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Refrigerants — Designation and safety classification

Fluides frigorigènes — Désignation et classification de sécurité

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ISO 817 was prepared by Technical Committee 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.

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.

2 Terms, definitions, abbreviated terms and symbols

2.1 Terms and definitions

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

2.1.1
acute toxicity
adverse health effect(s) from a single, short-term exposure, as might occur during an accidental release of refrigerants

2.1.2
acute-toxicity exposure limit
ATEL
maximum recommended refrigerant concentration determined in accordance with this International Standard and intended to reduce the risks of acute toxicity hazards to humans in the event of a refrigerant release

2.1.3
anaesthetic effect
impairment of the ability to perceive pain and other sensory stimulation

2.1.4
approximate lethal concentration
ALC
concentration of a refrigerant, that was 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

2.1.5
azeotrope
blend composed of two or more refrigerants whose equilibrium vapour and liquid phase compositions are the same at a given pressure, but may be different at other conditions

2.1.6
blends
mixtures composed of two or more refrigerants

2.1.7
burning velocity
S_u
maximum velocity at which a laminar flame propagates in a normal direction relative to the unburned gas ahead of it

NOTE This value is expressed in centimetres per second.

2.1.8
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

2.1.9
chronic toxicity
adverse health effect(s) from long-term repeated exposures

2.1.10
combustion
exothermal reaction between an oxidant component (combustive) and a reducer (combustible fuel)

2.1.11
compound
substance composed of two or more atoms chemically bonded in definite proportions

2.1.12
critical point
conditions above which distinct liquid and gas phases do not exist

2.1.13
cyclic compound
organic compound whose structure is characterized by a closed ring of atoms

2.1.14
effective concentration 50 %
EC_{50}
concentration of a refrigerant, that has caused a biological effect to 50 % of exposed animals in a test for anaesthetic or other effects

NOTE This value is typically a calculated value from experimental data.

2.1.15
elevated temperature flame limit
ETFL
minimum concentration by volume percent of the refrigerant that is capable of propagating a flame through a homogeneous mixture of the refrigerant and air under test conditions specified in subclause 5.1.2 at 60,0°C and 101,3 kPa

2.1.16
equivalence ratio
fraction of the combustible in the mixture divided by the combustible fraction at the stoichiometric conditions

NOTE 1 Can be written as (combustible fraction) / (combustible fraction)$_{st}$.

NOTE 2 Used in the determination of burning velocity.

NOTE 3 Lean mixtures have an equivalence ratio lower than one and rich mixtures have an equivalence ratio greater than one.

2.1.17
flame
space where combustion takes place, resulting in a temperature increase and light emission

2.1.18
flame propagation
combustion, causing a continuous flame which moves upward and outward from the point of ignition without help from the point of ignition without help from the ignition source

NOTE 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.

2.1.19
flammable
property of a mixture in which a flame is capable of self-propagating for a certain distance

NOTE 1 In its large sense, it characterizes relatively how easy it is for a chemical substance to be ignited and to sustain the combustion. In a more restrained manner, as used in the studies related to the ignition and burning of some products, it designates the capability of a product to burn and sustain a flame reaction under specified test conditions. A combustible-oxidant mixture is not always flammable but restricted to a continuous range of compositions or flammability range.

NOTE 2 The related noun is "flammability".

2.1.20
fractionation
change in composition of a blend by preferential evaporation of the more volatile component(s) or condensation of the less volatile component(s)

2.1.21
heat of combustion
HOC
heat evolved from a specified reaction of a substance with oxygen as determined in accordance with 5.1.2.5

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

2.1.22
isomers
two or more compounds having the same chemical composition with differing molecular configurations

NOTE Isomers will have different properties.

EXAMPLE An example is R-600 ($CH_3CH_2CH_2CH_3$) with a boiling point of 0 °C and R-600a ($CH(CH_3)_2CH_3$) with a boiling point of –12°C. Both of these compounds contain four carbon and 10 hydrogen atoms.

2.1.23
lethal concentration 50 %
LC_{50}
concentration that is lethal to 50 % of the test animals

2.1.24
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 test conditions specified in 5.1.2 at 23,0 °C and 101,3 kPa

NOTE The LFL is expressed as refrigerant percentage by volume.

2.1.25
lowest observed adverse effect level
LOAEL
lowest concentration of a refrigerant that has caused any observed adverse effect in one or more test animals

2.1.26
no observed adverse effect level
NOAEL
highest concentration of a refrigerant at which no adverse effect has been observed in any of the exposed animal population

2.1.27
nominal composition
nominal formulation
bulk manufactured composition of the refrigerant, which includes the gas and liquid phases

NOTE 1 Composition of the refrigerant blends as listed in Tables 6 and 7, column 2

NOTE 2 When a container is 80 % or more liquid filled, the liquid composition may be considered the nominal composition.

2.1.28
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, based on the OSHA PEL, ACGIH TLV-TWA, AIHA WEEL, MAK or consistent value

2.1.29
olefin
unsaturated chemical compound containing at least one carbon-to-carbon double bond

2.1.30
organic compound, saturated
organic, carbon-containing compound that has only single bonds between carbon atoms

2.1.31
organic compound, unsaturated
organic, carbon-containing compound containing at least one double or triple bond between carbon atoms

2.1.32
oxygen deprivation limit
ODL
concentration of a refrigerant or other gas that results in insufficient oxygen for normal breathing

2.1.33
propagation velocity of flame
velocity at which the flame propagates in the space

NOTE In this test method, it refers to the linear velocity at which the flame travels the tube.

2.1.34
quenching
effect of extinction of the flame as it approaches a surface due to heat conduction losses, absorption of active chemical species and viscous effects on the surface

2.1.35
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

2.1.36
refrigerant concentration limit
RCL
maximum refrigerant concentration, in air, determined in accordance with this International Standard and established to reduce the risks of acute toxicity, asphyxiation, and flammability hazards

2.1.37
relative molar mass
mass numerically equal to the molecular mass expressed in grams per mole, except that it is dimensionless

2.1.38
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

2.1.39
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

2.1.40
workplace environmental exposure limit
WEEL
occupational exposure limit set by the American Industrial Hygiene Association

2.1.41
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

NOTE For toxicity this is the composition with the highest concentration of the component(s) in the vapour or liquid phase for which the exposure limit is less than 400 ppm by volume (see F.6.2). For flammability this is the most flammable composition (i.e. if not flammable, the composition that most closely approaches the flammable region; or if flammable, the composition that produces the lowest value for the LFL and for burning velocity the composition that produces the highest S_u).

2.1.42
worst-case fractionated formulation
WCFF
composition produced during fractionation of the worst-case formulation that results in the most toxic or most flammable formulation

NOTE For toxicity this is the composition with the highest concentration of the component(s) in the vapour or liquid phase for which the exposure limit is less than 400 ppm by volume. For flammability this is the most flammable composition (i.e. if not flammable, the composition that most closely approaches the flammable region; or if flammable, the composition that produces the lowest value for the LFL and for burning velocity the composition that produces the highest S_u).

2.1.43
zeotrope
blend composed of two or more refrigerants whose equilibrium vapour and liquid phase compositions are not the same at a given pressure

2.2 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

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

2.3 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

3 Numbering of refrigerants

3.1 An identifying number shall be assigned to each refrigerant. Assigned numbers are shown in Tables 5, 6 and 7.

3.2 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.

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 determined according to 3.2.1 through 3.2.4 shows the presence of bromine or iodine. The number following the letter B or I shows the number of bromine or iodine atoms present.

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 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.

3.2.8 For cyclic compounds, the letter C is used before the identifying refrigerant numbers. (e.g. 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) 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. Bromine containing propane series isomers are not covered by the appended letters given in 3.2.11 and Table 2.

3.2.11 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 methlyene 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).

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, CHF_2-O-CF_3) 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 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 3.5.

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, CHF_2-O-CHF-CF_3).

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 CF_3-O-CF_2-CF_3, the suffix letters described in 3.2.9, 3.2.10 and 3.2.11 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" 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.

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, an upper case 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, an upper case letter (A, B, C, ...) is added after the number.

3.4.3 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.

3.5 **Miscellaneous organic compounds** shall be assigned numbers in the 600 series in decadal groups, as outlined in Table 5, 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.

