ANSI/ASHRAE Addenda v and w to
ANSI/ASHRAE Standard 34-2004

ASHRAE STANDARD

Designation and Safety Classification of Refrigerants

Approved by the ASHRAE Standards Committee on January 27, 2007; by the ASHRAE Board of Directors on March 2, 2007; and by the American National Standards Institute on March 27, 2007.

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SPECIAL NOTE

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FOREWORD

This addendum updates the Addendum 34u-2004 text and tables based on an increased ODL from 69,100 ppm to140,000 ppm; increased cardiac sensitization default from 0 to 1000 ppm; new toxicity information for R-22, 32, and 227ea; new LFL values; and the addition of new refrigerants.

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

Addendum v to 34-2004

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:

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

or

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

where

T = 4 hours and

t = the 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~~1000 ppm. The cardiac sensitization term is omitted from ATEL determination if the LC_{50} or ALC in (a) is less than 10,000 ppm by volume or if the refrigerant is found, by toxicological review, 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~~140,000 ppm by volume for locations with altitudes at and below 1000 meters (3300 feet) above sea level. At locations with altitudes greater than 1000 meters (3300 feet) above sea level, the ODL shall be 69,100 ppm.

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

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	$CClF_3$	Al			
13B1	bromotrifluoromethane	$CBrF_3$	Al			
14[d,e]	tetrafluoromethane (carbon tetrafluoride)	CF_4	Al	~~69000~~ 110000	~~250~~ 400	~~16~~ 25
21	dichlorofluoromethane	$CHCl_2F$	B1			

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

Refrigerant Number	Chemical Name[a,b]	Chemical Formula[a]	Safety Group	RCL[c] (ppm v/v)	RCL[c] (g/m^3)	RCL[c] (lb/Mcf)
22	chlorodifluoromethane	$CHClF_2$	A1	~~25000~~ 59000	~~89~~ 210	~~5.5~~ 13
23	trifluoromethane	CHF_3	A1	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~~ 36000	~~68~~ 77	~~4.2~~ 4.8
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~~ CCl_2FCClF_2	A1	2,600	20	1.2
114	1,2-dichloro-1,1,2,2-tetrafluoromethane	~~$CClF_2CClF_2$~~ $CClF_2CClF_2$	A1	20000	140	8.7
115[d,e]	chloropentafluoroethane	~~$CClF_2CF_3$~~ $CClF_2CF_3$	A1	~~69000~~ 120000	~~440~~ 760	~~27~~ 47
116[e]	hexafluoroethane	CF_3CF_3	A1	~~69000~~ 97000	~~390~~ 550	~~24~~ 34
123	2,2-dichloro-1,1,1-trifluoroethane	~~$CHCl_2CF_3$~~ $CHCl_2CF_3$	B1	9100	57	3.5
124	2-chloro-1,1,1,2-tetrafluoroethane	~~$CHClFCF_3$~~ $CHClFCF_3$	A1	10000	56	3.5
125[e]	pentafluoroethane	CHF_2CF_3	A1	~~69000~~ 75000	~~340~~ 370	~~21~~ 23
134a	1,1,1,2-tetrafluoroethane	~~CH_2FCF_3*~~ CH_2FCF_3	A1	50000	210	13
141b	1,1-dichloro-1-fluoroethane	~~CH_3CCl_2F*~~ CH_3CCl_2F		2600	12	0.78
142b	1-chloro-1,1-difluoroethane	~~CH_3CClF_2*~~ CH_3CClF_2	A2	~~15000~~ 20000	~~62~~ 83	~~3.9~~ 5.1
143a	1,1,1-trifluoroethane	~~CH_3CF_3*~~ CH_3CF_3	A2	~~18000~~ 21000	~~60~~ 70	~~3.8~~ 4.5
152a	1,1-difluoroethane	~~CH_3CHF_2*~~ CH_3CHF_2	A2	~~9300~~ 12000	~~25~~ 32	~~1.6~~ 2.0
Ethers						
170[d]	ethane	CH_3CH_3	A3	7000	8.7	0.54
E170	dimethyl ether	CH_3OCH_3	A3	8500	16	1.0
Propane Series						
218[e]	octafluoropropane	$CF_3CF_2CF_3$	A1	~~69000~~ 90000	~~530~~ 690	~~33~~ 43
227ea[e]	1,1,1,2,3,3,3-heptafluoropropane	CF_3CHFCF_3	A1	84000	580	36
236fa	1,1,1,3,3,3-hexafluoropropane	$CF_3CH_2CF_3$	A1	55000	340	21
245fa	1,1,1,3,3-pentafluoropropane	~~$CF_3CH_2CHF_2$~~ $CHF_2CH_2CF_3$	B1[e, d]	34000	190	12
290	propane	$CH_3CH_2CH_3$	A3	~~5000~~ 5300	~~9.0~~ 9.5	0.56

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

Refrigerant Number	Chemical Name[a,b]	Chemical Formula[a]	Safety Group	RCL[c] (ppm v/v)	RCL[c] (g/m^3)	RCL[c] (lb/Mcf)
Cyclic Organic Compounds						
C318[d]	octafluorocyclobutane	~~$-(CF_2)_4-$*~~ $-(CF_2)_4-$		69000	570	35
Miscellaneous Organic Compounds						
	Hydrocarbons					
600	butane	$CH_3CH_2CH_2CH_3$	A3	1000	2.4	0.1
600a	isobutane	~~$CH(CH_3)_2CH_3$*~~ $CH(CH_3)_2CH_3$	A3	~~2500~~ 4000	~~6.0~~ 9.6	~~0.37~~ 0.6
601	Pentane	$CH_3CH_2CH_2CH_2CH_3$				
601a	Isopentane	$CH(CH_3)_2CH_2CH_3$	A3	1000	2.9	0.2
	Oxygen Compounds					
610	ethyl ether	~~$CH_3CH_2OCH_2CH_3$*~~ $CH_3CH_2OCH_2CH_3$				
611	methyl formate	$HCOOCH_3$	B2			
	Sulfur Compounds					
620	(Reserved for future assignment)					
Nitrogen Compounds						
630	methyl amine	CH_3NH_2				
631	ethyl amine	~~$CH_3CH_2(NH_2)$*~~ $CH_3CH_2(NH_2)$				
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	1000	1.7	0.1

[a] The chemical name and chemical formula are not part of this standard.
[b] The preferred chemical name is followed by the popular name in parentheses.
[c] Data taken from J.M. Calm, "ARTI Refrigerant Database," Air- Conditioning and Refrigeration Technology Institute (ARTI), Arlington, VA, July 2001; J.M. Calm, "Toxicity Data to Determine Refrigerant Concentration Limits," Report DE/CE 23810-110, Air- Conditioning and Refrigeration Technology Institute (ARTI), Arlington, VA, September 2000; J.M. Calm, "The Toxicity of Refrigerants," *Proceedings of the 1996 International Refrigeration Conference*, Purdue University, West Lafayette, IN, pp. 157–62, 1996; D.P. Wilson and R.G. Richard, "Determination of Refrigerant Lower Flammability Limits (LFLs) in Compliance with Proposed Addendum p to ANSI/ASHRAE Standard 34-1992 (1073-RP)," *ASHRAE Transactions* 2002, 108(2); D.W. Coombs, "HFC-32 Assessment of Anesthetic Potency in Mice by Inhalation," Huntingdon Life Sciences Ltd., Huntingdon, Cambridgeshire, England, February 2004 and amendment February 2006; D.W. Coombs, "HFC-22 An Inhalation Study to Investigate the Cardiac Sensitization Potential in the Beagle Dog," Huntingdon Life Sciences Ltd., Huntingdon, Cambridgeshire, England, August 2005; and other toxicity studies.
[d] The RCL values for these refrigerants are provisional based on data found in searches for other refrigerants, but not fully examined.
[e] At locations with altitudes greater than 1000 meters (3300 feet) above sea level, the ODL and RCL shall be 69,100 ppm.

TABLE 2 Data and Safety Classifications for Refrigerant Blends

Zeotropes

Refrigerant Number	Composition (Mass %)	Safety Group	RCL[a] (ppm v/v)	RCL[a] (g/m^3)	RCL[a] (lb/Mcf)
400	R-12/114 (must be specified)	A1			
	(50.0/50.0)	A1	28000	160	10
	(60.0/40.0)	A1	~~26000~~ 30000	~~150~~ 170	~~9.3~~ 11
401A	R-22/152a/124 (53.0/13.0/34.0)[e]	A1	~~20000~~ 27000	~~77~~ 110	~~4.8~~ 6.6
401B	R-22/152a/124 (61.0/11.0/28.0)[e]	A1	~~21000~~ 30000	~~79~~ 120	~~4.9~~ 7.2
401C	R-22/152a/124 (33.0/15.0/52.0)[e]	A1	~~17000~~ 20000	~~71~~ 84	~~4.4~~ 5.2
402A	R-125/290/22 (60.0/2.0/38.0)[f]	A1	~~39000~~ 33000	~~160~~ 140	~~10~~ 8.5
402B	R-125/290/22 (38.0/2.0/60.0)[f]	A1	~~32000~~ 63000	~~120~~ 240	~~7.8~~ 15
403A	R-290/22/218 (5.0/75.0/20.0)[g]	A1	~~29000~~ 33000	~~110~~ 120	~~6.9~~ 7.6
403B[v]	R-290/22/218 (5.0/56.0/39.0)[g]	A1	~~34000~~ 70000	~~140~~ 290	~~8.9~~ 18
404A[v]	R-125/143a/134a (44.0/52.0/4.0)[f]	A1	~~69000~~ 130000	~~280~~ 500	~~17~~ 31
405A[t]	R-22/152a/142b/C318 (45.0/7.0/5.5/42.5)[h]		~~32000~~ 57000	~~150~~ 260	~~9.2~~ 16
406A	R-22/600a/142b (55.0/4.0/41.0)[i]	A2	~~25000~~ 21000	~~92~~ 25	~~5.7~~ 4.7
407A[v]	R-32/125/134a (20.0/40.0/40.0)[o]	A1	~~69000~~ 78000	~~260~~ 290	~~16~~ 18
407B[v]	R-32/125/134a (10.0/70.0/20.0)[o]	A1	~~69000~~ 77000	~~290~~ 320	~~18~~ 20
407C[v]	R-32/125/134a (23.0/25.0/52.0)[o]	A1	~~69000~~ 76000	~~240~~ 270	~~15~~ 17
407D	R-32/125/134a (15.0/15.0/70.0)[o]	A1	65000	240	15
407E[v]	R-32/125/134a (25.0/15.0/60.0)[r]	A1	~~69000~~ 75000	~~240~~ 260	~~15~~ 16
408A[v]	R-125/143a/22 (7.0/46.0/47.0)[f]	A1	~~47000~~ 95000	~~170~~ 340	~~10~~ 21
409A	R-22/124/142b (60.0/25.0/15.0)[k]	A1	~~20000~~ 29000	~~79~~ 110	~~4.9~~ 7.1
409B	R-22/124/142b (65.0/25.0/10.0)[k]	A1	~~20000~~ 30000	~~78~~ 120	~~4.9~~ 7.3
410A[v]	R-32/125 (50.0/50.0)[l]	A1	~~55000~~ 130000	~~160~~ 390	~~10~~ 25
410B[v]	R-32/125 (45.0/55.0)[n]	A1	~~58000~~ 130000	~~180~~ 390	~~11~~ 24
411A[u]	R-1270/22/152a) (1.5/87.5/11.0)[m]	A2	~~26000~~ 14000	~~86~~ 46	~~5.4~~ 2.9

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

Refrigerant Number	Composition (Mass %)	Safety Group	RCL[a] (ppm v/v)	RCL[a] (g/m^3)	RCL[a] (lb/Mcf)
411B[u]	R-1270/22/152a (3.0/94.0/3.0)[m]	A2	~~23000~~ 13000	~~80~~ 45	~~5.0~~ 2.8
412A	R-22/218/143b (70.0/5.0/25.0)[k]	A2	~~26000~~ 22000	~~97~~ 82	~~6.0~~ 5.1
413A	R-218/134a/600a (9.0/88.0/3.0)[q]	A2	~~49000~~ 22000	~~210~~ 94	~~13~~ 5.8
414A	R-22/124/600a/142b (51.0/28.5/4.0/16.5)[s]	A1	~~19000~~ 26000	~~76~~ 100	~~4.8~~ 6.4
414B	R-22/124/600a/142b (50.0/39.0/1.5/9.5)[s]	A1	~~18000~~ 23000	~~73~~ 95	~~4.5~~ 6.0
415A	R-22/152a (82.0/18.0)	A2	57000	190	12
415B	R-22/152a (25.0/75.0)	A2	52000	120	9.3
416A[tu]	R-134a/124/600 (59.0/39.5/1.5)	A1	~~21000~~ 14000	~~96~~ 62	~~6.0~~ 3.9
417A[tu]	R-125/134a/600 (46.6/50.0/3.4)	A1	~~45000~~ 13000	~~200~~ 56	~~12~~ 3.5
418A	R-290/22/152a (1.5/96.0/2.5)	A2	59000	200	13
419A[v]	R-125/134a/E170 (77.0/19.0/4.0)	A2	70000	310	19
420A	R-134a/142b (88.0/12.0)	A1	45000	190	12
421A	R-125/134a (58.0/42.0)	A1	61000	280	17
421B	R-125/134a (85.0/15.0)	A1	69000	330	21
422A	R-125/134a/600a (85.1/11.5/3.4)	A1	63000	290	18
422B	R-125/134a/600a (55.0/42.0/3.0)	A1	56000	250	16
422C	R-125/134a/600a (82.0/15.0/3.0)	A1	62000	290	18
422D	R-125/134a/600a (65.1/31.5/3.4)	A1	58000	260	16
423A	134a/227ea (52.5/47.5)	A1	59000	310	19
424A[tu]	R-125/134a/600a/600/601a (50.5/47.0/0.9/1.0/0.6)	A1	23000	100	6.2
425A	R-32/134a/227ea (18.5/69.5/12)	A1	67000	250	16
426A[tu]	R-125/134a/600/601a (5.1/93.0/1.3/0.6)	A1	20000	83	5.2

Azeotropes[b]

Refrigerant Number	Composition (Mass %)	Safety Group	RCL[a] (ppm v/v)	RCL[a] (g/m^3)	RCL[a] (lb/Mcf)
500	R-12/152a (73.8/26.2)	A1	~~29000~~ 30000	120	~~7.4~~ 7.6
501	R-22/12 (75.0/25.0)[c]	A1	~~27000~~ 54000	~~100~~ 210	~~6.4~~ 13
502	R-22/115 (48.8/51.2)	A1	~~35000~~ 73000	~~160~~ 330	~~10~~ 21
503	R-23/13 (40.1/59.9)				
504[tv]	R-32/115 (48.2/51.8)		~~41000~~ 140000	~~130~~ 460	~~8.4~~ 29
505	R-12/31 (78.0/22.0)[c]				
506	R-31/114 (55.1/44.9)				

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

Refrigerant Number	Composition (Mass %)	Safety Group	RCL[a] (ppm v/v)	RCL[a] (g/m^3)	RCL[a] (lb/Mcf)
507A[v]	R-125/143a (50.0/50.0)	A1	~~69000~~ 130000	~~280~~ 520	~~17~~ 32
508A	R-23/116 (39.0/61.0)	A1	55000	220	14
508B	R-23/116 (46.0/54.0)	A1	52000	200	13
509A[v]	R-22/218 (44.0/56.0)	A1	~~38000~~ 75000	~~190~~ 390	~~12~~ 24

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

[b] 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.

[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] At locations with altitudes greater than 1000 meters (3300 feet) above sea level, the ODL and RCL shall be 69,100 ppm.

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

FOREWORD

This addendum adds an informative appendix containing toxicity values for single-compound refrigerants.

Addendum w to 34-2004

8. REFRIGERANT CLASSIFICATIONS

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

APPENDIX E

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

[b]Refrigerant R-	Chemical Name	LC_{50}[c, d]	Cardiac Sensitization		Anesthesia			Other[i]	ATEL	ODL	FCL	RCL	LFL	ATEL Source	RCL Source
			LOEL[e]	NOEL[e]	EC_{50}[f]	LOEL[g]	NOEL[h]								
11	trichlorofluoromethane	26,200	4,800	1,100	35,000	ND	12,500	ND	1,100	140,000	NA	1,100	—	100% Cardiac NOEL	ATEL
12	dichlorodifluoromethane	>800,000	50,000	40,000	250,000	ND	200,000	22,700	22,000	140,000	NA	22,000	—	Other	ATEL
14	tetrafluoromethane	>390,000	ND	200,000	ND	ND	226,000	ND	110,000	140,000	NA	110,000	—	28.8% LC_{50}	ATEL
22	chlorodifluoromethane	220,000	50,000	59,300[k]	140,000	ND	ND	ND	59,000	140,000	NA	59,000	—	100% Cardiac NOEL	ATEL
23	trifluoromethane	>663,000	ND	800,000	ND	ND	51,000	ND	41,000	140,000	NA	41,000	—	80% Anesthesia NOEL	ATEL
32	difluoromethane (methylene fluroride)	>760,000	250,000	200,000	ND	ND	250,000	ND	200,000	140,000	36,000	36,000	144,000	80% Anesthesia NOEL	25% LFL
113	1,1,2-trichloro-1,2,2-trifluoroethane	52,500	4,850	2,600	28,000	ND	25,000	ND	2,600	140,000	NA	2,600	—	100% Cardiac NOEL	ATEL
114	1,2-dichloro-1,1,2,2-tetrafluoroethane	255,000[j]	25,000	ND	250,000	ND	100,000	ND	20,000	140,000	NA	20,000	—	80% Cardiac LOEL	ATEL
115	chloropentafluoroethane	>800,000	150,000	ND	ND	ND	800,000	ND	120,000	140,000	NA	120,000	—	80% Cardiac LOEL	ATEL
116	hexafluoroethane	>800,000	ND	200,000	ND	ND	121,000	ND	97,000	140,000	NA	97,000	—	80% Anesthesia NOEL	ATEL
123	2,2-dichloro-1,1,1-trifluoroethane	32,000	ND	10,300	27,000	ND	2,500	ND	9,100	140,000	NA	9,100	—	28.8% LC_{50}	ATEL
124	2-chloro-1,1,1,2-tetrafluoroethane	263,000	25,000	10,100	150,000	ND	48,000	ND	10,000	140,000	NA	10,000	—	100% Cardiac NOEL	ATEL
125	pentafluoroethane	>769,000	100,000	75,000	ND	ND	709,000	ND	75,000	140,000	NA	75,000	—	100% Cardiac NOEL	ODL
134a	1,1,1,2-tetrafluoroethane	>359,000[l]	75,200	49,800	270,000	ND	81,000	ND	50,000	140,000	NA	50,000	—	100% Cardiac NOEL	ATEL
141b	1,1-dichloro-1-fluoroethane	61,600	5,200	2,600	25,000	29,000	20,000	ND	2,600	140,000	15,000	2,600	60,000	100% Cardiac NOEL	ATEL
142b	1-chloro-1,1-difluoroethane	106,000[d]	50,000	25,000	250,000	ND	591,000	ND	25,000	140,000	20,000	20,000	80,000	100% Cardiac NOEL	25% LFL
143a	1,1,1-trifluoroethane	>591,000	300,000	250,000	500,000	ND	24,800	ND	170,000	140,000	21,000	21,000	82,000	28.3% LC_{50}	25% LFL
152a	1,1-difluoroethane	400,000[d]	150,000	50,000	ND	ND	100,000	500,000	50,000	140,000	12,000	12,000	48,000	100% Cardiac NOEL	25% LFL
170	ethane	>24,800	100,000	ND	ND	ND	ND	ND	7,000	140,000	7,700	7,000	31,000	28.3% LC_{50}	ATEL
E170	Dimethyl ether	164,000	200,000	100,000	ND	84,000	ND	ND	42,000	140,000	8,500	8,500	34,000	50% Anesthesia LOEL	25% LFL

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

[b]Refrigerant R-	Chemical Name	LC_{50}[c, d]	Cardiac Sensitization		Anesthesia			Other[i]	ATEL	ODL	FCL	RCL	LFL	ATEL Source	RCL Source
			LOEL[e]	NOEL[e]	EC_{50}[f]	LOEL[g]	NOEL[h]								
218	octafluoropropane	>400,000[d, m]	400,000	300,000	ND	ND	113,000	ND	90,000	140,000	NA	90,000	—	80% Anesthesia NOEL	ATEL
227ea	1,1,1,2,3,3,3-heptafluoropropane	>788,696	105,000	90,000	ND	ND	105,000	ND	70,000	140,000	NA	84,000	—	80% Anesthesia NOEL	ATEL
236fa	1,1,1,3,3,3-hexafluoropropane	>457,000	150,000	100,000	110,000	ND	20,000	ND	55,000	140,000	NA	55,000	—	80% Anesthesia EC_{50}	ODL
245fa	1,1,1,3,3-pentafluoropropane	>203,000	44,000	34,100	ND	ND	50,600	ND	34,000	140,000	NA	34,000	—	100% Cardiac NOEL	ATEL
290	propane	>200,000[n]	100,000	50,000	280,000	ND	ND	ND	50,000	140,000	5,300	5,300	21,000	100% Cardiac NOEL	25% LFL
C318	octafluorocyclobutane	>800,000	100,000	ND	>800,000	ND	800,000	ND	80,000	140,000	NA	80,000	—	80% Cardiac LOEL	ATEL
600	butane	272,000	ND	ND	ND	ND	ND	100,000	1000	140,000	5,000	1,000	20,000	Sect 7.1.1 (b)	ATEL
600a	isobutane	143,000[o]	50,000	25,000	200,000	10,000	ND	ND	25,000	140,000	4,000	4,000	16,000	100% Cardiac NOEL	25% LFL
601a	isopentane	434,000	ND	ND	ND	120,000	ND	ND	1000	140,000	3300	3300	13,000	Sect 7.1.1 (b)	ATEL
717	ammonia	3,300[q]	ND	-p-	ND	-p-	38,900	400	320	140,000	42,000	320	167,000	Other	ATEL
744	carbon dioxide	-s-	ND	-p-	ND	-p-	ND	50,000[r]	40,000	140,000	NA	40,000	—	NIOSH IDLH	ATEL
1270	propene (propylene)	>490,000[t]	ND	ND	ND	ND	10,000	7,200	1000	140,000	6,700	1,000	27,000	Sect 7.1.1 (b)	ATEL

ND: None Determined or Not Adequately Defined according to criteria of this standard.
NA: Not Applicable.
Note: The data shown in this table are rounded to three significant digits to avoid suggestion of artificial precision, but actual calculations used the data as published or converted to avoid propagation of errors in calculations, especially for blends. The ATEL and RCL concentrations are rounded to two significant figures.

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

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

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

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

[e] Dog with epinephrine injection.

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

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

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

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

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

[k] Not used.

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

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

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

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

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

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

[r] See NIOSH IDLH documentation for other effect.

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

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

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.