ANSI/ASHRAE Addenda a, b, c, e, f, k, n, o, p, q, r, s, and u to
ANSI/ASHRAE Standard 34-2004

ASHRAE ADDENDA

2006 Supplement

Designation and Safety Classification of Refrigerants

See appendix for approval dates by the ASHRAE Standards Committee, the ASHRAE Board of Directors, and the American National Standards Insitute.

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Addenda a, b, c, e, f, and n

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Addendum p

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Addendum u

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CONTENTS

ANSI/ASHRAE Addenda to ANSI/ASHRAE Standard 34-2004
Designation and Safety Classification of Refrigerants

NOTE

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FOREWORD

This addendum 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.

Addendum a to 34-2004

Add to Table 2 the following entries for R-422B:

TABLE 2 Data and Safety Classifications for Refrigerant Blends

Refrigerant Number	Composition (Mass %)	Composition Tolerances	Azeotropic Temperature (°C)	Azeotropic Temperature (°F)	Molecular Mass[a]	Normal Boiling Point[a] (°C)	Normal Boiling Point[a] (°F)	Safety Group
422B	R-125/134a/600a (55.0/42.0/3.0)	(±1.0/±1.0/+0.1, –0.5)						A1

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FOREWORD

This addendum 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.

Addendum b to 34-2004

Add to Table 2 the following entries for R-422C:

TABLE 2 Data and Safety Classifications for Refrigerant Blends

Refrigerant Number	Composition (Mass %)	Composition Tolerances	Azeotropic Temperature (°C)	Azeotropic Temperature (°F)	Molecular Mass[a]	Normal Boiling Point[a] (°C)	Normal Boiling Point[a] (°F)	Safety Group
422C	R-125/134a/600a (82.0/15.0/3.0)	(±1.0/±1.0/+0.1, –0.5)						A1

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FOREWORD

This addendum 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.

Addendum c to 34-2004

Add to Table 2 the following entries for R-423A:

TABLE 2 Data and Safety Classifications for Refrigerant Blends

Refrigerant Number	Composition (Mass %)	Composition Tolerances	Azeotropic Temperature (°C)	Azeotropic Temperature (°F)	Molecular Mass[a]	Normal Boiling Point[a] (°C)	Normal Boiling Point[a] (°F)	Safety Group
423A	R-134a/227ea (52.5/47.5)	(±1.0/±1.0)						A1

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FOREWORD

This addendum 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.

Addendum e to 34-2004

Add to Table 2 the following entries for R-424A:

TABLE 2 Data and Safety Classifications for Refrigerant Blends

Refrigerant Number	Composition (Mass %)	Composition Tolerances	Safety Group
424A	R-125/134a/600a/600/601a (50.5/47.0/0.9/1.0/0.6)	(±1.0/±1.0/+1.0,–0.2/+0.1,–0.2/+0.1,–0.2)	A1

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FOREWORD

This addendum 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.

Addendum f to 34-2004

Add to Table 2 the following entries for R-425A:

TABLE 2 Data and Safety Classifications for Refrigerant Blends

Refrigerant Number	Composition (Mass %)	Composition Tolerances	Safety Group
425A	R-32/134a/227ea (18.5/69.5/12.0)	(±0.5/±0.5/±0.5)	A1

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FOREWORD

This addendum adds a designation of R-601 for pentane (no safety classification) and a designation of R-601a for 2-methylbutane (isopentane) with a safety classification of A3.

Additions are shown in this addendum by underlining; deletions are shown by strikethrough.

Addendum k to 34-2004

Add to Table 1 the following entries for R- 601 and R-601a:

TABLE 1 Refrigerant Data and Safety Classifications

Refrigerant Number	Chemical Name[a,b]	Chemical Formula[a]	Molecular Mass[a]	Normal Boiling Point[a]		Safety Group
				(°C)	(F°)	
	Miscellaneous Organic Compounds					
	hydrocarbons					
601	pentane	$CH_3CH_2CH_2CH_2CH_3$	72.15	36.1	96.9	---
601a	2-methylbutane (isopentane)	$(CH_3)_2CHCH_2CH_3$	72.15	27.8	82.1	A3

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FOREWORD

This addendum provides general guidance for the numbering of C4-C8 alkanes.

Addendum n to 34-2004

Add the following underlined text to Section 4.5:

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

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FOREWORD

This addendum adds a designation of R-421A to the blend R-125/134a (58.0/42.0) with tolerances of (±1.0/ ±1.0) and a safety classification of A1.

Addendum o to 34-2004

Add to Table 2 the following entries for R-421A:

TABLE 2
Data and Safety Classifications for Refrigerant Blends

Refrigerant Number	Composition (Mass %)	Composition Tolerances	Azeotropic Temperature		Molecular Mass[a]	Normal Boiling Point[a]		Safety Group
			(°C)	(°F)		(°C)	(°F)	
421A	R-125/134a (58.0/42.0)	(±1.0/±1.0)						A1

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FOREWORD

The purposes of this addendum are to revise the refrigerant flammability classification in ANSI/ASHRAE Standard 34-2004 and to provide details on the required flammability and fractionation testing procedures. The history and rationale for these changes are explained in a paper by Wilson and Richard [ASHRAE Transactions, vol. 108, part 2, pp. 739-756 (2002)]. The major change is that flammability (as determined by flame propagation in air) is to be tested at 100°C for single-compound refrigerants. For refrigerant blends, two separate tests at 100°C and 60°C are to be conducted at compositions corresponding to the WCF and WCFF (see below for definitions), respectively. These are in contrast to the tests at 21-23°C currently specified in Standard 34-2004.

Details for the required flammability testing are provided in Section B.1 of new Appendix B. The procedures are based on ASTM Standard E681 but with specified conditions at which to run the test. The modifications include the specification of a 12-L test flask, ignition by an electric spark, and video recording of the results. Test conditions of temperature, pressure, and humidity are also specified as well as data reporting requirements.

Details for the required fractionation analysis for blends are provided in Section B.2 of new Appendix B. The analysis starts with the worst case of formulation for flammability (WCF—which is the nominal composition with the composition tolerances that results in the most flammable composition). The worst case of fractionation for flammability (WCFF) is the worst case resulting from a series of tests simulating (a) leakage of refrigerant from a storage container under storage and shipping conditions, (b) leakage from equipment, and (c) composition shift from successive recharging of equipment. Conditions of temperature, filling ratio, and leak rate for the analysis and data reporting requirements are specified. The analysis for WCFF must be done experimentally and may use mathematical modeling to reduce the number of experiments. The theory behind the fractionation analysis is given by Kim and Didion [Int. J. HVAC&R Research, vol 1, pp. 3-20 (1995)].

Several definitions have been added or modified. These include the definition for heat of combustion as well as several relating to flammability and fractionation.

Additions are shown in this addendum by underlining; deletions are shown by strikethrough.

Addendum p to 34-2004

3. DEFINITIONS OF TERMS

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 B.1.1 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 B.1.8 in Appendix B.

***heat of combustion (HOC)*:** ~~the heat released when substances are combusted, determined as the difference in the enthalpy between the reactants, fuel (refrigerant), and air, and the reaction products after combustion. The heat of combustion exceeds zero for exothermic reactions (those that give off heat) and is negative for endothermic reactions (those that require heat).~~ 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 6.1.3.5. The heat or enthalpy of combustion is often expressed as energy per mass (e.g., kJ/kg or Btu/lb).

***lower flammability limit (LFL)*:** the minimum concentration of ~~the refrigerant~~a substance, a refrigerant in this standard, that is capable of propagating a flame through a homogeneous mixture of the ~~refrigerant~~substance and air under specified test conditions ~~specified in ASTM E681[1]. The LFL normally is expressed as refrigerant percentage by volume~~.

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 as the nominal composition.

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.

4. NUMBERING OF REFRIGERANTS

4.4 Blends shall be ~~designated by their respective refrigerant numbers and mass proportions~~ identified by the designations assigned in this standard.. ~~Refrigerants shall be named~~ Blends without assigned designations shall be identified by their compositions, listing the components in order of increasing normal boiling points ~~of the components~~ 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). 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. ~~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).~~

6. SAFETY GROUP CLASSIFICATIONS

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 done 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 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 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.

~~***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).~~

~~***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 for 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 is a Class 2 refrigerant.~~

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 B.2 in 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 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 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 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 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 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 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 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 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),

(2) the WCFF has an LFL ≤ 0.10 kg/m^3 (0.0062 lb/ft^3) [see 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 [see Table 3].

(c) For the WCFF of a refrigerant blend, the $EFTL_{60}$ shall be used in lieu of the LFL [see Table 3].

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 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. 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, 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).

8. APPLICATION INSTRUCTIONS

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

(p) Proposed composition tolerances for classification.

(q) Worst case of formulation for flammability (WCF) of the blend.

(r) Worst case of fractionation for flammability (WCFF) of the blend.

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

(n) Proposed composition tolerances for classification.

(o) Worst case of formulation for flammability (WCF) of the blend.

(p) Worst case of fractionation for flammability (WCFF) of the blend.

8.7 Flammability Information Applications for single-compound refrigerants and refrigerant blends shall include ~~the~~ tabulated flammability test data and information identified in ~~8.7.1~~B.1.9 in Appendix B. Applications for refrigerant blends shall also include ~~the~~tabulated fractionation data and information identified in ~~8.2.6 and 8.7.2~~B.2.6 in Appendix B. See 8.1.6 regarding blend components.

~~**8.7.1 Flame Propagation** Applicants 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~~1 Fractionation Analysis Applications shall include an analysis of fractionation and shall include test results determined in accordance with B.2 in Appendix B.

9. REFERENCES

[9] *Standard for Safety – Refrigerants*, UL Standard 2182, Underwriters Laboratories, Inc., Northbrook, IL, 1994.

[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.

Add Table 3

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 6.1.3.4.

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

APPENDIX B
DETAILS OF TESTING—FLAMMABILITY

B.1 Flammability Testing Flammability tests shall be conducted in accordance with ASTM E681 (reference 1). The test vessel size shall be a nominal 12 liter (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 millimeters (1/4 inch) 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)].

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.

B.1.1

(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 B.2. When application of the composition tolerances to the nominal formulation produces several possible worst case of fractionation for flammability formulations, the applicant shall conduct flammability testing on all possible worst case of fractionation for flammability formulations or provide sufficient justification for eliminating one or more of the possible worst case of fractionation for flammability 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 at 23.0°C (73.4°F) and 101.3 kPa (14.7 psia), the LFL normally is expressed as refrigerant percentage by volume percent by 0.00041 × molecular mass (gram-mole) to obtain kg/m^3 or by 0.000026 × molecular mass (gram-mole) to obtain lb/ft^3. For refrigerant blends, these tests shall be conducted on the WCF and the WCFF.

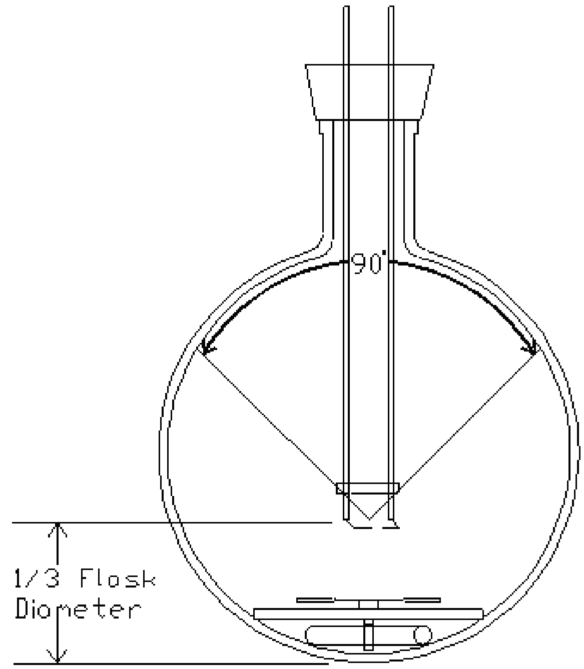

Figure B.1 Test Apparatus

Notes for Figure B.1:

(a) Test vessel is a 12 liter spherical glass flask .

(b) Ignition source electrodes are positioned at a height from the bottom 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.

B.1.2 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.

B.1.3 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.

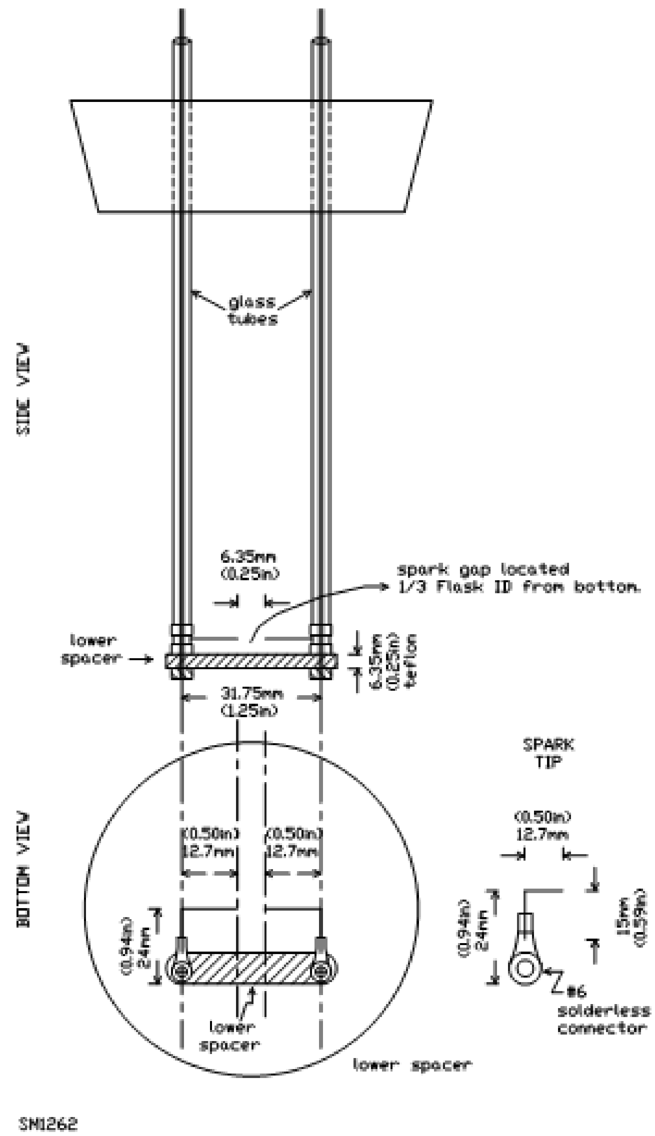

Figure B.2 Spark Electrodes

B.1.4 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 range, whichever is smaller.

B.1.5 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.

B.1.6 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 second but at least 0.2 second.

B.1.7 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.

B.1.8 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 fom 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).

B.1.9 Flammability Test Data Required Applications shall include test results determined in accordance with B.1. 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)

B.2 Fractionation Analysis Applications shall include an analysis of fractionation.

B.2.1 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 B.2.4) and successive charge/recharge conditions (see B.2.5). 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.

B.2.2 All fractionation analysis shall begin using the WCF. When application of the composition tolerances to the nominal formulation produces several possible worst case of formulation for flammability formulations, the applicant shall investigate all possible worst case of formulation for flammability formulations or provide sufficient justification for eliminating one or more of the possible worst case of formulation for flammability formulations.

B.2.3 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.

B.2.4 Leakage Testing Refrigerant blends containing a flammable component(s) shall be evaluated to determine their worst case of fractionation for flammability 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.

B.2.4.1 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,

(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 worst case of fractionation for flammability 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.

B.2.4.2 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,

(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 worst case of fractionation for flammability 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.

B.2.5 Charge/Recharge Testing Refrigerant blends containing a 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 worst case of formulation for flammability 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.

B.2.6 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 %)

(c) for modeled analysis, model accuracy at conditions that predict the worst case of fractionation for flammability (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.

Note:

Appendix B, "Bibliography," is now Appendix C.

Appendix C, "Addenda Description Information," is now Appendix D. Table C-1 is now Table D-1.

(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 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.

Additions are shown in this addendum by underlining; deletions are shown by strikethrough.

Addendum q to 34-2004

Add to Table 2 the following entry for R-422A:

TABLE 2 Data and Safety Classifications for Refrigerant Blends

Refrigerant Number	Composition (Mass %)	Composition Tolerances	Azeotropic Temperature (°C) (°F)	Molecular Mass[a]	Normal Boiling Point[a] (°C) (F°)	Safety Group
<u>422A</u>	<u>R-125/134a/600a (85.1/11.5/3.4)</u>	<u>(±1.0/±1.0/+0.1, -0.4)</u>				<u>A1</u>

(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 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.

Additions are shown in this addendum by underlining; deletions are shown by strikethrough.

Addendum r to 34-2004

Add to Table 2 the following entry for R-421B:

TABLE 2 Data and Safety Classifications for Refrigerant Blends

Refrigerant Number	Composition (Mass %)	Composition Tolerances	Azeotropic Temperature (°C) (°F)	Molecular Mass[a]	Normal Boiling Point[a] (°C) (F°)	Safety Group
421B	R-125/134a (85.0/15.0)	(±1.0/±1.0)				A1

(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 designation for R-227ea for 1,1,1,2,3,3,3-heptafluoropropane and a safety classification of A1. Additions are shown in this addendum by underlining; deletions are shown by strikethrough.

Addendum s to 34-2004

Add to Table 1 the following entry for R-227ea:

TABLE 1 Refrigerant Data and Safety Classifications

Refrigerant Number	Chemical Name[a,b]	Chemical Formula[a]	MolecularMass[a]	Normal Boiling Point[a]		Safety Group
				(°C)	(F°)	
R-227ea	1,1,1,2,3,3,3-heptafluoropropane	CF_3CHFCF_3	170.03	-15.6	3.9	A1

(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

The purpose of this addendum is to add a new section to the standard to specify the criteria to determine recommended "Refrigerant Concentration Limits" (RCL) in occupied spaces and to add RCL values to Tables 1 and 2. It is anticipated that the RCL calculation method and values will eventually be referenced in Standard 15 as part of an ongoing, coordinated effort by SSPC 15 and SSPC 34 to consolidate toxicity and flammability data for refrigerants contained in Standard 34 and requirements to use refrigerants, based on these and other data, contained in Standard 15. Informative items from Tables 1 and 2 that are not part of the standard have been deleted, i.e., molecular mass, normal boiling point, and azeotropic molecular mass and azeotropic temperature. This addendum also includes new definitions, calculational and data criteria, and supporting references. The definitions relate an intermediate term, the "acute toxicity exposure limit" (ATEL), to the "immediately dangerous to life and health" (IDLH) concentration for which IDLH values have not been adopted.

The RCL values for six refrigerants have a footnote stating: "the RCL values for these refrigerants are provisional based on data found in searches for other refrigerants, but not fully examined." The provisional RCL values can be finalized and the provisional footnote removed through continuous maintenance after completion of a literature search or after examination of new toxicity information.

Addendum u to 34-2004

[Add new definitions in Section 3 as follows.]

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 LFL, 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.

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

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.

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.

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.

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.

oxygen deprivation limit (ODL): the concentration of a refrigerant or other gas that results in insufficient oxygen for normal breathing. For this standard, the ODL is the concentration that reduces the oxygen content in normal air to below 19.5%, assuming uniform mixing.

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.

[Add a new Section 7 as follows. Also, renumber existing Sections 7 (Refrigerant Classifications), 8 (Application Instructions), and 9 (References) as Sections 8, 9, and 10, respectively. Revise all references to these sections accordingly.]

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 7.1.1, 7.1.2, and 7.1.3, using data as indicated in 7.3 and adjusted in accordance with 7.4. Determination shall assume full vaporization; 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)-(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, and

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, 0 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, to not 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 69,100 ppm by volume.

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

7.2 Blends. The RCL for refrigerants comprising multiple compounds shall be determined by the method in 7.1 except that individual parameter values in 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 7, 8, 9, or 10 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 7.1.1. (a)-(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:

1. Where subsequent, peer-reviewed studies explicitly document flaws in or refinements to previously published data, the newer values shall be used.
2. For the cardiac sensitization and anesthetic effect NOEL in 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 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 items 7.1.1 (a)-(d), the ATEL calculation required by 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 items 7.1.1(a)-(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 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):

$$RCL_M = \text{RCL} \cdot a \cdot M$$

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 $g/\ m^3$($1.160\ \times 10^{-3}$ 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.

$$rcl_a = RCL_M \cdot (1\text{-}[b \cdot h])$$

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 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.

[Add a new Section 8.8 to the current Section 8 (to be renumbered as Section 9) as follows.]

8.8 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.

[Add a new Section 8.8.8 to the current Section 8 (to be renumbered as Section 9) as follows.]

8.8.8 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 8.8.5.

> **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.

[Update the following references in the current Section 9 (to be renumbered as Section 10) as shown. Added parts are shown with underlining and deleted parts shown with strikethrough.]

[7] *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 <u>as revised through 1999</u>.

[8] *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, ~~1996~~ <u>1 April 2000</u>

[9] *Good Laboratory Practice Standards*, Environmental Protection Agency, 40 CFR Part 792, Subparts A-J, Government Printing Office, Washington, DC, ~~1996~~ <u>1 July 2000</u>

[The following reference has not changed from the currently published standard. It is included here for context only.

[10] *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

[Delete Tables 1 and 2 in Standard 34-2004 and replace them with Tables 1 and 2 on the following pages. In the replacement tables, the following columns have been deleted (Modular Mass, Normal Boiling Point, and Azeotropic Temperature) and new columns with RCL values have been added. The footnotes in Standard 34-2004 have been deleted and replaced by the new footnotes of the replacement tables. The only other change is that two specific compositions are shown for Zeotrope 400 (50.0/50.0 and 60.0/40.0). Note that values shown in the Composition Tolerance column of Table 2 in Standard 34-2000 have been moved to footnotes to the table in this addendum.]

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/m^3)	RCL[c] (lb/Mcf)
Methane Series						
11	trichlorofluoromethane	CCl_3F	A1	1100	6.2	0.39
12	dichlorodifluoromethane	CCl_2F_2	A1	18000	90	5.6
12B1	bromochlorodifluoromethane	$CBrClF_2$				
13	chlorotrifluoromethane	$CClF_3$	AI			
13B1	bromotrifluoromethane	$CBrF_3$	AI			
14[d]	tetrafluoromethane (carbon tetrafluoride)	CF_4	AI	69000	250	16
21	dichlorofluoromethane	$CHCl_2F$	B1			
22	chlorodifluoromethane	$CHClF_2$	AI	25000	89	5.5
23	trifluoromethane	CHF_3	AI	41000	120	7.3
30	dichloromethane (methylene chloride)	CH_2Cl_2	B2			
31	chlorofluoromethane	CH_2ClF				
32	difluoromethane (methylene fluoride)	CH_2F_2	A2	32000	68	4.2
40	chloromethane (methyl chloride)	CH_3Cl	B2			
41	fluoromethane (methyl fluoride)	CH_3F				
50	methane	CH_4	A3			
Ethane Series						
113	1,1,2-trichloro-1,2,2-trifluoroethane	CCl_2FCClF_2	A1	2600	20	1.2
114	1,2-dichloro-1,1,2,2-tetrafluoroethane	$CClF_2CClF_2$	A1	20000	140	8.7
115[d]	chloropentafluoroethane	$CClF_2CF_3$	A1	69000	440	27
116	hexafluoroethane	CF_3CF_3	A1	69000	390	24
123	2,2-dichloro-1,1,1-trifluoroethane	$CHCl_2CF_3$	B1	9100	57	3.5
124	2-chloro-1,1,1,2-tetrafluoroethane	$CHClFCF_3$	A1	10000	56	3.5
125	pentafluoroethane	CHF_2CF_3	A1	69000	340	21
134a	1,1,1,2-tetrafluoroethane	CH_2FCF_3	A1	50000	210	13
141b	1,1-dichloro-1-fluoroethane	CH_3CCl_2F		2600	12	0.78
142b	1-chloro-1,1-difluoroethane	CH_3CClF_2	A2	15000	62	3.9
143a	1,1,1-trifluoroethane	CH_3CF_3	A2	18000	60	3.8
152a	1,1-difluoroethane	CH_3CHF_2	A2	9300	25	1.6
170[d]	ethane	CH_3CH_3	A3	7000	8.7	0.54
Ethers						
E170	dimethyl ether	CH_3OCH_3	A3			
Propane Series						
218	octafluoropropane	$CF_3CF_2CF_3$	A1	69000	530	33
236fa	1,1,1,3,3,3-hexafluoropropane	$CF_3CH_2CF_3$	A1	55000	340	21
245fa	1,1,1,3,3-pentafluoropropane	$CHF_2CH_2CF_3$	B1	34000	190	12
290	propane	$CH_3CH_2CH_3$	A3	5000	9.0	0.56

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

Refrigerant Number	Chemical Name[a,b]	Chemical Formula[a]	Safety Group	RCL[c] (ppm v/v)	RCL[c] (g/m^3)	RCL[c] (lb/Mcf)
Cyclic Organic Compounds						
C318[d]	octafluorocyclobutane	$-(CF_2)_4-$	A1	69000	570	35
See Table 2 for Blends						
Miscellaneous Organic Compounds						
	hydrocarbons					
600	butane	$CH_3CH_2CH_2CH_3$	A3			
600a	isobutane	$CH(CH_3)_2CH_3$	A3	2500	6.0	0.37
	oxygen compounds					
610	ethyl ether	$CH_3CH_2OCH_2CH_3$				
611	methyl formate	$HCOOCH_3$	B2			
	sulfur compounds					
620[d]	(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	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	A1	40000	72	4.5
744A	nitrous oxide	N_2O				
764	sulfur dioxide	SO_2	B1			
Unsaturated Organic Compounds						
1150	ethene (ethylene)	$CH_2=CH_2$	A3			
1270[d]	propene (propylene)	$CH_3CH=CH_2$	A3			

[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] J.M. Calm, "Toxicity Data to Determine Refrigerant Concentration Limits," report DOE/CE/23810-110, Air-Conditioning and Refrigeration Technology Institute (ARTI) Arlington, VA, USA, September 2000 (and references therein).
[d] The RCL values for these refrigerants are provisional based on data found in searches for other refrigerants, but not fully examined.

TABLE 2
Data and Safety Classifications for Refrigerant Blends

Refrigerant Number	Composition (Mass %)	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)	A1	28000	160	10
	(60.0/40.0)	A1	26000	150	9.3
401A	R-22/152a/124 (53.0/13.0/34.0)[e]	A1	20000	77	4.8
401B	R-22/152a/124 (61.0/11.0/28.0)[e]	A1	21000	79	4.9
401C	R-22/152a/124 (33.0/15.0/52.0)[e]	A1	17000	71	4.4
402A	R-125/290/22 (60.0/2.0/38.0)[f]	A1	39000	160	10
402B	R-125/290/22 (38.0/2.0/60.0)[f]	A1	32000	120	7.8
403A	R-290/22/218 (5.0/75.0/20.0)[g]	A1	29000	110	6.9
403B	R-290/22/218 (5.0/56.0/39.0)[g]	A1	34000	140	8.9
404A	R-125/143a/134a (44.0/52.0/4.0)[f]	A1	69000	280	17
405A[t]	R-22/152a/142b/C318 (45.0/7.0/5.5/42.5)[h]		32000	150	9.2
406A	R-22/600a/142b (55.0/4.0/41.0)[i]	A2	25000	92	5.7
407A	R-32/125/134a (20.0/40.0/40.0)[o]	A1	69000	260	16
407B	R-32/125/134a (10.0/70.0/20.0)[o]	A1	69000	290	18
407C	R-32/125/134a (23.0/25.0/52.0)[o]	A1	69000	240	15
407D	R-32/125/134a (15.0/15.0/70.0)[o]	A1	65000	240	15
407E	R-32/125/134a (25.0/15.0/60.0)[r]	A1	69000	240	15
408A	R-125/143a/22 (7.0/46.0/47.0)[f]	A1	47000	170	10
409A	R-22/124/142b (60.0/25.0/15.0)[k]	A1	20000	79	4.9
409B	R-22/124/142b (65.0/25.0/10.0)[k]	A1	20000	78	4.9
410A	R-32/125 (50.0/50.0)[l]	A1	55000	160	10
410B	R-32/125 (45.0/55.0)[n]	A1	58000	180	11
411A[u]	R-1270/22/152a (1.5/87.5/11.0)[m]	A2	26000	86	5.4
411B[u]	R-1270/22/152a (3.0/94.0/3.0)[m]	A2	23000	80	5.0
412A	R-22/218/142b (70.0/5.0/25.0)[k]	A2	26000	97	6.0
413A	R-218/134a/600a (9.0/88.0/3.0)[q]	A2	49000	210	13
414A	R-22/124/600a/142b (51.0/28.5/4.0/16.5)[s]	A1	19000	76	4.8
414B	R-22/124/600a/142b (50.0/39.0/1.5/9.5)[s]	A1	18000	73	4.5
415A	R-22/152a (82.0/18.0)[n]	A2			
415B	R-22/152a (25.0/75.0)[n]	A2			
416A[t,u]	R-134a/124/600 (59.0/39.5/1.5)[v]	A1	21000	96	6.0
417A[t,u]	R-125/134a/600 (46.6/50.0/3.4)[w]	A1	45000	200	12
418A	R-290/22/152a (1.5/96.0/2.5)[x]	A2			
419A	R-125/134a/E170 (77.0/19.0/4.0)[y]	A2			
420A	R-134a/142b (88.0/12.0)[z]	A1			

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

Refrigerant Number	Composition (Mass %)	Safety Group	RCL[a] (ppm v/v)	RCL[a] (g/m^3)	RCL[a] (lb/Mcf)
	Azeotropes[b]				
500	R-12/152a (73.8/26.2)	A1	29000	120	7.4
501	R-22/12 (75.0/25.0)[c]	A1	27000	100	6.4
502	R-22/115 (48.8/51.2)	A1	35000	160	10
503	R-23/13 (40.1/59.9)				
504[t]	R-32/115 (48.2/51.8)		41000	130	8.4
505	R-12/31 (78.0/22.0)[c]				
506	R-31/114 (55.1/44.9)				
507A[d]	R-125/143a (50.0/50.0)	A1	69000	280	17
508A[d]	R-23/116 (39.0/61.0)	A1	55000	220	14
508B	R-23/116 (46.0/54.0)	A1	52000	200	13
509A[d]	R-22/218 (44.0/56.0)	A1	38000	190	12

[a] J.M. Calm, "Toxicity Data to Determine Refrigerant Concentration Limits," report DOE/CE/23810-110, Air-Conditioning and Refrigeration Technology Institute (ARTI) Arlington, VA, USA, September 2000 (and references therein).
[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/±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).
[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/±2.0/±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).

(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.)

APPENDIX
18-MONTH SUPPLEMENT
ADDENDA TO ANSI/ASHRAE STANDARD 34-2004

This supplement includes Addenda *a*, *b*, *c*, *e*, *f*, *k*, *n*, *o*, *p*, *q*, *r*, *s*, and *u* to ANSI/ASHRAE Standard 34-2004. The following table 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 each addendum.

Addendum	Section(s) Affected	Description of Changes[a]	ASHRAE Approval (StdC/BOD)	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
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
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
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
34u	Sections 3 and 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

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.