$-CCl_2-$	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 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 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 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 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 (subsection 4.1).

4.4 Blends shall be designated by their respective refrigerant numbers and mass proportions. Refrigerants shall be named in order of increasing normal boiling points of the components. Compositions shall be specified to the nearest 0.1% m/m. No component shall be permitted at less than 0.6% m/m nominal. For example, a 10/90 blend by mass of Refrigerants 12 and 22 shall be indicated as R-22/12 (90.0/10.0) or Refrigerant 22/12 (90.0/10.0). A blend of 92% m/m R-502 (the azeotrope of R-22 and R-115) with 8% m/m R-290 (propane) shall be indicated as R-290/22/115 (8.0/44.9/47.1).

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.

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 (36/24/40), 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. 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 [36/24/40]). Linked prefixes (e.g., HCFC/HFC/CFC-22/152a/114 [36/24/40]) and prefixes implying synthesized compositions (e.g., HCFC-500 or HCFC-22/152a/114 [36/24/40]) 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 5.2.1, augmented if necessary as indicated in 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 5.2.2).

5.4 The convention specified in 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 6.1.2; the arabic numeral denotes the flammability as determined by 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[1] using a spark ignition source. Testing of all halocarbon refrigerants shall be in accordance with the Annex of ASTM E681.

> ***Class 1*** indicates refrigerants that do not show flame propagation when tested in air at 101 kPa (14.7 psia) and 21°C (70°F).
>
> ***Class 2*** signifies refrigerants having a lower flammability limit (LFL) of more than 0.10 kg/m^3 (0.00625 lb/ft^3) at 21°C and 101 kPa (70°F and 14.7 psia) *and* a heat of combustion of less than 19,000 kJ/kg (8,174 Btu/lb). The heat of combustion shall be calculated assuming that combustion products are in the gas phase and in their most stable state (e.g., C, N, S give CO_2, N_2, SO_3; F and Cl give HF and HCl if there is enough H in the molecule, otherwise they give F_2 and Cl_2; excess H is converted to H_2O).

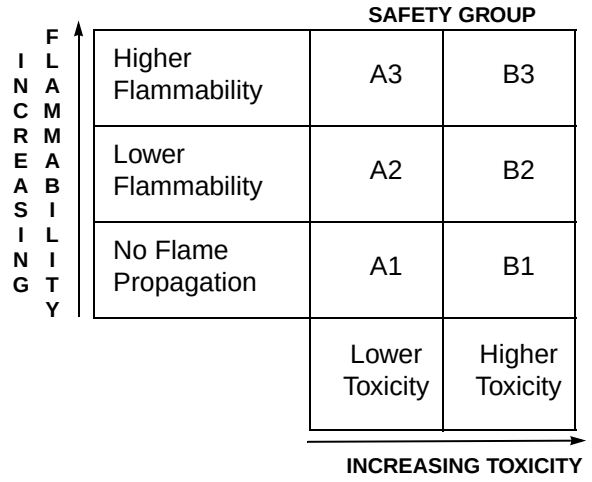

Figure 1 Refrigerant safety group classification.

Class 3 indicates refrigerants that are highly flammable, as defined by an LFL of less than or equal to 0.10 kg/m^3 (0.00625 lb/ft^3) at 21°C and 101 kPa (70°F and 14.7 psia) *or* a heat of combustion greater than or equal to 19,000 kJ/kg (8,174 Btu/lb). The heat of combustion is calculated as explained above in the definition of a Class 2 category.

Definitions of flammability differ depending on the purpose. For example, ammonia is classified for transportation purposes as a nonflammable gas by the U.S. Department of Transportation, but it is a Class 2 refrigerant.

6.1.4 Matrix Diagram of Safety Group Classification System. The toxicity and flammability classifications described in 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).

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

7. REFRIGERANT CLASSIFICATIONS

Refrigerants are assigned the classifications indicated in Tables 1 and 2.

8. APPLICATION INSTRUCTIONS

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

8.1 Eligibility

8.1.1 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.

8.1.2 Fee. There is no application fee.

8.1.3 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 8.8.6) 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.

8.1.4 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.

8.1.5 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 8.2, 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 8.4.2. 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.

8.1.6 Blends

8.1.6.1 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.

8.1.6.2 Single Application. A designation, 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.

8.1.7 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.

8.2 Organization and Content. Separate applications shall be submitted for each refrigerant. Applications shall be organized into the following parts as further identified in 8.3 through 8.8:

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

8.3 Cover. The cover shall identify the applicant and primary contact, the refrigerant in accordance with 8.5.1, 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.

8.4 Administrative Information

8.4.1 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 electronic-mail addresses also may be provided to facilitate communications. The applicant's interest in the subject refrigerant shall be stated.

8.4.2 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 34-2004 (including all published addenda thereto) and that the information provided in this application is consistent with the requirements of that standard.

8.4.3 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.

8.5 Designation Information Applications for refrigerant designations shall contain the information identified in 8.5.1 through 8.5.3.

8.5.1 Refrigerant Identification

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

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

8.5.2 Refrigerant Data

8.5.2.1 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) Freezing or triple point temperature.
(f) Normal boiling point temperature (at 101 kPa [14.7 psia]).
(g) Saturation vapor pressure at 20°C and 60°C (68°F and 140°F).
(h) Temperature at the critical point.
(i) Specific volume at the critical point.
(j) Uses and typical application temperatures (i.e., evaporating and condensing ranges).

8.5.2.2 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) Vapor composition for the as-formulated saturated liquid composition at the normal boiling point and at 20°C (68°F).
(i) Saturation vapor pressure at 20°C and 60°C (68°F and 140°F) as formulated.
(j) Evidence of azeotropy, including a detailed description of testing and a vapor-liquid equilibrium diagram (optional supporting information may be provided as an appendix).
(k) Latent heat of vaporization at 60°C (140°F).
(l) Specific heat ratio of the vapor at 60°C (140°F).
(m) Temperature at the critical point.
(n) Specific volume at the critical point.
(o) Uses and typical application temperatures (i.e., evaporating and condensing ranges).

8.5.2.3 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) Vapor composition for the as-formulated saturated liquid composition at the normal boiling point and at 20°C (68°F).

(h) Dew-point vapor pressure at 20°C and 60°C (68°F and 140°F).

(i) Latent heat of vaporization at 60°C (140°F).

(j) Specific heat ratio of the vapor at 60°C (140°F).

(k) Temperature at the critical point.

(l) Specific volume at the critical point.

(m) Uses and typical application temperatures (i.e., evaporating and condensing ranges).

8.5.2.4 Refrigerants with Low Critical Temperatures. If the critical temperature is less than a temperature at which data are required in 8.5.2.1, 8.5.2.2, and 8.5.2.3, 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.

8.5.2.5 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.

8.6 Toxicity Information. Applications shall include the data identified in 8.6.1, 8.6.2, and 8.6.3. 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.

8.6.1 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,

(f) cardiac sensitization response level.

8.6.2 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,

(d) OSHA PEL if assigned; otherwise, a recommended exposure value, determined on a consistent basis, with an explanation of how it was determined.

8.6.3 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.

8.7 Flammability Information. Applications for single-compound refrigerants shall include the data identified in 8.7.1. Applications for refrigerant blends shall include the data identified in 8.7.1 and 8.7.2. See 8.1.6 regarding blend components.

8.7.1 Flame Propagation. Applications for single-compound refrigerants and for refrigerant blends shall include test results determined in accordance with 6.1.3. Applications shall include a description of the apparatus and methods used, including (but not limited to)

(a) schematic of the apparatus,

(b) vessel size and shape,

(c) ignition method,

(d) preparation procedures including cleaning between tests,

(e) method(s) used to control and verify test concentration(s),

(f) how horizontal flame propagation was determined.

8.7.2 Fractionation Analysis. Applications shall include an analysis of fractionation.

8.8 Submission

8.8.1 Language. Applications shall be submitted in English.