INTERNATIONAL STANDARD

ISO 817

Third edition
2014-05-15

Refrigerants — Designation and safety classification

Fluides frigorigènes — Désignation et classification de sécurité

Reference number
ISO 817:2014(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.

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The committee responsible for this document is ISO/TC 86, *Refrigeration and air-conditioning*, Subcommittee SC 8, *Refrigerants and refrigeration lubricants*.

This third edition cancels and replaces the second edition (ISO 817:2005), which has been technically revised.

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.

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 LC_{50} 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 %
EC_{50}
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 %
LC_{50}
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 % O_2/79 % N_2 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 back bone 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, $CF_3CF_2CF_3$ 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, CHF_2-O-CF_3) 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, CHF_2-O-CHF-CF_3).

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 CF_3-O-CF_2-CF_3, 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.