ANSI/ASHRAE Standard 34-2007
(Supersedes ANSI/ASHRAE Standard 34-2004)
Includes ANSI/ASHRAE Addenda listed in Appendix F

ASHRAE STANDARD

Designation and Safety Classification of Refrigerants

See Appendix F for approval dates by the ASHRAE Standards Committee, the ASHRAE Board of Directors, and the American National Standards Institute.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines may be obtained in electronic form from the ASHRAE Web site, http://www.ashrae.org, or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: orders@ashrae.org. Fax: 404-321-5478. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in US and Canada).

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SPECIAL NOTE

This American National Standard (ANS) is a national voluntary consensus standard developed under the auspices of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). *Consensus* is defined by the American National Standards Institute (ANSI), of which ASHRAE is a member and which has approved this standard as an ANS, as “substantial agreement reached by directly and materially affected interest categories. This signifies the concurrence of more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that an effort be made toward their resolution.” Compliance with this standard is voluntary until and unless a legal jurisdiction makes compliance mandatory through legislation.

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The Assistant Director of Technology for Standards and Special Projects of ASHRAE should be contacted for:

a. interpretation of the contents of this Standard,
b. participation in the next review of the Standard,
c. offering constructive criticism for improving the Standard, or
d. permission to reprint portions of the Standard.

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NOTE

When addenda, interpretations, or errata to this standard have been approved, they can be downloaded free of charge from the ASHRAE Web site at http://www.ashrae.org.

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FOREWORD

ANSI/ASHRAE Standard 34-2007 is the latest edition of Standard 34, which describes a shorthand way of naming refrigerants and assigns safety classifications based on toxicity and flammability data. The 2007 edition combines Standard 34-2004 and the 23 approved and published addenda to the 2004 edition, thereby providing an easy-to-use consolidated standard. More specific information on the contents of each addendum and its approval dates is included in an informative appendix at the end of this standard.

First published in 1978, Standard 34 is now updated on a regular basis using ASHRAE's continuous maintenance procedures. According to these procedures, Standard 34 is continuously revised—often several times a year—by addenda that are publicly reviewed, approved by ASHRAE and ANSI, and published on the ASHRAE Web site. Because the standard changes as new addenda are published, users are encouraged to sign up for the free Internet list server for the ASHRAE Standards Actions publication, which provides notice of all public reviews and approved and published addenda and errata. At the minimum, users should periodically review the ASHRAE Web site to ensure that they have all of the published addenda.

Among the key changes that were incorporated in the 2007 edition are the following:

- *Added thirteen refrigerants to Table 2 and three to Table 1.*
- *Added the requirement for refrigerant applications in electronic format in addition to the printed copies.*
- *Added a column to Tables 1 and 2 titled "Highly Toxic or Toxic Under Code Classification," with each refrigerant designated as highly toxic, toxic (as defined by the International Fire Code, Uniform Fire Code, and OSHA), or neither (for refrigerants less toxic than as defined above); also added definitions for these terms and updated the references.*
- *Removed the following four data requirements from the application instructions: freezing point or triple point for individual chemicals, vapor composition for the as-formulated saturated liquid composition at the normal boiling point and at 20°C for all blends, and the dew-point vapor pressure at 20°C and 60°C for zeotropic blends.*
- *Added guidance for the numbering of C4-C8 alkanes.*
- *Revised the refrigerant flammability classification and provided details on the required flammability and fractionation testing procedures.*
- *Added an informative appendix containing refrigerant data such as molecular mass and normal boiling point for the refrigerants listed. It also provides bubble points and dew points for azeotropic blends.*
- *Added a new section to the standard to specify the criteria to determine recommended RCLs in occupied spaces and added refrigerant concentration limit (RCL) values to Tables 1 and 2.*
- *Increased the oxygen deprivation limit (ODL) from 69,100 to 140,000 ppm for locations with altitudes at and below 1000 m (3300 ft) above sea level.*
- *Increased the cardiac sensitization default from 0 to 1000 ppm.*
- *Added an informative appendix containing toxicity and flammability data for single-compound refrigerants.*

Users of the standard are encouraged and invited to use the continuous maintenance procedure to suggest changes for further improvements. A form for submitting proposed changes to the standard is included at the back of this edition. The project committee for Standard 34 will take formal action on all proposals received.

1. PURPOSE

This standard is intended to establish a simple means of referring to common refrigerants instead of using the chemical name, formula, or trade name. It also establishes a uniform system for assigning reference numbers and safety classifications to refrigerants. The standard identifies requirements to apply for designations and safety classifications for refrigerants, including blends, in addenda or revisions to this standard.

2. SCOPE

This standard provides an unambiguous system for numbering refrigerants and assigning composition-designating prefixes for refrigerants. Safety classifications based on toxicity and flammability data are included. This standard does not imply endorsement or concurrence that individual refrigerant blends are suitable for any particular application.

3. DEFINITIONS OF TERMS

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

acute-toxicity exposure limit (ATEL): the refrigerant concentration limit determined in accordance with this standard and intended to reduce the risks of acute toxicity hazards in normally occupied, enclosed spaces. ATEL values are similar to the Immediately Dangerous to Life or Health (IDLH) concentrations set by the National Institute of Occupational Safety and Health (NIOSH). ATELs include explicit, additional components for cardiac sensitization and anesthetic effects, but they do not address flammability. The lowest of the ATEL, 50,000 ppm by volume, or 10% of the lower flammability limit, therefore, provides a conservative approximation to IDLH concentrations when needed for refrigerants without adopted IDLH values.

approximate lethal concentration (ALC): the concentration of a substance, a refrigerant in this standard, that was lethal to even a single test animal when tested by the same conditions as for an LC_{50} test.

anesthetic effect: loss of the ability to perceive pain and other sensory stimulation.

azeotropic: an azeotropic blend is one containing two or more refrigerants whose equilibrium vapor and liquid phase compositions are the same at a given pressure. At this pressure, the slope of the temperature vs. composition curve equals zero, which mathematically is expressed as $(dt/dx)_p = 0$, which, in turn, implies the occurrence of a maximum, minimum, or saddle point temperature. Azeotropic blends exhibit some segregation of components at other conditions. The extent of the segregation depends on the particular azeotrope and the application.

azeotropic temperature: the temperature at which the liquid and vapor phases of a blend have the same mole fraction of each component at equilibrium for a specified pressure.

blends: refrigerants consisting of mixtures of two or more different chemical compounds, often used individually as refrigerants for other applications.

cardiac sensitization: an acute effect in which the heart is rendered more sensitive to the body's own catecholamine compounds or administered drugs, such as epinephrine, possibly resulting in irregular heart beat (cardiac arrhythmia), which could be fatal.

ceiling: an exposure level, permissible exposure level-ceiling (PEL-C), or threshold limit value-ceiling (TLV-C), that should not be exceeded during any part of the day.

central nervous system (CNS) effect: treatment-related depression, distraction, stimulation, or other behavioral modification suggesting temporary or permanent changes to control by the brain.

chronic toxicity: adverse health effect(s) from long-term, repeated exposures. This information is used, in part, to establish a TLV-TWA, PEL, or consistent indices.

committee: as used in the standard, refers to ASHRAE Standing Standards Project Committee (SSPC) 34.

compounds: substances formed by the chemical combination of two or more elements in definite proportions by mass.

critical point: the location on a plot of thermodynamic properties at which the liquid and vapor states of a substance meet and become indistinguishable. The temperature, density, and composition of the substance are the same for the liquid and vapor phases at this point. The density, pressure, specific volume, and temperature at the critical point are referred to as the *critical density*, *critical pressure*, *critical volume*, and *critical temperature*, respectively.

cyclic compound: an organic compound that contains three or more atoms arranged in a ring structure.

EC_{50} (effective concentration 50%): the concentration of a material, a refrigerant in this standard, that has caused a biological effect to 50% of test animals.

elevated temperature flame limit (ETFL): the minimum concentration of refrigerant that is capable of propagating a flame through a homogeneous mixture of the refrigerant and air using test equipment and procedures specified in Section B1.1 (in Normative Appendix B) at 101.3 kPa (14.7 psia) and either 60.0°C (140°F) or 100°C (212°F). It is normally expressed as a refrigerant percentage by volume. When tested at 60.0°C, it is called the $ETFL_{60}$. When tested at 100°C, it is called the $ETFL_{100}$.

flame propagation: any combustion that moves upward and outward from the point of ignition as defined in Section B1.8 in Normative Appendix B.

flammable concentration limit (FCL): the refrigerant concentration limit, in air, determined in accordance with this standard and intended to reduce the risk of fire or explosion in normally occupied, enclosed spaces.

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

glide: the absolute value of the difference between the starting and ending temperatures of a phase-change process by a refrigerant within a component of a refrigerating system, exclusive of any subcooling or superheating. This term usually describes condensation or evaporation of a zeotrope.

halocarbon: as used in this standard, a hydrocarbon derivative containing one or more of the halogens bromine, chlorine, or fluorine; hydrogen also may be present.

heat of combustion (HOC): the heat released when a substance is combusted, determined as the difference in the enthalpy between the reactants (refrigerant[s] and air) and their products after combustion as defined in Section 6.1.3.5. The heat or enthalpy of combustion is often expressed as energy per mass (e.g., kJ/kg or Btu/lb).

highly toxic: A material that produces a lethal dose or lethal concentration that falls within any of the following categories:[12,13,14]

1. A chemical that has a median lethal dose (LD_{50}) of 50 milligrams or less per kilogram of body weight when administered orally to albino rats weighing between 200 and 300 grams each.
2. A chemical that has a median lethal dose (LD_{50}) of 200 milligrams or less per kilogram of body weight when administered by continuous contact for 24 hours (or less if death occurs within 24 hours) with the bare skin of albino rabbits weighing between 2 and 3 kilograms each.
3. A chemical that has a median lethal concentration (LC_{50}) in air of 200 parts per million by volume or less of gas or vapor, or 2 milligrams per liter or less of mist, fume, or dust, when administered by continuous inhalation for one hour (or less if death occurs within one hour) to albino rats weighing between 200 and 300 grams each.

hydrocarbon: a compound containing only the elements hydrogen and carbon.

isomer: one of a group of compounds having the same chemical composition with differing molecular structures. Examples include R-123 and R-123a, both of which contain one hydrogen atom and two carbon, three flourine, and two chlorine atoms; both chlorine atoms are bonded to the same carbon atom in R-123 ($CHCl_2CF_3$), but one is bonded to each in

R-123a ($CHClFCClF_2$). The methane series of refrigerants cannot form isomers because the single-carbon nucleus does not enable structural variations.

LC_{50}: a measure of acute inhalation toxicity representing a lethal concentration for 50% of exposed test animals for a specified time interval and species of animal.

lower flammability limit (LFL): the minimum concentration of a substance, a refrigerant in this standard, that is capable of propagating a flame through a homogeneous mixture of the substance and air under specified test conditions.

lowest observed effect level (LOEL): the concentration of a material, a refrigerant in this standard, that has caused any observed effect to even one test animal.

maximum temperature glide: the difference between the saturated liquid temperature (bubble point) and the saturated vapor temperature (dew point) for the "as formulated" blend composition at constant pressure. For a given pressure, the evaporator temperature glide in a direct expansion system will typically be 70% to 80% of the maximum temperature glide, as the refrigerant blend entering the evaporator is a mixture of liquid and vapor, and not at the saturated liquid temperature of the "as formulated" blend composition.

near azeotropic: a zeotropic blend with a temperature glide sufficiently small that it may be disregarded without consequential error in analysis for a specific application.

nominal formulation: the bulk manufactured composition of the refrigerant, which includes the gas and liquid phases. For the purpose of this standard, when a container is 80% or more liquid filled, the liquid composition may be considered the nominal composition.

no-observed-effect level (NOEL): the highest concentration of a material, a refrigerant in this standard, at which no effect has been observed in even one test animal.

nonazeotropic: a synonym for *zeotropic*, the latter being the preferred descriptor. Both *non* and *a* are negation prefixes, the latter from Latin, and therefore cancel one another (i.e., not-not-zeotropic, hence zeotropic). The double negative results from antecedent interest in, and the need to make a distinction with, azeotropic mixtures.

oxygen deprivation limit (ODL): the concentration of a refrigerant or other gas that results in insufficient oxygen for normal breathing.

ppm: parts per million.

permissible exposure level (PEL): the time-weighted average concentration (set by the US Occupational Safety and Health Administration [OSHA]) for a normal 8-hour work day and a 40-hour work week to which nearly all workers can be repeatedly exposed without adverse effect. Chemical manufacturers publish similar recommendations (e.g., acceptable exposure level, AEL; industrial exposure limit, IEL; or occupational exposure limit, OEL, depending on the company), generally for substances for which PEL has not been established.

refrigerant: the fluid used for heat transfer in a refrigerating system; the refrigerant absorbs heat and transfers it at a higher temperature and a higher pressure, usually with a phase change. Substances added to provide other functions, such as lubrication, leak detection, absorption, or drying, are not refrigerants.

refrigerant concentration limit (RCL): the refrigerant concentration limit, in air, determined in accordance with this standard and intended to reduce the risks of acute toxicity, asphyxiation, and flammability hazards in normally occupied, enclosed spaces.

relative molecular mass: the ratio of the mass of a molecule to 1/12 of that of carbon-12. The relative molecular mass is numerically equivalent to the molecular weight expressed in g/mol, but it is dimensionless.

saturated: an organic (carbon-containing) compound in which each carbon atom is joined to four other atoms; all of the chemical bonds in a saturated compound are single.

short-term exposure limit (STEL): typically a 15-minute time-weighted average (TWA) exposure that should not be exceeded at any time during a work day.

temperature glide: see *glide*.

threshold limit values (TLVs): refer to airborne concentrations of substances and represent conditions under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse health effects. Because of the wide variation in individual susceptibility, however, a small percentage of workers may experience discomfort from some substances at concentrations at or below the threshold limit; a smaller percentage may be affected more seriously by aggravation of a pre-existing condition or by development of an occupational illness. Smoking of tobacco is harmful for several reasons. Smoking may act to enhance the biological effects of chemicals encountered in the workplace and may reduce the body's defense mechanisms against toxic substances.

Individuals may also be hypersusceptible or otherwise unusually responsive to some industrial chemicals because of genetic factors, age, personal habits (smoking, use of alcohol or other drugs), medication, or previous exposure. Such workers may not be adequately protected from adverse health effects from certain chemicals at concentrations at or below the threshold limits. An occupational physician should evaluate the extent to which such workers require additional protection.

TLVs are based on the best available information from industrial experience, from experimental human and animal studies, and, when possible, from a combination of the three. The basis on which the values are established may differ from substance to substance; protection against impairment of health may be a guiding factor for some, whereas reasonable freedom from irritation, narcosis, nuisance, or other forms of stress may form the basis for others.[1] (This definition reprinted by permission of ACGIH.)

threshold limit value–time-weighted average (TLV-TWA): the time-weighted average concentration for a normal 8-hour workday and a 40-hour workweek, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect.[1] (This definition reprinted by permission of ACGIH.)

toxic: A chemical falling within any of the following categories:[12,13,14]

1. A chemical that has a median lethal dose (LD_{50}) of more than 50 milligrams per kilogram but not more than 500 milligrams per kilogram of body weight when administered orally to albino rats weighing between 200 and 300 grams each.
2. A chemical that has a median lethal dose (LD_{50}) of more than 200 milligrams per kilogram but not more than 1000 milligrams per kilogram of body weight when administered by continuous contact for 24 hours (or less if death occurs within 24 hours) with the bare skin of albino rabbits weighing between 2 and 3 kilograms each.
3. A chemical that has a median lethal concentration (LC_{50}) in air of more than 200 parts per million but not more than 2000 parts per million by volume of gas or vapor, or more than 2 milligrams per liter but not more than 20 milligrams per liter of mist, fume, or dust, when administered by continuous inhalation for one hour (or less if death occurs within one hour) to albino rats weighing between 200 and 300 grams each.

toxicity: the ability of a refrigerant to be harmful or lethal due to acute or chronic exposure by contact, inhalation, or ingestion. The effects of concern include, but are not limited to, those of carcinogens, poisons, reproductive toxins, irritants, corrosives, sensitizers, hepatoxins, nephrotoxins, neurotoxins, agents that act on the hematopoietic system, and agents that damage the lungs, skin, eyes, or mucous membranes. For this standard, temporary discomfort at a level that is not impairing is excluded.

workplace environmental exposure level (WEEL): an occupational exposure limit set by the American Industrial Hygiene Association (AIHA).

worst case of formulation for flammability (WCF): the nominal formulation, including the composition tolerances, that results in the most flammable concentration of components.

worst case of fractionation for flammability (WCFF): the composition produced during fractionation of the worst case of formulation for flammability that results in the highest concentration of flammable component(s) as identified in this standard in the vapor or liquid phase.

zeotropic: blends comprising multiple components of different volatilities that, when used in refrigeration cycles, change volumetric composition and saturation temperatures as they evaporate (boil) or condense at constant pressure. The word is derived from the Greek words *zein* (to boil) and *tropos* (to change).

4. NUMBERING OF REFRIGERANTS

An identifying number shall be assigned to each refrigerant. Reference 1 in Informative Appendix C provides background on the need for a standard refrigerant nomenclature. Assigned numbers are shown in Tables 1 and 2.

4.1 The identifying numbers assigned to the hydrocarbons and halocarbons of the methane, ethane, propane, and cyclobutane series are such that the chemical composition of the compounds can be explicitly determined from the refrigerant numbers, and vice versa, without ambiguity. The molecular structure can be similarly determined for the methane, ethane, and most of the propane series.

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

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

4.1.3 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.

4.1.4 The fourth digit from the right is equal to the number of unsaturated carbon-carbon bonds in the compound. When this digit is zero, it is omitted from the number.

4.1.5 In those instances where bromine (Br) is present in place of part or all of the chlorine, the same rules apply, except that the uppercase letter *B* after the designation for the parent chlorofluoro compound shows the presence of bromine. The number following the letter *B* shows the number of bromine atoms present.

4.1.6 The number of chlorine (Cl) atoms in the compound is found by subtracting the sum of fluorine (F), bromine (Br), and hydrogen (H) atoms from the total number of atoms that can be connected to the carbon (C) atoms. For saturated refrigerants, this number is $2n + 2$, where n is the number of carbon atoms. The number is $2n$ for mono-unsaturated and cyclic-saturated refrigerants.

4.1.7 The carbon atoms shall be numbered sequentially, in order of appearance, with the number 1 assigned to the end carbon with the most number of hydrogen substituents. In the case where both end carbons contain the same number of (but different) halogen atoms, the number 1 shall be assigned to the first end carbon, defined as having the largest number of bromine, then chlorine, then fluorine, and then iodine atoms.

4.1.8 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 lowercase 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. For an example of this system, see Informative Appendix A.

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

$-CCl_2-$	a
$-CClF-$	b
$-CF_2-$	c
$-CClH-$	d
$-CFH-$	e
$-CH_2-$	f

For halogenated derivatives of cyclopropane, the carbon atom with the largest sum of attached atomic masses shall be considered the *central* carbon atom; for these compounds, the first appended letter is omitted. The second appended letter indicates the relative symmetry of the substituents on the end carbon atoms (C1 and C3). Symmetry is determined by first summing the atomic masses of the halogen and hydrogen atoms attached to the C1 and C3 carbon atoms. One sum is subtracted from the other; the smaller the absolute value of this difference, the more symmetrical the isomer. In contrast to the ethane series, however, the most symmetrical isomer has a second appended letter of *a* (as opposed to no appended letter for ethane isomers); increasingly asymmetrical isomers are assigned successive letters. Appended letters are omitted when no isomers are possible, and the number alone represents the molecular structure unequivocally; for example, $CF_3CF_2CF_3$ is designated R-218, not R-218ca. An example of this system is given in Informative Appendix A.

4.1.10 Bromine-containing, propane-series isomers cannot be uniquely designated by this system.

4.2 For cyclic derivatives, the letter *C* is used before the identifying refrigerant numbers.

4.3 Ether-based refrigerants shall be designated with the prefix "E" (for "ethers") immediately preceding the number.

Except for the following differences, the root number designations for the hydrocarbon atoms shall be determined according to the current standard for hydrocarbon nomenclature (see Section 4.1).

4.3.1 Two-carbon, dimethyl ethers require no further suffixes, as the presence of the "E" prefix provides an unambiguous description.

4.3.2 Straight chain, three-carbon ethers require the agreement of the hydrocarbon ordering in Section 4.1.7.

4.3.2.1 The position(s) of the ether oxygen(s) shall be given by the carbons to which they are first encountered. An additional integer identifying the first carbon to which the ether oxygen is attached will be appended to the suffix letters.

4.3.2.2 In the case of otherwise symmetric hydrocarbon structures, the ether oxygen shall appear in the earliest sequential position.

4.3.2.3 Even in those cases where only a single propane isomer exists for the hydrocarbon portion of the ether structure, such as CF_3-O-CF_2-CF_3, the suffix letters described in Section 4.1.9 shall be retained. In this cited example, the correct designation shall be R-E218ca1.

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

4.3.3 For cyclic ethers carrying both the "C" and "E" prefixes, the "C" shall precede the "E," as "CE," to designate "cyclic ethers."

For four-membered cyclic ethers, including three carbon and one ether oxygen atom, the root number designations for the hydrocarbon atoms shall be constructed according to the current standard for hydrocarbon nomenclature (Section 4.1).

4.4 Blends shall be identified by the designations assigned in this standard. Blends without assigned designations shall be identified by their compositions, listing the components in order of increasing normal boiling points separated by slashes, for example, R-32/134a for a blend of R-32 and R-134a. Specific formulations shall be further identified by appending the corresponding mass fractions expressed as percentages to one decimal place and enclosed in parentheses, for example, R-32/134a (30.0/70.0). No component shall be permitted at less than 0.6% m/m nominal. When formulation tolerances are relevant to the discussion, the corresponding tolerances shall be appended in a second set of parentheses, for example R-32/125/134a (30.0/10.0/60.0) (+1.0,-2.0/±2.0/±2.0) for a blend of R-32, R-125, and R-134a with nominal mass fractions of 30.0%, 10.0%, and 60.0%, respectively, and mass fractions of 28.0%–31.0%, 8.0%–12.0%, and 58.0%–62.0% with tolerances, again respectively.

4.4.1 Designation. Zeotropic blends shall be assigned an identifying number in the 400 series. Azeotropes shall be assigned an identifying number in the 500 series. To differentiate among blends having the same components with different proportions (% m/m), an uppercase letter shall be added as a suffix in serial order of assignment. An example of a zeotrope would be R-401A, and an example of an azeotrope would be R-508A.

4.4.2 Composition Tolerances. Blends shall have tolerances specified for individual components. Those tolerances shall be specified to the nearest 0.1% m/m. The maximum tolerance above or below the nominal shall not exceed 2.0% m/m. The tolerance above or below the nominal shall not be less than 0.1% m/m. 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 1, 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 the table below. For example, R-601a is assigned for 2-methylbutane (isopentane) and R-601b would be assigned for 2,2-dimethylpropane (neopentane).

Attached Group(s)	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 numbers in the 700 and 7000 series.

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

4.6.2 For compounds with relative molecular masses equal to or greater than 100, the number shall be the sum of 7000 and the relative molecular mass, rounded to the nearest integer.

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

5. DESIGNATION

5.1 General. This section provides guidance on prefixes for refrigerants to improve uniformity in order to promote understanding. Both technical and nontechnical designations are provided, to be selected based on the nature and audience of the use.

5.2 Identification. Refrigerants shall be identified in accordance with Section 5.2.1, 5.2.2, or 5.2.3. Section 5.2.1 shall be used in technical publications (for international uniformity and to preserve archival consistency), on equipment nameplates, and in specifications. Section 5.2.2 can be used for single-component halocarbon refrigerants, where distinction between the presence or absence of chlorine or bromine is pertinent. Composition designation may be appropriate for nontechnical, public, and regulatory communications addressing ozone-depleting compounds. Section 5.2.3 can be used, under the same circumstances as Section 5.2.2, for blends (both azeotropic and zeotropic). Section 5.2.1 shall be used for miscellaneous organic and inorganic compounds.

5.2.1 Technical Prefixes. The identifying number, as determined by Section 4, shall be preceded by the letter *R*, the word *Refrigerant* (*Refrigerants* if more than one), or the manufacturer's trademark or trade name. Examples include: R 12, R-12, Refrigerant 12, <Trade Name> 12, <Trade Name> R 12, R-500, R-22/152a/114 (36.0/24.0/40.0), and R-717. Trademarks and trade names shall not be used to identify refrigerants on equipment nameplates or in specifications.

5.2.2 Composition-Designating Prefixes. The identifying number, as determined by Section 4, shall be prefixed by the letter *C* for carbon and preceded by *B*, *C*, or *F*—or a combination thereof in this sequence—to signify the presence of bromine, chlorine, or fluorine, respectively. Compounds that also contain hydrogen shall be further preceded by the letter *H* to signify the increased deterioration potential before reaching the stratosphere.[3] The compositional designating prefixes for ether shall substitute an "E" for "C," such that "HFE," "HCFE," and "CFE" refer to hydrofluoroethers, hydrochlorofluoroethers, and chlorofluoroethers, respectively. Examples include: CFC-11, CFC-12, BCFC-12B1, BFC-13B1, HCFC-22, HC-50, CFC-113, CFC-114, CFC-115, HCFC-123, HCFC-124, HFC-125, HFC-134a, HCFC-141b, HCFC-142b, HFC-143a, HFC-152a, HC-170, and FC-C318.

5.2.3 Recognized blends (whether azeotropic, near-azeotropic, or zeotropic) with assigned numbers can be identified by linking the appropriate composition-designating prefixes of individual components (e.g., CFC/HFC-500). 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]). Linked prefixes (e.g., HCFC/HFC/CFC-22/152a/114 [36.0/24.0/40.0]) and prefixes implying synthesized compositions (e.g., HCFC-500 or HCFC-22/152a/114 [36.0/24.0/40.0]) shall not be used.

5.2.4 Composition-designating prefixes should be used only in nontechnical publications in which the potential for ozone depletion is pertinent. The prefixes specified in Section 5.2.1, augmented if necessary as indicated in Section 5.4, are preferred in other communications. Section 5.2.1 also may be preferable for blends when the number of components makes composition-designating prefixes awkward, such as for those containing more than three individual components (e.g., in tetrary and pentary blends).

5.3 Other prefixes, including ACFC and HFA, for *alternative to chlorofluorocarbons* and *hydrofluorocarbon alternative*, respectively, shall not be used. Similarly, neither FC nor CFC shall be used as universal prefixes to signify the fluorocarbon and chlorofluorocarbon families of refrigerants (i.e., other than as stipulated in Section 5.2.2).

5.4 The convention specified in Section 5.2.1 can be complemented with pertinent data, when appropriate, as a preferred alternative to composition-designating prefixes in technical communications. For example, the first mention of R-12 in a discussion of the ozone-depletion issue might read, "R-12, a CFC" or "R-12 (ODP = 1.0)." Similarly, a document on the greenhouse effect could cite "R-22 (GWP = 0.34 relative to R-11)," and one on flammability might refer to "R-152a (LFL = 4.1%)."

6. SAFETY GROUP CLASSIFICATIONS

6.1 Refrigerants shall be classified into safety groups according to the following criteria.

6.1.1 Classification. The safety classification shall consist of two alphanumeric characters (e.g., A2 or B1). The capital letter indicates the toxicity as determined by Section 6.1.2; the arabic numeral denotes the flammability as determined by Section 6.1.3.

6.1.2 Toxicity Classification. Refrigerants shall be assigned to one of two classes—A or B—based on allowable exposure:

> ***Class A*** signifies refrigerants for which toxicity has not been identified at concentrations less than or equal to 400 ppm by volume, based on data used to determine threshold limit value–time-weighted average (TLV–TWA) or consistent indices.
>
> ***Class B*** signifies refrigerants for which there is evidence of toxicity at concentrations below 400 ppm by volume, based on data used to determine TLV-TWA or consistent indices.

6.1.3 Flammability Classification. Refrigerants shall be assigned to one of three classes—1, 2, or 3—based on flammability. Tests shall be conducted in accordance with ASTM E681[2] using a spark ignition source. Testing of all halocarbon refrigerants shall be in accordance with the Annex of ASTM E681. Single-compound refrigerants shall be assigned a single flammability classification. Refrigerant blends shall be assigned flammability classifications as specified in Section 6.1.5. Blends shall be assigned a flammability classification based on their WCF and WCFF, as determined from a fractionation analysis (see Section B2 in Normative Appendix B). A fractionation analysis for flammability is not required if the components of the blend are all in one class; the blend shall be that same class (see Table 3).

6.1.3.1 Class 1

a. A single-compound refrigerant shall be classified as Class 1 if the refrigerant does not show flame propagation when tested in air at 100°C (212°F) and 101.3 kPa (14.7 psia).
b. The WCF of a refrigerant blend shall be classified as Class 1 if the WCF of the blend does not show flame propagation when tested in air at 100°C (212°F) and 101.3 kPa (14.7 psia).
c. The WCFF of a refrigerant blend shall be classified as Class 1 if the WCFF of the blend, as determined from a fractionation analysis specified by Section B.2 in Normative Appendix B, does not show flame propagation when tested at 60.0°C (140°F) and 101.3 kPa (14.7 psia).

6.1.3.2 Class 2

a. A single-compound refrigerant shall be classified as Class 2 if the refrigerant meets all three of the following conditions:
   1. exhibits flame propagation when tested at 100°C (212°F) and 101.3 kPa (14.7 psia),
   2. has an LFL > 0.10 kg/m^3 (0.0062 lb/ft^3) (see Section 6.1.3.4 if the refrigerant has no LFL at 23.0°C and 101.3 kPa), and
   3. has a heat of combustion <19,000 kJ/kg (8,169 Btu/lb) (see Section 6.1.3.5).
b. The WCF of a refrigerant blend shall be classified as Class 2 if it meets all three of the following conditions:
   1. exhibits flame propagation when tested at 100°C (212°F) and 101.3 kPa (14.7 psia),
   2. has an LFL > 0.10 kg/m^3 (0.0062 lb/ft^3) (see Section 6.1.3.4 if the WCF of the blend has no LFL at 23.0°C and 101.3 kPa), and
   3. has a heat of combustion <19,000 kJ/kg (8,169 Btu/lb) (see Section 6.1.3.5).
c. The WCFF of a refrigerant blend shall be classified as Class 2 if it meets all three of the following conditions:
   1. exhibits flame propagation when tested at 60.0°C (140°F) and 101.3 kPa (14.7 psia),
   2. has an LFL > 0.10 kg/m^3 (0.0062 lb/ft^3) (see Section 6.1.3.4 if the WCFF of the blend has no LFL at 23.0°C and 101.3 kPa), and
   3. has a heat of combustion <19,000 kJ/kg (8,169 Btu/lb) (see Section 6.1.3.5).

6.1.3.3 Class 3

a. A single-compound refrigerant shall be classified as Class 3 if the refrigerant meets both of the following conditions:
   1. exhibits flame propagation when tested at 100°C (212°F) and 101.3 kPa (14.7 psia) and
   2. has an LFL ≤ 0.10 kg/m^3 (0.0062 lb/ft^3) (see Section 6.1.3.4 if the refrigerant has no LFL at 23.0°C and 101.3 kPa) or it has a heat of combustion that is ≥19,000 kJ/kg (8,169 Btu/lb).
b. The WCF of a refrigerant blend shall be classified as Class 3 if it meets both of the following conditions:
   1. the WCF exhibits flame propagation when tested at 100°C (212°F) and 101.3 kPa (14.7 psia) and
   2. the WCF has an LFL ≤ 0.10 kg/m^3 (0.0062 lb/ft^3) (see Section 6.1.3.4 if the WCF of the blend has no LFL at 23.0°C and 101.3 kPa) or the WCF of the blend has a heat of combustion that is ≥19,000 kJ/kg (8,169 Btu/lb).
c. The WCFF of a refrigerant blend shall be classified as Class 3 if it meets both of the following conditions:
   1. the WCFF exhibits flame propagation when tested at 60.0°C (140°F) and 101.3 kPa (14.7 psia) and
   2. the WCFF has an LFL ≤ 0.10 kg/m^3 (0.0062 lb/ft^3) (see Section 6.1.3.4 if the WCFF of the blend has no LFL at 23.0°C and 101.3 kPa) or the WCFF of the blend has a heat of combustion that is ≥19,000 kJ/kg (8,169 Btu/lb).

6.1.3.4 For Class 2 or Class 3 refrigerants or refrigerant blends, the LFL shall be determined. For those Class 2 or Class 3 refrigerants or refrigerant blends that show no flame propagation when tested at 23.0°C (73.4°F) and 101.3 kPa (14.7 psia) (i.e., no LFL), an elevated temperature flame limit (ETFL) shall be used in lieu of the LFL for determining their flammability classifications, as follows.

a. For a single-compound refrigerant, the $ETFL_{100}$ shall be used in lieu of the LFL.
b. For the WCF of a refrigerant blend, the $EFTL_{100}$ shall be used in lieu of the LFL.
c. For the WCFF of a refrigerant blend, the $EFTL_{60}$ shall be used in lieu of the LFL.

6.1.3.5 The heat of combustion shall be calculated for conditions of 25°C (77°F) and 101.3 kPa (14.7 psia).

a. For single-component refrigerants, the heat of combustion can be calculated, if the heat of formation (enthalpy of formation) of the refrigerant and its products of reaction are known. Values for heats of formation are tabulated in several chemical and physical property handbooks and databases. The heat of combustion is the enthalpy of formation of the reactants (refrigerant and oxygen) minus the enthalpy of formation of the products of reaction. In this standard, the heat of combustion is positive for exothermic reactions. 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 CO_2 (N_2 or SO_2 if nitrogen or sulfur are part of the refrigerant's molecular structure), HF and HCl, if there is enough hydrogen in the molecule. If there is insufficient hydrogen available for the formation of both HF and HCl, then the formation of HF takes preference over the formation of HCl. The remaining F and Cl produce F_2 and Cl_2. Excess H shall be assumed to be converted to H_2O.

b. For refrigerant blends, the heat of combustion shall be measured or calculated from a balanced stoichiometric equation of all component refrigerants.

c. Heats of formation and heats of combustion are normally expressed as energy per mole (kJ/mol or Btu/mol). For purposes of flammability classification under this standard, convert the heat of combustion for a refrigerant from an energy per mole value to an energy per mass value (kJ/kg or Btu/lb).

6.1.4 Matrix Diagram of Safety Group Classification System. The toxicity and flammability classifications described in Sections 6.1.1, 6.1.2, and 6.1.3 yield six separate safety group classifications (A1, A2, A3, B1, B2, and B3) for refrigerants. These classifications are represented by the matrix shown in Figure 1.

6.1.5 Safety Classification of Refrigerant Blend. Blends, whether zeotropic or azeotropic, whose flammability and/or toxicity characteristics may change as the composition changes during fractionation, shall be assigned a safety group classification based on the worst case of fractionation. This classification shall be determined according to the same criteria as that for a single-compound refrigerant.

For flammability, *worst case of fractionation* is defined as the composition during fractionation that results in the highest concentration of the flammable component(s) in the vapor or liquid phase. For toxicity, *worst case of fractionation* is defined as the composition during fractionation that results in the highest concentration of the component(s) in the vapor or liquid phase for which the TLV-TWA is less than 400 ppm by volume. The TLV-TWA for a specific blend composition shall be calculated from the TLV-TWA of the individual components (Appendix C of Reference 2).

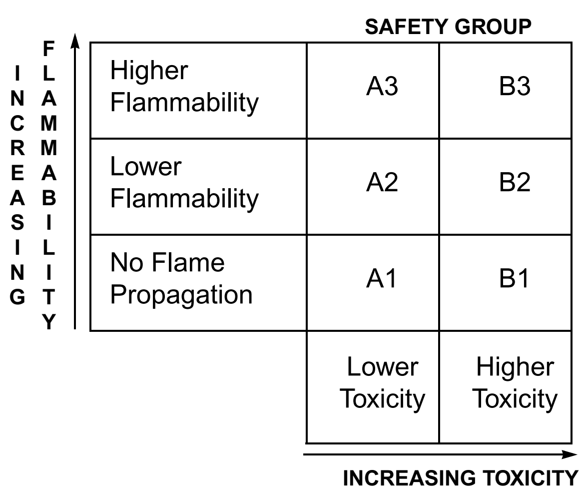

Figure 1 Refrigerant safety group classification.

6.2 Other Standards. This classification is to be used in conjunction with other relevant safety standards, such as *ANSI/ASHRAE Standard 15, Safety Standard for Refrigeration Systems*.[4]

7. REFRIGERANT CONCENTRATION LIMIT (RCL)

7.1 Single-Compound Refrigerants. The RCL for each refrigerant shall be the lowest of the quantities calculated in accordance with Sections 7.1.1, 7.1.2, and 7.1.3, using data as indicated in Section 7.3 and adjusted in accordance with Section 7.4. Determination shall assume full vaporization with no removal by ventilation, dissolution, reaction, or decomposition and complete mixing of the refrigerant in the space to which it is released.

7.1.1 Acute-Toxicity Exposure Limit (ATEL). The ATEL shall be the lowest of items (a) through (d) as follows:

a. **Mortality:** 28.3% of the 4-hour LC_{50} for rats. If not determined, 28.3% of the 4-hour ALC for rats. If neither has been determined, 0 ppm. The following equations shall be used to adjust LC_{50} or ALC values that were determined with 15-minute to 8-hour tests for refrigerants for which 4-hour test data are not available:

$$LC_{50 \text{ for } T} = LC_{50 \text{ for } t} \cdot (t/T)^{1/2}$$

or

$$ALC_T = ALC_t \cdot (t/T)^{1/2}$$

where

T = 4 hours

t = test duration expressed in hours, 0.25–8

b. **Cardiac Sensitization:** 100% of the NOEL for cardiac sensitization in unanesthetized dogs. If not determined, 80% of the LOEL for cardiac sensitization in dogs. If neither has been determined, 1000 ppm. The cardiac sensitization term is omitted from ATEL determination if the LC_{50} or ALC in (a) is less than 10,000 ppm by volume or if the refrigerant is found, by toxicological review, not to cause cardiac sensitization.

c. **Anesthetic or Central Nervous System Effects:** 50% of the 10-minute EC_{50} in mice or rats for loss of righting ability in a rotating apparatus. If not determined, 50% of the LOEL for signs of any anesthetic or CNS effect in rats during acute toxicity studies. If neither has been determined, 80% of the NOEL for signs of any anesthetic or CNS effect in rats during an acute, subchronic, or chronic toxicity study in which clinical signs are documented.

d. **Other Escape-Impairing Effects and Permanent Injury:** 80% of the lowest concentration, for human exposures of 30 minutes, that is likely to impair ability to escape or to cause irreversible health effects.

7.1.2 Oxygen Deprivation Limit (ODL). The ODL shall be 140,000 ppm by volume for locations with altitudes at and below 1000 m (3300 ft) above sea level. At locations with altitudes greater than 1000 m (3300 ft) above sea level, the ODL shall be 69,100 ppm.

7.1.3 Flammable Concentration Limit (FCL). The FCL shall be calculated as 25% of the LFL determined in accordance with Section 6.1.3.

7.2 Blends. The RCL for refrigerants comprising multiple compounds shall be determined by the method in Section 7.1 except that individual parameter values in Section 7.1.1 (a) through (d) shall be calculated as the mole-weighted average, by composition of the nominal formulation, of the values for the components.

7.3 Data for Calculations. The data used to calculate the RCL shall be taken from scientific and engineering studies or published safety assessments by governmental agencies or expert panels. The applications submitted under Section 8, or therein referenced source studies for toxicity data, must indicate the extent of compliance with good laboratory practices (GLP) in accordance with references 5, 6, 7, or 8 or earlier editions of these references in effect when the studies were performed. Data from peer-reviewed publications, including journal articles and reports, also are allowed.

7.3.1 Alternative Data. Data from studies that have not been published, from studies that have not been peer reviewed, or from studies involving species other than those indicated in Section 7.1.1 (a) through (d), shall be submitted to the authority having jurisdiction (AHJ) for approval. For RCL values to be published in addenda or revisions to this standard, the AHJ shall be the committee. Submissions shall include an evaluation of the experimental and analytical methods used, data from alternative sources, and the extent of the data search. The submissions shall summarize the qualifications of the person or persons providing the evaluation.

7.3.2 Conservative Data. Where multiple data values have been published, the values used shall be those resulting in the lowest RCL.

Exceptions:

a. Where subsequent, peer-reviewed studies explicitly document flaws in or refinements to previously published data, the newer values shall be used.
b. For the cardiac sensitization and anesthetic effect NOEL in Section 7.1.1 (b) and (c), respectively, the highest-published NOEL not exceeding a published LOEL, for any fraction of tested animals, shall be used. Both the NOEL and LOEL must conform to Section 7.3 or 7.3.1 for this exception.

7.3.3 No-Effect Data. Where no treatment-related effect was observed in animal tests for Section 7.1.1 items (a) through (d), the ATEL calculation required by Section 7.1.1 shall use the highest concentration tested in lieu of the specified effect or no-effect level.

7.3.4 ALC and LOEL Qualification. No ALC or LOEL shall be used for Section 7.1.1 items (a) through (c) if it resulted in the effect measured (mortality, cardiac sensitization, or anesthetic effect) in more that half the animals exposed at that concentration or if there is a lower ALC or LOEL for any fraction of tested animals.

7.3.5 Consistent Measures. Use of data that are determined in consistent manner, or by methods that consistently yield a lower RCL for the same effects, is allowed for the parameters identified in Section 7.1.

7.4 Units Conversion

7.4.1 Mass per Unit Volume. The following equation shall be used to convert the RCL from a volumetric ratio, ppm by volume, to mass per unit volume, g/m^3 (lb/Mcf):

$$\mathrm{RCL}_M = \mathrm{RCL} \cdot a \cdot M$$

where

RCL_M = the RCL expressed as g/m^3 (lb/Mcf)
RCL = the RCL expressed as ppm v/v
a = $4.096 \cdot 10^{-5}$ for g/m^3 (1.160×10^{-3} for lb/Mcf)
M = the molecular mass of the refrigerant in g/mol (lb/mol)

7.4.2 Adjustment for Altitude. The RCL shall be adjusted for altitude, when expressed as mass per unit volume, g/m^3 (lb/Mcf), for locations above sea level. The RCL shall not be adjusted when expressed as a volumetric ratio, ppm.

$$rcl_a = \mathrm{RCL}_M \cdot (1 - [b \cdot h])$$

where

rcl_a = the adjusted RCL_M
b = $7.94 \cdot 10^{-5}$ for m ($2.42 \cdot 10^{-5}$ for ft)
h = altitude above sea level in m (ft)

7.5 RCL Values. Refrigerants are assigned the RCLs indicated in Tables 1 and 2.

7.5.1 Influence of Contaminants. The RCLs indicated in Tables 1 and 2 are based on data for pure chemicals; RCLs shall be determined in accordance with Section 7.5.2 for refrigerants containing contaminants or other impurities that alter the flammability or toxicity.

7.5.2 RCLs for Other Refrigerants. RCLs for other refrigerants shall be determined in accordance with this standard and submitted to the authority having jurisdiction (AHJ) for approval. Submissions shall include an evaluation of the experimental and analytical methods used, data from alternative sources, and an indication of the extent of the data search. The submission shall summarize the qualifications of the person or persons that prepared the recommended RCLs.

8. REFRIGERANT CLASSIFICATIONS

Refrigerants are assigned the classifications indicated in Tables 1 and 2. Toxicity and flammability data used to determine RCL values are summarized in informative Appendix E.

9. APPLICATION INSTRUCTIONS

This section identifies requirements to apply for designations and safety classifications for refrigerants, including blends, in addenda or revisions to the standard.

9.1 Eligibility

9.1.1 Applicants. Any interested party may request designations and safety classifications for refrigerants. Applicants may be individuals, organizations, businesses, or government agencies. A primary contact shall be identified for groups of individuals, organizations, businesses, or agencies. Neither the individuals nor primary contacts need be members of ASHRAE.

9.1.2 Fee. There is no application fee.

9.1.3 Timing. Applications may be submitted at any time. Committee consideration will be deferred if received by committee members less than 30 calendar days before a scheduled meeting. Applicants may communicate with the Manager of Standards (see Section 9.8.6) to determine when the next meeting is scheduled and the additional lead time required. Consideration also may be deferred, by vote of the majority of voting members present, if inadequate opportunity was afforded for review based on the number or complexity of applications received for a specific meeting.

9.1.4 Precedence. Applications normally will be taken up in the order received. Early submission will be beneficial in the event that too many applications are received for consideration at a specific meeting.

9.1.5 Amendments. Pending applications may be amended to revise or add information whether initiated by the applicant or in response to a committee request for further information. Amended applications will be resequenced to the date of receipt of the last amendment to determine the order of consideration. Amendments shall be separated into the parts indicated in Section 9.2, beginning the information for each part on a new page to facilitate insertion in the original or previously amended application. Amendments must repeat the data certification specified in Section 9.4.2. Rejected applications may not be amended, but they may be resubmitted in their entirety as new applications based on new information that may become available.

9.1.6 Blends

9.1.6.1 Components. The components of refrigerant blends must be individually classified before safety classifications will be assigned to blends containing them. Applications for designation and classification of blends, therefore, shall be accompanied or preceded by applications for all components not yet classified in this standard.

9.1.6.2 Single Application. Designations, formulation tolerances, and safety classifications (both as formulated and for the worst case of fractionation) shall be requested in a single application for blends. None of these will be assigned separately. Revisions of these items may be requested separately.

9.1.7 Confidentiality. Confidential information shall not be included in applications. All information contained in applications and amendments thereto shall be deemed to be public information, even if marked as confidential or proprietary. Restricted handling of data would unduly impede committee deliberations and assignment of designations and classifications through a consensus review process.

9.2 Organization and Content. Separate applications shall be submitted for each refrigerant. Applications shall be organized into the following parts as further identified in Sections 9.3 through 9.8:

a. Cover
b. Administrative information
c. Designation information
d. Toxicity information
e. Flammability information
f. Other safety information (if applicable)
g. Appendices (if applicable)

9.3 Cover. The cover shall identify the applicant and primary contact, the refrigerant in accordance with Section 9.5.1, and requested action. Requested actions may include assignment or revision of a designation, safety classification, or—for blends—formulation tolerance. Commercial and trade names for refrigerants shall not be used on the cover.

9.4 Administrative Information

9.4.1 Applicant Identification. The applicant, primary contact, and other persons authorized to represent the applicant shall be identified. Names, titles, addresses, and phone numbers shall be provided for the primary contact and other representatives. Fax numbers and e-mail addresses also may be provided to facilitate communications. The applicant's interest in the subject refrigerant shall be stated.

9.4.2 Data Certification. An application shall include the following statements signed by the individual(s) or—for organizations and businesses—both a corporate officer and the primary contact:

> I/We certify that the information provided in this application (including its appendices) is true and accurate to the best of my/our knowledge and that no information that would affect classification of toxicity or flammability safety is being withheld. I/We further certify that I/we have reviewed ANSI/ASHRAE Standard 34-2007 (including all published addenda thereto) and that the information provided in this application is consistent with the requirements of that standard.

9.4.3 Designation and Classification Certification. Applications shall include the following statement signed by the individual(s) or—for organizations and businesses—both a corporate officer and the primary contact:

> I/We understand that designations and safety classifications recommended for public review approval or publication are not assigned and may be revised or disapproved until actually published in an addendum or revision to Standard 34.

9.5 Designation Information. Applications for refrigerant designations shall contain the information identified in Sections 9.5.1 through 9.5.3.

9.5.1 Refrigerant Identification

9.5.1.1 Single-compound refrigerants shall be identified in accordance with Section 4 with the exception of Section 4.4, which applies to blends.

9.5.1.2 Blends shall be identified in accordance with Section 4.4, but not Section 4.4.1. Applicants shall indicate whether the blend is azeotropic or zeotropic (including near azeotropic) as defined in Section 3.

9.5.2 Refrigerant Data

9.5.2.1 Individual Compounds. The following information shall be provided for single-compound refrigerants or for each component of blends:

a. Chemical name
b. Chemical formula
c. Chemical Abstract Service registry number
d. Molecular mass
e. Normal boiling point temperature at 101 kPa (14.7 psia)
f. Saturation vapor pressure at 20°C and 60°C (68°F and 140°F)
g. Temperature at the critical point
h. Specific volume at the critical point
i. Uses and typical application temperatures (i.e., evaporating and condensing ranges)

9.5.2.2 Azeotropic Blends. The following additional information shall be provided for azeotropes:

a. Azeotropic temperature
b. Formulation at the azeotropic temperature
c. Molecular mass as formulated
d. Molecular mass of the saturated vapor at 60°C (140°F)
e. Normal boiling point temperature (bubble-point temperature) at 101 kPa (14.7 psia) as formulated
f. Normal dew-point temperature at 101 kPa (14.7 psia) as formulated
g. Maximum temperature glide at the normal boiling point and at 20°C (68°F)
h. Saturation vapor pressure at 20°C and 60°C (68°F and 140°F) as formulated
i. Evidence of azeotropy, including a detailed description of testing and a vapor-liquid equilibrium diagram (optional supporting information may be provided as an appendix)
j. Latent heat of vaporization at 60°C (140°F)
k. Specific heat ratio of the vapor at 60°C (140°F)
l. Temperature at the critical point
m. Specific volume at the critical point
n. Uses and typical application temperatures (i.e., evaporating and condensing ranges)
o. Proposed composition tolerances for classification
p. Worst case of formulation for flammability (WCF) of the blend
q. Worst case of fractionation for flammability (WCFF) of the blend

9.5.2.3 Zeotropic Blends. The following additional information shall be provided for zeotropes (including near azeotropes):

a. Formulation
b. Molecular mass as formulated
c. Molecular mass of the vapor at 60°C (140°F)
d. Bubble-point temperature at 101 kPa (14.7 psia)
e. Dew-point temperature at 101 kPa (14.7 psia)
f. Maximum temperature glide at the normal boiling point and at 20°C (68°F)
g. Latent heat of vaporization at 60°C (140°F)
h. Specific heat ratio of the vapor at 60°C (140°F)
i. Temperature at the critical point
j. Specific volume at the critical point
k. Uses and typical application temperatures (i.e., evaporating and condensing ranges)
l. Proposed composition tolerances for classification
m. Worst case of formulation for flammability (WCF) of the blend
n. Worst case of fractionation for flammability (WCFF) of the blend

9.5.2.4 Refrigerants with Low Critical Temperatures. If the critical temperature is less than a temperature at which data are required in Sections 9.5.2.1, 9.5.2.2, and 9.5.2.3, substitute as follows:

a. For data requirements at 20°C (68°F), provide the required data at the normal boiling point or 0°C (32°F), whichever is higher. For pressure data, also provide the superheated vapor pressure at 20°C (68°F) and the critical density.
b. For data requirements at 60°C (140°F), provide the required data at a temperature calculated as the normal boiling point plus 80% of the difference between the critical temperature and the normal boiling point. For pressure data, also provide the superheated vapor pressure at 60°C (140°F) and the critical density.
c. Indicate the applicable temperature, or temperature and critical density, at which the substitute data are provided.

9.5.2.5 Critical Point for Blends. For refrigerant blends, the critical temperature and pressure shall be calculated as the weighted average by mole fractions of the critical temperatures and pressures, respectively, of the blend components in the as-formulated composition.

9.6 Toxicity Information. Applications shall include the data identified in Sections 9.6.1, 9.6.2, and 9.6.3. The sources for these data shall be identified, and the applicant shall provide copies if requested by the committee. The identified sources shall describe the test methods, specimens, and materials used and also document clinical observations and the test results. The documentation must indicate compliance with Good Laboratory Practices (GLP) in accordance with reference 5, 6, 7, or 8 for toxicity tests since 1985. Data from peer-reviewed publications, including journal articles, reports, and assessments, also are allowed provided that they demonstrate examination of the same information. Material Safety Data Sheets (MSDSs), Hygiene Standard Sheets, manufacturers' product literature, and databases are not acceptable as sources for toxicity information for this section.

9.6.1 Acute Toxicity. Applications shall include the following short-term toxicity data, with identified sources, for single-compound refrigerants or for each component of blends:

a. ACGIH TLV-C if assigned,
b. ACGIH TLV-STEL if assigned,

c. NIOSH IDLH if assigned,
d. LC_{50} for four hours for rats,
e. LD_{50} if available, and
f. cardiac sensitization response level.

9.6.2 Chronic Toxicity. For single-compound refrigerants or for each component of blends and for the blend itself, applications shall include, with identified sources,

a. repeat exposure toxicity data if available,
b. ACGIH TLV-TWA or TLV-C if assigned,
c. AIHA WEEL if assigned, and
d. OSHA PEL if assigned; otherwise, a recommended exposure value, determined on a consistent basis, with an explanation of how it was determined.

9.6.3 Material Safety Data Sheets (MSDSs). Applications for single-compound refrigerants shall include an MSDS, or information consistent therewith, as an appendix. Applications for blends shall include MSDSs for the blend as formulated and for each component of the blend as appendices.

9.7 Flammability Information. Applications for single-compound refrigerants and refrigerant blends shall include flammability test data and information identified in Section B1.9 in Normative Appendix B. Applications for refrigerant blends shall also include tabulated fractionation data and information identified in Section B.2.6 in Normative Appendix B. See Section 9.1.6 regarding blend components.

9.7.1 Fractionation Analysis. Applications shall include an analysis of fractionation and shall include test results determined in accordance with Section B2 in Normative Appendix B.

9.8 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.

9.9 Submission

9.9.1 Language. Applications shall be submitted in English.

9.9.2 Units. Applications shall be submitted either in SI (metric) units or in dual units (SI and inch-pound).

9.9.3 Printed and Electronic Format. Required information and evidence must be submitted in both printed and electronic formats.

9.9.4 Format. Applications shall be provided on 8.5 × 11 in. or A4 (21 × 29.7 cm) paper. Reproduction may be either single- or double-sided (on one or both sides of the paper). Pages shall be bound using a cover that facilitates disassembly, insertion of supplementary pages, and reassembly without staples or binding machines, such as three-ring binders or covers with three bend-over tabs (standard two- or four-ring binders or covers with two bend-over tabs for A4 paper). Tabbed dividers shall be inserted before each part identified in Section 9.2 except the cover.

9.9.5 Quantity. Thirty-five bound copies shall be provided for committee and administrative use plus one unbound set for further reproduction by ASHRAE if needed. In addition, 35 compact disks with the application in electronic format shall be provided. The electronic format shall be a true PDF file. A scanned PDF file with large memory requirements is not acceptable except for figures and other inserts. Committee members may request only the compact disk, thereby reducing the number of bound paper copies required.

9.9.6 Recipient. Submit applications to the following address:

Manager of Standards
ASHRAE
1791 Tullie Circle NE
Atlanta, GA 30329-2305 USA

9.9.7 Elaborate Applications. Elaborate proposals containing brochures on the applicant, performance data, and other material not needed for committee deliberations are discouraged.

9.9.8 Substantiation. Copies of data sources referenced in applications shall be submitted for committee use upon request by the Manager of Standards. These copies shall include the complete documents or pertinent chapters, to enable verification of methods and limitations. The quantity shall be as indicated in Section 9.8.5.

Exception: The quantity shall be reduced to four copies for copyrighted journal articles, conference papers, reports, or other publications for which royalties are charged for reproduction.

10. REFERENCES

[1] *1990-1991 Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices*, American Conference of Governmental Industrial Hygienists, Cincinnati, OH, 1990.

[2] ASTM E681-2001, *Standard Test Method for Concentration Limits of Flammability of Chemicals (Vapors and Gases)*, American Society of Testing and Materials, West Conshohocken, PA, 2001.

[3] J.M. Calm, "Composition Designations for Refrigerants," *ASHRAE Journal*, Vol. 31, No. 11, pp. 48-51, November 1989.

[4] *ANSI/ASHRAE Standard 15-2007, Safety Standard for Refrigeration Systems.*

[5] *OECD Principles of Good Laboratory Practice, Annex 2 of Decision C(81)30(Final),* Organization for Economic Co-operation and Development (OECD), Paris, France, 13 May, 1981 as revised through 1999.

[6] *Good Laboratory Practice for Nonclinical Laboratory Studies, Food and Drug Administration (FDA), 21 CFR Chapter 1 Part 58, Subparts A-K,* Government Printing Office, Washington, DC, 1 April 2000.

[7] *Good Laboratory Practice Standards,* Environmental Protection Agency, 40 CFR Part 792, Subparts A-J, Government Printing Office, Washington, DC, 1 July 2000.

[8] *GLP for Industrial Chemicals*, Kikyoku [Basic Industries Bureau] Dispatch 85, Ministry of International Trade and Industry (MITI), and Kanpogyo [Planning and

Coordination Bureau] Dispatch 39, Environmental Agency, Tokyo, Japan, 31 March 1984.

[9] *Standard for Safety – Refrigerants*, UL Standard 2182, Underwriters Laboratories, Inc., Northbrook, IL, 2006.

[10] *Title 49 CFR* (*Code of Federal Regulations*), Section 173.306.

[11] Richard, R., *Refrigerant Flammability Testing in Large Volume Vessels,* (ARTI MCLR Final Report DOE/CE/23810-87), Air-Conditioning and Refrigeration Technology Institute, Arlington, VA, 1998.

[12] *International Fire Code* (IFC), International Code Council, Fairfax, VA, section 3702, 2003.

[13] *Uniform Fire Code* (UFC), Western Fire Chiefs Association, Walnut Creek, CA, sections 209 and 221, 2000.

[14] *Health Hazard Definitions (Mandatory)*, Occupational Safety And Health Administration (OSHA), US Department of Labor, 29 Code of Federal Regulations (CFR) 1910.1200 Subpart Z Appendix A, US Government Printing Office, Washington, DC, 2004.

TABLE 1 Refrigerant Data and Safety Classifications

Refrigerant Number	Chemical Name[a,b]	Chemical Formula[a]	Safety Group	RCL[c] (ppm v/v)	RCL[c] (g/m³)	RCL[c] (lb/Mcf)	Highly Toxic or Toxic[e] Under Code Classification
Methane Series							
11	trichlorofluoromethane	CCl_3F	A1	1100	6.2	0.39	Neither
12	dichlorodifluoromethane	CCl_2F_2	A1	18,000	90	5.6	Neither
12B1	bromochlorodifluoromethane	$CBrClF_2$					Neither
13	chlorotrifluoromethane	$CClF_3$	Al				Neither
13B1	bromotrifluoromethane	$CBrF_3$	Al				Neither
14[d,f]	tetrafluoromethane (carbon tetrafluoride)	CF_4	Al	110,000	400	25	Neither
21	dichlorofluoromethane	$CHCl_2F$	B1				Toxic
22	chlorodifluoromethane	$CHClF_2$	Al	59,000	210	13	Neither
23	trifluoromethane	CHF_3	Al	41,000	120	7.3	Neither
30	dichloromethane (methylene chloride)	CH_2Cl_2	B2				Neither
31	chlorofluoromethane	CH_2ClF					Neither
32	difluoromethane (methylene fluoride)	CH_2F_2	A2	36,000	77	4.8	Neither
40	chloromethane (methyl chloride)	CH_3Cl	B2				Toxic
41	fluoromethane (methyl fluoride)	CH_3F					Neither
50	methane	CH_4	A3				Neither
Ethane Series							
113	1,1,2-trichloro-1,2,2-trifluoroethane	CCl_2FCClF_2	A1	2600	20	1.2	Neither
114	1,2-dichloro-1,1,2,2-tetrafluoroethane	$CClF_2CClF_2$	A1	20,000	140	8.7	Neither
115[d]	chloropentafluoroethane	$CClF_2CF_3$	A1	120,000	760	47	Neither
116	hexafluoroethane	CF_3CF_3	A1	97,000	550	34	Neither
123	2,2-dichloro-1,1,1-trifluoroethane	$CHCl_2CF_3$	B1	9100	57	3.5	Neither
124	2-chloro-1,1,1,2-tetrafluoroethane	$CHClFCF_3$	A1	10,000	56	3.5	Neither
125	pentafluoroethane	CHF_2CF_3	A1	75,000	370	23	Neither
134a	1,1,1,2-tetrafluoroethane	CH_2FCF_3	A1	50,000	210	13	Neither
141b	1,1-dichloro-1-fluoroethane	CH_3CCl_2F		2600	12	0.78	Neither
142b	1-chloro-1,1-difluoroethane	CH_3CClF_2	A2	20,000	83	5.1	Neither
143a	1,1,1-trifluoroethane	CH_3CF_3	A2	21,000	70	4.5	Neither
152a	1,1-difluoroethane	CH_3CHF_2	A2	12,000	32	2.0	Neither
170[d]	ethane	CH_3CH_3	A3	7000	8.7	0.54	Neither
Ethers							
E170	dimethyl ether	CH_3OCH_3	A3	8500	16	1.0	Neither
Propane							
218[f]	octafluoropropane	$CF_3CF_2CF_3$	A1	90,000	690	43	Neither
227ea[f]	1,1,1,2,3,3,3-heptafluoropropane	CF_3CHFCF_3	A1	84,000	580	36	
236fa	1,1,1,3,3,3-hexafluoropropane	$CF_3CH_2CF_3$	A1	55,000	340	21	Neither
245fa	1,1,1,3,3-pentafluoropropane	$CHF_2CH_2CF_3$	B1	34,000	190	12	Neither
290	propane	$CH_3CH_2CH_3$	A3	5300	9.5	0.56	Neither

TABLE 1 Refrigerant Data and Safety Classifications *(continued)*

Refrigerant Number	Chemical Name[a,b]	Chemical Formula[a]	Safety Group	RCL[c] (ppm v/v)	RCL[c] (g/m³)	RCL[c] (lb/Mcf)	Highly Toxic or Toxic[e] Under Code Classification
Cyclic Organic Compounds							
C318[d]	octafluorocyclobutane	$-(CF_2)_4-$	A1	69,000	570	35	Neither
	See Table 2 for Blends						
Miscellaneous Organic Compounds							
hydrocarbons							
600	butane	$CH_3CH_2CH_2CH_3$	A3				Neither
600a	isobutane	$CH(CH_3)_2CH_3$	A3	4000	9.6	0.6	Neither
601	pentane	$CH_3CH_2CH_2CH_2CH_3$					
601a	isopentane	$(CH_3)_2CHCH_2CH_3$	A3	1000	2.9	0.2	
oxygen compounds							
610	ethyl ether	$CH_3CH_2OCH_2CH_3$					Neither
611	methyl formate	$HCOOCH_3$	B2				Neither
sulfur compounds							
620	(Reserved for future assignment)						
Nitrogen Compounds							
630	methyl amine	CH_3NH_2					Toxic
631	ethyl amine	$CH_3CH_2(NH_2)$					Neither
Inorganic Compounds							
702	hydrogen	H_2	A3				Neither
704	helium	He	A1				Neither
717	ammonia	NH_3	B2	320	0.22	0.014	Neither
718	water	H_2O	A1				Neither
720	neon	Ne	A1				Neither
728	nitrogen	N_2	A1				Neither
732	oxygen	O_2					Neither
740	argon	Ar	A1				Neither
744	carbon dioxide	CO_2	A1	40,000	72	4.5	Neither
744A	nitrous oxide	N_2O					Neither
764	sulfur dioxide	SO_2	B1				Neither
Unsaturated Organic Compounds							
1150	ethene (ethylene)	$CH_2{=}CH_2$	A3				Neither
1270[d]	propene (propylene)	$CH_3CH{=}CH_2$	A3	1000	1.7	0.1	Neither

[a]The chemical name and chemical formula are not part of this standard.
[b]The preferred chemical name is followed by the popular name in parentheses.
[c]Data taken from J.M. Calm, "ARTI Refrigerant Database," Air- Conditioning and Refrigeration Technology Institute (ARTI), Arlington, VA, July 2001; J.M. Calm, "Toxicity Data to Determine Refrigerant Concentration Limits," Report DE/CE 23810-110, Air- Conditioning and Refrigeration Technology Institute (ARTI), Arlington, VA, September 2000; J.M. Calm, "The Toxicity of Refrigerants," *Proceedings of the 1996 International Refrigeration Conference*, Purdue University, West Lafayette, IN, pp. 157–62, 1996; D.P. Wilson and R.G. Richard, "Determination of Refrigerant Lower Flammability Limits (LFLs) in Compliance with Proposed Addendum p to ANSI/ASHRAE Standard 34-1992 (1073-RP)," *ASHRAE Transactions* 2002, 108(2); D.W. Coombs, "HFC-32 Assessment of Anesthetic Potency in Mice by Inhalation," Huntingdon Life Sciences Ltd., Huntingdon, Cambridgeshire, England, February 2004 and amendment February 2006; D.W. Coombs, "HFC-22 An Inhalation Study to Investigate the Cardiac Sensitization Potential in the Beagle Dog," Huntingdon Life Sciences Ltd., Huntingdon, Cambridgeshire, England, August 2005; and other toxicity studies.
[d]The RCL values for these refrigerants are provisional based on data found in searches for other refrigerants, but not fully examined.
[e]*Highly toxic*, *toxic*, or *neither*, where *highly toxic* and *toxic* are as defined in the *International FIre Code*, *Uniform FIre Code*, and OSHA regulations, and *neither* identifies those refrigerants having lesser toxicity than either of those groups.[12,13,14]
[f]At locations with altitudes greater than 1000 meters (3300 feet) above sea level, the ODL and RCL shall be 69,100 ppm.

TABLE 2 Data and Safety Classifications for Refrigerant Blends

Refrigerant Number	Composition (Mass %)	Safety Group	RCL[a]			Highly Toxic or Toxic[aa] Under Code Classification
			(ppm v/v)	(g/m^3)	(lb/Mcf)	
Zeotropes						
400	R-12/114 (must be specified)	A1				Neither
	(50.0/50.0)	A1	28,000	160	10	
	(60.0/40.0)	A1	30,000	170	11	
401A	R-22/152a/124 (53.0/13.0/34.0)[e]	A1	27,000	110	6.6	Neither
401B	R-22/152a/124 (61.0/11.0/28.0)[e]	A1	30,000	120	7.2	Neither
401C	R-22/152a/124 (33.0/15.0/52.0)[e]	A1	20,000	84	5.2	Neither
402A	R-125/290/22 (60.0/2.0/38.0)[r]	A1	33,000	140	8.5	Neither
402B	R-125/290/22 (38.0/2.0/60.0)[r]	A1	63,000	240	15	Neither
403A	R-290/22/218 (5.0/75.0/20.0)[g]	A1	33,000	120	7.6	Neither
403B[ab]	R-290/22/218 (5.0/56.0/39.0)[g]	A1	70,000	290	18	Neither
404A[ab]	R-125/143a/134a (44.0/52.0/4.0)[f]	A1	130,000	500	31	Neither
405A[t]	R-22/152a/142b/C318 (45.0/7.0/5.5/42.5)[h]		57,000	260	16	Neither
406A	R-22/600a/142b (55.0/4.0/41.0)[i]	A2	21,000	25	4.7	Neither
407A[ab]	R-32/125/134a (20.0/40.0/40.0)[o]	A1	78,000	290	18	Neither
407B[ab]	R-32/125/134a (10.0/70.0/20.0)[o]	A1	77,000	320	20	Neither
407C[ab]	R-32/125/134a (23.0/25.0/52.0)[o]	A1	76,000	270	17	Neither
407D	R-32/125/134a (15.0/15.0/70.0)[o]	A1	65,000	240	15	Neither
407E[o,ab]	R-32/125/134a (25.0/15.0/60.0)[o]	A1	75,000	260	16	Neither
408A[ab]	R-125/143a/22 (7.0/46.0/47.0)[f]	A1	95,000	340	21	Neither
409A	R-22/124/142b (60.0/25.0/15.0)[k]	A1	29,000	110	7.1	Neither
409B	R-22/124/142b (65.0/25.0/10.0)[k]	A1	30,000	120	7.3	Neither
410A[ab]	R-32/125 (50.0/50.0)[l]	A1	130,000	390	25	Neither
410B[ab]	R-32/125 (45.0/55.0)[n]	A1	130,000	390	24	Neither
411A[u]	R-1270/22/152a (1.5/87.5/11.0)[m]	A2	14,000	46	2.9	Neither
411B[u]	R-1270/22/152a (3.0/94.0/3.0)[m]	A2	13,000	45	2.8	Neither
412A	R-22/218/142b (70.0/5.0/25.0)[k]	A2	22,000	82	5.1	Neither
413A	R-218/134a/600a (9.0/88.0/3.0)[q]	A2	22,000	94	5.8	Neither
414A	R-22/124/600a/142b (51.0/28.5/4.0/16.5)[s]	A1	26,000	100	6.4	Neither
414B	R-22/124/600a/142b (50.0/39.0/1.5/9.5)[s]	A1	23,000	95	6.0	Neither
415A	R-22/152a (82.0/18.0)[n]	A2	57,000	190	12	Neither
415B	R-22/152a (25.0/75.0)[n]	A2	52,000	120	9.3	Neither
416A[t,u]	R-134a/124/600 (59.0/39.5/1.5)[v]	A1	14,000	62	3.9	Neither
417A[t,u]	R-125/134a/600 (46.6/50.0/3.4)[w]	A1	13,000	56	3.5	Neither
418A	R-290/22/152a (1.5/96.0/2.5)[x]	A2	59,000	200	13	Neither
419A[ab]	R-125/134a/E170 (77.0/19.0/4.0)[y]	A2	70,000	310	19	Neither
420A	R-134a/142b (88.0/12.0)[z]	A1	45,000	190	12	Neither
421A	R-125/134a (58.0/42.0)[n]	A1	61,000	280	17	Neither
421B	R-125/134a (85.0/15.0)[n]	A1	69,000	330	21	
422A	R-125/134a/600a (85.1/11.5/3.4)[ac]	A1	63,000	290	18	

TABLE 2 Data and Safety Classifications for Refrigerant Blends *(continued)*

Refrigerant Number	Composition (Mass %)	Safety Group	RCL[a] (ppm v/v)	RCL[a] (g/m³)	RCL[a] (lb/Mcf)	Highly Toxic or Toxic[aa] Under Code Classification
Zeotropes *(continued)*						
422B	R-125/134a/600a (55.0/42.0/3.0)[ad]	A1	56,000	250	16	
422C	R-125/134a/600a (82.0/15.0/3.0)[ad]	A1	62,000	290	18	
422D	R-125/134a/600a (65.1/31.5/3.4)[ae]	A1	58,000	260	16	
423A	R-134a/227ea (52.5/47.5)[n]	A1	59,000	310	19	
424A[t,u]	R-125/134a/600a/600/601a (50.5/47.0/0.9/1.0/0.6)[af]	A1	23,000	100	6.2	
425A	R-32/134a/227ea (18.5/69.5/12.0)[ag]	A1	67,000	250	16	
426A[t,u]	R-125/134a/600a/601a (5.1/93.0/1.3/0.6)[ah]	A1	20,000	83	5.2	
427A	R-32/125/143a/134a (15.0/25.0/10.0/50.0)[ai]	A1				
428A	R-125/143a/290/600a (77.5/20.0/0.6/1.9)[ah]	A1				
Azeotropes[b]						
500	R-12/152a (73.8/26.2)	A1	30,000	120	7.6	Neither
501	R-22/12 (75.0/25.0)[c]	A1	54,000	210	13	Neither
502	R-22/115 (48.8/51.2)	A1	73,000	330	21	Neither
503	R-23/13 (40.1/59.9)					Neither
504[t,ab]	R-32/115 (48.2/51.8)		140,000	460	29	Neither
505	R-12/31 (78.0/22.0)[c]					Neither
506	R-31/114 (55.1/44.9)					Neither
507A[ab]	R-125/143a (50.0/50.0)	A1	130,000	520	32	Neither
508A	R-23/116 (39.0/61.0)	A1	55,000	220	14	Neither
508B	R-23/116 (46.0/54.0)	A1	52,000	200	13	Neither
509A[ab]	R-22/218 (44.0/56.0)	A1	75,000	390	24	Neither

[a]The chemical name and chemical formula are not part of this standard.
[b]Azeotropic refrigerants exhibit some segregation of components at conditions of temperature and pressure other than those at which they were formulated. The extent of segregation depends on the particular azeotrope and hardware system configuration.
[c]The exact composition of this azeotrope is in question, and additional experimental studies are needed.
[d]R-507, R-508, and R-509 are allowed alternative designations for R-507A, R-508A, and R-509A due to a change in designations after assignment of R-500 through R-509. Corresponding changes were not made for R-500 through R-506.
[e]Composition tolerances are (±2.0/+0.5, –1.5/±1.0).
[f]Composition tolerances are (±2.0/±1.0/±2.0).
[g]Composition tolerances are (+0.2, -2.0/±2.0/±.0).
[h]Composition tolerances for the individual components are (±.0/±1.0/±1.0/±2.0) and for the sum of R-152a and R-142b are (+0.0, –2.0).
[i]Composition tolerances are (±2.0/±1.0/±.0).
[k]Composition tolerances are (±2.0/±2.0/±1.0).
[l]Composition tolerances are (+0.5, –1.5/+1.5, –0.5).
[m]Composition tolerances are (+0.0, –1.0/+2.0, –0.0/+0.0, –1.0).
[n]Composition tolerances are (±1.0/±1.0).
[o]Composition tolerances are (±2.0/±2.0/±2.0).
[q]Composition tolerances are (±1.0/±2.0/+0.0,–1.0).
[r]Composition tolerances are (±2.0/+1.0,–1.0/±2.0).
[s]Composition tolerances are (±2.0/±2.0/±0.5/+0.5, –1.0).
[t]The RCL values for these refrigerants are provisional based on data found in searches for other refrigerants, but not fully examined.
[u]The RCL values for these refrigerant blends are approximated in the absence of adequate data for a component comprising less than 4% m/m of the blend and expected to have only a small influence in an acute, accidental release.
[v]Composition tolerances are (+0.5,–1.0/+1.0,–0.5/+1.0,–0.2).
[w]Composition tolerances are (±1.1/±1.0/+0.1,–0.4).
[x]Composition tolerances are (±0.5/±1.0/±0.5).
[y]Composition tolerances are (±1.0/±1.0/±1.0).
[z]Composition tolerances are (+1.0,–0.0/+0.0,–1.0).
[aa]*Highly toxic*, *toxic*, or *neither*, where *highly toxic* and *toxic* are as defined in the *International FIre Code*, *Uniform FIre Code*, and OSHA regulations, and *neither* identifies those refrigerants having lesser toxicity than either of those groups.[12,13,14]
[ab]At locations with altitudes greater than 1000 meters (3300 feet) above sea level, the ODL and RCL shall be 69,100 ppm.
[ac]Composition tolerances are (±1.0/±1.0/+0.1,–0.4).
[ad]Composition tolerances are (±1.0/±1.0/+0.1,–0.5).
[ae]Composition tolerances are (+0.9,–1.1/±1.0/+0.1,–0.4).
[af]Composition tolerances are (±1.0/±1.0/+0.1,–0.2/+0.1,+0.2/+0.1,–0.2).
[ag]Composition tolerances are (±0.5/±0.5/±0.5).
[ah]Composition tolerances are (±1.0/±1.0/+0.1,–0.2/+0.1,–0.2).
[ai]Composition tolerances are (±2.0/±2.0/±2.0/±2.0).

TABLE 3 Flammability Classifications

Class	Single-Component Refrigerant	WCF of a Refrigerant Blend	WCFF of a Refrigerant Blend
1	No flame propagation when tested at 100°C (212°F) and 101.3 kPa (14.7 psia)	No flame propagation when tested at 100°C (212°F) and 101.3 kPa (14.7 psia)	No flame propagation when tested at 60.0°C (140°F) and 101.3 kPa (14.7 psia)
2	Flame propagation when tested at 100°C (212°F) and 101.3 kPa (14.7 psia) *and* LFL[a] > 0.10 kg/m^3 (> 0.0062 lb/ft^3) *and* heat of combustion <19,000 kJ/kg (<8,169 Btu/lb)	Flame propagation when tested at 100°C (212°F) and 101.3 kPa (14.7 psia) *and* LFL[a] > 0.10 kg/m^3 (> 0.0062 lb/ft^3) *and* heat of combustion <19,000 kJ/kg (<8,169 Btu/lb)	Flame propagation when tested at 60.0°C (140°F) and 101.3 kPa (14.7 psia) *and* LFL[a] > 0.10 kg/m^3 (> 0.0062 lb/ft^3) *and* heat of combustion <19,000 kJ/kg (<8,169 Btu/lb)
3	Flame propagation when tested at 100°C (212°F) and 101.3 kPa (14.7 psia) *and* LFL[a] ≤ 0.10 kg/m^3 (≤ 0.0062 lb/ft^3) *or* heat of combustion ≥ 19,000 kJ/kg (≥ 8,169 Btu/lb)	Flame propagation when tested at 100°C (212°F) and 101.3 kPa (14.7 psia) *and* LFL[a] ≤ 0.10 kg/m^3 (≤ 0.0062 lb/ft^3) *or* heat of combustion ≥ 19,000 kJ/kg (≥ 8,169 Btu/lb)	Flame propagation when tested at 60.0°C (212°F) and 101.3 kPa (14.7 psia) *and* LFL[a] ≤ 0.10 kg/m^3 (≤ 0.0062 lb/ft^3) *or* heat of combustion ≥ 19,000 kJ/kg (≥ 8,169 Btu/lb)

[a]Lower flammability limit (LFL) is determined at ambient temperature and pressure. If an LFL does not exist at 23.0°C (73.4°F) and 101.3 kPa (14.7 psia), refer to Section 6.1.3.4.

(This appendix is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)

INFORMATIVE APPENDIX A
ISOMER DESIGNATION EXAMPLES

Table A1 illustrates the designation of isomers for the ethane series with three isomers of dichlorotrifluoroethane. Table A2 illustrates the designation of isomers for the propane series with nine isomers of dichloropentafluoropropane.

TABLE A1 Ethane Series Isomers

Isomer	Chemical Formula	Attached Mass		
		W_1	W_2	$\lvert W_1 - W_2 \rvert$
R-123	$CHCl_2CF_3$	71.9	57.0	14.9
R-123a	$CHClFCClF_2$	55.5	73.4	17.9
R-123b	CCl_2FCHF_2	89.9	39.0	50.9

where

W_i = the sum of the atomic mass of halogens and hydrogens attached to carbon atom *i*

TABLE A2 Propane Series Isomers

Isomer	Chemical Formula	C2 Group	Attached Mass		
			W_1	W_3	$\lvert W_1 - W_3 \rvert$
R-225aa	$CF_3CCl_2CHF_2$	CCl_2	57.0	39.0	18.0
R-225ba	$CHClFCClFCF_3$	CClF	55.5	57.0	1.5
R-225bb	$CClF_2CClFCHF_2$	CClF	73.4	39.0	34.4
R-225ca	$CHCl_2CF_2CF_3$	CF_2	71.9	57.0	14.9
R-225cb	$CHClFCF_2CClF_2$	CF_2	55.5	73.4	17.9
R-225cc	$CCl_2FCF_2CHF_2$	CF_2	89.9	39.0	50.9
R-225da	$CClF_2CHClCF_3$	CHCl	73.4	57.0	16.4
R-225ea	$CClF_2CHFCClF_2$	CHF	73.4	73.4	0.0
R-225eb	$CCl_2FCHFCF_3$	CHF	89.9	57.0	32.9

where

C2 = the central (second) carbon atom and

W_i = the sum of the atomic mass of halogens and hydrogens attached to carbon atom *i*

(This appendix is a normative appendix and is part of this standard.)

NORMATIVE APPENDIX B
DETAILS OF TESTING—FLAMMABILITY

B1. FLAMMABILITY TESTING

Flammability tests shall be conducted in accordance with ASTM E681 (reference 1). The test vessel size shall be a nominal 12 L (0.424 ft^3) spherical glass flask (see Figure B.1). The ignition source shall be a spark from a transformer secondary rated at 15 kV and 30 mA alternating current (A/C) as described in ASTM E681, with a 0.4 second spark duration. The electrodes shall be 1 mm, L-shaped tungsten wire electrodes that are spaced 6.4 mm (0.25 in.) apart and that extend out of the plane of the electrode holder (see spark assembly diagram in Figure B.2 for more details). The ignition source shall be placed at a height from the bottom of the test vessel that is one-third the diameter of the vessel. Tests shall be conducted at the temperatures specified below and at 1% by volume (refrigerant/air) increments. The absolute humidity of the air used for mixing shall be 0.0088 grams of water vapor per gram of dry air (which equates to 50% relative humidity at 23.0°C [73.4°F] and 101.3 kPa [14.7 psia]).

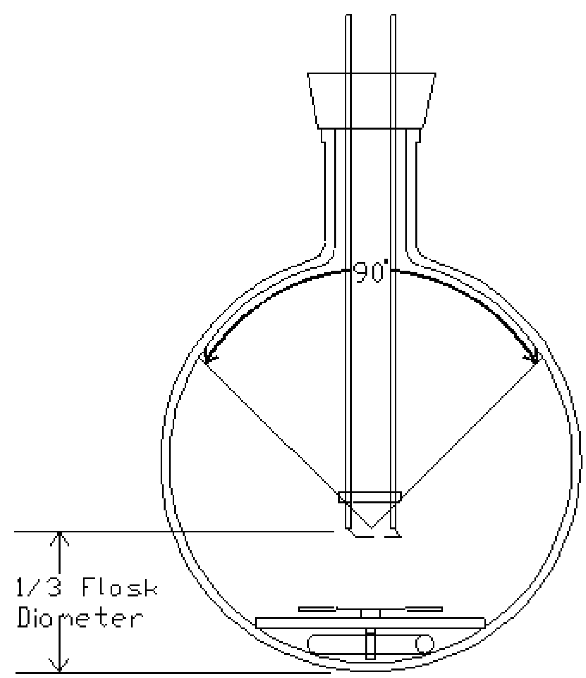

Figure B.1 Test apparatus.
- **a. Test vessel is a 12-liter spherical glass flask.**
- **b. Ignition source electrodes are positioned at a height from the bottom of the vessel that is equal to 1/3 of the diameter of the vessel.**
- **c. The substended arc represents $\pi/2$ (90 degree) fan for determining flame propagation.**
- **d. A stirrer shall be installed in the flask to ensure mixing of vapors prior to ignition.**

CAUTION: Flammability test procedures specified in this standard are modified procedures of an ASTM test that uses a glass flask as a test vessel. Extreme caution should be employed by test facilities to safeguard against personal injury and equipment damage. Vessels are subject to explode during test. Combustion of refrigerants may produce highly toxic or corrosive by-products. Testing facilities should consult safety precautions cited in the ASTM test standard, along with state and federal regulations.

B1.1 Test Conditions

a. For single-compound refrigerants, flammability tests shall be conducted at 100°C (212°F) and 101.3 kPa (14.7 psia). Testing shall be conducted up to and including the point at which flame propagation is demonstrated. If no flame propagation is apparent, testing shall be done until at least three consecutive concentration increments have been made beyond the stoichiometric composition and beyond the point that combustion around the spark has diminished.

b. For refrigerant blends, flammability tests shall be conducted on the WCF at 100°C (212°F) and 101.3 kPa (14.7 psia) and also shall be conducted on the WCFF at 60.0°C (140°F) and 101.3 kPa (14.7 psia). The WCFF shall be determined by the method specified in Section B2. When application of the composition tolerances to the nominal formulation produces several possible WCFF formulations, the applicant shall conduct flammability testing on all possible WCFF formulations or provide sufficient justification for eliminating one or more of the possible WCFF formulations.

c. For those refrigerants that show flame propagation in accordance with step (a) or (b) above, flammability testing shall also be conducted at 23.0°C (73.4°F) and 101.3 kPa (14.7 psia) to determine the LFL. Under test conditions specified in B.1. The LFL normally is expressed as refrigerant percentage by volume percent; multiply this by 0.00041 × molecular mass (g-mol) to obtain kg/m^3 or by 0.000026 × molecular mass (g-mol) to obtain lb/ft^3. For refrigerant blends, these tests shall be conducted on the WCF and the WCFF.

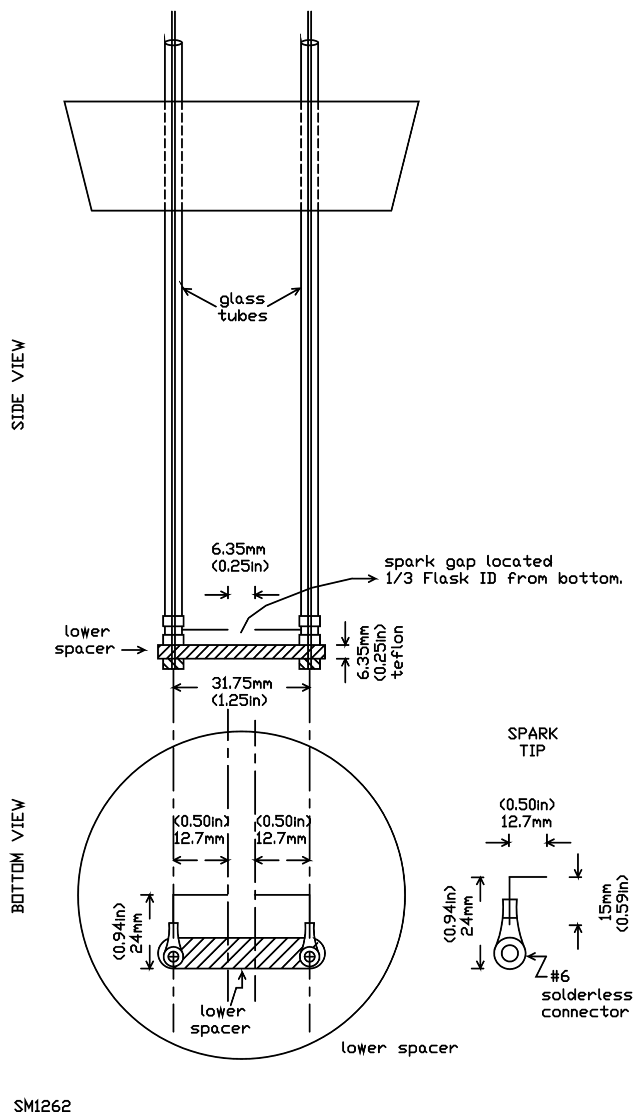

Figure B.2 Spark electrodes.

B1.2 When a refrigerant blend containing one or more flammable component(s) is being examined, testing shall be conducted up to and including the point at which flame propagation is demonstrated. If no flame propagation is apparent, testing shall be done until at least three consecutive concentration increments have been made beyond the stoichiometric composition and beyond the point that combustion around the spark has diminished.

B1.3 When the $ETFL_{100}$ of the flammable component(s) is known, testing for the $ETFL_{100}$, the $ETFL_{60}$, or the LFL shall begin at 1%, by volume, lower than the lowest $ETFL_{100}$. When the $ETFL_{100}$ is not known, testing shall begin at 1% refrigerant by volume. If the test of the initial concentration results in a flame propagation, then subsequent testing concentrations shall be reduced in 1% volume increments until the appropriate flame limit is determined.

B1.4 The mass percent formulation of the tested blend shall be verified through gas chromatography to a tolerance of ±0.5 mass percent or one-fourth of the composition tolerance range, whichever is smaller.

B1.5 Samples shall be introduced into the flammability test apparatus in the vapor phase in accordance with ASTM E681. Liquid samples of the refrigerant or blend composition to be tested shall be expanded into a suitable evacuated container such that only vapor under pressure is present. The vapors shall be introduced into the flammability test apparatus. Air shall then be added to the test apparatus. Measurement of the refrigerant-to-air concentration shall be by partial pressures. The refrigerant and air shall be mixed in the chamber for at least 2 minutes. Activation of the ignition source shall commence within 30 to 60 seconds of stirrer deactivation.

B1.6 If flame propagation is observed while the spark is still active (i.e., the spark is overdriving the test vessel), then the test shall be repeated using a spark duration of less than 0.4 but at least 0.2 second.

B1.7 All flammability tests shall be recorded using a video recorder. A playback device capable of freeze frame and single-frame advance shall be available during testing. A copy of the video recordings, on NTSC format VHS tape, shall be submitted upon request of the committee.

B1.8 Criterion for Determining Flame Propagation. A refrigerant-air concentration shall be considered flammable for flammability classification under this standard only if a flame propagation occurs in at least two of three flammability tests on that refrigerant-air concentration. A flame propagation is any combustion that, having moved upward and outward from the point of ignition to the walls of the flask, is continuous along an arc that is greater than that subtended by an angle equal to $\pi/2$ (90 degrees), as measured from the point of ignition to the walls of the flask (see Figure B.1).

B1.9 Flammability Test Data Required. Applications shall include test results determined in accordance with Section B1. Test conditions shall be controlled to the tolerances cited below. Applications shall include tabulated flammability test data for each refrigerant or refrigerant blend composition tested. These data shall include but are not limited to:

a. refrigerant blend composition tested: ±0.1 mass %
b. flammability test temperature: ±3°C (±5°F)
c. fractionation or leak test temperature: ±0.1°C (±0.2°F)
d. test pressure: ±0.7 kPa (±0.1 psi)
e. humidity: ±0.0005 grams of water vapor per gram of dry air
f. refrigerant/air concentration: ±0.2% by volume
g. spark duration: ±0.05 seconds
h. flame propagation determination as measured from the point of ignition to the walls of the flask: ±0.087 radians (±5.0 degrees)

B2. FRACTIONATION ANALYSIS

Applications shall include an analysis of fractionation.

B2.1 The applicant shall report results of a fractionation analysis conducted to determine vapor and liquid phase compositions of refrigerant blends under conditions of leakage (see Section B2.4) and successive charge/recharge conditions (see Section B2.5). The analysis shall be validated through experimentation. A computer or mathematical model may be used to identify the WCFF. If a computer or mathematical model is used, then the applicant shall identify the model used and shall submit experimental data that verifies the accuracy of the model at the conditions that predict the WCFF.

B2.2 All fractionation analysis shall begin using the WCF. When application of the composition tolerances to the nominal formulation produces several possible WCF formulations, the applicant shall investigate all possible WCF formulations or provide sufficient justification for eliminating one or more of the possible WCF formulations.

B2.3 The mass percent formulation of the tested blend shall be verified through gas chromatography to a tolerance of ±0.5 mass % or one-fourth of the composition tolerance, whichever is smaller.

B2.4 Leakage Testing. Refrigerant blends containing flammable component(s) shall be evaluated to determine their WCFF formulation(s) during storage/shipping or use. Experimental tests or computer/mathematical modeling shall be conducted to simulate leaks from

a. a container under storage/shipping conditions and
b. a container representing air-conditioning and refrigeration equipment during normal operation, standby, and shipping conditions.

Note: The container used for these tests shall be rated to handle the vapor pressure of the formulation at the highest temperature encountered.

B2.4.1 Leaks Under Storage/Shipping Conditions. To simulate leaks under storage/shipping conditions, the container shall be filled with the WCF at 23.0°C (73.4°F) to 90% of the maximum permissible, that which precludes a 100% liquid fill at 54.4°C (130°F), and then shall be vapor leaked, 2% by mass of the starting initial charge per hour, at the following temperatures:

a. 54.4°C (130°F),
b. –40.0°C (-40.0°F) or the bubble point plus 10.0°C (18.0°F), whichever is warmer, and
c. the temperature that results in the WCFF between (a) and (b) if the WCFF does not exist at either (a) or (b). If no temperature between (a) and (b) results in the WCFF, then the fractionation test shall instead be conducted at 23.0°C (73.4°F). The applicant shall justify and document what constitutes the temperature at which the WCFF formulation occurs.

In the fractionation experiment, the composition of the head space gas and remaining liquid shall be determined by analysis. Analyses shall be made initially after 2% of the total charge has leaked (vapor leak), next at 10% loss of the initial mass, then at 10% mass loss intervals of the initial mass until atmospheric pressure is reached in the cylinder or no liquid remains. If liquid remains after 90% of the initial mass is lost and atmospheric pressure has not been reached, then the next and last analysis of head space gas and remaining liquid shall be done at 95% mass loss.

B2.4.2 Leaks from Equipment. To simulate leaks from equipment, the container shall be filled with the WCF at ambient temperature to 15% of the maximum permissible fill and then shall be vapor leaked at the following temperatures:

a. 60.0°C (140°F),
b. –40.0°C (-40.0°F) or the bubble point plus 10.0°C (18.0°F), whichever is warmer, and
c. the temperature that results in the WCFF between (a) and (b) if the WCFF does not exist at either (a) or (b). If no temperature between (a) and (b) results in the WCFF, then the fractionation test shall instead be conducted at 23.0°C (73.4°F). The applicant shall justify and document what constitutes the temperature at which the WCFF formulation occurs.

In the fractionation experiment, the composition of the head space gas and remaining liquid shall be determined by analysis. Analyses shall be made initially after 2% of the total charge has leaked, next at 10% loss of the initial mass, then at 10% mass loss intervals of the initial mass until atmospheric pressure is reached in the cylinder or no liquid remains. If liquid remains after 90% of the initial mass is lost and atmospheric pressure has not been reached, then the next and last analysis of head space gas and remaining liquid shall be done at 95% mass loss.

B2.5 Charge/Recharge Testing. Refrigerant blends containing flammable component(s) shall be evaluated to determine the fractionation effects of successive leakage and recharging on the composition of the blend. A container shall be charged to 15% full of its maximum permitted fill with the WCF formulation of the refrigerant blend. A vapor leak at a rate of 2% by mass of the starting charge per hour shall be created and maintained at ambient temperature until 20% of the starting charge has been leaked. When 20% leak is reached, the composition of the head space gas shall be determined by analysis. The container shall again be charged with the WCF to 15% full, leaked, and measured in the above defined manner. The charge/leak cycle shall be performed a total of five times. At the conclusion of the fifth leakage, the composition of the head space gas and liquid shall again be determined by gas chromatography.

B2.6 Fractionation Analysis Data Required. The applicant shall submit for each fractionation scenario:

a. fractionation or leak test temperature (±0.1°C; ±0.2°F),
b. tabulated liquid and vapor compositions at each leaked increment (±0.1 mass %), and
c. for modeled analysis, model accuracy at conditions that predict the WCFF formulation.

The applicant shall also provide a description of test apparatus and procedures used. If the applicant uses a computer or mathematical model for determining the WCFF, the applicant shall identify the model used and submit supporting data verifying the accuracy of the model against experimental measurements at conditions that predict the WCFF.

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INFORMATIVE APPENDIX C BIBLIOGRAPHY

[1]T. Atwood, "The Need for Standard Nomenclature for Refrigerants," *ASHRAE Journal*, Vol. 31, No. 11, pp. 44-47, November 1989.

[2]*ANSI/NFPA 704-90, Identification of the Fire Hazards of Materials*, National Fire Protection Association, 1 Batterymarch Park, Quincy, MA 02269-9101, 1990.

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INFORMATIVE APPENDIX D REFRIGERANT DATA (INFORMATIVE)

This appendix provides refrigerant data such as molecular mass and normal boiling point for the refrigerants listed. It also provides bubble points and dew points for azeotropic blends.

TABLE D1 Refrigerant Data

Refrigerant Number	Chemical Name[a]	Chemical Formula	Molecular Mass	Normal Boiling Point (°C)	Normal Boiling Point (°F)
Methane Series					
11	trichlorofluoromethane	CCl_3F	137.4	24	75
12	dichlorodifluoromethane	CCl_2F_2	120.9	–30	–22
12B1	bromochlorodifluoromethane	$CBrClF_2$	165.4	–4	25
13	chlorotrifluoromethane	$CClF_3$	104.5	–81	–115
13B1	bromotrifluoromethane	$CBrF_3$	148.9	–58	–72
14	tetrafluoromethane (carbon tetrafluoride)	CF_4	88.0	–128	–198
21	dichlorofluoromethane	$CHCl_2F$	102.9	9	48
22	chlorodifluoromethane	$CHClF_2$	86.5	–41	–41
23	trifluoromethane	CHF_3	70.0	–82	–116
30	dichloromethane (methylene chloride)	CH_2Cl_2	84.9	40	104
31	chlorofluoromethane	CH_2ClF	68.5	–9	16
32	difluoromethane (methylene fluoride)	CH_2F_2	52.0	–52	–62
40	chloromethane (methyl chloride)	CH_3Cl	50.5	–24	–12
41	fluoromethane (methyl fluoride)	CH_3F	34.0	–78	–108
50	methane	CH_4	16.0	–161	–259
Ethane Series					
113	1,1,2-trichloro-1,2,2-trifluoroethane	$CC1_2FCC1F_2$	187.4	48	118
114	1,2-dichloro-1,1,2,2-tetrafluoromethane	$CC1F_2CC1F_2$	170.9	4	38
115	chloropentafluoroethane	$CC1F_2CF_3$	154.5	–39	–38
116	hexafluoroethane	CF_3CF_3	138.0	–78	–109
123	2,2-dichloro-1,1,1-trifluoroethane	$CHC1_2CF_3$	153.0	27	81
124	2-chloro-1,1,1,2-tetrafluoroethane	$CHC1FCF_3$	136.5	–12	10
125	pentafluoroethane	CHF_2CF_3	120.0	–49	–56
134a	1,1,1,2-tetrafluoroethane	CH_2FCF_3	102.0	–26	–15
141b	1,1-dichloro-1-fluoroethane	CH_3CC1_2F	117.0	32	90
142b	1-chloro-1,1-difluoroethane	CH_3CC1F_2	100.5	–10	14
143a	1,1,1-trifluoroethane	CH_3CF_3	84.0	–47	–53
152a	1,1-difluoroethane	CH_3CHF_2	66.0	–25	–13
170	ethane	CH_3CH_3	30.0	–89	–128
Ethers					
E170	dimethyl ether	CH_3OCH_3	46.1	–25	–13
Propane Series					
218	octafluoropropane	$CF_3CF_2CF_3$	188.0	–37	–35
236fa	1,1,1,3,3,3-hexafluoropropane	$CF_3CH_2CF_3$	152.0	–1	29
245fa	1,1,1-3,3-pentafluoropropane	$CF_3CH_2CHF_2$	134.0	15	59
290	propane	$CH_3CH_2CH_3$	44.0	–42	–44
Cyclic Organic Compounds					
C318	octafluorocyclobutane	$-(CF_2)_4-$	200.0	–6	21

TABLE D1 Refrigerant Data *(continued)*

Refrigerant Number	Chemical Name[a]	Chemical Formula	Molecular Mass	Normal Boiling Point (°C)	(°F)
Miscellaneous Organic Compounds					
hydrocarbons					
600	butane	$CH_3CH_2CH_2CH_3$	58.1	0	31
600a	isobutane	$CH(CH_3)_2CH_3$	58.1	–12	11
oxygen compounds					
610	ethyl ether	$CH_3CH_2OCH_2CH_3$	74.1	35	94
611	methyl formate	$HCOOCH_3$	60.0	32	89
sulfur compounds					
620	(Reserved for future assignment)				
Nitrogen Compounds					
630	methylamine	CH_3NH_2	31.1	–7	20
631	ethyl amine	$CH_3CH_2(NH_2)$	45.1	17	62
Inorganic Compounds					
702	hydrogen	H_2	2.0	–253	–423
704	helium	He	4.0	–269	–452
717	ammonia	NH_3	17.0	–33	–28
718	water	H_2O	18.0	100	212
720	neon	Ne	20.2	–246	–411
728	nitrogen	N_2	28.1	–196	–320
732	oxygen	O_2	32.0	–183	–297
740	argon	Ar	39.9	–186	–303
744	carbon dioxide	CO_2	44.0	–78	–109
744A	nitrous oxide	N_2O	44.0	–90	–129
764	sulfur dioxide	SO_2	64.1	–10	14
Unsaturated Organic Compounds					
1150	ethene (ethylene)	$CH_2=CH_2$	28.1	–104	–155
1270	propene (propylene)	$CH_3CH=CH_2$	42.1	–48	–54

[a]The preferred chemical name is followed by the popular name in parentheses.

TABLE D2 Data for Refrigerant Blends

Refrigerant Number	Composition (Weight %)	Average Molecular Mass	Bubble Point (°C)	Dew Point (°C)	Bubble Point (°F)	Dew Point (°F)
Zeotropes						
400	R-12/114 (must be specified)					
	(50.0/50.0)					
	(60.0/40.0)					
401A	R-22/152a/124 (53/13/34)[d]	94.4	–34.4	–28.8	–29.9	–19.8
401B	R-22/152a/124 (61/11/28)[d]	92.8	–35.7	–30.8	–32.3	–23.4
401C	R-22/152a/124 (33/15/52)[d]	101.0	–30.5	–23.8	–22.9	–10.8
402A	R-125/290/22 (60/2/38)[e]	101.6	–49.2	–47.0	–56.6	–52.6
402B	R-125/290/22 (38/2/60)[e]	94.7	–47.2	–44.9	–53.0	–48.8
403A	R-290/22/218 (5/75/20)[f]	92.0	–44.0	–42.3	–47.2	–44.1
403B	R-290/22/218 (5/56/39)[f]	103.3	–43.8	–42.3	–46.8	–44.1
404A	R-125/143a/134a (44/52/4)[e]	97.6	–46.6	–45.8	–51.9	–50.4
405A	R-22/152a/142b/C318 (45/7/5.5/42.5)[g]	111.9	–32.9	–24.5	–27.2	–12.1
406A	R-22/600a/142b (55/4/41)[h]	89.9	–32.7	–23.5	–26.9	–10.3
407A	R-32/125/134a (20/40/40)[m]	90.1	–45.2	–38.7	–49.4	–37.7
407B	R-32/125/134a (10/70/20)[m]	102.9	–46.8	–42.4	–52.2	–44.3
407C	R-32/125/134a (23/25/52)[m]	86.2	–43.8	–36.7	–46.8	–34.1
407D	R-32/125/134a (15/15/70)[m]	91.0	–39.4	–32.7	–38.9	–26.9
407E	R-32/125/134a (25/15/60)[o]	83.8	–42.8	–35.6	–45.0	–32.1
408A	R-125/143a/22 (7/46/47)[e]	87.0	–45.5	–45.0	–49.9	–49.0
409A	R-22/124/142b (60/25/15)[i]	97.4	–35.4	–27.5	–31.7	–17.5
409B	R-22/124/142b (65/25/10)[i]	96.7	–36.5	–29.7	–33.7	–21.5
410A	R-32/125 (50/50)[j]	72.6	–51.6	–51.5	–60.9	–60.7
410B	R-32/125 (45/55)[l]	75.6	–51.5	–51.4	–60.7	–60.5
411A	R-1270/22/152a) (1.5/87.5/11.0)[k]	82.4	–39.7	–37.2	–39.5	–35.0
411B	R-1270/22/152a (3.0/94.0/3.0)[k]	83.1	–41.6	–41.3	–42.9	–42.3
412A	R-22/218/143b (70/5/25)[i]	92.2	–36.4	–28.8	–33.5	–19.8
413A	R-218/134a/600a (9/88/3)[n]	104.0	–29.3	–27.6	–20.7	–17.7
414A	R-22/124/600a/142b (51/28.5/4/16.5)[p]	96.9	–34.0	–25.8	–29.2	–14.4
414B	R-22/124/600a/142b (50/39/1.5/9.5)[p]	101.6	–34.4	–26.1	–29.9	–15.0
415A	R-22/152a (82.0/18.0)[l]	81.9	–37.5	–34.7	–35.5	–30.5
415B	R-22/152a (25.0/75.0)[l]	70.2	–23.4	–21.8	–10.1	–7.2
416A	R-134a/124/600 (59.0/39.5/1.5)[q]	111.9	–38.0	–32.9	–36.4	–27.2
417A	R-125/134a/600 (46.6/50.0/3.4)[r]	106.7	–41.2	–40.1	–42.2	–40.2
418A	R-290/22/152a (1.5/96.0/2.5)[s]	84.6	–42.6	–36.0	–44.7	–32.8
419A	R-125/134a/E170 (77.0/19.0/4.0)[t]	109.3	–25.0	–24.2	–13.0	–11.6
420A	R-134a/142b (88.0/12.0)[u]	101.8	–34.4	–28.8	–29.9	–19.8

TABLE D2 Data for Refrigerant Blends *(continued)*

Refrigerant Number	Composition (Weight %)	Azeotropic Temperature (°C)	Azeotropic Temperature (°F)	Azeotropic Molecular Mass	Normal BPt.[a] (°C)	Normal BPt.[a] (°F)
Azeotropes[a]						
500	R-12/152a (73.8/26.2)	0	32	99.3	–33	–27
501	R-22/12 (75.0/25.0)[b]	–41	–42	93.1	–41	–42
502	R-22/115 (48.8/51.2)	19	66	112.0	–45	–49
503	R-23/13 (40.1/59.9)	88	126	87.5	–88	–126
504	R-32/115 (48.2/51.8)	17	63	79.2	–57	–71
505	R-12/31 (78.0/22.0)[b]	115	239	103.5	–30	–22
506	R-31/114 (55.1/44.9)	18	64	93.7	–12	10
507A[c]	R-125/143a (50/50)	–40	–40	98.9	–46.7	–52.1
508A[c]	R-23/116 (39/61)	–86	–122	100.1	–86	–122
508B	R-23/116 (46/54)	–45.6	–50.1	95.4	–88.3	–126.9
509A[c]	R-22/218 (44/56)	0	32	124.0	–47	–53

[a]Azeotropic refrigerants exhibit some segregation of components at conditions of temperature and pressure other than those at which they were formulated. The extent of segregation depends on the particular azeotrope and hardware system configuration.
[b]The exact composition of this azeotrope is in question, and additional experimental studies are needed.
[c]R-507, R-508, and R-509 are allowed alternative designations for R-507A, R-508A, and R-509A due to a change in designations after assignment of R-500 through R-509. Corresponding changes were not made for R-500 through R-506.
[d]Composition tolerances are (±2/+0.5, –1.5/±1).
[e]Composition tolerances are (±2/±1/±2).
[f]Composition tolerances are (+0.2, –2.0/±2.0/±2.0).
[g]Composition tolerances for the individual components are (±2/±1/±1/±2) and for the sum of R-152a and R-142b are (+0, –2).
[h]Composition tolerances are (±2/±1/±1).
[i]Composition tolerances are (±2/±2/±1).
[j]Composition tolerances are (+0.5, –1.5/+1.5, –0.5).
[k]Composition tolerances are (+0, –1/+2, –0/+0, –1).
[l]Composition tolerances are (±1/±1).
[m]Composition tolerances are (±2/±2/±2).
[n]Composition tolerances are (±1/±2/+0,–1).
[o]Composition tolerances are (±2, ±2, ±2).
[p]Composition tolerances are (±2, ±2, ±0.5/+0.5, –1).
[q]Composition tolerances are (+0.5,–1.0/+1.0,–0.5/+1.0,–0.2).
[r]Composition tolerances are (±1.1/±1.0/+0.1,–0.4).
[s]Composition tolerances are (±0.5/±1.0/±0.5).
[t]Composition tolerances are (±1.0/±1.0/±1.0).
[u]Composition tolerances are (+1.0,–0.0/+0.0,–1.0).

(This appendix is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)

INFORMATIVE APPENDIX E—TOXICITY AND FLAMMABILITY DATA FOR SINGLE-COMPOUND REFRIGERANTS

TABLE E1 Toxicity Table for Standard 34—ATEL, ODL, FCL, and RCL Values for Single-Compound Refrigerants[a] (ppm v/v)

Refrigerant R- [b]	Chemical Name	LC_{50} [c,d]	Cardiac Sensitization		Anesthesia			Other[i]	ATEL	ODL	FCL	RCL	LFL	ATEL Source	RCL Source
			LOEL[e]	NOEL[e]	EC_{50} [f]	LOEL[g]	NOEL[h]								
11	trichlorofluoromethane	26,200	4800	1100	35,000	ND	12,500	ND	1100	140,000	NA	1100	—	100% Cardiac NOEL	ATEL
12	dichlorodifluoromethane	>800,000	50,000	40,000	250,000	ND	200,000	22,700	18,000	140,000	NA	18,000	—	Other	ATEL
14	tetrafluoromethane	>390,000	ND	200,000	ND	ND	226,000	ND	110,000	140,000	NA	110,000	—	28.8% LC_{50}	ATEL
22	chlorodifluoromethane	220,000	50,000	59,300[k]	140,000	ND	ND	ND	59,000	140,000	NA	59,000	—	100% Cardiac NOEL	ATEL
23	trifluoromethane	>663,000	ND	800,000	ND	ND	51,000	ND	41,000	140,000	NA	41,000	—	80% Anesthesia NOEL	ATEL
32	difluoromethane (methylene fluroride)	>760,000	250,000	200,000	ND	ND	250,000	ND	200,000	140,000	36,000	36,000	144,000	80% Anesthesia NOEL	25% LFL
113	1,1,2-trichloro-1,2,2-trifluoroethane	52,500	4850	2600	28,000	ND	25,000	ND	2600	140,000	NA	2600	—	100% Cardiac NOEL	ATEL
114	1,2-dichloro-1,1,2,2-tetrafluoroethane	255,000 [j]	25,000	ND	250,000	ND	100,000	ND	20,000	140,000	NA	20,000	—	80% Cardiac LOEL	ATEL
115	chloropentafluoroethane	>800,000	150,000	ND	ND	ND	800,000	ND	120,000	140,000	NA	120,000	—	80% Cardiac LOEL	ATEL
116	hexafluoroethane	>800,000	ND	200,000	ND	ND	121,000	ND	97,000	140,000	NA	97,000	—	80% Anesthesia NOEL	ATEL
123	2,2-dichloro-1,1,1-trifluoroethane	32,000	ND	10,300	27,000	ND	2500	ND	9100	140,000	NA	9100	—	28.8% LC_{50}	ATEL
124	2-chloro-1,1,1,2-tetrafluoroethane	263,000	25,000	10,100	150,000	ND	48,000	ND	10,000	140,000	NA	10,000	—	100% Cardiac NOEL	ATEL
125	pentafluoroethane	>769,000	100,000	75,000	ND	ND	709,000	ND	75,000	140,000	NA	75,000	—	100% Cardiac NOEL	ATEL
134a	1,1,1,2-tetrafluoroethane	>359,000[l]	75,200	49,800	270,000	ND	81,000	ND	50,000	140,000	NA	50,000	—	100% Cardiac NOEL	ATEL
141b	1,1-dichloro-1-fluoroethane	61,600	5200	2600	25,000	29,000	20,000	ND	2600	140,000	15,000	2600	60,000	100% Cardiac NOEL	ATEL
142b	1-chloro-1,1-difluoroethane	106,000[d]	50,000	25,000	250,000	ND	591,000	ND	25,000	140,000	20,000	20,000	80,000	100% Cardiac NOEL	25% LFL
143a	1,1,1-trifluoroethane	>591,000	300,000	250,000	500,000	ND	24,800	ND	170,000	140,000	21,000	21,000	82,000	28.3% LC_{50}	25% LFL
152a	1,1-difluoroethane	400,000[d]	150,000	50,000	ND	ND	100,000	500,000	50,000	140,000	12,000	12,000	48,000	100% Cardiac NOEL	25% LFL
170	ethane	>24,800	100,000	ND	ND	ND	ND	ND	7000	140,000	7700	7000	31,000	28.3% LC_{50}	ATEL
E170	Dimethyl ether	164,000	200,000	100,000	ND	84,000	ND	ND	42,000	140,000	8500	8500	34,000	50% Anesthesia LOEL	25% LFL
218	octafluoropropane	>400,000[d, m]	400,000	300,000	ND	ND	113,000	ND	90,000	140,000	NA	90,000	—	80% Anesthesia NOEL	ATEL
227ea	1,1,1,2,3,3,3-heptafluoropropane	>788,696	105,000	90,000	ND	ND	105,000	ND	84,000	140,000	NA	84,000	—	80% Anesthesia NOEL	ATEL
236fa	1,1,1,3,3,3-hexafluoropropane	>457,000	150,000	100,000	110,000	ND	20,000	ND	55,000	140,000	NA	55,000	—	80% Anesthesia EC_{50}	ATEL

TABLE E1 Toxicity Table for Standard 34—ATEL, ODL, FCL, and RCL Values for Single-Compound Refrigerants[a] (ppm v/v) *(continued)*

Refrig-erant R-[b]	Chemical Name	LC_{50}[c,d]	Cardiac Sensitization		Anesthesia			Other[i]	ATEL	ODL	FCL	RCL	LFL	ATEL Source	RCL Source
			LOEL[e]	NOEL[e]	EC_{50}[f]	LOEL[g]	NOEL[h]								
245fa	1,1,1,3,3-pentafluoropropane	>203,000	44,000	34,100	ND	ND	50,600	ND	34,000	140,000	NA	34,000	—	100% Cardiac NOEL	ATEL
290	propane	>200,000[n]	100,000	50,000	280,000	ND	ND	ND	50,000	140,000	5300	5300	21,000	100% Cardiac NOEL	25% LFL
C318	octafluorocyclobutane	>800,000	100,000	ND	>800,000	ND	800,000	ND	80,000	140,000	NA	80,000	—	80% Cardiac LOEL	ATEL
600	butane	272,000	ND	ND	ND	ND	ND	100,000	1000	140,000	5000	1000	20,000	Sect 7.1.1 (b)	ATEL
600a	isobutane	143,000[o]	50,000	25,000	200,000	10,000	ND	ND	25,000	140,000	4000	4000	16,000	100% Cardiac NOEL	25% LFL
601a	isopentane	434,000	ND	ND	ND	120,000	ND	ND	1000	140,000	3300	1000	13,000	Sect 7.1.1 (b)	ATEL
717	ammonia	3300[q]	ND	-p-	ND	-p-	38,900	400	320	140,000	42,000	320	167,000	Other	ATEL
744	carbon dioxide	-s-	ND	-p-	ND	-p-	ND	50,000[r]	40,000	140,000	NA	40,000	—	NIOSH IDLH	ATEL
1270	propene (propylene)	>490,000[t]	ND	ND	ND	ND	10,000	7200	1000	140,000	6700	1000	27,000	Sect 7.1.1 (b)	ATEL

ND: None Determined or Not Adequately Defined according to criteria of this standard.

NA: Not Applicable.

Note: The data shown in this table are rounded to three significant digits to avoid suggestion of artificial precision, but actual calculations used the data as published or converted to avoid propagation of errors in calculations, especially for blends. The ATEL and RCL concentrations are rounded to two significant figures.

[a]Data taken from J.M. Calm, "ARTI Refrigerant Database," Air- Conditioning and Refrigeration Technology Institute (ARTI), Arlington, VA, July 2001; J.M. Calm, "Toxicity Data to Determine Refrigerant Concentration Limits," Report DE/CE 23810-110, Air-Conditioning and Refrigeration Technology Institute (ARTI), Arlington, VA, September 2000; J.M. Calm, "The Toxicity of Refrigerants," *Proceedings of the 1996 International Refrigeration Conference*, Purdue University, West Lafayette, IN, pp. 157–62, 1996; D.P. Wilson and R.G. Richard, "Determination of Refrigerant Lower Flammability Limits (LFLs) in Compliance with Proposed Addendum p to ANSI/ASHRAE Standard 34-1992 (1073-RP)," *ASHRAE Transactions* 2002, 108(2); D.W. Coombs, "HFC-32 Assessment of Anesthetic Potency in Mice by Inhalation," Huntingdon Life Sciences Ltd., Huntingdon, Cambridgeshire, England, February 2004 and amendment February 2006; D.W. Coombs, "HFC-22 An Inhalation Study to Investigate the Cardiac Sensitization Potential in the Beagle Dog," Huntingdon Life Sciences Ltd., Huntingdon, Cambridgeshire, England, August 2005; and other toxicity studies.

[b]From ANSI/ASHRAE Standard 34-2004 and subsequent published addenda.

[c]4-hr LC_{50} rat used for mortality indicator; some federal and fire code toxicity classifications are based on a 1-hr LC_{50} rat.

[d]4-hr approximate lethal concentration (ALC) rat used for mortality indicator; LC_{50} not determined.

[e]Dog with epinephrine injection.

[f]10-min EC_{50} mouse or rat.

[g]Lowest anesthetic/CNS LOEL rat during ALC, LC_{50}, or other acute toxicity study.

[h]Highest anesthetic/CNS NOEL rat in any toxicity study not exceeding an acute LOEL.

[i]Other escape-impairing or permanently injuring effects, including severe sensory irritation, for short exposures.

[j]R-114 30-min LC_{50} rat - 720,000 ppm v/v, 2-hr LC_{50} rat > 600,000 ppm v/v.

[k]Not used.

[l]R-134a LC_0 substituted for ALC; > 50% of animals died at ALC of 566,700 ppm v/v.

[m]R-218 1-hr ALC rat > 800,000 ppm v/v.

[n]R-290 15-min LC_{50} rat > 800,000 ppm v/v.

[o]R-600a 15-min LC_{50} rat = 570,000 ppm v/v; anesthetic/CNS value is a 17-min EC_{50} mouse.

[p]No data, but believed to exceed LC_{50} and ALC.

[q]Published LC_{50} values - 6,586–19,671 ppm v/v for 1 hr and 2,000–4,067 for 4 hr; conversion of the lowest 1-hr LC_{50} rat to 4-hr yields 3,300, approximately the midpoint of the 4-hr values.

[r]See NIOSH IDLH documentation for other effect.

[s]R-744 treated as simple asphyxiant; 5-min LC_{Lo} human = 90,000 ppm v/v.

[t]R-1270 6-hr ALC > 400,000 ppm v/v; cardiac sensitization in 2 of 2 dogs at 100,000 ppm; respiratory rate decrease in half of tested animals at 7,200 ppm v/v.

(This appendix is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)

INFORMATIVE APPENDIX F
ADDENDA DESCRIPTION INFORMATION

ANSI/ASHRAE Standard 34-2007 incorporates ANSI/ASHRAE Standard 34-2004 and Addenda a, b, c, d, e, f, g, h, i, j, k, l, m, n, o, p, q, r, s, t, u, v, and w to ANSI/ASHRAE Standard 34-2004. Table F1 lists each addendum and describes the way in which the standard is affected by the change. It also lists the ASHRAE and ANSI approval dates for the addenda.

TABLE F1 Addenda to ANSI/ASHRAE Standard 34-2004

Addendum	Section(s) Affected	Description of Changes*	ASHRAE Standards Approval	ASHRAE Board of Directors Approval	ANSI Approval
34a	Table 2	Adds a designation of R-422B to the blend R-125/134a/600a (55.0/42.0/3.0) with tolerances of (±1.0/ ±1.0/ +0.1,–0.5) and a safety classification of A1.	1/21/06	1/26/06	4/10/06
34b	Table 2	Adds a designation of R-422C to the blend R-125/134a/600a (82.0/15.0/3.0) with tolerances of (±1.0/ ±1.0/ +0.1,–0.5) and a safety classification of A1.	1/21/06	1/26/06	4/10/06
34c	Table 2	Adds a designation of R-423A to the blend R-134a/227ea (52.5/47.5) with tolerances of (±1.0/ ±1.0) and a safety classification of A1.	1/21/06	1/26/06	4/10/06
34d	Section 9	Adds the requirement for refrigerant applications in electronic format in addition to the printed copies.	1/27/07	3/2/07	3/3/07
34e	Table 2	Adds a designation of R-424A to the blend R-125/134a/600a/600/601a (50.5/47.0/0.9/1.0/0.6) with tolerances of (±1.0/ ±1.0/+0.1,–0.2/+0.1,–0.2/+0.1,–0.2) and a safety classification of A1.	1/21/06	1/26/06	4/10/06
34f	Table 2	Adds a designation of R-425A to the blend R-32/134a/227ea (18.5/69.5/12.0) with tolerances of (±0.5/ ±0.5/ ±0.5) and a safety classification of A1.	1/21/06	1/26/06	4/10/06
34g	Tables 1 and 2	Adds a column to Table 1 and 2 titled “Toxicity Under Code Classification” with each refrigerant designated as highly toxic, toxic (as defined by the International Fire Code, Uniform Fire Code and OSHA) or neither (for refrigerants less toxic than defined above).	6/24/06	6/29/06	7/27/06
34h	Table 2	Adds a designation of R-422D to the blend R-125/134a/600a (65.1/35.5/3.4) with tolerances of (+0.9,–1.1/ ±1.0/ +0.1,–0.4) and a safety classification of A1.	6/24/06	6/29/06	6/30/06
34i	Table 2	Adds a designation of R-426A to the blend R-125/134a/600/601a (5.1/93.0/1.3/0.6) with tolerances of (±1.0/ ±1.0/+0.1,–0.2, +0.1,–0.2) and a safety classification of A1.	1/27/07	3/2/07	3/3/07
34j	Table 2	Adds a designation of R-427A to the blend R-32/125/143a/134a (15.0/25.0/10.0/50.0) with tolerances of (±2.0/ ±2.0/±2.0/±2.0) and a safety classification of A1.	1/27/07	3/2/07	3/3/07
34k	Table 1	Adds a designation of R-601 for pentane (no safety classification) and a designation of R-601a for isopentane with a safety classification of A3.	6/25/05	6/30/05	7/1/05

TABLE F1 Addenda to ANSI/ASHRAE Standard 34-2004 *(continued)*

Addendum	Section(s) Affected	Description of Changes	ASHRAE Standards Approval	ASHRAE Board of Directors Approval	ANSI Approval
34l	Table 2	Adds a designation of R-428A to the blend R-125/143a/290/600a (77.5/20.0/0.6/1.9) with tolerances of (±1.0/ ±1.0/+0.1,–0.2/+0.1,–0.2) and a safety classification of A1.	1/27/07	3/2/07	3/3/07
34m	Section 9	Removes data element requirements that are not needed in determining the refrigerant designation or safety classifications.	1/27/07	3/2/07	3/3/07
34n	Section 4.5	Provides general guidance for numbering of C4-C8 alkanes.	1/21/06	1/26/06	4/10/06
34o	Table 2	Adds a designation of R-421A to the blend R-125/134a (58.0/42.0) and a safety classification of A1.	10/3/04	2/10/05	2/10/05
34p	Several	Revises the refrigerant flammability classification and specifies the flammability and fractionation testing procedures.	6/25/05	6/30/05	7/28/05
34q	Table 2	Adds a designation of R-422A to the blend R-125/134a/600a (85.1/11.5/3.4) with tolerances of (±1.0/ ±1.0/+0.1, –0.4) and a safety classification of A1.	6/25/05	6/30/05	7/1/05
34r	Table 2	Adds a designation of R-421B to the blend R-125/134a (85.0/15.0) with tolerances of (±1.0/ ±1.0) and a safety classification of A1.	6/25/06	6/30/05	7/1/05
34s	Table 1	Adds a designation for R-227ea for 1,1,1,2,3,3,3-heptafluoropropane and a safety classification of A1.	6/25/05	6/30/05	7/1/05
34t	Appendix D	Adds an informative appendix containing refrigerant data removed from the standard by Addendum 34u-2004 and bubble/dew points for azeotropic blends.	1/27/07	3/2/07	3/3/07
34u	Section 7, Tables 1 and 2	Adds a new section to specify the criteria to determine recommended "Refrigerant Concentration Limits (RCL)" in occupied spaces and adds RCL values to Tables 1 and 2.	10/3/04	2/10/05	4/21/06
34v	Section 7, Tables 1 and 2	Updates Addendum 34u-2004 text and tables based on an increased ODL from 69,100 ppm to 140,000 ppm, increased cardiac sensitization default from 0 to 1000 ppm, new toxicity information for R-22, 32 and 227ea, new LFL values, and addition of new refrigerants.	1/27/07	3/2/07	3/27/07
34w	Section 8, Appendix E	Adds an informative appendix containing toxicity values for single-compound refrigerants.	1/27/07	3/2/07	3/27/07

* These descriptions may not be complete and are provided for information only.

NOTE

When addenda, interpretations, or errata to this standard have been approved, they can be downloaded free of charge from the ASHRAE Web site at http://www.ashrae.org.

NOTICE

INSTRUCTIONS FOR SUBMITTING A PROPOSED CHANGE TO THIS STANDARD UNDER CONTINUOUS MAINTENANCE

This standard is maintained under continuous maintenance procedures by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. SSPC consideration will be given to proposed changes at the Annual Meeting (normally June) if proposed changes are received by the Manager of Standards (MOS) no later than December 31. Proposals received after December 31 shall be considered by the SSPC no later than at the Annual Meeting of the following year.

Proposed changes must be submitted to the MOS in the latest published format available from the MOS. However, the MOS may accept proposed changes in an earlier published format if the MOS concludes that the differences are immaterial to the proposed change submittal. If the MOS concludes that a current form must be utilized, the proposer may be given up to 20 additional days to resubmit the proposed changes in the current format.

ELECTRONIC PREPARATION/SUBMISSION OF FORM FOR PROPOSING CHANGES

An electronic version of each change, which must comply with the instructions in the Notice and the Form, is the preferred form of submittal to ASHRAE Headquarters at the address shown below. The electronic format facilitates both paper-based and computer-based processing. Submittal in paper form is acceptable. The following instructions apply to change proposals submitted in electronic form.

Use the appropriate file format for your word processor and save the file in either a recent version of Microsoft Word (preferred) or another commonly used word-processing program. Please save each change proposal file with a different name (for example, "prop01.doc," "prop02.doc," etc.). If supplemental background documents to support changes submitted are included, it is preferred that they also be in electronic form as word-processed or scanned documents.

ASHRAE will accept the following as equivalent to the signature required on the change submittal form to convey non-exclusive copyright:

Files attached to an e-mail:	Electronic signature on change submittal form (as a picture; *.tif, or *.wpg).
Files on a CD:	Electronic signature on change submittal form (as a picture; *.tif, or *.wpg) or a letter with submitter's signature accompanying the CD or sent by facsimile (single letter may cover all of proponent's proposed changes).

Submit an e-mail or a CD containing the change proposal files to:
Manager of Standards
ASHRAE
1791 Tullie Circle, NE
Atlanta, GA 30329-2305
E-mail: change.proposal@ashrae.org
(Alternatively, mail paper versions to ASHRAE address or fax to 404-321-5478.)

The form and instructions for electronic submittal may be obtained from the Standards section of ASHRAE's Home Page, www.ashrae.org, or by contacting a Standards Secretary, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305.
Phone: 404-636-8400. Fax: 404-321-5478. E-mail: standards.section@ashrae.org.

FORM FOR SUBMITTAL OF PROPOSED CHANGE TO AN ASHRAE STANDARD UNDER CONTINUOUS MAINTENANCE

NOTE: Use a separate form for each comment. Submittals (Microsoft Word preferred) may be attached to e-mail (preferred), submitted on a CD, or submitted in paper by mail or fax to ASHRAE, Manager of Standards, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: change.proposal@ashrae.org. Fax: +1-404/321-5478.

1. Submitter:

Affiliation:

Address: City: State: Zip: Country:

Telephone: Fax: E-Mail:

I hereby grant the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc. (ASHRAE) the non-exclusive royalty rights, including non-exclusive rights in copyright, in my proposals. I understand that I acquire no rights in publication of the standard in which my proposals in this or other analogous form is used. I hereby attest that I have the authority and am empowered to grant this copyright release.

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All electronic submittals must have the following statement completed:

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3. Page number and clause (section), subclause, or paragraph number:

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6. Reason and substantiation:

7. Will the proposed change increase the cost of engineering or construction? If yes, provide a brief explanation as to why the increase is justified.

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POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

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ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the standards and guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive technical committee structure, continue to generate up-to-date standards and guidelines where appropriate and adopt, recommend, and promote those new and revised standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating standards and guidelines.

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ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

86089
PC 5/07

ANSI/ASHRAE Addenda a, b, c, d, e, f, g, and h to
ANSI/ASHRAE Standard 34-2007

ASHRAE ADDENDA

Designation and Safety Classification of Refrigerants

Approved by the ASHRAE Standards Committee on June 23, 2007, by the ASHRAE Board of Directors on June 27, 2007, and by the American National Standards Insitute on June 28, 2007.

This standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the standard. The change submittal form, instructions, and deadlines may be obtained in electronic form from the ASHRAE Web site, http://www.ashrae.org, or in paper form from the Manager of Standards. The latest edition of an ASHRAE Standard may be purchased from ASHRAE Customer Service, 1791 Tullie Circle, NE, Atlanta, GA 30329-2305. E-mail: orders@ashrae.org. Fax: 404-321-5478. Telephone: 404-636-8400 (worldwide), or toll free 1-800-527-4723 (for orders in US and Canada).

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This American National Standard (ANS) is a national voluntary consensus standard developed under the auspices of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE). *Consensus* is defined by the American National Standards Institute (ANSI), of which ASHRAE is a member and which has approved this standard as an ANS, as "substantial agreement reached by directly and materially affected interest categories. This signifies the concurrence of more than a simple majority, but not necessarily unanimity. Consensus requires that all views and objections be considered, and that an effort be made toward their resolution." Compliance with this standard is voluntary until and unless a legal jurisdiction makes compliance mandatory through legislation.

ASHRAE obtains consensus through participation of its national and international members, associated societies, and public review.

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b. participation in the next review of the Standard,
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FOREWORD

This addendum adds a designation of R-429A to the blend R-E170/152a/600a (60.0/10.0/30.0) with composition tolerances of (±1.0/±1.0/±1.0), a safety classification of A3, and an RCL of 6300 ppm, 13 g/m^3, 0.81lb/Mcf.

Note: In this addendum, changes to the current standard are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) unless the instructions specifically mention some other means of indicating the changes.

Addendum a to 34-2007

Add to Table 2 the following entries for R-429A:

Refrigerant Number = 429A
Composition (Mass %) = R-E170/152a/600a (60.0/10.0/30.0)
Composition Tolerances = (±1.0/±1.0/±1.0)
Safety Group = A3
RCL = 6300 (ppm v/v), 13 (g/m^3), 0.81 (lb/Mcf)

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FOREWORD

This addendum adds a designation of R-430A to the blend R-152a/600a (76.0/24.0) with composition tolerances of (±1.0/±1.0), a safety classification of A3, and an RCL of 8000 ppm, 21 g/m^3, 1.3 lb/Mcf.

Note: In this addendum, changes to the current standard are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) unless the instructions specifically mention some other means of indicating the changes.

Addendum b to 34-2007

Add to Table 2 the following entries for R-430A:

Refrigerant Number = 430A
Composition (Mass %) = R-152a/600a (76.0/24.0)
Composition Tolerances = (±1.0/±1.0)
Safety Group = A3
RCL = 8000 (ppm v/v), 21 (g/m^3), 1.3 (lb/Mcf)

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FOREWORD

This addendum adds a designation of R-431A to the blend R-290/152a (71.0/29.0) with composition tolerances of (±1.0/±1.0), a safety classification of A3, and an RCL of 5500 ppm, 11g/m^3, 0.69 lb/Mcf.

Note: In this addendum, changes to the current standard are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) unless the instructions specifically mention some other means of indicating the changes.

Addendum c to 34-2007

Add to Table 2 the following entries for R-431A:

Refrigerant Number = 431A
Composition (Mass %) = R-290/152a (71.0/29.0)
Composition Tolerances = (±1.0/±1.0)
Safety Group = A3
RCL = 5500 (ppm v/v), 11 (g/m^3), 0.69 (lb/Mcf)

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FOREWORD

This addendum adds a designation of R-432A to the blend R-1270/E170 (80.0/20.0) with composition tolerances of (±1.0/±1.0), a safety classification of A3, and an RCL of 1200 ppm, 2.1 g/m^3, 0.13 lb/Mcf.

Note: In this addendum, changes to the current standard are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) unless the instructions specifically mention some other means of indicating the changes.

Addendum d to 34-2007

Add to Table 2 the following entries for R-432A:

Refrigerant Number = 432A
Composition (Mass %) = R-1270/E170 (80.0/20.0)
Composition Tolerances = (±1.0/±1.0)
Safety Group = A3
RCL = 1200 (ppm v/v), 2.1 (g/m^3), 0.13 (lb/Mcf)

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FOREWORD

This addendum adds a designation of R-433A to the blend R-1270/290 (30.0/70.0) with composition tolerances of (±1.0/±1.0), a safety classification of A3, and an RCL of 3100 ppm, 5.5 g/m^3, 0.34 lb/Mcf.

Note: In this addendum, changes to the current standard are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) unless the instructions specifically mention some other means of indicating the changes.

Addendum e to 34-2007

Add to Table 2 the following entries for R-433A:

Refrigerant Number = 433A
Composition (Mass %) = R-1270/290 (30.0/70.0)
Composition Tolerances = (±1.0/±1.0)
Safety Group = A3
RCL = 3100 (ppm v/v), 5.5 (g/m^3), 0.34 (lbs/Mcf)

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FOREWORD

This addendum updates the RCL value for R-C318 in Table 1 to 80,000 ppm and adds RCL values for R-427A and R-428A in Table 2.

Note: In this addendum, changes to the current standard are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) unless the instructions specifically mention some other means of indicating the changes.

Addendum f to 34-2007

Modify Table 1 for R-C318 as shown below:

RCL = ~~69,000~~ 80,000 (ppm v/v), ~~570~~ 660 (g/m^3), ~~35~~ 41 (lb/Mcf)

Add RCL values to Table 2 for R-427A and R-428A as shown below:

R-427A
RCL = 76,000 (ppm v/v), 280 (g/m^3), 18 (lb/Mcf)

R-428A
RCL = 83,000 (ppm v/v), 370 (g/m^3), 23 (lb/Mcf)

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FOREWORD

This addendum modifies the method of calculating the heat of combustion to more closely represent what actually occurs. It also adds an informative appendix with an example calculation.

Note: In this addendum, changes to the current standard are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) unless the instructions specifically mention some other means of indicating the changes.

Addendum g to 34-2007

Revise clauses 6.1.3.5a and 6.1.3.5b as follows:

6.1.3.5 The heat of combustion shall be calculated for conditions of 25°C (77°F) and 101.3 kPa (14.7 psia).

a. For single-component refrigerants, the heat of combustion ~~can~~shall be calculated~~,if the heat of formation (enthalpy of formation) of the refrigerant and its products of reaction are known. Values for heats of formation are tabulated in several chemical and physical properties handbooks and databases.~~ The heat of combustion is the enthalpy of formation of the reactants (refrigerant and oxygen) minus the enthalpy of formation of the products of reaction. Values for heats of formation are tabulated in several chemical and physical properties handbooks and databases. In this standard, the heat of combustion is positive for exothermic reactions. 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(g) [note, not aqueous solution (aq)], CO_2(g), (N_2(g) or SO_2(g) if nitrogen or sulfur are part of the refrigerant's molecular structure) HCl(g), and H_2O(g) ~~CO_2, (N_2 or SO_2 if nitrogen or sulfur are part of the refrigerant's molecular structure) HF and HCl, if there is enough hydrogen in the molecule. If there is insufficient hydrogen available for the formation of both HF and HCl, then the formation of HF takes preference over the formation of HCl. The remaining F and Cl produce F_2 and Cl_2. Excess H shall be assumed to be converted to H_2O~~.

If there is insufficient H (hydrogen) available for the formation of HF(g), HCl(g), and H_2O(g) then the formation of HF(g) takes preference over the formation of HCl(g) which takes preference over the formation of H_2O. If there is insufficient hydrogen available for all of the F (fluorine) to form HF(g), then the remaining F produces COF_2(g) or CF_4(g) in preference of C (carbon) forming CO_2. Any remaining Cl (chloride) produces Cl_2(g) (chlorine).

b. For refrigerant blends, the heat of combustion shall be ~~measured or~~ calculated from a balanced stoichiometric equation of all component refrigerants. 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, hydrogen, fluorine, etc. as is in the original blend. The hypothetical molecule would then be treated as a pure refrigerant as in section 6.1.3.5 (a). The heat of formation for this hypothetical molecule is the molar average of the heats of formation for the original blend molecules.

Note: The molar percent or mass percent weighted average of the HOC of the pure component of a blend produces incorrect results. For an example see Appendix F.

Add informative Appendix F as follows:

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APPENDIX F
EXAMPLE CALCULATIONS FOR HEATS OF COMBUSTION (INFORMATIVE)

F.1. REACTION STOICHIOMETRY FOR A REFRIGERANT BLEND

Consider the combustion of the mixture R-125/290 (45/55), which corresponds to a mole fraction ratio of (0.2311/0.7689). If the R-125 and R-290 were to burn individually, they would undergo the following reactions:

$$\text{R-125: } C_2HF_5 + O_2 \rightarrow CO_2 + CF_4 + HF \qquad \text{(F.1)}$$

and

$$\text{R-290: } C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_20 \qquad \text{(F.2)}$$

Taking x = 0.2311 (the mole fraction of R-125) and y = 0.7689 (the mole fraction of R-290), the mixture might be thought to undergo the following combustion reaction:

$$xC_2HF_5 + yC_3H_8 + (x + 5y)O_2 \rightarrow (x + 3y)CO_2 + xCF_4 + xHF + 4yH_2O \qquad \text{(F.3)}$$

But Equation F.3 would be incorrect. Instead combine the atoms of the R-125 and R-290 into a hypothetical molecule:

$$xC_2HF_5 + yC_3H_8 \rightarrow C_{2x + 3y}H_{x + 8y}F_{5x} \qquad \text{(F.4)}$$

This hypothetical molecule is then reacted with oxygen:

$$C_{2x + 3y}H_{x + 8y}F_{5x} + (x + 5y)O_2 \rightarrow (2x + 3y)CO_2 + 5xHF + (x + 8y - 5x) / 2H_2O \qquad \text{(F.5)}$$

In comparing Equations F.3 and F.5 note that the products of combustion are different. There is no CF_4 formed in (F.5); instead, the H (hydrogen) from the R-290 combines with the F (fluorine) from the R-125 to form additional HF.

F.2. HEAT OF COMBUSTION FOR A REFRIGERANT BLEND

The enthalpy of formation of the hypothetical blend molecule is the mole-fraction weighted average of the components:

$$\begin{aligned}\Delta h_f(\text{blend}) &= x\Delta h_f(\text{R125}) + y\Delta h_f(\text{R290})\\ &= 0.2311\ (-264.0\ \text{kcal/mol}) + 0.7689\ (-25.02\ \text{kcal/mol})\\ &= -80.25\ \text{kcal/mol}\end{aligned} \tag{F.6}$$

The heat of combustion is the enthalpy of formation of the reactants (refrigerant and oxygen) minus the enthalpy of formation of the products of reaction:

$$\begin{aligned}\Delta h_{combustion} &= \sum \Delta h_f(\text{reactants}) - \sum \Delta h_f(\text{products})\\ &= \{\Delta h_f(C_{2x+3y}H_{x+8y}F_{5x}) + (x+5y)\Delta h_f(O_2)\}\\ &\quad - \{(2x+3y)\Delta h_f(CO_2) + (5x)\Delta h_f(HF) + (-4x+3y)\Delta h_f(H_2O)\}\\ &= \{-80.25 + [0.2311 + 5(0.7689)][0]\}\\ &\quad - \{[2(0.2311) + 3(0.7689)][-94.05] + [5(0.2311)][-65.32] + [-2(0.2311) + 4(0.7689)][-57.80]\}\\ &= 406.70\ \text{kcal/mol}\end{aligned} \tag{F.7}$$

Note that the enthalpy of formation of any element (*i.e.* O_2) in its normal state at 25°C is zero, by definition.

TABLE F1 Sample Heats of Formation

Refrigerant	Heat of Formation, (kcal/mol)
CO_2 (g)	–94.05
H_2O (g)	–57.796
HF (g)	–65.32
HCl (g)	–22.06
HI(g)	6.33
HBr(g)	–8.69
SO_2 (g)	–70.94
SO_3 (g)	–105.41
CF_4 (g)	–223.0
CF_2O (g)	–152.7
$COCl_2$ (g)	–52.32
R290 (g)	–25.02
R125 (g)	–264.0

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FOREWORD

This addendum adds an informative appendix showing an example of the calculation of the ATEL and RCL for a refrigerant blend. Section 7.2 is also modified to refer the reader to the informative appendix.

Note: In this addendum, changes to the current standard are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) unless the instructions specifically mention some other means of indicating the changes.

Addendum h to 34-2007

Revise Section 7.2 as follows:

7.2 Blends. The RCL for refrigerants comprising multiple compounds shall be determined by the method in Section 7.1 except that individual parameter values in Section 7.1.1 (a) through (d) shall be calculated as the mole-weighted average, by composition of the nominal formulation, of the values for the components. The calculation used to determine the ATEL and RCL of a refrigerant blend is summarized in Appendix G. The calculation can also be performed using a computer program or spreadsheet.

Add informative Appendix G as follows:

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APPENDIX G
CALCULATION OF RCL AND ATEL FOR BLENDS (INFORMATIVE)

The ATEL for a refrigerant blend shall be set as the lowest of the blend acute toxic concentration factors (TCFs) (*a*)–(*d*) in Section 7.1.1, where each blend acute TCF quantity is calculated from the acute TCF values of its individual components, following the Additivity Method for Mixtures (reference the 2006 American Conference of Governmental Industrial Hygienists (ACGIH), *Threshold Limit Values for Chemical Substances and Physical Agents).* The additivity method is especially applicable to materials of similar chemical properties, for example, hydrocarbons or halogenated hydrocarbons.

The blend acute toxicity calculation shall be done as follows:

$$\text{Blend Mortality Indicator } (a)_{blend} = \frac{1}{\frac{mf_1}{a_1} + \frac{mf_2}{a_2} + \ldots + \frac{mf_n}{a_n}}$$

where a_n is the mortality indicator for component n in the blend (i.e., the four-hour LC_{50}), and mf_n is the mole fraction of component n.

In a similar fashion, Blend Cardiac Sensitization Indicator $(b)_{blend}$ can be calculated from $1/(\sum mf_n / b_n)$, where b_n is the cardiac sensitization indicator for component n in the blend (i.e., 100% of the NOEL, or if not determined, 80% of the LOEL), and from the mole fraction mf_n of component n, and so forth for the acute TCFs (*a*)–(*d*).

Each acute TCF for a blend can be expressed in ppm (parts per million of substance in air by volume) if the acute TCFs for each component n are expressed in ppm and mf_n is expressed as the mole fraction of component n in the blend. [The TCF of each component shall be determined according to the priority indicated in Section 7. Thus, the determining method for each component may not be consistent such as 100% of NOEL of component A and 80% of LOEL of component B.]

Example:
ATEL Calculation for R-410A (50/50 wt% R-32/R-125)

R-410A composition expressed in mole fraction is (0.698 mole fraction R-32/0.302 mole fraction R-125).

$$\text{Mortality Indicator (a) of R-410A} = \frac{1}{\frac{0.698}{215,000\text{ ppm}} + \frac{0.302}{218,000\text{ ppm}}}$$

where $(a)_{R\text{-}32}$ = the LC_{50} of R-32 or 760,000 ppm · 0.283 = 215,000 ppm and $(a)_{R\text{-}125}$ = the LC_{50} of R-125 or 769,000 ppm · 0.283 = 218,000 ppm. $(a)_{R\text{-}410A}$ = **216,000 ppm as the R-410A mortality indicator**.

$$\text{Cardiac Sensitization Indicator (b) of R-410A} = \frac{1}{\frac{0.698}{200,000\text{ ppm}} + \frac{0.302}{75,000\text{ ppm}}}$$

where $(b)_{R\text{-}32}$ = Cardiac Sensitization Indicator NOEL for R-32 or 200,000 ppm and $(b)_{R\text{-}125}$ = Cardiac Sensitization Indicator NOEL for R-125 or 75,000 ppm (NOEL).

$(b)_{R\text{-}410A}$ = **133,000 ppm as the R-410A cardiac sensitization indicator.**

$$\text{Anesthetic Effect Indicator (c) or R-410A} = \frac{1}{\frac{0.698}{200,000\text{ ppm}} + \frac{0.302}{567,000\text{ ppm}}}$$

where $(c)_{R\text{-}32}$ = Anesthetic Effect Indicator NOEL for R-32 or 250,000 ppm · 0.8 = 200,000 ppm and $(c)_{R\text{-}125}$ = Anesthetic Effect Indicator NOEL for R-125 or 709,000 ppm · 0.8 = 567,000 ppm. $(c)_{R\text{-}410A}$ = **249,000 ppm as the R-410A anesthetic indicator.**

Note: EC_{50} was not used because there was no value for R-32 or R-125, and LOEL was not used because the values for

R-32 and R-125 affected over half (10/10 and >5/10) the animals. Had legitimate EC_{50}, LOEL, or NOEL values been available, it would have been possible to use a EC_{50} for one blend component, a LOEL for a second, and a NOEL for a third, etc.

There are no pertinent escape-impairing or permanent injury effect indicators (*d*) known for R-410A. Therefore, the ATEL for R-410A is set on the Cardiac Sensitization Effect (*b*), 133,000 ppm, which is the lowest of acute TCFs (*a*)–(*c*) for the blend. Rounding to two significant figures gives 130,000 ppm as the ATEL of R-410A.

RCL for R-410A

Since the blend is nonflammable and the ATEL is less than the oxygen deprivation level of 140,000 ppm, the RCL is also 130,000 ppm.

POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

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The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

Errata Sheet for ANSI/ASHRAE Standard 34-2007,
Designation and Safety Classification of Refrigerants

November 19, 2007

The corrections listed in this errata sheet apply to the first printing of ANSI/ASHRAE Standard 34-2007 identified on the outside back cover as "86089 PC 5/07".

Page	**Erratum**
Inside Cover	**ASHRAE Standing Standard Project Committee 34.** Some of the initial copies of the first printing of the standard were published with the incorrect SSPC 34 roster on the inside cover. Correct roster attached. *Note that later versions of the first printing of the standard already include the corrected roster as a sticker and therefore this erratum may not apply in all cases.*
18	**Table 2 Data and Safety Classifications for Refrigerant Blends.** Change the composition for refrigerant number 426A from "R-125/134a/600a/601a" to "R-125/134a/600/601a".
18	**Table 2 Data and Safety Classifications for Refrigerant Blends.** Change the composition tolerances (shaded) in the following footnotes in Table 2 to read:

[g]Composition tolerances are (+0.2, -2.0/±2.0/±2.0).
[h]Composition tolerances for the individual components are (±2.0/±1.0/±1.0/±2.0) and for the sum of R-152a and R-142b are (+0.0, -2.0).
[i]Composition tolerances are (±2.0/±1.0/±1.0).
[r]Composition tolerances are (±2.0/+0.1, -1.0/±2.0).

ANSI/ASHRAE Addenda i, j, and k to
ANSI/ASHRAE Standard 34-2007

ASHRAE STANDARD

Designation and Safety Classification of Refrigerants

Approved by the ASHRAE Standards Committee on January 19, 2008; by the ASHRAE Board of Directors on January 23, 2008; and by the American National Standards Institute on January 24, 2008.

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FOREWORD

This addendum adds a designation of R-434A to the blend R125/143a/134a/600a (63.2/18.0/16.0/2.8) with composition tolerances of (±1.0/±1.0/±1.0/+0.1,–0.2); a safety classification of A1; an RCL of 73,000 ppm, 320 g/m^3, 20 lb/Mcf; and a code classification of neither highly toxic nor toxic. It also updates Table D2 with the molecular mass, bubble point, and dew point data as provided in the application.

Note: In this addendum, changes to the current standard are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) unless the instructions specifically mention some other means of indicating the changes.

Addendum i to Standard 34-2007

Add the following entries for R-434A:

TABLE 2 Data and Safety Classifications for Refrigerant Blends

Refrigerant Number = 434A
Composition (Mass %) =
R-125/143a/134a/600a (63.2/18.0/16.0/2.8)
Composition Tolerances = (±1.0/±1.0/±1.0/+0.1, –0.2)
Safety Group = A1
RCL = 73,000 ppm (v/v), 320 g/m^3, 20 lb/Mcf
Highly Toxic or Toxic Under Code Classification = Neither

TABLE D2 Data for Refrigerant Blends

Refrigerant Number = 434A
Composition (Weight %) =
R-125/143a/134a/600a (63.2/18.0/16.0/2.8)
Average Molecular Mass = 105.7
Bubble Point (°C) = –45.0
Dew Point (°C) = –42.3
Bubble Point (°F) = –49.0
Dew Point (°F) = –44.1

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FOREWORD

This addendum adds data for R-601 to Table 1 and adds R-601 to Table D1 and Table E1 with underlying toxicity and flammability data as provided in the application, with the following exceptions: 1) LFL = 1.2 vol%, 2) the rat LC_{50} for isopentane shall be applied to n-pentane.

Note: In this addendum, changes to the current standard are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) unless the instructions specifically mention some other means of indicating the changes.

Addendum j to Standard 34-2007

Add the following entries for R-601:

TABLE 1 Refrigerant Data and Safety Classifications

Refrigerant Number = 601
Chemical Name = pentane
Chemical Formula = $CH_3CH_2CH_2CH_2CH_3$
Safety Group = A3
RCL = 1,000 ppm (v/v), 2.9 g/m^3, 0.2 lb/Mcf
Highly Toxic or Toxic Under Code Classification = Neither

TABLE D1 Refrigerant Data

Refrigerant Number = 601
Chemical Name = pentane
Chemical Formula = $CH_3CH_2CH_2CH_2CH_3$
Molecular Mass = 72.1
Normal Boiling Point (°C) = 36.1
Normal Boiling Point (°F) = 97.0

TABLE E1 Toxicity and Flammability Data for Single-Compound Refrigerants

Refrigerant R- = 601
Chemical Name = pentane
LC_{50} = 434,000[u]
Cardiac Sensitization LOEL = ND
Cardiac Sensitization NOEL = ND
Anesthesia EC_{50} = ND
Anesthesia LOEL = 32,000
Anesthesia NOEL = 16,000
Other = ND
ATEL = 1,000
ODL = 140,000
FCL = 3,000
RCL = 1,000
LFL = 12,000
ATEL Source = Sect 7.1.1 (b)
RCL Source = ATEL

[u] The value shown is the LC_{50} for isopentane. The value for pentane is expected to be similar.

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FOREWORD

This addendum adds to Section 9.6.1 the following missing information to complete refrigerant applications:

g. anesthetic and central nervous system effects

h. other escape-impairing effects and permanent injury

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Addendum k to Standard 34-2007

9.6.1 Acute Toxicity. Applications shall include the following short-term toxicity data, with identified sources, for single-compound refrigerants or for each component of blends:

a. ACGIH TLV-C if assigned,
b. ACGIH TLV-STEL if assigned,
c. NIOSH IDLH if assigned,
d. LC50 for four hours for rats,
e. LD50 if available, ~~and~~
f. cardiac sensitization response level,
g. anesthetic and central nervous system effects, and
h. other escape-impairing effects and permanent injury.

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ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the standards and guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive technical committee structure, continue to generate up-to-date standards and guidelines where appropriate and adopt, recommend, and promote those new and revised standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating standards and guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

ANSI/ASHRAE Addendum l to
ANSI/ASHRAE Standard 34-2007

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FOREWORD

This addendum revises Sections B2.4.1, B2.4.2, and B2.5 to clarify the requirements for fractionation analysis when applying for designation and safety classification of a refrigerant.

Note: In this addendum, changes to the current standard are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) unless the instructions specifically mention some other means of indicating the changes.

Addendum l to Standard 34-2007

B2.4.1 Leaks Under Storage/Shipping Conditions. To simulate leaks under storage/shipping conditions, the container shall be filled with the WCF ~~at 23.0°C (73.4°F)~~ to 90%, by mass, of the maximum ~~permissible~~ fill~~, that which precludes~~. The maximum fill is the calculated mass that gives a 100% liquid fill at 54.4°C (130°F)~~, and then~~. The charged blend shall be vapor leaked, 2% by mass of the ~~starting~~ initial charge per hour, at the following temperatures:

(Remainder unchanged.)

B2.4.2 Leaks from Equipment. To simulate leaks from equipment, the container shall be filled with the WCF ~~at ambient temperature~~ to 15% of the maximum ~~permissible~~ fill (as defined in Section B2.4.1) and then shall be vapor leaked at the following temperatures:

(Remainder unchanged.)

B2.5 Leak~~Charge~~/Recharge Testing. Refrigerant blends containing flammable component(s) shall be evaluated to determine the fractionation effects of successive leakage and recharging on the composition of the blend. A container shall be charged to 15% ~~full~~ of ~~its~~the maximum ~~permitted~~fill (as defined in Section B2.4.1) with the WCF formulation of the refrigerant blend. A vapor leak at a rate of 2% by mass of the starting charge per hour shall be created and maintained at ambient temperature until 20% of the starting charge has been leaked. When 20% leak is reached, the composition of the head space gas shall be determined by analysis. The container shall again be charged with the WCF to 15% ~~full~~ of the maximum fill (as defined in Section B2.4.1), leaked, and measured in the above defined manner. The charge/leak cycle shall be performed a total of five times. At the conclusion of the fifth leakage, the composition of the head space gas and liquid shall again be determined by gas chromatography.

(Remainder unchanged.)

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ANSI/ASHRAE Addenda m, n, o, p, q, r, s, t, u, and v to
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FOREWORD

This addendum adds the refrigerant concentration limit (RCL) to the purpose and scope of Standard 34.

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Addendum m to Standard 34-2007

Revise Sections 1 and 2 as follows.

1. PURPOSE

This standard is intended to establish a simple means of referring to common refrigerants instead of using the chemical name, formula, or trade name. It ~~also~~ establishes a uniform system for assigning reference numbers, ~~and~~ safety classifications, and refrigerant concentration limits to refrigerants. The standard also identifies requirements to apply for designations and safety classifications for refrigerants~~, including blends,~~ and to determine refrigerant concentration limits ~~in addenda or revisions to this standard~~.

2. SCOPE

This standard provides an unambiguous system for numbering refrigerants and assigning composition-designating prefixes for refrigerants. Safety classifications based on toxicity and flammability data are included along with refrigerant concentration limits for the refrigerants. This standard does not imply endorsement or concurrence that individual refrigerant blends are suitable for any particular application.

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FOREWORD

This addendum adds R-435A, a new zeotropic refrigerant blend, to Tables 2 and D2.

Note: In this addendum, changes to the current standard are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) unless the instructions specifically mention some other means of indicating the changes.

Addendum n to Standard 34-2007

Add the following to Table 2 in the columns indicated:

TABLE 2— DATA AND SAFETY CLASSIFICATIONS FOR REFRIGERANT BLENDS

Refrigerant Number = 435A
Composition (Mass %) = R-E170/152a (80.0/20.0)
Composition Tolerances = (±1.0 /±1.0)
Safety Group = A3
RCL = 8,500 ppm (v/v), 17 g/m^3, 1.1 lb/Mcf
Highly Toxic or Toxic Under Code Classification = Neither

Add the following to Table D2 in the columns indicated:

TABLE D2— DATA FOR REFRIGERANT BLENDS

Refrigerant Number = 435A
Composition (Weight %) = R-E170/152a (80.0/20.0)
Average Molecular Mass = 49.04
Bubble Point (°C) = –26.1
Dew Point (°C) = –25.9
Bubble Point (°F) = –15.0
Dew Point (°F) = –14.6

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FOREWORD

This addendum adds R-510A, a new azeotropic refrigerant blend, to Tables 2 and D2.

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Addendum o to Standard 34-2007

Add the following to Table 2 in the columns indicated:

TABLE 2— DATA AND SAFETY CLASSIFICATIONS FOR REFRIGERANT BLENDS

Refrigerant Number = 510A
Composition (Mass %) = R-E170/600a (88.0/12.0)
Composition Tolerances = (±0.5 /±0.5)
Safety Group = A3
RCL = 7,300 ppm (v/v), 14 g/m^3, 0.87 lb/Mcf
Highly Toxic or Toxic Under Code Classification = Neither

Add the following to Table D2 in the columns indicated:

TABLE D2— DATA FOR REFRIGERANT BLENDS

Refrigerant Number = 510A
Composition (Weight %) = R-E170/600a (88.0/12.0)
Azeotropic Temperature = –25.2 (°C), –13.4 (°F)
Azeotropic Molecular Mass = 47.24
Normal BPt. (°C) = –25.2
Normal BPt. (°F) = –13.4

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FOREWORD

This addendum adds R-436A, a new zeotropic refrigerant blend, to Tables 2 and D2.

Note: In this addendum, changes to the current standard are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) unless the instructions specifically mention some other means of indicating the changes.

Addendum p to Standard 34-2007

Add the following to Table 2 in the columns indicated:

TABLE 2— DATA AND SAFETY CLASSIFICATIONS FOR REFRIGERANT BLENDS

Refrigerant Number = 436A
Composition (Mass %) = R-290/600a (56.0/44.0)
Composition Tolerances = (±1.0 /±1.0)
Safety Group = A3
RCL = 4,000 ppm (v/v), 8 g/m^3, 0.5 lb/Mcf
Highly Toxic or Toxic Under Code Classification = Neither

Add the following to Table D2 in the columns indicated:

TABLE D2— DATA FOR REFRIGERANT BLENDS

Refrigerant Number = 436A
Composition (Weight %) = R-290/600a (56.0/44.0)
Average Molecular Mass = 49.33
Bubble Point (°C) = –34.3
Dew Point (°C) = –26.2
Bubble Point (°F) = –29.7
Dew Point (°F) = –16.2

(This foreword is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)

FOREWORD

This addendum adds R-436B, a new zeotropic refrigerant blend, to Tables 2 and D2.

Note: In this addendum, changes to the current standard are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) unless the instructions specifically mention some other means of indicating the changes.

Addendum q to Standard 34-2007

Add the following to Table 2 in the columns indicated:

TABLE 2
DATA AND SAFETY CLASSIFICATIONS FOR REFRIGERANT BLENDS

Refrigerant Number = 436B
Composition (Mass %) = R-290/600a (52.0/48.0)
Composition Tolerances = (±1.0 /±1.0)
Safety Group = A3
RCL = 4,000 ppm (v/v), 8.1 g/m^3, 0.5 lb/Mcf
Highly Toxic or Toxic Under Code Classification = Neither

Add the following to Table D2 in the columns indicated:

TABLE D2—
DATA FOR REFRIGERANT BLENDS

Refrigerant Number = 436B
Composition (Weight %) = R-290/600a (52.0/48.0)
Average Molecular Mass = 49.87
Bubble Point (°C) = –33.4
Dew Point (°C) = –25.0
Bubble Point (°F) = –28.1
Dew Point (°F) = –13.0

(This foreword is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)

FOREWORD

This addendum adds R-437A, a new zeotropic refrigerant blend, to Tables 2 and D2.

Note: In this addendum, changes to the current standard are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) unless the instructions specifically mention some other means of indicating the changes.

Addendum r to Standard 34-2007

Add the following to Table 2 in the columns indicated:

TABLE 2— DATA AND SAFETY CLASSIFICATIONS FOR REFRIGERANT BLENDS

Refrigerant Number = 437A

Composition (Mass %) = R-125/134a/600/601 (19.5/78.5/1.4/0.6)

Composition Tolerances = (+0.5,–1.8 / +1.5,–0.7 / +0.1,–0.2 / +0.1,–0.2)

Safety Group = A1

RCL = 19,000 ppm v/v, 81 g/m^3, 5 lb/Mcf

Highly Toxic or Toxic Under Code Classification = Neither

Add the following to Table D2 in the columns indicated:

TABLE D2— DATA FOR REFRIGERANT BLENDS

Refrigerant Number = 437A

Composition (Weight %) = R-125/134a/600/601 (19.5/78.5/1.4/0.6)

Average Molecular Mass = 103.7

Bubble Point (°C) = –32.9

Dew Point (°C) = –29.2

Bubble Point (°F) = –27.2

Dew Point (°F) = –20.6

(This foreword is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)

FOREWORD

This addendum revises the oxygen deprivation limit (ODL) adjustment for altitude by adding an intermediate adjustment at 1500 m.

Note: In this addendum, changes to the current standard are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) unless the instructions specifically mention some other means of indicating the changes.

Addendum s to Standard 34-2007

7.1.2 Oxygen Deprivation Limit (ODL). The ODL shall be 140,000 ppm by volume for locations with altitudes at and below 1000 m (3300 ft) above sea level. At locations ~~with altitudes greater~~ higher than 1000 m (3300 ft) but below or equal to 1500 m (4920 ft), the ODL shall be 112,000 ppm and at altitudes higher than 1500 m (4920 ft) ~~above sea level,~~ the ODL shall be 69,100 ppm (19.5% oxygen by volume).

Correct footnote f to Table 1 and footnote ab to Table 2 to read as follows:

At locations with altitudes higher than 1500 m (4920 ft), the ODL and RCL shall be 69,100 ppm.

In addition to the refrigerants already footnoted accordingly, footnote f shall be added to R-116 and R-125 in Table 1 and footnote ab shall be added to R-434a and R-502 in Table 2.

Add the following new footnote h to Table 1 and footnote am to Table 2, as shown below. The new footnote shall replace footnote ab for R-404A, R-410A, R-410B, R-504, and R-507A, and shall be added to R-115:

At locations with altitudes higher than 1000 m (3300 ft), but below or equal to 1500 m (4920 ft), the ODL and RCL shall be 112, 000 ppm, and at altitudes higher than 1500 m (4920 ft), the ODL and RCL shall be 69,100 ppm.

(This foreword is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)

FOREWORD

This addendum adds occupational exposure limits (OELs) for the refrigerants to Tables 1 and 2.

Note: In this addendum, changes to the current standard are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) unless the instructions specifically mention some other means of indicating the changes.

Addendum t to Standard 34-2007

Revise Tables 1 and 2 as follows. The last column, "Highly Toxic or Toxic Under Code Classification" is not shown; all the values in that column remain the same as in 34-2007 and published addenda.

TABLE 1 Refrigerant Data and Safety Classifications

Refrigerant Number	Chemical Name[a,b]	Chemical Formula[a]	OEL[g]	Safety Group	RCL[c] (ppm v/v)	RCL[c] (g/m^3)	RCL[c] (lb/Mcf)
Methane Series							
11	trichlorofluoromethane	CCl_3F	C1000	A1	1100	6.2	0.39
12	dichlorodifluoromethane	CCl_2F_2	1000	A1	18,000	90	5.6
12B1	bromochlorodifluoromethane	$CBrClF_2$					
13	chlorotrifluoromethane	$CClF_3$	1000	A1			
13B1	bromotrifluoromethane	$CBrF_3$	1000	A1			
14[d,f]	tetrafluoromethane (carbon tetrafluoride)	CF_4	1000	A1	110,000	400	25
21	dichlorofluoromethane	$CHCl_2F$		B1			
22	chlorodifluoromethane	$CHClF_2$	1000	A1	59,000	210	13
23	trifluoromethane	CHF_3	1000	A1	41,000	120	7.3
30	dichloromethane (methylene chloride)	CH_2Cl_2		B2			
31	chlorofluoromethane	CH_2ClF					
32	difluoromethane (methylene fluoride)	CH_2F_2	1000	A2	36,000	77	4.8
40	chloromethane (methyl chloride)	CH_3Cl		B2			
41	fluoromethane (methyl fluoride)	CH_3F					
50	methane	CH_4	1000	A3			
Ethane Series							
113	1,1,2-trichloro-1,2,2-trifluoroethane	CCl_2FCClF_2	1000	A1	2600	20	1.2
114	1,2-dichloro-1,1,2,2-tetrafluoroethane	$CClF_2CClF_2$	1000	A1	20,000	140	8.7
115[d,h]	chloropentafluoroethane	$CClF_2CF_3$	1000	A1	120,000	760	47
116[f]	hexafluoroethane	CF_3CF_3	1000	A1	97,000	550	34
123	2,2-dichloro-1,1,1-trifluoroethane	$CHCl_2CF_3$	50	B1	9100	57	3.5
124	2-chloro-1,1,1,2-tetrafluoroethane	$CHClFCF_3$	1000	A1	10,000	56	3.5
125[f]	pentafluoroethane	CHF_2CF_3	1000	A1	75,000	370	23
134a	1,1,1,2-tetrafluoroethane	CH_2FCF_3	1000	A1	50,000	210	13
141b	1,1-dichloro-1-fluoroethane	CH_3CCl_2F	500		2600	12	0.78
142b	1-chloro-1,1-difluoroethane	CH_3CClF_2	1000	A2	20,000	83	5.1
143a	1,1,1-trifluoroethane	CH_3CF_3	1000	A2	21,000	70	4.5
152a	1,1-difluoroethane	CH_3CHF_2	1000	A2	12,000	32	2.0
170[d]	ethane	CH_3CH_3	1000	A3	7000	8.7	0.54

TABLE 1 Refrigerant Data and Safety Classifications *(Continued)*

Refrigerant Number	Chemical Name[a,b]	Chemical Formula[a]	OEL[g]	Safety Group	RCL[c] (ppm v/v)	(g/m^3)	(lb/Mcf)
Ethers							
E170	dimethyl ether	CH_3OCH_3	1000	A3	8500	16	1.0
Propane							
218[f]	octafluoropropane	$CF_3CF_2CF_3$	1000	A1	90,000	690	43
227ea[f]	1,1,1,2,3,3,3-heptafluoropropane	CF_3CHFCF_3	1000	A1	84,000	580	36
236fa	1,1,1,3,3,3-hexafluoropropane	$CF_3CH_2CF_3$	1000	A1	55,000	340	21
245fa	1,1,1,3,3-pentafluoropropane	$CHF_2CH_2CF_3$	300	B1	34,000	190	12
290	propane	$CH_3CH_2CH_3$	1000	A3	5300	9.5	0.56
Cyclic Organic Compounds							
C318[d]	octafluorocyclobutane	$-(CF_2)_4-$	1000	A1	69,000	570	35
	See Table 2 for Blends						
Miscellaneous Organic Compounds							
hydrocarbons							
600	butane	$CH_3CH_2CH_2CH_3$	1000	A3			
600a	isobutane	$CH(CH_3)_2CH_3$	1000	A3	4000	9.6	0.6
601	pentane	$CH_3CH_2CH_2CH_2CH_3$	600				
601a	isopentane	$(CH_3)_2CHCH_2CH_3$	600	A3	1000	2.9	0.2
oxygen compounds							
610	ethyl ether	$CH_3CH_2OCH_2CH_3$	400				
611	methyl formate	$HCOOCH_3$	100	B2			
sulfur compounds							
620	(Reserved for future assignment)						
Nitrogen Compounds							
630	methyl amine	CH_3NH_2					
631	ethyl amine	$CH_3CH_2(NH_2)$					
Inorganic Compounds							
702	hydrogen	H_2		A3			
704	helium	He		A1			
717	ammonia	NH_3	25	B2	320	0.22	0.014
718	water	H_2O		A1			
720	neon	Ne		A1			
728	nitrogen	N_2		A1			
732	oxygen	O_2					
740	argon	Ar		A1			
744	carbon dioxide	CO_2	5000	A1	40,000	72	4.5
744A	nitrous oxide	N_2O					
764	sulfur dioxide	SO_2		B1			

TABLE 1 Refrigerant Data and Safety Classifications *(Continued)*

Refrigerant Number	Chemical Name[a,b]	Chemical Formula[a]	OEL[g]	Safety Group	RCL[c] (ppm v/v)	RCL[c] (g/m^3)	RCL[c] (lb/Mcf)
Unsaturated Organic Compounds							
1150	ethene (ethylene)	$CH_2{=}CH_2$	200	A3			
1270[d]	propene (propylene)	$CH_3CH{=}CH_2$	500	A3	1000	1.7	0.1

[a]The chemical name and chemical formula are not part of this standard.
[b]The preferred chemical name is followed by the popular name in parentheses.
[c]Data taken from J.M. Calm, "ARTI Refrigerant Database," Air- Conditioning and Refrigeration Technology Institute (ARTI), Arlington, VA, July 2001; J.M. Calm, "Toxicity Data to Determine Refrigerant Concentration Limits," Report DE/CE 23810-110, Air- Conditioning and Refrigeration Technology Institute (ARTI), Arlington, VA, September 2000; J.M. Calm, "The Toxicity of Refrigerants," *Proceedings of the 1996 International Refrigeration Conference*, Purdue University, West Lafayette, IN, pp. 157–62, 1996; D.P. Wilson and R.G. Richard, "Determination of Refrigerant Lower Flammability Limits (LFLs) in Compliance with Proposed Addendum p to ANSI/ASHRAE Standard 34-1992 (1073-RP)," *ASHRAE Transactions* 2002, 108(2); D.W. Coombs, "HFC-32 Assessment of Anesthetic Potency in Mice by Inhalation," Huntingdon Life Sciences Ltd., Huntingdon, Cambridgeshire, England, February 2004 and amendment February 2006; D.W. Coombs, "HFC-22 An Inhalation Study to Investigate the Cardiac Sensitization Potential in the Beagle Dog," Huntingdon Life Sciences Ltd., Huntingdon, Cambridgeshire, England, August 2005; and other toxicity studies.
[d]The RCL values for these refrigerants are provisional based on data found in searches for other refrigerants, but not fully examined.
[e]*Highly toxic*, *toxic*, or *neither*, where *highly toxic* and *toxic* are as defined in the *International FIre Code*, *Uniform FIre Code*, and OSHA regulations, and *neither* identifies those refrigerants having lesser toxicity than either of those groups.[12,13,14]
[f]At locations with altitudes higher than 1500 m (4920 ft), the ODL and RCL shall be 69,100 ppm.
[g]The OELs are 8-hour TWAs as defined in section 3 unless otherwise noted; a C designation denotes a ceiling limit.
[h]At locations with altitudes higher than 1000 m (3300 ft), but below or equal to 1500 m (4920 ft), the ODL and RCL shall be 112,000 ppm, and at altitudes higher than 1500 m (4920 ft), the ODL and RCL shall be 69,100 ppm.

TABLE 2 Data and Safety Classifications for Refrigerant Blends

Refrigerant Number	Composition (Mass %)	OEL[al]	Safety Group	RCL[a] (ppm v/v)	RCL[a] (g/m^3)	RCL[a] (lb/Mcf)
Zeotropes						
400	R-12/114 (must be specified)		A1			
	(50.0/50.0)	1000	A1	28,000	160	10
	(60.0/40.0)	1000	A1	30,000	170	11
401A	R-22/152a/124 (53.0/13.0/34.0)[e]	1000	A1	27,000	110	6.6
401B	R-22/152a/124 (61.0/11.0/28.0)[e]	1000	A1	30,000	120	7.2
401C	R-22/152a/124 (33.0/15.0/52.0)[e]	1000	A1	20,000	84	5.2
402A	R-125/290/22 (60.0/2.0/38.0)[r]	1000	A1	33,000	140	8.5
402B	R-125/290/22 (38.0/2.0/60.0)[r]	1000	A1	63,000	240	15
403A	R-290/22/218 (5.0/75.0/20.0)[g]	1000	A1	33,000	120	7.6
403B[ab]	R-290/22/218 (5.0/56.0/39.0)[g]	1000	A1	70,000	290	18
404A[am]	R-125/143a/134a (44.0/52.0/4.0)[f]	1000	A1	130,000	500	31
405A[t]	R-22/152a/142b/C318 (45.0/7.0/5.5/42.5)[h]	1000		57,000	260	16
406A	R-22/600a/142b (55.0/4.0/41.0)[i]	1000	A2	21,000	25	4.7
407A[ab]	R-32/125/134a (20.0/40.0/40.0)[o]	1000	A1	78,000	290	18
407B[ab]	R-32/125/134a (10.0/70.0/20.0)[o]	1000	A1	77,000	320	20
407C[ab]	R-32/125/134a (23.0/25.0/52.0)[o]	1000	A1	76,000	270	17
407D	R-32/125/134a (15.0/15.0/70.0)[o]	1000	A1	65,000	240	15
407E[o,ab]	R-32/125/134a (25.0/15.0/60.0)[o]	1000	A1	75,000	260	16
408A[ab]	R-125/143a/22 (7.0/46.0/47.0)[f]	1000	A1	95,000	340	21
409A	R-22/124/142b (60.0/25.0/15.0)[k]	1000	A1	29,000	110	7.1
409B	R-22/124/142b (65.0/25.0/10.0)[k]	1000	A1	30,000	120	7.3
410A[am]	R-32/125 (50.0/50.0)[l]	1000	A1	130,000	390	25
410B[am]	R-32/125 (45.0/55.0)[n]		A1	130,000	390	24
411A[u]	R-1270/22/152a (1.5/87.5/11.0)[m]	990	A2	14,000	46	2.9

TABLE 2 Data and Safety Classifications for Refrigerant Blends *(Continued)*

Refrigerant Number	Composition (Mass %)	OEL[al]	Safety Group	RCL[a] (ppm v/v)	RCL[a] (g/m^3)	RCL[a] (lb/Mcf)
411B[u]	R-1270/22/152a (3.0/94.0/3.0)[m]	980	A2	13,000	45	2.8
412A	R-22/218/142b (70.0/5.0/25.0)[k]	1000	A2	22,000	82	5.1
413A	R-218/134a/600a (9.0/88.0/3.0)[q]	1000	A2	22,000	94	5.8
414A	R-22/124/600a/142b (51.0/28.5/4.0/16.5)[s]	1000	A1	26,000	100	6.4
414B	R-22/124/600a/142b (50.0/39.0/1.5/9.5)[s]	1000	A1	23,000	95	6.0
415A	R-22/152a (82.0/18.0)[n]	1000	A2	57,000	190	12
415B	R-22/152a (25.0/75.0)[n]	1000	A2	52,000	120	9.3
416A[t,u]	R-134a/124/600 (59.0/39.5/1.5)[v]	1000	A1	14,000	62	3.9
417A[t,u]	R-125/134a/600 (46.6/50.0/3.4)[w]	1000	A1	13,000	56	3.5
418A	R-290/22/152a (1.5/96.0/2.5)[x]	1000	A2	59,000	200	13
419A[ab]	R-125/134a/E170 (77.0/19.0/4.0)[y]	1000	A2	70,000	310	19
420A	R-134a/142b (88.0/12.0)[z]	1000	A1	45,000	190	12
421A	R-125/134a (58.0/42.0)[n]	1000	A1	61,000	280	17
421B	R-125/134a (85.0/15.0)[n]	1000	A1	69,000	330	21
422A	R-125/134a/600a (85.1/11.5/3.4)[ac]	1000	A1	63,000	290	18
422B	R-125/134a/600a (55.0/42.0/3.0)[ad]	1000	A1	56,000	250	16
422C	R-125/134a/600a (82.0/15.0/3.0)[ad]	1000	A1	62,000	290	18
422D	R-125/134a/600a (65.1/31.5/3.4)[ae]	1000	A1	58,000	260	16
423A	R-134a/227ea (52.5/47.5)[n]	1000	A1	59,000	310	19
424A[t,u]	R-125/134a/600a/600/601a (50.5/47.0/0.9/1.0/0.6)[af]	970	A1	23,000	100	6.2
425A	R-32/134a/227ea (18.5/69.5/12.0)[ag]	1000	A1	67,000	250	16
426A[t,u]	R-125/134a/600a/601a (5.1/93.0/1.3/0.6)[ah]	990	A1	20,000	83	5.2
427A	R-32/125/143a/134a (15.0/25.0/10.0/50.0)[ai]	1000	A1			
428A	R-125/143a/290/600a (77.5/20.0/0.6/1.9)[ah]	1000	A1			
429A	R-E170/152a/600a (60.0/10.0/30.0)[y]	1000	A3	6300	13	0.81
430A	R-152a/600a (76.0/24.0)[n]	1000	A3	8000	21	1.3
431A	R-290/152a (71.0/29.0)[n]	1000	A3	5500	11	.069
432A	R-1270/E170 (80.0/20.0)[n]	710	A3	1200	2.1	0.13
433A	R-1270/290 (30.0/70.0)[n]	880	A3	3100	5.5	0.34
434A[ab]	R-125/143a/134a/600a[aj]	1000	A1	73000	320	20
435A	R-E170/152a (80.0/20.0)[n]	1000	A3	8500	17	1.1
436A	R-290/600a (56.0/44.0)[n]	1000	A3	4000	8	0.5
436B	R-290/600a (52.0/48.0)[n]	1000	A3	4000	8	0.5
437A	R-125/134a/600/601 (19.5/78.5/1.4/0.6)[ak]	990	A1	19000	81	5
Azeotropes[b]						
500	R-12/152a (73.8/26.2)	1000	A1	30,000	120	7.6
501	R-22/12 (75.0/25.0)[c]	1000	A1	54,000	210	13
502[ab]	R-22/115 (48.8/51.2)	1000	A1	73,000	330	21
503	R-23/13 (40.1/59.9)	1000				
504[t,am]	R-32/115 (48.2/51.8)	1000		140,000	460	29

TABLE 2 Data and Safety Classifications for Refrigerant Blends *(Continued)*

Refrigerant Number	Composition (Mass %)	OEL[al]	Safety Group	RCL[a] (ppm v/v)	(g/m^3)	(lb/Mcf)
505	R-12/31 (78.0/22.0)[c]					
506	R-31/114 (55.1/44.9)					
507A[am]	R-125/143a (50.0/50.0)	1000	A1	130,000	520	32
508A	R-23/116 (39.0/61.0)	1000	A1	55,000	220	14
508B	R-23/116 (46.0/54.0)	1000	A1	52,000	200	13
509A[ab]	R-22/218 (44.0/56.0)	1000	A1	75,000	390	24
510A	R-E170/600a (88.0/12.0)	1000	A3	7300	14	0.87

[a]The chemical name and chemical formula are not part of this standard.
[b]Azeotropic refrigerants exhibit some segregation of components at conditions of temperature and pressure other than those at which they were formulated. The extent of segregation depends on the particular azeotrope and hardware system configuration.
[c]The exact composition of this azeotrope is in question, and additional experimental studies are needed.
[d]R-507, R-508, and R-509 are allowed alternative designations for R-507A, R-508A, and R-509A due to a change in designations after assignment of R-500 through R-509. Corresponding changes were not made for R-500 through R-506.
[e]Composition tolerances are (±2.0/+0.5, –1.5/±1.0).
[f]Composition tolerances are (±2.0/±1.0/±2.0).
[g]Composition tolerances are (+0.2, -2.0/±2.0/±.0).
[h]Composition tolerances for the individual components are (±.0/±1.0/±1.0/±2.0) and for the sum of R-152a and R-142b are (+0.0, –2.0).
[i]Composition tolerances are (±2.0/±1.0/±.0).
[k]Composition tolerances are (±2.0/±2.0/±1.0).
[l]Composition tolerances are (+0.5, –1.5/+1.5, –0.5).
[m]Composition tolerances are (+0.0, –1.0/+2.0, –0.0/+0.0, –1.0).
[n]Composition tolerances are (±1.0/±1.0).
[o]Composition tolerances are (±2.0/±2.0/±2.0).
[q]Composition tolerances are (±1.0/±2.0/+0.0,–1.0).
[r]Composition tolerances are (±2.0/+1.0,–1.0/±2.0).
[s]Composition tolerances are (±2.0/±2.0/±0.5/+0.5, –1.0).
[t]The RCL values for these refrigerants are provisional based on data found in searches for other refrigerants, but not fully examined.
[u]The RCL values for these refrigerant blends are approximated in the absence of adequate data for a component comprising less than 4% m/m of the blend and expected to have only a small influence in an acute, accidental release.
[v]Composition tolerances are (+0.5,–1.0/+1.0,–0.5/+1.0,–0.2).
[w]Composition tolerances are (±1.1/±1.0/+0.1,–0.4).
[x]Composition tolerances are (±0.5/±1.0/±0.5).
[y]Composition tolerances are (±1.0/±1.0/±1.0).
[z]Composition tolerances are (+1.0,–0.0/+0.0,–1.0).
[aa]*Highly toxic*, *toxic*, or *neither*, where *highly toxic* and *toxic* are as defined in the *International FIre Code*, *Uniform FIre Code*, and OSHA regulations, and *neither* identifies those refrigerants having lesser toxicity than either of those groups.[12,13,14]
[ab]At locations with altitudes higher than 1500 m (4920 ft), the ODL and RCL shall be 69,100 ppm.
[ac]Composition tolerances are (±1.0/±1.0/+0.1,–0.4).
[ad]Composition tolerances are (±1.0/±1.0/+0.1,–0.5).
[ae]Composition tolerances are (+0.9,–1.1/±1.0/+0.1,–0.4).
[af]Composition tolerances are (±1.0/±1.0/+0.1,–0.2/+0.1,+0.2/+0.1,–0.2).
[ag]Composition tolerances are (±0.5/±0.5/±0.5).
[ah]Composition tolerances are (±1.0/±1.0/+0.1,–0.2/+0.1,–0.2).
[ai]Composition tolerances are (±2.0/±2.0/±2.0/±2.0).
[aj]Composition tolerances are (±1/±1±/±0.1, –0.2).
[ak]Composition tolerances are (+0.5, –1.8/+1.5, –0.7/+0.1, –0.2/+0.1, –0.2).
[al]The OELs are 8-hour TWAs as defined in section 3 unless otherwise noted; a C designation denotes a ceiling limit.
[am]At locations with altitudes higher than 1000 m (3300 ft), but below or equal to 1500 m (4920 ft), the ODL and RCL shall be 112,000 ppm, and at altitudes higher than 1500 m (4920 ft), the ODL and RCL shall be 69,100 ppm.

(This foreword is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)

FOREWORD

This addendum adds a definition of OEL to Section 3 and revises Section 6.1.2 to clarify the intent.

Note: In this addendum, changes to the current standard are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) unless the instructions specifically mention some other means of indicating the changes.

Addendum u to Standard 34-2007

Add the following definition to Section 3:

occupational exposure limit (OEL): the 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, the AIHA WEEL, or consistent value.

Revise Section 6.1.2 as follows:

6.1.2 Toxicity Classification. Refrigerants shall be assigned to one of two classes—A or B—based on allowable exposure:

Class A refrigerants are of a lower degree of toxicity as indicated by a PEL of 400 ppm or greater, if assigned; otherwise, a recommended occupational exposure limit (OEL) of 400 ppm or greater~~signifies refrigerants for which toxicity has not been identified at concentrations less than or equal to 400 ppm by volume, based on data used to determine threshold limit value–time-weighted average (TLV–TWA) or consistent indices~~.

Class B refrigerants are those of higher degree of toxicity as indicated by a PEL of less than 400 ppm, if assigned; otherwise, a recommended OEL of less than 400 ppm~~signifies refrigerants for which there is evidence of toxicity at concentrations below 400 ppm by volume, based on data used to determine TLV-TWA or consistent indices~~.

(This foreword is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ASHRAE or ANSI.)

FOREWORD

This addendum modifies data for R-600 in Table E1 by adding an anesthetic NOEL of 130,000 and changing "Other" to 10,000.

Note: In this addendum, changes to the current standard are indicated in the text by underlining (for additions) and ~~strikethrough~~ (for deletions) unless the instructions specifically mention some other means of indicating the changes.

Addendum v to Standard 34-2007

Add the following to Table E1 for R-600, butane, in the columns indicated:

TABLE E1— TOXICITY TABLE FOR STANDARD 34— ATEL, ODL, FCL, AND RCL VALUES FOR SINGLE-COMPOUND REFRIGERANTS (PPM V/V)

R-600, butane

Anesthesia NOEL = 130,000

Other = 10,000

POLICY STATEMENT DEFINING ASHRAE'S CONCERN FOR THE ENVIRONMENTAL IMPACT OF ITS ACTIVITIES

ASHRAE is concerned with the impact of its members' activities on both the indoor and outdoor environment. ASHRAE's members will strive to minimize any possible deleterious effect on the indoor and outdoor environment of the systems and components in their responsibility while maximizing the beneficial effects these systems provide, consistent with accepted standards and the practical state of the art.

ASHRAE's short-range goal is to ensure that the systems and components within its scope do not impact the indoor and outdoor environment to a greater extent than specified by the standards and guidelines as established by itself and other responsible bodies.

As an ongoing goal, ASHRAE will, through its Standards Committee and extensive technical committee structure, continue to generate up-to-date standards and guidelines where appropriate and adopt, recommend, and promote those new and revised standards developed by other responsible organizations.

Through its *Handbook*, appropriate chapters will contain up-to-date standards and design considerations as the material is systematically revised.

ASHRAE will take the lead with respect to dissemination of environmental information of its primary interest and will seek out and disseminate information from other responsible organizations that is pertinent, as guides to updating standards and guidelines.

The effects of the design and selection of equipment and systems will be considered within the scope of the system's intended use and expected misuse. The disposal of hazardous materials, if any, will also be considered.

ASHRAE's primary concern for environmental impact will be at the site where equipment within ASHRAE's scope operates. However, energy source selection and the possible environmental impact due to the energy source and energy transportation will be considered where possible. Recommendations concerning energy source selection should be made by its members.

Errata Sheet for ANSI/ASHRAE Standard 34-2007,
Designation and Safety Classification of Refrigerants

June 30, 2008

The corrections listed in this errata sheet apply to the first printing of ANSI/ASHRAE Standard 34-2007 identified on the outside back cover as “86089 PC 5/07”. The shaded item has been added since the previously published errata sheet dated 11/19/2007 was distributed.

Page	Erratum
Inside Cover	**ASHRAE Standing Standard Project Committee 34.** Some of the initial copies of the first printing of the standard were published with the incorrect SSPC 34 roster on the inside cover. Correct roster attached. *Note that later versions of the first printing of the standard already include the corrected roster as a sticker and therefore this erratum may not apply in all cases.*
18	**Table 2 Data and Safety Classifications for Refrigerant Blends.** Change the composition for refrigerant number 426A from “R-125/134a/600a/601a” to “R-125/134a/600/601a”.
18	**Table 2 Data and Safety Classifications for Refrigerant Blends.** Change the composition tolerances (as shown) in the following footnotes in Table 2 to read: [g]Composition tolerances are (+0.2, -2.0/±2.0/±2.0). [h]Composition tolerances for the individual components are (±2.0/±1.0/±1.0/±2.0) and for the sum of R-152a and R-142b are (+0.0, -2.0). [i]Composition tolerances are (±2.0/±1.0/±1.0). [r]Composition tolerances are (±2.0/+0.1, -1.0/±2.0).
24	**Table D1, Refrigerant Data.** Change the Normal Boiling Point of R-152a from –25 °C and –13 °F to –24 °C and –11 °F.