

Australian/New Zealand Standard™

Refrigerants—Designation and safety classification



AS/NZS ISO 817:2016

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Australian Industry Group
Australian Institute of Refrigeration, Air Conditioning and Heating
Australian National Retailers Association
Australian Refrigeration Council
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Australian/New Zealand Standard™

Refrigerants—Designation and safety classification

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PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee ME-006 Refrigeration, to supersede AS/NZS 1677.1:1998 *Refrigerating systems, Part 1: Refrigerant classification*.

The objective of this Standard is to provide an unambiguous system for assigning designations to refrigerants. It also establishes a system for assigning a safety classification to refrigerants based on toxicity and flammability data.

This Standard does not address the hazards caused by products of combustion or decomposition of refrigerants. These products may include (but are not limited to) hydrogen fluoride. Exposure to these products can be harmful.

Lubricants and associated hazards are also not covered by this Standard. Lubricants can present significant health and environmental hazards.

This Standard is identical with, and has been reproduced from ISO 817:2014, *Refrigerants—Designation and safety classification*. This Standard is to be read in conjunction with the relevant legislation, regulation and national Refrigeration Industry Codes of Practice.

As this Standard is reproduced from an International Standard, the following applies:

- (a) In the source text ‘this International Standard’ should read ‘this Australian/New Zealand Standard’.
- (b) A full point substitutes for a comma when referring to a decimal marker.

None of the normative references in the source document have been adopted as Australian or Australian/New Zealand Standards.

The terms ‘normative’ and ‘informative’ have been used in this Standard to define the application of the annex to which they apply. A ‘normative’ annex is an integral part of a Standard, whereas an ‘informative’ annex is only for information and guidance.

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INTRODUCTION

This third edition has been technically revised by the addition of new refrigerant designations and a safety classification system based on toxicity and flammability data.

The safety classifications in this International Standard do not consider decomposition products or by-products of combustion. Product and system safety standards (e.g. ISO 5149, IEC 60335-2-24, IEC 60335-2-34, IEC 60335-2-40 and IEC 60335-2-89) address the prevention of ignition of refrigerant based on the characteristics provided in this International Standard.

AUSTRALIAN/NEW ZEALAND STANDARD

Refrigerants—Designation and safety classification**1 Scope**

This International Standard provides an unambiguous system for assigning designations to refrigerants. It also establishes a system for assigning a safety classification to refrigerants based on toxicity and flammability data, and provides a means of determining the refrigerant concentration limit. Tables listing the refrigerant designations, safety classifications and the refrigerant concentration limits are included based on data made available.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable to its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ANSI/ASHRAE Standard 34, *Designation and Safety Classification of Refrigerants*

ASTM E681, *Standard Test Method for Concentration Limits of Flammability of Chemicals (Vapours and Gases)*

3 Terms, definitions, abbreviated terms and symbols**3.1 Terms and definitions**

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

3.1.1**acute toxicity**

adverse health effect(s) from a single, short-term exposure

3.1.2**acute-toxicity exposure limit****ATEL**

maximum recommended refrigerant concentration determined in accordance with the established systems and intended to reduce the risks of acute toxicity hazards to humans in the event of a refrigerant release

Note 1 to entry: The systems are specified in this International Standard.

3.1.3**anaesthetic effect**

impairment of the ability to perceive pain and other sensory stimulation

3.1.4**approximate lethal concentration****ALC**

concentration of a refrigerant that is lethal to even a single test animal but to less than 50 % of the animals in that group when tested by the same conditions as for an LC₅₀ test

3.1.5**azeotrope**

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

3.1.6**blend**

mixture composed of two or more refrigerants

3.1.7**burning velocity** S_u

velocity, relative to the unburnt gas, at which a laminar flame propagates in a direction normal to the flame front, at the concentration of refrigerant with air giving the maximum velocity

Note 1 to entry: This value is expressed in centimetres per second.

3.1.8**central nervous system effect****CNS**

treatment-related depression, distraction, stimulation, or other behavioural modification to a degree that could represent an impairment of the ability to escape from a hazard

3.1.9**chronic toxicity**

adverse health effect(s) from long-term repeated exposures

3.1.10**combustion**

exothermal reaction between an oxidant component (combustive) and a reducer (combustible fuel)

3.1.11**compound**

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

3.1.12**critical point**

point with conditions above which distinct liquid and gas phases do not exist

3.1.13**cyclic compound**

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

3.1.14**effective concentration 50 %****EC₅₀**

concentration of a refrigerant, which causes a biological effect to 50 % of exposed animals in a test for anaesthetic or other effects

Note 1 to entry: This value is typically a calculated value from experimental data.

3.1.15**elevated temperature flame limit****ETFL**

minimum concentration by volumic ratio (volume per cent) of the refrigerant, which is capable of propagating a flame through a homogeneous mixture of the refrigerant and air under the specified test conditions at 60,0°C and 101,3 kPa

Note 1 to entry: The test conditions are specified in [6.1.3](#).

3.1.16**equivalence ratio**

fraction of the combustible in the mixture divided by the combustible fraction at the stoichiometric conditions

Note 1 to entry: It can be written as (combustible fraction)/(combustible fraction)_{st}.

Note 2 to entry: It is used in the determination of burning velocity.

Note 3 to entry: Lean mixtures have an equivalence ratio lower than one and rich mixtures have an equivalence ratio greater than one.

3.1.17

flame

collection of gases of a rapid combustion, generally visible due to the emission of light

3.1.18

flame propagation

combustion, causing a continuous flame which moves upward and outward from the point of ignition without help from the ignition source

Note 1 to entry: Flame propagation as applied in the test method for determining LFL and flammability classification is specified in [B.1.7](#). Flame propagation as applied in the test method for determining burning velocity is described in [Annex C](#).

3.1.19

flammable

property of a mixture in which a flame is capable of self-propagating for a certain distance

3.1.20

fractionation

change in composition of a blend by preferential evaporation of the more volatile component(s) or condensation of the less volatile component(s)

3.1.21

heat of combustion

HOC

heat evolved from a specified reaction of a substance with oxygen

Note 1 to entry: The heat of combustion is as determined in accordance with [6.1.3.7](#).

Note 2 to entry: The heat of combustion for this International Standard is expressed as a positive value for exothermic reactions in energy per unit mass (kJ/kg).

3.1.22

isomers

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

3.1.23

lethal concentration 50 %

LC₅₀

concentration that is lethal to 50 % of the test animals

3.1.24

lower flammability limit

LFL

minimum concentration of the refrigerant that is capable of propagating a flame through a homogeneous mixture of the refrigerant and air under the specified test conditions at 23,0 °C and 101,3 kPa

Note 1 to entry: The test conditions are specified in [6.1.3](#).

Note 2 to entry: The LFL is expressed as refrigerant percentage by volume.

3.1.25

lowest observed adverse effect level

LOAEL

lowest concentration of a refrigerant that causes any observed adverse effect in one or more test animals

3.1.26**no observed adverse effect level****NOAEL**

highest concentration of a refrigerant at which no adverse effect is observed in any of the exposed animal population

3.1.27**nominal composition****nominal formulation**

design composition as stated in the refrigerant blend application, excluding any tolerances

Note 1 to entry: Composition of the refrigerant blends shall be as listed in [Tables 6](#) and [7](#), column 2.

Note 2 to entry: When a container with the nominal composition is 80 % or more liquid filled, the liquid composition may be considered the nominal composition.

3.1.28**occupational exposure limit**

time-weighted average concentration for a normal eight-hour work day and a 40-hour work week to which nearly all workers can be repeatedly exposed without adverse effect

Note 1 to entry: It is based on national regulations, such as OSHA PEL, ACGIH TLV-TWA, TERA WEEL, or MAK.

3.1.29**olefin**

unsaturated chemical compound containing at least one carbon-to-carbon double bond

3.1.30**organic compound, saturated**

carbon-containing compound that has only single bonds between carbon atoms

3.1.31**organic compound, unsaturated**

carbon-containing compound containing at least one double or triple bond between carbon atoms

3.1.32**oxygen deprivation limit****ODL**

concentration of a refrigerant or other gas that can result in insufficient oxygen for normal breathing

3.1.33**propagation velocity of flame**

velocity at which a flame propagates in a space

3.1.34**quenching**

effect of extinction of a flame as it approaches a surface due to heat conduction losses, absorption of active chemical species and viscous effects on the surface

3.1.35**refrigerant**

fluid used for heat transfer in a 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

3.1.36**refrigerant concentration limit****RCL**

maximum refrigerant concentration, in air, determined and established to reduce the risks of acute toxicity, asphyxiation and flammability hazards

Note 1 to entry: It is determined in accordance with this International Standard.

3.1.37**relative molar mass**

mass numerically equal to the molecular mass expressed in grams per mole, except that it is dimensionless

3.1.38**stoichiometric concentration for combustion**

C_{st}

concentration of a fuel in a fuel-air mixture that contains exactly the necessary quantity of air (21 % O₂/79 % N₂ by volume) needed for the complete oxidation of all the compounds present

3.1.39**threshold limit value-time weighted average****TLV-TWA**

time weighted average concentration for a normal eight-hour workday and a 40-hour workweek, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect

3.1.40**workplace environmental exposure limit****WEEL**

occupational exposure limit set by the Toxicology Excellence for Risk Assessment (TERA)

3.1.41**worst-case formulation****WCF**

composition that results from application of the tolerances to the nominal composition resulting in the most toxic or the most flammable formulation

3.1.42**worst-case fractionated formulation****WCFF**

composition produced during fractionation of the worst-case formulation that results in the most toxic or most flammable formulation

3.1.43**zeotrope**

blend composed of two or more refrigerants whose equilibrium vapour and liquid phase compositions are not the same at any pressure below the critical pressure

3.2 Abbreviated terms

ALC	approximate lethal concentration
ATEL	acute-toxicity exposure limit
CNS	central nervous system effect
EC ₅₀	effective concentration 50 %
ETFL	elevated temperature flame limit
HOC	heat of combustion
LC ₅₀	lethal concentration 50 %
LFL	lower flammability limit
LOAEL	lowest observed adverse effect level
MAK	Maximale Arbeitsplatz-Konzentration (Maximum workplace concentration) as set by Deutsche Forschungsgemeinschaft (German Research Foundation)
NOAEL	no observed adverse effect level
ODL	oxygen deprivation limit
PEL	permissible exposure limit
RCL	refrigerant concentration limit
RCL _M	RCL expressed as grams per cubic metre
RCL _{ppm}	RCL expressed as parts per million by volume
TCF	toxic concentration factor
TLV-TWA	threshold limit value-time weighted average
WCF	worst-case formulation
WCFF	worst-case fractionated formulation
WEEL	workplace environmental exposure limit

3.3 Symbols

a_{blend}	mortality indicator for a refrigerant blend
a_n	mortality indicator for component n in a refrigerant blend
a_f	cross-sectional area of the flame base
A_f	flame surface area
b_n	cardiac sensitization indicator for component n in a refrigerant blend
b_{blend}	cardiac sensitization indicator of a refrigerant blend
c_n	anaesthetic effect indicator for component n in a refrigerant blend
c_{blend}	anaesthetic effect indicator of a refrigerant blend
C_{blend}	toxic concentration factor of a refrigerant blend
C_n	toxic concentration factor for component n
C_{st}	stoichiometric concentration for combustion
S_s	flame propagation speed, expressed in centimetres per second
S_u	burning velocity, expressed in centimetres per second
x_n	mole fraction of component n of a refrigerant blend
Φ_{max}	equivalence ratio at the maximum burning velocity

4 Numbering of refrigerants

4.1 An identifying number shall be assigned to each refrigerant. Assigned numbers and safety classifications are shown in [Tables 5, 6](#) and [7](#). [Tables E.4, E.5](#) and [E.6](#) provide designations for refrigerants for which insufficient data are available for safety classification or determination of an ATEL or RCL value.

4.2 The identifying numbers assigned to the hydrocarbons, halocarbons and ethers of the methane, ethane, ethene, propane, propene 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, ethene and most of the propane and propene series from only the identification number.

4.2.1 The first digit on the right is the number of fluorine (F) atoms in the compound.

4.2.2 The second digit from the right is one more than the number of hydrogen (H) atoms in the compound.

4.2.3 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.

4.2.4 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.

4.2.5 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 determined according to [4.2.1](#) to [4.2.4](#) shows the presence of

bromine or iodine. The number following the letter B or I shows the number of bromine or iodine atoms present.

4.2.6 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.

4.2.7 The carbon atoms shall be numbered with the number 1 assigned to the end carbon with the greatest number of halogen atoms, and the following carbon atoms are numbered sequentially as they appear on a straight chain. In the case where both end carbons contain the same number of (but different) halogen atoms, the number 1 shall be assigned to the end carbon having the largest number of bromine then chlorine then fluorine, and then iodine atoms. If the compound is an olefin, then the end carbon nearest to the double bond will be assigned the number 1, as the presence of a double bond in the backbone of the molecule has priority over substituent groups on the molecule.

4.2.8 For cyclic compounds, the letter C is used before the identifying refrigerant numbers. (e.g. R-C318, PFC-C318).

4.2.9 In the case of isomers in the ethane series, each shall have 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.

4.2.10 In the case of isomers in the propane series, each shall have the same number, and the isomers shall be distinguished by two appended lower case letters. The first appended letter indicates the substitution on the central carbon atom (C2) as indicated in [Table 1](#).

Table 1 — Propane isomer appended letters

Isomer	Appended letter
CCl ₂	a
CClF	b
CF ₂	c
CHCl	d
CHF	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](#). Propane series isomers containing bromine are not covered by the appended letters given in [4.2.11](#) and [Table 2](#).

4.2.11 In the case of isomers in the propene series, each has the same number, with the isomers distinguished by two appended lower case letters. The first appended letter designates the one atom

attached to the central carbon atom and shall be x, y, or z for Cl, F, and H, respectively. The second letter designates the substitution on the terminal methylene carbon as indicated in [Table 2](#).

Table 2 — Propene isomer appended letters

Isomer	Appended letter
CCl ₂	a
CClF	b
CF ₂	c
CHCl	d
CHF	e
CH ₂	f

In the case where stereoisomers can exist, the opposed (Entgegen) isomer will be identified by the suffix (E) and the same side (Zusammen) isomer will be identified by the suffix (Z).

4.3 Ether-based refrigerants shall be designated with the prefix “E” (for “ethers”) immediately preceding the number. [Subclause 4.2](#) applies except for the following differences.

4.3.1 Two-carbon, dimethyl ethers (e.g. R-E125, CHF₂-O-CF₃) require no suffixes other than those specified in [4.2.9](#), as the presence of the “E” prefix provides an unambiguous description.

4.3.2 For straight chain, three carbon ethers, the carbon atoms shall be numbered with the number 1 assigned to the end carbon with the highest number of halogens, and the following carbon atoms are numbered sequentially as they appear on a straight chain. In the case where both end carbons contain the same number of (but different) halogen atoms, the number 1 shall be assigned to the end carbon having the largest number of bromine, then chlorine, then fluorine and then iodine atoms. For ethers with more than three carbons, the compound shall be assigned a number in the 600 series, miscellaneous organic compounds, as described in [4.5](#).

4.3.2.1 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).

4.3.2.2 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.

4.3.2.3 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 [4.2.9](#), [4.2.10](#) and [4.2.11](#) shall be omitted. In this cited example, the correct designation shall be R-E218.

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

4.3.3 For cyclic ethers carrying both the “C” and “E” pre-fixes, 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, as described in [3.2](#).

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

4.4.1 Zeotropes shall be serially assigned an identifying number in the 400 series. In order to differentiate among the different zeotropes having the same components but in different proportions, an upper case letter (A, B, C, ...) is added after the number.

4.4.2 Azeotropes shall be serially assigned an identifying number in the 500 series. In order to differentiate among the different azeotropes having the same components but in different proportions, an upper case letter (A, B, C, ...) is added after the number.

4.4.3 Blends shall have tolerances specified for individual components. Those tolerances shall be specified to the nearest 0,1 % mass fraction. The maximum tolerance above or below the nominal shall not exceed 2,0 % mass fraction. The tolerance above or below the nominal shall not be less than 0,1 % mass fraction. The difference between the highest and the lowest tolerances shall not exceed one-half of the nominal component composition.

4.5 Miscellaneous organic compounds shall be assigned numbers in the 600 series in decadal groups, as outlined in [Table E.4](#), in serial order of designation within the groups. For the saturated hydrocarbons with 4 to 8 carbon atoms, the number assigned shall be 600 plus the number of carbon atoms minus 4. For example, butane is R-600, pentane is R-601, hexane is R-602, heptane is R-603, and octane is R-604. The straight chain or "normal" hydrocarbon has no suffix. For isomers of the hydrocarbons with 4 to 8 carbon atoms, the lower case letters "a", "b", "c", etc., are appended to isomers according to the group(s) attached to the longest carbon chain as indicated in [Table 3](#). For example, R-601a is assigned for 2-methylbutane (isopentane) and R-601b would be assigned for 2,2-dimethylpropane (neopentane). Mixed isomers where the concentration of one isomer is greater than or equal to 4 % shall be assigned a number in the 400 or 500 series.

Table 3 — Miscellaneous organic compound suffixes

Attached group	Suffix
none (straight chain)	No suffix
2-methyl-	a
2,2-dimethyl-	b
3-methyl-	c
2,3-dimethyl-	d
3,3-dimethyl-	e
2,4-dimethyl-	f
2,2,3-trimethyl-	g
3-ethyl-	h
4-methyl-	i
2,5-dimethyl-	j
3,4-dimethyl-	k
2,2,4-trimethyl-	l
2,3,3-trimethyl-	m
2,3,4-trimethyl-	n
2,2,3,3-tetramethyl	o
3-ethyl-2-methyl-	p
3-ethyl-3-methyl-	q

4.6 Inorganic compounds shall be assigned identifying numbers in the 700 series and 7000 series.

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

4.6.2 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.

4.6.3 When two or more inorganic refrigerants have the same molar masses, upper case letters (i.e. A, B, C, etc.) shall be added in serial order of designation to distinguish among them starting with the letter A for the second identified inorganic refrigerant of the given molar mass.

5 Designation prefixes

5.1 General prefixes

The identifying number, as determined by [Clause 4](#), shall be preceded by the letter R or the word Refrigerant(s) unless composition designating prefixes, as described in [5.2](#) are being used. Between the letter R or the word Refrigerant and the designation number, no space, a blank or a dash is used. Examples include: R134a, Refrigerant 134a, R 134a, and R-134a.

5.2 Composition-designating prefixes

For the fluorocarbon and the hydrocarbon families, the identifying number, as determined by [Clause 4](#), 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.

NOTE 1 Halogenated compounds that contain hydrogen have increased deterioration potential before reaching the stratosphere.

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. E in the identifying number shall be omitted when composition-designating prefixes are used. The composition designating prefixes for halogenated olefins shall be either CFC, HCFC, or HFC to refer to chlorofluorocarbon, hydrochlorofluorocarbon, or hydrofluorocarbon, respectively, or with substitution of an O for the carbon C as CFO, HCFO, or HFO to refer to chlorofluoro-olefin, hydrochlorofluoro-olefin, or hydrofluoro-olefin, respectively.

NOTE 2 Halogenated olefins are a subset of halogenated organic [or carbon containing] compounds having significantly shorter atmospheric lifetimes than their saturated counterparts.

In addition, when a refrigerant compound is fully fluorinated the notation PFC is used. Examples are shown in [Table 4](#).

Table 4 — Examples of composition-designating prefixes

Refrigerant	Composition	Prefix and designation
Chlorofluorocarbon 12	CCl_2F_2	CFC-12
Hydrochlorofluorocarbon 22	CHClF_2	HCFC-22
Hydrofluorocarbon 134a	CH_2FCF_3	HFC-134a
Perfluorocarbon 116	CF_3CF_3	PFC-116
Hydrocarbon 600a	$(\text{CH}_3)_2\text{CH CH}_3$	HC-600a
Perfluorocarbon C318	$-(\text{CF}_2)_4-$	PFC-C318
Hydrofluoroether E125	CHF_2OCF_3	HFE-125
Hydrofluoro-olefin 1234yf	$\text{CF}_3\text{CF}=\text{CH}_2$	HFO-1234yf

Blends with assigned numbers may be identified by linking the appropriate composition-designating prefixes of individual components (e.g. R-500 [CFC-12/HFC-152a]). Blend components shall be listed in order of increasing normal boiling point. Blends without assigned numbers can be identified using appropriate composition-designating prefixes for each component (e.g. HCFC-22/HFC-152a/CFC-114).

[36,0/24,0/40,0]). Here [36,0/24,0/40,0] represents the mass fraction of each component, expressed as a percentage.

6 Safety classifications

6.1 General

6.1.1 Safety classification — Composition

The safety classification shall consist of two alphanumeric characters (e.g. A2 or B1) with a third character L designating low burning velocity. The capital letter indicates the toxicity as determined by [6.1.2](#); the Arabic numeral denotes the flammability as determined by [6.1.3](#). Blends shall be assigned a dual safety group classification, with the two classifications separated by a slash (/). The first classification listed shall be the classification of the worst-case formulation (WCF) of the blend. The second classification listed shall be the classification of the worst-case fractionated formulation (WCFF).

6.1.2 Toxicity classification

Refrigerants shall be assigned to one of two classes, A or B, based on allowable exposure:

- class A (lower chronic toxicity) signifies refrigerants that have an occupational exposure limit of 400 ppm¹⁾ or greater;
- class B (higher chronic toxicity) signifies refrigerants that have an occupational exposure limit of less than 400 ppm.

NOTE The occupational exposure limit is based on the OSHA PEL, ACGIH TLV-TWA, TERA WEEL, or the MAK.

6.1.3 Flammability classification — General

6.1.3.1 Flammability classification

Refrigerants shall be assigned to one of four classes (1, 2L, 2 or 3) based on lower flammability limit testing conducted in accordance with ASTM E681 as specified in [Annex B](#), the maximum burning velocity measurement conducted in the method as described hereafter, and the heat of combustion determined in accordance with [6.1.3.7](#). Both lower flammability limit and burning velocity tests shall be conducted at the temperatures specified below.

Burning velocity measurements shall be conducted according to [Annex C](#) or other credible method. The selected method shall be in agreement with established methods of determining burning velocity by demonstrating to the ISO 817 Maintenance Agency (MA) measurement results of $6,7 \pm 0,7$ cm/s burning velocity for R-32 and $23,0 \pm 2,3$ cm/s for R-152a, or by presenting other evidence supporting the accuracy of the method. Measurement shall be conducted starting from the LFL to at least 125 % of the stoichiometric concentration. Measurements shall be done with increments of at most 10 % of the stoichiometric concentration and each measurement shall be repeated at least 2 times. The maximum burning velocity is the maximum value obtained from the best curve fitting to the measurement points. The gas mixture shall be made by any method that produces a blend of air/refrigerant that is accurate to $\pm 0,1$ % in the test chamber. Dry reconstituted air (less than 0,000 15 g of water vapour per gram of dry air) containing $21,0 \pm 0,1$ % O₂ shall be used as oxidant. The flammable gas shall have a minimum purity of 99,5 % mass fraction.

NOTE 1 Methods for burning velocity determination include the vertical tube method and the closed-vessel method.^[14]

1) 0,01 vol % (per cent volume fraction) is the equivalent of 100 ppm; ppm is a deprecated unit at ISO.

NOTE 2 Methods that have been used for mixing include: a) pressurized mixture made using partial pressure, or b) quantitative flow methods like volumetric flow meters and mass flow controllers fixing the ratio of air and refrigerant.

6.1.3.2 Class 1 (no flame propagation)

Single compound refrigerants or refrigerant blends WCF and WCFF that do not exhibit flame propagation when tested in air at 60 °C and 101,3 kPa.

6.1.3.3 Class 2L (lower flammability)

Single compound refrigerants or refrigerant blends (WCF and WCFF) that meet all of the following conditions:

- a) exhibit flame propagation when tested at 60 °C and 101,3 kPa,
- b) have a LFL > 3,5 % by volume (see [6.1.3.6](#) if the refrigerant has no LFL at 23 °C and 101,3 kPa.),
- c) have a heat of combustion < 19 000 kJ/kg (see [6.1.3.7](#)), and,
- d) have a maximum burning velocity of ≤ 10 cm/s when tested at 23 °C and 101,3 kPa.

6.1.3.4 Class 2 (flammable)

Single compound refrigerants or refrigerant blends (WCF and WCFF) that meet all of the following conditions:

- a) exhibit flame propagation when tested at 60 °C and 101,3 kPa,
- b) have a LFL > 3,5 % by volume (see [6.1.3.6](#) if the refrigerant has no LFL at 23 °C and 101,3 kPa.), and
- c) have a heat of combustion < 19 000 kJ/kg (see [6.1.3.7](#)).

6.1.3.5 Class 3 (higher flammability)

Single compound refrigerants or refrigerant blend WCF and WCFF that meet the following conditions:

- a) exhibit flame propagation when tested at 60°C and 101,3 kPa and
- b) have a LFL $\leq 3,5$ % by volume (see [6.1.3.6](#) if the refrigerant has no LFL at 23°C and 101,3 kPa); or have a heat of combustion that is $\geq 19\,000$ kJ/kg.

6.1.3.6 LFL or ETFL

For Class 2L, 2 or Class 3 refrigerants or refrigerant blends the LFL shall be determined. For those Class 2L, 2, or Class 3 refrigerants or refrigerant blends that show no flame propagation when tested at 23 °C and 101,3 kPa (i.e. no LFL), the elevated temperature flame limit (ETFL) shall be used in lieu of the LFL for determining their flammability classifications.

6.1.3.7 Heat of combustion

The heat of combustion shall be determined at 25 °C and 101,3 kPa as follows.

6.1.3.7.1 For single component refrigerants, the heat of combustion shall be calculated. Values for heats of formation are tabulated in several chemical and physical properties handbooks and databases. The heat of combustion (positive values are exothermic) is the enthalpy of formation of the reactants (refrigerant and oxygen) minus the enthalpy of formation of the products of reaction. Calculated values shall be based on the complete combustion of one mole of refrigerant with enough oxygen for a stoichiometric reaction. The reactants and the combustion products shall be assumed to be in the gas phase. The combustion products shall be HF, CO₂ (N₂, SO₂ if nitrogen or sulfur are part of the refrigerant's molecular structure).

and HCl, if there is enough hydrogen in the molecule. Excess H shall be assumed to be converted to H₂O. If there is insufficient hydrogen available for the formation of HF and HCl but sufficient to form HF, then the formation of HF takes preference over the formation of HCl. If there is insufficient hydrogen available for the formation of HF, then the remaining F produces COF₂ in preference to the formation of CO₂. The remaining Cl produces Cl₂.

6.1.3.7.2 For refrigerant blends, the heat of combustion of the nominal composition shall be calculated from a balanced stoichiometric equation of all component refrigerants, where the total number of moles of refrigerant shall be equal to 1.

NOTE This can be thought of conceptually as breaking the refrigerant molecules into their constituent atoms and creating a hypothetical molecule with the same molar ratio of total carbons, hydrogens, fluorines, etc. as in the original blend. The hypothetical molecule would then be treated as a pure refrigerant as in 6.1.3.7.1. The heat of formation for this hypothetical molecule is the molar average of the heats of formation for the original blend molecules.

6.2 Matrix diagram of safety group classification system

The toxicity and flammability classifications described in 6.1.2 and 6.1.3 yield eight separate safety classifications (A1, A2L, A2, A3, B1, B2L, B2, and B3) for refrigerants. These classifications are represented by the matrix shown in [Figure 1](#).

	Safety group	
Higher Flammability	A3	B3
Flammable	A2	B2
Lower flammability	A2L	B2L
No flame Propagation	A1	B1
	Lower Toxicity	Higher Toxicity

Figure 1 — Safety groups as determined by flammability and toxicity

7 Refrigerant classifications

Refrigerants are assigned the classifications indicated in [Tables 5, 6 and 7](#).

8 Refrigerant concentration limit (RCL)

8.1 General

Determination of the RCL shall assume full vaporization and uniform mixing; no removal by dissolution, reaction, or decomposition in the volume to which it is released. Safety factors are included for consideration of temporary local concentrations or uncertainties in the test data.

The RCL for each refrigerant shall be the lowest of the quantities calculated in accordance with [8.1.1.1](#), [8.1.2](#) and [8.1.3](#), using data as indicated in [8.2](#), and adjusted in accordance with [8.4](#) unless there is a valid scientific argument to support an alternative value.

8.1.1 General

8.1.1.1 Acute-toxicity exposure limit (ATEL)

The ATEL shall be the lowest of the toxic concentration factors (TCF) [8.1.1.2](#), [8.1.1.3](#), [8.1.1.4](#) and [8.1.1.5](#). For blends, the individual parameter values in [8.1.1.1](#) to [8.1.1.5](#) shall be calculated according to the following formula:

$$\frac{1}{C_{\text{blend}}} = \frac{x_1}{C_1} + \frac{x_2}{C_2} + \dots + \frac{x_n}{C_n}$$

where

x_n is the mole fraction of component n of the blend;

C_n is the TCF for component n in accordance with ISO 10298.

NOTE See [Annex D](#) for a sample calculation of ATEL and [Annex E](#) for a list of values related to calculation of ATEL and RCL.

8.1.1.2 Mortality

Value shall be chosen according to the following priority.

First priority: 28,3 % of the 4-h LC₅₀ for rats.

Second priority: 28,3 % of the 4-h ALC for rats provided it did not result in mortality for more than half the exposed animals.

NOTE 28,3 % is based on the recalculation of LC₅₀ for 30 min with a safety factor of 10. The time of 30 min is meant to represent the time required for escape from an area where a refrigerant leak has occurred: $0,283 = (4/0,5)^{1/2}/10$

Third priority: if neither has been determined, 0 ppm¹⁾.

Formulae (1) and (2) shall be used to adjust LC₅₀ or ALC values that were determined with 15-min to 8-h tests, for refrigerants for which 4-h data are not available:

$$LC_{50(t_1)} = LC_{50(t_2)} \times (t_2/t_1)^{1/2} \quad (1)$$

and

$$ALC_{t_1} = ALC_{t_2} \times (t_2/t_1)^{1/2} \quad (2)$$

where

t_1 is 4 h;

t_2 is the test duration, expressed in hours, applicable for 0,25 h to 8 h.

8.1.1.3 Cardiac sensitization

The cardiac sensitization study is not required in the ATEL determination if the 4-h LC₅₀ or 4-h ALC in [8.1.1.3](#) is less than 10 000 ppm by volume, or if the refrigerant is found, by toxicological review, to not cause cardiac sensitization.

NOTE 1 Cardiac sensitization is in part a function of attaining a certain minimum blood level of the agent. If the agent is too toxic, one will see other manifestations of toxicity or lethality before cardiac arrhythmias develop. None of the hydrocarbons or hydrohalocarbons that have low LC₅₀ have ever been shown to cause cardiac arrhythmias.^[13]

Value shall be chosen according to the following priority.

First priority: 100 % of the NOAEL for cardiac sensitization in unanaesthetized dogs. If during the cardiac sensitization test other effects cause curtailment of the study prior the determination of a threshold for cardiac sensitization, the highest exposure level tested for which data were collected for at least half of the animals tested may be used as the estimated NOAEL for the cardiac sensitization end point. The conditions where this could occur would be the observance of clinical signs of central nervous system effects or marked signs of systemic toxicity. In these situations the NOAEL for these signs will be lower than the exposure level that resulted in curtailment of the cardiac sensitization study. Therefore the requirement for a determination of the cardiac sensitization evaluation should be considered fulfilled. This NOAEL value should be considered along with the results from all other appropriate studies for the determination of the ATEL.

NOTE 2 This approach is adopted because the emergence of other effects (e.g. tremors or anaesthesia) precludes the ability to determine a cardiac sensitization value.

Second priority: 80 % of the LOAEL provided the LOAEL did not induce sensitization in more than half the exposed animals.

Third priority: if no value can be determined, consideration may be given to cardiac sensitization data derived from other similar compounds provided there is a good scientific justification. If cardiac sensitization data are not determined, the NOAEL is assigned a value of 1 000 ppm.

8.1.1.4 Anaesthetic or central nervous system (CNS) effects

Value shall be chosen according to the following priority.

First priority: 50 % of the 10-min EC₅₀, in mice or rats for loss of righting ability in a rotating apparatus.

Second priority: 100 % of NOAEL, in mice or rats for loss of righting ability in a rotating apparatus.

Third priority: 50 % of the LOAEL for signs of any anaesthetic or CNS effect in rats during acute toxicity studies, provided the LOAEL did not induce an anaesthetic effect for more than half the exposed animals.

Fourth priority: 80 % of the NOAEL for signs of anaesthesia or CNS effect in rats during an acute, subchronic, or chronic toxicity study in which clinical signs are documented.

8.1.1.5 Other escape-impairing symptoms and permanent injury

80 % of the lowest concentration, for human exposures of 30 min, that is likely to impair an individual's ability to escape or to cause irreversible, adverse health effects. The source of the value shall be documented.

8.1.2 Oxygen deprivation limit (ODL)

The ODL shall be 140 000 ppm by volume of refrigerant in air (18 % O₂) for locations with altitudes up to and including 1 000 m above sea level. At locations higher than 1 000 m but below or equal to 1 500 m above sea level, the ODL shall be 112 000 ppm, and at altitudes higher than 1 500 m above sea level the ODL shall be 69 100 ppm by volume (19,5 % O₂).

8.1.3 Flammable concentration limit (FCL)

The FCL shall be expressed in parts per million¹⁾ and calculated as 20 % of the LFL, expressed in ppm, and determined in accordance with [Annex B](#).

8.2 Data for calculations

8.2.1 Data sources

8.2.1.1 Data for calculations: the data used to calculate the RCL shall be taken from peer reviewed scientific publications, published safety assessments by governmental agencies or expert panels or scientific and engineering studies. Applications submitting scientific and engineering studies under [Annex F](#), for toxicity data shall indicate the extent of compliance with good laboratory practices (GLP) in effect when the studies were performed, for example Reference [6]. The information shall be supplied in English. Submissions shall include a description of the experimental and analytical methods used and summarize the qualifications of the person or persons providing the evaluation.

8.2.1.2 Alternative toxicity data: data from studies which have not been published, from studies which have not been peer reviewed, or from studies involving species other than those indicated in [8.1.1.1](#), [8.1.1.2](#), [8.1.1.3](#), and [8.1.1.4](#), or involving chemical analogues, may be submitted to the ISO 817 Maintenance Agency (see [Annex F](#)) for consideration. Data are not treated as confidential. Submissions shall include a description of the experimental and analytical methods used, an evaluation of data from alternative sources, and the extent of the data search. The submissions shall summarize the qualifications of the person or persons who conducted the evaluation.

8.2.1.3 Multiple data values: where multiple data values have been published and submitted to the MA, the MA shall make a judgement as to the values which appear to be the most accurate and realistic. The MA shall keep the record of the logic for the decision.

Exception: For the cardiac sensitization and anaesthetic effect NOAEL in [8.1.1.3](#) and [8.1.1.4](#), respectively, the highest-published NOAEL not exceeding a published LOAEL, for any fraction of tested animals, shall be used.

8.2.1.4 Alternative flammability data: data from studies, which have not been published or from studies which have not been peer reviewed, shall be submitted to the ISO 817 Maintenance Agency for consideration. Submissions shall include a description of the experimental and analytical methods used, and an evaluation of the data from alternative sources, and the extent of the data search. The submissions shall summarize the qualifications of the person or persons who conducted the evaluation. The values used shall be those resulting in the lowest LFL or highest burning velocity when conducted according to the method prescribed in [Clause 6](#).

8.2.2 Consistent measures

Use of data that are determined by the MA to be generated in a manner consistent with those used deriving the data in [8.1.1.2](#), [8.1.1.3](#), [8.1.1.4](#) and [8.1.1.5](#) is allowed for the parameters identified in [8.1](#).

8.3 Contaminants and impurities

Identify contaminants and impurities, including isomeric and decomposition impurities, from manufacturing, transport, and storage known to increase the flammability or toxicity within the precision of the RCL. Also identify limits for those impurities. See AHRI Standard 700.

8.4 Conversion of units — Volumic mass and altitude adjustment

Formula (3) shall be used to convert the RCL from a volumetric ratio (ppm by volume) to volumic mass (g/m³):

$$RCL_M = RCL_{ppm} \times a \times M \times 10^{-6} \quad (3)$$

where

RCL_M is the RCL (g/m³);

RCL_{ppm} is the RCL (ppm by volume);

M is the relative molar mass of the refrigerant (g/mol).

$$a = P/RT$$

where

T is the temperature in Kelvin and equal to 298 in standard calculation;

P is the pressure, in Pascal (pressures shall be adjusted for altitude when greater than 1 500 m above sea level using the following formula: $P = 1,013\,25 \times 10^5 - 10,001 \times h$, where h is the height, in metres);

R equals 8,314 J/mol K.

Table 5 — Refrigerant designations

Refrigerant number	Composition designating prefix	Chemical name ^b	Chemical formula	Relative molar mass ^a g/mol	Normal boiling point ^a °C	Safety group ^d	LFL (ppm by volume)	ATEL (ppm by volume)	RCL (ppm by volume)
		Methane series							
R-11	CFC	trichlorofluoromethane	CCl ₃ F	137,4	24	A1		1 100	1 100
R-12	CFC	dichlorodifluoromethane	CCl ₂ F ₂	120,9	-30	A1		18 000	18 000
R-14	PFC	tetrafluoromethane (carbon tetrafluoride)	CF ₄	88,0	-128	A1		110 000	110 000
R-22	HCFC	chlorodifluoromethane	CHClF ₂	86,5	-41	A1		59 000	59 000
R-23	HFC	trifluoromethane	CHF ₃	70,0	-82	A1		51 000	51 000
R-32	HFC	difluoromethane (methylene fluoride)	CH ₂ F ₂	52,0	-52	A2L	144 000	220 000	29 000
		Ethane series							
R-113	CFC	1,1,2-trichloro-1,2,2-trifluoroethane	CCl ₂ FCClF ₂	187,4	48	A1		2 600	2 600
R-114	CFC	1,2-dichloro-1,1,2,2-tetrafluoroethane	CClF ₂ CClF ₂	170,9	4	A1		20 000	20 000
R-115	CFC	chloropentafluoroethane	CClF ₂ CF ₃	154,5	-39	A1		120 000	120 000
R-116	PFC	hexafluoroethane	CF ₃ CF ₃	138,0	-78	A1		120 000	120 000
R-123	HCFC	2,2-dichloro-1,1,1-trifluoroethane	CHCl ₂ CF ₃	153,0	27	B1		9 100	9 100
R-124	HCFC	2-chloro-1,1,1,2-tetrafluoroethane	CHClF ₂ CF ₃	136,5	-12	A1		10 000	10 000
R-125	HFC	pentafluoroethane	CHF ₂ CF ₃	120,0	-49	A1		75 000	75 000
R-134a	HFC	1,1,1,2-tetrafluoroethane	CH ₂ FCF ₃	102,0	-26	A1		50 000	50 000
R-142b	HCFC	1-chloro-1,1-difluoroethane	CH ₃ CClF ₂	100,5	-10	A2	80 000	25 000	16 000
R-143a	HFC	1,1,1-trifluoroethane	CH ₃ CF ₃	84,0	-47	A2L	82 000	170 000	16 000
R-152a	HFC	1,1-difluoroethane	CH ₃ CHF ₂	66,0	-25	A2	48 000	50 000	9 600
R-170	HC	ethane	CH ₃ CH ₃	30,0	-89	A3	31 000	7 000	6 200
R-E170		methoxymethane (dimethyl ether)	CH ₃ OCH ₃	46,1	-25	A3	34 000	42 000	6 800
		Propane series							
R-218	PFC	octafluoropropane	CF ₃ CF ₂ CF ₃	188,0	-37	A1		110 000	110 000
R-227ea	HFC	1,1,1,2,3,3,3-heptafluoropropane	CF ₃ CHFCF ₃	170,0	-16	A1		90 000	90 000
R-236fa	HFC	1,1,1,3,3,3-hexafluoropropane	CF ₃ CH ₂ CF ₃	152,0	-1	A1		55 000	55 000
R-245fa	HFC	1,1,1,3,3-pentafluoropropane	CHF ₂ CH ₂ CF ₃	134,0	15	B1		34 000	34 000
R-290	HC	propane	CH ₃ CH ₂ CH ₃	44,0	-42	A3	21 000	50 000	4 200

Table 5 (continued)

Refrigerant number	Composition designating prefix	Chemical name ^b	Chemical formula	Relative molar mass ^a g/mol	Normal boiling point ^a °C	Safety group ^d	LFL (ppm by volume)	ATEL (ppm by volume)	RCL (ppm by volume)
		Cyclic organic compound							
R-C318	PFC	octafluorocyclobutane	$\text{CF}_2\text{CF}_2\text{CF}_2\text{CF}_2$	200,0	-6	A1		80 000	80 000
		Misc. organic compounds							
		Hydrocarbons							
R-600	HC	butane	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3$	58,1	0	A3	16 000	1 000	1 000
R-600a	HC	2-methylpropane (isobutane)	$(\text{CH}_3)_2\text{CHCH}_3$	58,1	-12	A3	18 000	25 000	3 600
R-601	HC	pentane	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$	72,2	36	A3	12 000	1 000	1 000
R-601a	HC	2-methylbutane (isopentane)	$(\text{CH}_3)_2\text{CHCH}_2\text{CH}_3$	72,2	27	A3	10 000	1 000	1 000
		Inorganic compounds							
R-702		hydrogen	H_2	2,0	-253	A3	40 000		
R-704		helium	He	4,0	-269	A1			
R-717		ammonia	NH_3	17,0	-33	B2L	167 000	320	320
R-744		carbon dioxide	CO_2	44,0	-78 ^c	A1		40 000	40 000
		Propene series							
R-1234yf	HFO	2,3,3,3-tetrafluoro-1-propene	$\text{CF}_3\text{CF}=\text{CH}_2$	114,0	-29,4	A2L	62 000	100 000	12 000
R-1234ze(E)	HFO	trans-1,3,3,3-tetrafluoro-1-propene	$\text{CF}_3\text{CH}=\text{CHF}$	114,0	-19,0	A2L	65 000	59 000	13 000
R-1270	HC	propene (propylene)	$\text{CH}_3\text{CH}=\text{CH}_2$	42,1	-48	A3	27 000	1 000	1 000
^a The relative molar 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 Reference [3] or Reference [4].									
^c Sublimes.									
^d Table E.4 provides designations for single-compound refrigerants for which insufficient data are available for safety classification or determination of an ATEL or RCL value.									

