preferred chemical name is followed by the popular name in parentheses. The preferred chemical name and formula are in accordance with [4] and [5]. See Bibliography. ^c Sublimes. ^d Reserved for future assignment.					

Table 2 — Refrigerant designations of R400 blends

Refrigerant number	Nominal composition ^c	Composition tolerances	Bubble point/ Dew point ^a
	mass %	%	°C
R-400	R-12/114 ^d		
R-401A	R-22/152a/124 (53/13/34)	±2,0/+0,5–1,5/±1,0	–33,3/–26,4
R-401B	R-22/152a/124 (61/11/28)	±2,0/+0,5–1,5/±1,0	–34,9/–28,8
R-401C	R-22/152a/124 (33/15/52)	±2,0/+0,5–1,5/±1,0	–30,5/–23,8
R-402A	R-125/290/22 (60/2/38)	±2,0/+0,1–1,0/±2,0	–49,0/–46,9
R-402B	R-125/290/22 (38/2/60)	±2,0/+0,1–1,0/±2,0	–47,0/–44,7
R-403A	R-290/22/218 (5/75/20)	+0,2–2,0/±2,0/±2,0	–47,8/–44,3
R-403B	R-290/22/218 (5/56/39)	+0,2–2,0/±2,0/±2,0	–49,2/–46,8
R-404A	R-125/143a/134a (44/52/4)	±2,0/±1,0/±2,0	–46,2/–45,5
R-405A	R-22/152a/142b/C318 (45/7/5,5/42,5)	±2,0/±1,0/±1,0/±2,0 ^b	–35,9/–24,5
R-406A	R-22/600a/142b (55/4/41)	±2,0/±1,0/±1,0	–32,7/–23,5
R-407A	R-32/125/134a (20/40/40)	±2,0/±2,0/±2,0	–45,3/–38,9
R-407B	R-32/125/134a (10/70/20)	±2,0/±2,0/±2,0	–46,8/–42,5
R-407C	R-32/125/134a (23/25/52)	±2,0/±2,0/±2,0	–43,6/–36,6
R-407D	R-32/125/134a (15/15/70)	±2,0/±2,0/±2,0	–39,5/–32,9
R-407E	R-32/125/134a (25/15/60)	±2,0/±2,0/±2,0	–42,9/–35,8
R-408A	R-125/143a/22 (7/46/47)	±2,0/±1,0/±2,0	–44,6/–44,1
R-409A	R-22/124/142b (60/25/15)	±2,0/±2,0/±1,0	–34,7/–26,4
R-409B	R-22/124/142b (65/25/10)	±2,0/±2,0/±1,0	–35,6/–27,9
R-410A	R-32/125 (50/50)	+0,5–1,5/+1,5–0,5	–51,4/–51,4
R-410B	R-32/125 (45/55)	±1,0/±1,0	–51,3/–51,6
R-411A	R-1270/22/152a (1,5/87,5/11,0)	+0,0–1,0/+2,0–0,0/+0,0–1,0	–39,5/–36,6
R-411B	R-1270/22/152a (3/94/3)	+0,0–1,0/+2,0–0,0/+0,0–1,0	–41,6/–40,0
R-412A	R-22/218/142b (70/5/25)	±2,0/±2,0/±1,0	–38,0/–28,7
R-413A	R-218/134a/600a (9/88/3)	±1,0/±2,0/+0,0–1,0	–30,6/–27,9
R-414A	R-22/124/600a/142b (51,0/28,5/4,0/16,5)	±2,0/±2,0/±0,5/+0,5–1,0	–34,0/–25,8
R-414B	R-22/124/600a/142b (50,0/39,0/1,5/9,5)	±2,0/±2,0/±0,5/+0,5–1,0	–32,9/–24,3
R-415A	R-22/152a (82,0/18,0)	±1,0/±1,0	–37,5/–34,7
R-416A	R-134a/124/600 (59,0/39,5/1,5)	+0,5–1,0/+1,0–0,5/+0,1–0,2	–23,4/–21,8
R-417A	R-125/134a/600 (46,6/50,0/3,4)	±1,1/±1,0/+0,1–0,4	–38,0/–32,9
R-418A	R-290/22/152a (1,5/96,0/2,5)	±0,5/±1,0/±0,5	–41,2/–40,1

^a The “bubble point” and the “dew point” temperatures are not part of this International Standard; they are provided for information only. The “bubble point” is defined as the liquid saturation temperature of a refrigerant: the temperature at which a liquid refrigerant first begins to boil. The bubble point of a zeotropic refrigerant blend, at constant pressure, is lower than the dew point. The “dew point” is defined as the vapour saturation temperature of a refrigerant: the temperature at which the last drop of liquid refrigerant boils. The dew point of a zeotropic refrigerant blend, at constant pressure, is higher than the bubble point.

^b The composition tolerances for the sum of R152a and R142b are (+0/–2).

^c Blend components are conventionally listed in order of increasing normal boiling point.

^d Shall be specified.

Table 3 — Refrigerant designations of R500 blends ¹⁾

Refrigerant number	Nominal composition ^d mass %	Composition tolerances %	Azeotropic temperature ^c °C	Bubble point/Dew point ^a °C
R-500	R-12/152a (73,8/26,2)	+1,0-0,0/+0,0-1,0	0	-33,6/-33,6
R-501	R-22/12 (75,0/25,0) ^b		-41	-40,5/-40,3
R-502	R-22/115 (48,8/51,2)		19	-45,2/-45,0
R-503	R-23/13 (40,1/59,9)		88	-87,8/-87,8
R-504	R-32/115 (48,2/51,8)		17	-57,1/-56,2
R-505	R-12/31 (78,0/22,0) ^b		115	
R-506	R-31/114 (55,1/44,9)		18	
R-507A	R-125/143a (50/50)	+1,5-0,5/+0,5-1,5	-40	-46,7/-46,7
R-508A	R-23/116 (39/61)	±2,0/±2,0	-86	-87,4/-87,4
R-508B	R-23/116 (46/54)	±2,0/±2,0	-46	-87,0/-87,0
R-509A	R-22/218 (44/56)	±2,0/±2,0	0	-49,8/-48,1

^a The “bubble point” and the “dew point” temperatures are not part of this International Standard; they are provided for information only. The “bubble point” is defined as the liquid saturation temperature of a refrigerant: the temperature at which a liquid refrigerant first begins to boil. The bubble point of a zeotropic refrigerant blend, at constant pressure, is lower than the dew point. The “dew point” is defined as the vapour saturation temperature of a refrigerant: the temperature at which the last drop of liquid refrigerant boils. The dew point of a zeotropic refrigerant blend, at constant pressure, is higher than the bubble point.

^b The exact composition of this azeotrope is in question, and additional experimental studies are needed.

^c Under vapour-liquid equilibrium (VLE) conditions.

^d Blend components are conventionally listed in order of increasing normal boiling point.

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1) Azeotropic refrigerants exhibit some segregation of components at conditions of temperature and pressure other than those at which they are formulated. The extent of segregation depends on the particular azeotrope and hardware system configuration.