ADDENDA

ANSI/ASHRAE Addendum f to
ANSI/ASHRAE Standard 34-2019

Designation and Safety Classification of Refrigerants

Approved by the ASHRAE Standards Committee on October 16, 2019; by the ASHRAE Board of Directors on November 15, 2019; and by the American National Standards Institute on December 12, 2019.

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FOREWORD

Addendum f adds LFL data to Tables 4-1 and 4-2.

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

Addendum f to Standard 34-2019

Modify Tables 4-1 and 4-2 as shown. NOTE: Values in bold reflect changes made to the table by Addendum c to the 2019 edition.

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Table 4-1 Refrigerant Data and Safety Classifications

Refrigerant Number	Chemical Name[a,b]	Chemical Formula[a]	OEL[f], ppm v/v	Safety Group	RCL[c] (ppm v/v)	RCL[c] (lb/Mcf)	RCL[c] (g/m^3)	LFL (ppm v/v)	LFL (lb/Mcf)	LFL (g/m^3)	Highly Toxic or Toxic[d] Under Code Classification
Methane Series											
11	trichlorofluoromethane	CCl_3F	1000	A1	1100	0.39	**6.1**				Neither
12	dichlorodifluoromethane	CCl_2F_2	1000	A1	18,000	5.6	90				Neither
12B1	bromochlorodifluoromethane	$CBrClF_2$									Neither
13	chlorotrifluoromethane	$CClF_3$	1000	Al							Neither
13B1	bromotrifluoromethane	$CBrF_3$	1000	Al							Neither
14[e]	tetrafluoromethane (carbon tetrafluoride)	CF_4	1000	Al	110,000	25	400				Neither
21	dichlorofluoromethane	$CHCl_2F$		B1							Toxic
22	chlorodifluoromethane	$CHClF_2$	1000	Al	59,000	13	210				Neither
23	trifluoromethane	CHF_3	1000	Al	41,000	7.3	120				Neither
30	dichloromethane (methylene chloride)	CH_2Cl_2		B1							Neither
31	chlorofluoromethane	CH_2ClF									Neither
32	difluoromethane (methylene fluoride)	CH_2F_2	1000	A2L	36,000	4.8	77	144,000	19.1	306	Neither
40	chloromethane (methyl chloride)	CH_3Cl		B2							Toxic
41	fluoromethane (methyl fluoride)	CH_3F									Neither
50	methane	CH_4	1000	A3				50,000			Neither
Ethane Series											
113	1,1,2-trichloro-1,2,2-trifluoroethane	CCl_2FCClF_2	1000	A1	2600	1.2	20				Neither
114	1,2-dichloro-1,1,2,2-tetrafluoroethane	$CClF_2CClF_2$	1000	A1	20,000	8.7	140				Neither

a. The chemical name and chemical formula are not part of this standard. Chemical names conform to IUPAC nomenclature[6,7] except where shortened, unambiguous names are used following ASHRAE Standard 34 convention.
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. *Highly toxic*, *toxic*, or *neither*, where *highly toxic* and *toxic* are as defined in the *International Fire Code*, *Uniform Fire Code*, and OSHA regulations, and *neither* identifies those refrigerants having lesser toxicity than either of those groups[1,2,3].
e. At locations with altitudes higher than 4920 ft (1500 m), the ODL and RCL shall be 69,100 ppm.
f. The OELs are eight-hour TWAs, as defined in Section 3, unless otherwise noted; a "C" designation denotes a ceiling limit.
g. At locations with altitudes higher than 3300 ft (1000 m) but below or equal to 4920 ft (1500 m), the ODL and RCL shall be 112,000 ppm, and at altitudes higher than 4920 ft (1500 m), the ODL and RCL shall be 69,100 ppm.

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Table 4-1 Refrigerant Data and Safety Classifications *(Continued)*

Refrigerant Number	Chemical Name[a,b]	Chemical Formula[a]	OEL[f], ppm v/v	Safety Group	RCL[c] (ppm v/v)	RCL[c] (lb/Mcf)	RCL[c] (g/m^3)	LFL (ppm v/v)	LFL (lb/Mcf)	LFL (g/m^3)	Highly Toxic or Toxic[d] Under Code Classification
115[g]	chloropentafluoroethane	$CClF_2CF_3$	1000	A1	120,000	47	760				Neither
116[e]	hexafluoroethane	CF_3CF_3	1000	A1	97,000	34	550				Neither
123	2,2-dichloro-1,1,1-trifluoroethane	$CHCl_2CF_3$	50	B1	9100	3.5	57				Neither
124	2-chloro-1,1,1,2-tetrafluoroethane	$CHClFCF_3$	1000	A1	10,000	3.5	56				Neither
125[e]	pentafluoroethane	CHF_2CF_3	1000	A1	75,000	23	370				Neither
134a	1,1,1,2-tetrafluoroethane	CH_2FCF_3	1000	A1	50,000	13	210				Neither
141b	1,1-dichloro-1-fluoroethane	CH_3CCl_2F	500		2600	0.78	12	60,000	17.8	287	Neither
142b	1-chloro-1,1-difluoroethane	CH_3CClF_2	1000	A2	20,000	5.1	**82**	80,000	20.4	329	Neither
143a	1,1,1-trifluoroethane	CH_3CF_3	1000	A2L	21,000	**4.4**	70	82,000	17.5	282	Neither
152a	1,1-difluoroethane	CH_3CHF_2	1000	A2	12,000	2.0	32	48,000	8.1	130	Neither
170	ethane	CH_3CH_3	1000	A3	7000	0.54	**8.6**	31,000	2.4	38	Neither
Ethers											
E170	methoxymethane (dimethyl ether)	CH_3OCH_3	1000	A3	8500	1.0	16	34,000	4.0	64	Neither
Propane											
218[e]	octafluoropropane	$CF_3CF_2CF_3$	1000	A1	90,000	43	690				Neither
227ea[e]	1,1,1,2,3,3,3-heptafluoropropane	CF_3CHFCF_3	1000	A1	84,000	36	580				Neither
236fa	1,1,1,3,3,3-hexafluoropropane	$CF_3CH_2CF_3$	1000	A1	55,000	21	340				Neither
245fa	1,1,1,3,3-pentafluoropropane	$CHF_2CH_2CF_3$	300	B1	34,000	12	190				Neither
290	propane	$CH_3CH_2CH_3$	1000	A3	5300	**0.59**	9.5	21,000	2.4	38	Neither

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e. At locations with altitudes higher than 4920 ft (1500 m), the ODL and RCL shall be 69,100 ppm.
f. The OELs are eight-hour TWAs, as defined in Section 3, unless otherwise noted; a "C" designation denotes a ceiling limit.
g. At locations with altitudes higher than 3300 ft (1000 m) but below or equal to 4920 ft (1500 m), the ODL and RCL shall be 112,000 ppm, and at altitudes higher than 4920 ft (1500 m), the ODL and RCL shall be 69,100 ppm.

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Table 4-1 Refrigerant Data and Safety Classifications *(Continued)*

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Cyclic Organic Compounds											
C318	octafluorocyclobutane	$-(CF_2)_4-$	1000	A1	80,000	41	**650**				Neither
Miscellaneous Organic Compounds											
hydrocarbons											
600	butane	$CH_3CH_2CH_2CH_3$	1000	A3	1000	0.15	2.4	20,000	3.0	48	Neither
600a	2-methylpropane (isobutane)	$CH(CH_3)_2CH_3$	1000	A3	4000	0.59	**9.5**	16,000	2.4	38	Neither
601	pentane	$CH_3CH_2CH_2CH_2CH_3$	600	A3	1000	0.18	2.9	12,000	2.2	35	Neither
601a	2-methylbutane (isopentane)	$(CH_3)_2CHCH_2CH_3$	600	A3	1000	0.18	2.9	13,000	2.4	38	Neither
oxygen compounds											
610	ethoxyethane (ethyl ether)	$CH_3CH_2OCH_2CH_3$	400								Neither
611	methyl formate	$HCOOCH_3$	100	B2							Neither
sulfur compounds											
620	(Reserved for future assignment)										
Nitrogen Compounds											
630	methanamine (methyl amine)	CH_3NH_2									Toxic
631	ethanamine (ethyl amine)	$CH_3CH_2(NH_2)$									Neither
Inorganic Compounds											
702	hydrogen	H_2		A3							Neither
704	helium	He		A1							Neither
717	ammonia	NH_3	25	B2L	320	0.014	0.22	167,000	7.2	116	Neither

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d. *Highly toxic*, *toxic*, or *neither*, where *highly toxic* and *toxic* are as defined in the *International Fire Code*, *Uniform Fire Code*, and OSHA regulations, and *neither* identifies those refrigerants having lesser toxicity than either of those groups[1,2,3].
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Table 4-1 Refrigerant Data and Safety Classifications *(Continued)*

Refrigerant Number	Chemical Name[a,b]	Chemical Formula[a]	OEL[f], ppm v/v	Safety Group	RCL[c] (ppm v/v)	RCL[c] (lb/Mcf)	RCL[c] (g/m^3)	LFL (ppm v/v)	LFL (lb/Mcf)	LFL (g/m^3)	Highly Toxic or Toxic[d] Under Code Classification
718	water	H_2O		A1							Neither
720	neon	Ne		A1							Neither
728	nitrogen	N_2		A1							Neither
732	oxygen	O_2									Neither
740	argon	Ar		A1							Neither
744	carbon dioxide	CO_2	5000	A1	30,000	3.4	54				Neither
744A	nitrous oxide	N_2O									Neither
764	sulfur dioxide	SO_2		B1							Neither
Unsaturated Organic Compounds											
1130(E)	trans-1,2-dichloroethene	CHCl=CHCl	200	**B2**	**1000**	0.25	4	65,000	16	258	Neither
1132a	1,1-difluoroethylene	$CF_2=CH_2$	500	A2	13,000	2.0	33	50,000	8.1	131	Neither
1150	ethene (ethylene)	$CH_2=CH_2$	200	A3				31,000	2.2	36	Neither
1224yd(Z)	(Z)-1-chloro-2,3,3,3-tetrafluoropropene	CF3CF=CHCl	1000	A1	60,000	23	**370**				Neither
1233zd(E)	trans-1-chloro-3,3,3-trifluoro-1-propene	$CF_3CH=CHCl$	800	A1	16,000	5.3	85				Neither
1234yf	2,3,3,3-tetrafluoro-1-propene	$CF_3CF=CH_2$	500	A2L	16,000	**4.5**	75	62,000	18.0	289	Neither
1234ze(E)	trans-1,3,3,3-tetrafluoro-1-propene	$CF_3CH=CFH$	800	A2L	16,000	4.7	**76**	65,000	18.8	303	Neither
1270	propene (propylene)	$CH_3CH=CH_2$	500	A3	1000	0.11	1.7	27,000	2.9	46	Neither
1336mzz(E)	trans-1,1,1,4,4,4-hexafluoro-2-butene	$CF_3CH=CHCF_3$	400	A1	7200	3.0	48				Neither
1336mzz(Z)	cis-1,1,1,4,4,4-hexaflouro-2-butene	$CF_3CHCHCF_3$	500	A1	13,000	**5.2**	**84**				Neither

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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. *Highly toxic*, *toxic*, or *neither*, where *highly toxic* and *toxic* are as defined in the *International Fire Code*, *Uniform Fire Code*, and OSHA regulations, and *neither* identifies those refrigerants having lesser toxicity than either of those groups[1,2,3].
e. At locations with altitudes higher than 4920 ft (1500 m), the ODL and RCL shall be 69,100 ppm.
f. The OELs are eight-hour TWAs, as defined in Section 3, unless otherwise noted; a "C" designation denotes a ceiling limit.
g. At locations with altitudes higher than 3300 ft (1000 m) but below or equal to 4920 ft (1500 m), the ODL and RCL shall be 112,000 ppm, and at altitudes higher than 4920 ft (1500 m), the ODL and RCL shall be 69,100 ppm.

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Table 4-2 Data and Safety Classifications for Refrigerant Blends

Refrigerant Number	Composition (Mass%)	Composition Tolerances	OEL[h], ppm v/v	Safety Group	RCL[a] (ppm v/v)	RCL[a] (lb/Mcf)	RCL[a] (g/m^3)	LFL (ppm v/v)	LFL (lb/Mcf)	LFL (g/m^3)	Highly Toxic or Toxic[f] Under Code Classification
Zeotropes											
400	R-12/114 (must be specified)			A1							Neither
	(50.0/50.0)		1000	A1	28,000	10	160				
	(60.0/40.0)		1000	A1	30,000	11	170				
401A	R-22/152a/124 (53.0/13.0/34.0)	(±2.0/+0.5, –1.5/±1.0)	1000	A1	27,000	6.6	110				Neither
401B	R-22/152a/124 (61.0/11.0/28.0)	(±2.0/+0.5, –1.5/±1.0)	1000	A1	30,000	7.2	**110**				Neither
401C	R-22/152a/124 (33.0/15.0/52.0)	(±2.0/+0.5, –1.5/±1.0)	1000	A1	20,000	5.2	84				Neither
402A	R-125/290/22 (60.0/2.0/38.0)	(±2.0/+0.1, –1.0/±2.0)	1000	A1	66,000	17	270				Neither
402B	R-125/290/22 (38.0/2.0/60.0)	(±2.0/+0.1, –1.0/±2.0)	1000	A1	63,000	15	240				Neither
403A	R-290/22/218 (5.0/75.0/20.0)	(+0.2, –2.0/±2.0/±2.0)	1000	A2	33,000	7.6	120				Neither
403B[g]	R-290/22/218 (5.0/56.0/39.0)	(+0.2, –2.0/±2.0/±2.0)	1000	A1	**68,000**	18	290				Neither
404A[i]	R-125/143a/134a (44.0/52.0/4.0)	(±2.0/±1.0/±2.0)	1000	A1	130,000	31	500				Neither
405A	R-22/152a/142b/C318 (45.0/7.0/5.5/42.5)	Individual components = (±2.0/±1.0/±1.0/±2.0); sum of R-152a and R-142b = (+0.0, –2.0)	1000		57,000	16	260				Neither
406A	R-22/600a/142b (55.0/4.0/41.0)	(±2.0/±1.0/±1.0)	1000	A2	21,000	4.7	**75**	82,000[l]	18.8[l]	301.9[l]	Neither
407A[g]	R-32/125/134a (20.0/40.0/40.0)	(±2.0/±2.0/±2.0)	1000	A1	83,000	19	300				Neither

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.

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. 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.

f. *Highly toxic*, *toxic*, or *neither*, where *highly toxic* and *toxic* are as defined in the *International Fire Code*, *Uniform Fire Code*, and OSHA regulations, and *neither* identifies those refrigerants having lesser toxicity than either of those groups [1,2,3].

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

h. The OELs are eight-hour TWAs as defined in Section 3 unless otherwise noted; a "C" designation denotes a ceiling limit.

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

j. LFL is based on WCF @23°C (73.4°F) unless otherwise noted.

k. WCFF LFL @60°C (140°FF)

l. WCFF LFL @23°C (73.4°F)

m. WCF LFL @100°C (212°F)

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Table 4-2 Data and Safety Classifications for Refrigerant Blends *(Continued)*

Refrigerant Number	Composition (Mass%)	Composition Tolerances	OEL[h], ppm v/v	Safety Group	RCL[a] (ppm v/v)	RCL[a] (lb/Mcf)	RCL[a] (g/m^3)	LFL (ppm v/v)	LFL (lb/Mcf)	LFL (g/m^3)	Highly Toxic or Toxic[f] Under Code Classification
407B[g]	R-32/125/134a (10.0/70.0/20.0)	(±2.0/±2.0/±2.0)	1000	A1	79,000	21	330				Neither
407C[g]	R-32/125/134a (23.0/25.0/52.0)	(±2.0/±2.0/±2.0)	1000	A1	81,000	18	290				Neither
407D	R-32/125/134a (15.0/15.0/70.0)	(±2.0/±2.0/±2.0)	1000	A1	68,000	16	250				Neither
407E[g]	R-32/125/134a (25.0/15.0/60.0)	(±2.0/±2.0/±2.0)	1000	A1	80,000	17	280				Neither
407F	R-32/125/134a (30.0/30.0/40.0)	(±2.0/±2.0/±2.0)	1000	A1	95,000	20	320				Neither
407G	R-32/125/134a (2.5/2.5/95.0)	(±0.5/±0.5/±1.0)	1000	A1	52,000	13	210				Neither
407H	R-32/125/134a (32.5/15.0/52.5)	(±1.0/±1.0/±2.0)	1000	A1	92,000	19	300				Neither
407I	R-32/125/134a (19.5/8.5/72.0)	(+1.0, –2.0/+2.0, –1.0/±2.0)	1000	A1	71,100	16	250				Neither
408A[g]	R-125/143a/22 (7.0/46.0/47.0)	(±2.0/±1.0/±2.0)	1000	A1	**94,000**	21	**330**				Neither
409A	R-22/124/142b (60.0/25.0/15.0)	(±2.0/±2.0/±1.0)	1000	A1	29,000	7.1	110				Neither
409B	R-22/124/142b (65.0/25.0/10.0)	(±2.0/±2.0/±1.0)	1000	A1	30,000	7.3	120				Neither
410A[i]	R-32/125 (50.0/50.0)	(+0.5, –1.5/+1.5, –0.5)	1000	A1	140,000	26	420				Neither
410B[i]	R-32/125 (45.0/55.0)	(±1.0/±1.0)	**1000**	A1	140,000	27	430				Neither
411A[e]	R-1270/22/152a (1.5/87.5/11.0)	(+0.0, –1.0/+2.0, –0.0/+0.0, –1.0)	**970**	A2	14,000	2.9	46	55,000[k]	11.6[k]	185.6[k]	Neither
411B[e]	R-1270/22/152a (3.0/94.0/3.0)	(+0.0, –1.0/+2.0, –0.0/+0.0, –1.0)	**940**	A2	13,000	2.8	45	70,000[k]	14.8[k]	238.3[k]	Neither
412A	R-22/218/142b (70.0/5.0/25.0)	(±2.0/±2.0/±1.0)	1000	A2	22,000	5.1	82	87,000[k]	20.5[k]	328.6[k]	Neither
413A	R-218/134a/600a (9.0/88.0/3.0)	(±1.0/±2.0/+0.0, –1.0)	1000	A2	22,000	5.8	**93**	88,000[k]	23.4[k]	374.9[k]	Neither

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.

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. 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.

f. *Highly toxic*, *toxic*, or *neither*, where *highly toxic* and *toxic* are as defined in the *International Fire Code*, *Uniform Fire Code*, and OSHA regulations, and *neither* identifies those refrigerants having lesser toxicity than either of those groups [1,2,3].

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

h. The OELs are eight-hour TWAs as defined in Section 3 unless otherwise noted; a "C" designation denotes a ceiling limit.

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

j. LFL is based on WCF @23°C (73.4°F) unless otherwise noted.

k. WCFF LFL @60°C (140°FF)

l. WCFF LFL @23°C (73.4°F)

m. WCF LFL @100°C (212°F)

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Table 4-2 Data and Safety Classifications for Refrigerant Blends *(Continued)*

Refrigerant Number	Composition (Mass%)	Composition Tolerances	OEL[h], ppm v/v	Safety Group	RCL[a] (ppm v/v)	RCL[a] (lb/Mcf)	RCL[a] (g/m^3)	LFL (ppm v/v)	LFL (lb/Mcf)	LFL (g/m^3)	Highly Toxic or Toxic[f] Under Code Classification
414A	R-22/124/600a/142b (51.0/28.5/4.0/16.5)	(±2.0/±2.0/±0.5/+0.5, –1.0)	1000	A1	26,000	6.4	100				Neither
414B	R-22/124/600a/142b (50.0/39.0/1.5/9.5)	(±2.0/±2.0/±0.5/+0.5, –1.0)	1000	A1	23,000	6.0	**96**				Neither
415A	R-22/152a (82.0/18.0)	(±1.0/±1.0)	1000	A2	14,000	2.9	47	56,000[l]	11.7[l]	187.9[l]	Neither
415B	R-22/152a (25.0/75.0)	(±1.0/±1.0)	1000	A2	12,000	2.1	34	47,000	8.4	135.1	Neither
416A[e]	R-134a/124/600 (59.0/39.5/1.5)	(+0.5, –1.0/+1.0, –0.5/+1.0, –0.2)	1000	A1	14,000	3.9	62				Neither
417A[e]	R-125/134a/600 (46.6/50.0/3.4)	(±1.1/±1.0/+0.1, –0.4)	1000	A1	13,000	3.5	**55**				Neither
417B	R-125/134a/600 (79.0/18.3/2.7)	(±1.0/±1.0/+0.1, –0.5)	1000	A1	15,000	4.3	**69**				Neither
417C	R-125/134a/600 (19.5/78.8/1.7)	(±1.0/±1.0/+0.1, –0.5)	1000	A1	21,000	5.4	87				Neither
418A	R-290/22/152a (1.5/96.0/2.5)	(±0.5/±1.0/±0.5)	1000	A2	22,000	4.8	77	89,000[l]	19.2[l]	308.4[l]	Neither
419A[g]	R-125/134a/E170 (77.0/19.0/4.0)	(±1.0/±1.0/±1.0)	1000	A2	15,000	4.2	67	60,000[l]	16.7[l]	268.6[l]	Neither
419B	R-125/134a/E170 (48.5/48.0/3.5)	(±1.0/±1.0/±0.5)	1000	A2	17,000	4.6	74	69,000[l]	18.5[l]	297.3[l]	Neither
420A	R-134a/142b (88.0/12.0)	(+1.0, –0.0/+0.0, –1.0)	1000	A1	**44,000**	12	**180**				Neither
421A	R-125/134a (58.0/42.0)	(±1.0/±1.0)	1000	A1	61,000	17	280				Neither
421B	R-125/134a (85.0/15.0)	(±1.0/±1.0)	1000	A1	69,000	21	330				Neither
422A	R-125/134a/600a (85.1/11.5/3.4)	(±1.0/±1.0/+0.1, –0.4)	1000	A1	63,000	18	290				Neither
422B	R-125/134a/600a (55.0/42.0/3.0)	(±1.0/±1.0/+0.1, –0.5)	1000	A1	56,000	16	250				Neither
422C	R-125/134a/600a (82.0/15.0/3.0)	(±1.0/±1.0/+0.1, –0.5)	1000	A1	62,000	18	290				Neither

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.

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

h. The OELs are eight-hour TWAs as defined in Section 3 unless otherwise noted; a "C" designation denotes a ceiling limit.

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

j. LFL is based on WCF @23°C (73.4°F) unless otherwise noted.

k. WCFF LFL @60°C (140°FF)

l. WCFF LFL @23°C (73.4°F)

m. WCF LFL @100°C (212°F)

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Table 4-2 Data and Safety Classifications for Refrigerant Blends *(Continued)*

Refrigerant Number	Composition (Mass%)	Composition Tolerances	OEL[h], ppm v/v	Safety Group	RCL[a] (ppm v/v)	RCL[a] (lb/Mcf)	RCL[a] (g/m^3)	LFL (ppm v/v)	LFL (lb/Mcf)	LFL (g/m^3)	Highly Toxic or Toxic[f] Under Code Classification
422D	R-125/134a/600a (65.1/31.5/3.4)	+0.9, –1.1/±1.0/+0.1, –0.4)	1000	A1	58,000	16	260				Neither
422E	R-125/134a/600a (58.0/39.3/2.7)	(±1.0/+1.7, –1.3/+0.3, –0.2)	1000	A1	57,000	16	260				Neither
423A	R-134a/227ea (52.5/47.5)	(±1.0/±1.0)	1000	A1	59,000	19	**300**				Neither
424A[e]	R-125/134a/600a/600/601a (50.5/47.0/0.9/1.0/0.6)	(±1.0/±1.0/+0.1, –0.2/+0.1, +0.2/+0.1, –0.2)	**990**	A1	23,000	6.2	100				Neither
425A	R-32/134a/227ea (18.5/69.5/12.0)	(±0.5/±0.5/±0.5)	1000	A1	72,000	16	260				Neither
426A[e]	R-125/134a/600/601a (5.1/93.0/1.3/0.6)	(±1.0/±1.0/+0.1, –0.2/+0.1, –0.2)	990	A1	20,000	5.2	83				Neither
427A	R-32/125/143a/134a (15.0/25.0/10.0/50.0)	(±2.0/±2.0/±2.0/±2.0)	1000	A1	79,000	18	290				Neither
428A	R-125/143a/290/600a (77.5/20.0/0.6/1.9)	(±1.0/±1.0/+0.1, –0.2/+0.1, –0.2)	1000	A1	**84,000**	23	370				Neither
429A	R-E170/152a/600a (60.0/10.0/30.0)	(±1.0/±1.0/±1.0)	1000	A3	6300	0.81	13	25,000	3.2	83.8	Neither
430A	R-152a/600a (76.0/24.0)	(±1.0/±1.0)	1000	A3	8000	1.3	21	32,000	5.2	44.0	Neither
431A	R-290/152a (71.0/29.0)	(±1.0/±1.0)	1000	A3	5500	**0.68**	11	22,000	2.7	38.6	Neither
432A	R-1270/E170 (80.0/20.0)	(±1.0/±1.0)	**550**	A3	1200	0.13	**2.2**	22,000	2.4	39.2	Neither
433A	R-1270/290 (30.0/70.0)	(±1.0/±1.0)	**760**	A3	3100	0.34	5.5	20,000	2.4	32.4	Neither
433B	R-1270/290 (5.0/95.0)	(±1.0/±1.0)	950	A3	**3500**	**0.39**	**6.3**	18,000	2.0	32.1	Neither
433C	R-1270/290 (25.0/75.0)	(±1.0/±1.0)	790	A3	**3700**	0.41	**6.5**	18,000	2.0	83.8	Neither
434A[g]	R-125/143a/134a/600a (63.2/18.0/16.0/2.8)	(±1.0/±1.0/±1.0/+0.1, –0.2)	1000	A1	73,000	20	320				Neither

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.

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k. WCFF LFL @60°C (140°FF)

l. WCFF LFL @23°C (73.4°F)

m. WCF LFL @100°C (212°F)

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Refrigerant Number	Composition (Mass%)	Composition Tolerances	OEL[h], ppm v/v	Safety Group	RCL[a] (ppm v/v)	RCL[a] (lb/Mcf)	RCL[a] (g/m^3)	LFL (ppm v/v)	LFL (lb/Mcf)	LFL (g/m^3)	Highly Toxic or Toxic[f] Under Code Classification
435A	R-E170/152a (80.0/20.0)	(±1.0/±1.0)	1000	A3	8500	1.1	17	34,000	4.3	68.2	Neither
436A	R-290/600a (56.0/44.0)	(±1.0/±1.0)	1000	A3	4000	0.50	8.1	16,000	2.0	32.3	Neither
436B	R-290/600a (52.0/48.0)	(±1.0/±1.0)	1000	A3	4000	0.51	8.2	16,000	2.0	32.7	Neither
436C	R-290/600a (95.0/5.0)	(±1.2/±1.2)	**1000**	A3	5000	0.57	9.1	20,000	2.3	36.5	Neither
437A	R-125/134a/600/601 (19.5/78.5/1.4/0.6)	(+0.5, –1.8/+1.5, –0.7/+0.1, –0.2/+0.1, –0.2)	990	A1	19,000	**5.1**	82				Neither
438A	R-32/125/134a/600/601a (8.5/45.0/44.2/1.7/0.6)	(+0.5, –1.5/±1.5/±1.5/+0.1, –0.2/+0.1, –0.2)	990	A1	20,000	4.9	79				Neither
439A	R-32/125/600a (50.0/47.0/3.0)	(±1.0/±1.0/±0.5)	**1000**	A2	26,000	4.7	76	104,000	18.9	303.3	Neither
440A	R-290/134a/152a (0.6/1.6/97.8)	(±0.1/±0.6/±0.5)	1000	A2	12,000	1.9	31	46,000[m]	7.8[m]	124.7[m]	Neither
441A	R-170/290/600a/600 (3.1/54.8/6.0/36.1)	(±0.3/±2.0/±0.6/±2.0)	1000	A3	3200	0.39	6.3	16,000	2.0	31.7	Neither
442A	R-32/125/134a/152a/227ea (31.0/31.0/30.0/3.0/5.0)	(±1.0/±1.0±/1.0/±0.5/±1.0)	1000	A1	100,000	21	330				Neither
443A	R-1270/290/600a (55.0/40.0/5.0)	(±2.0/±2.0/±1.2)	**640**	A3	1700	0.19	3.1	20,000	2.2	35.6	Neither
444A	R-32/152a/1234ze(E) (12.0/5.0/83.0)	(±1.0/±1.0/±2.0)	850	A2L	21,000	5.1	81	82,000	19.9	324.8	Neither
444B	R-32/152a/1234ze(E) (41.5/10.0/48.5)	(±1.0/±1.0/±1.0)	**930**	A2L	23,000	4.3	69	93,000	17.3	277.3	Neither
445A	R-744/134a/1234ze(E) (6.0/9.0/85.0)	(±1.0/±1.0/±2.0)	930	A2L	16,000	4.2	67	63,000	2.7	347.4	Neither
446A	R-32/1234ze(E)/600 (68.0/29.0/3.0)	(+0.5, –1.0/+2.0, –0.6/+0.1, –1.0)	960	A2L	16,000	2.5	39	62,000[l]	13.5[l]	217.4[l]	Neither

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.

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. 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.

f. *Highly toxic*, *toxic*, or *neither*, where *highly toxic* and *toxic* are as defined in the *International Fire Code*, *Uniform Fire Code*, and OSHA regulations, and *neither* identifies those refrigerants having lesser toxicity than either of those groups [1,2,3].

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

h. The OELs are eight-hour TWAs as defined in Section 3 unless otherwise noted; a "C" designation denotes a ceiling limit.

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

j. LFL is based on WCF @23°C (73.4°F) unless otherwise noted.

k. WCFF LFL @60°C (140°FF)

l. WCFF LFL @23°C (73.4°F)

m. WCF LFL @100°C (212°F)

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Table 4-2 Data and Safety Classifications for Refrigerant Blends *(Continued)*

Refrigerant Number	Composition (Mass%)	Composition Tolerances	OEL[h], ppm v/v	Safety Group	RCL[a] (ppm v/v)	RCL[a] (lb/Mcf)	RCL[a] (g/m^3)	LFL (ppm v/v)	LFL (lb/Mcf)	LFL (g/m^3)	Highly Toxic or Toxic[f] Under Code Classification
447A	R-32/125/1234ze(E) (68.0/3.5/28.5)	(+1.5, –0.5/+1.5, –0.5/+1.0, –1.0)	**960**	A2L	16,000	2.6	42	65,000[1]	18.9[1]	303.5[1]	Neither
447B	R-32/125/1234ze(E) (68.0/8.0/24.0)	(+1.0, –2.0/+2.0, –1.0/+1.0, –2.0)	970	A2L	**16,000**	**2.6**	**42**	121,000	20.6	312.7	Neither
448A	R-32/125/1234yf/134a/1234ze(E) (26.0/26.0/20.0/21.0/7.0)	(+0.5, –2.0/+2.0, –0.5/+0.5, –2.0/+2.0, –1.0/+0.5, –2.0)	**860**	A1	110,000	24	390				Neither
449A	R-32 /125 /1234yf /134a (24.3/24.7/25.3/25.7)	(+0.2, –1.0/+1.0, –0.2/+0.2, –1.0/+1.0, –0.2)	**840**	A1	100,000	23	370				Neither
449B	R-32/125/1234yf/134a (25.2/24.3/23.2/27.3)	(+0.3, –1.5/+1.5, –0.3/+0.3, –1.5/+1.5, –0.3)	850	A1	100,000	23	370				Neither
449C	R-32/125/1234yf/134a (20.0/20.0/31.0/29.0)	(+0.5, –1.5/+1.5, –0.5/+0.5, –1.5/+1.5, –0.5)	800	A1	98,000	23	360				Neither
450A	R-134a/1234ze(E) (42.0/58.0)	(±2.0/±2.0)	880	A1	72,000	20	320				Neither
451A	R-1234yf/134a (89.8/10.2)	(±0.2/±0.2)	**530**	A2L	18,000	**5.0**	81	70,000[1]	20.3[1]	326.6[1]	Neither
451B	R-1234yf/134a (88.8/11.2)	(±0.2/±0.2)	530	A2L	18,000	**5.0**	81	70,000[1]	20.3[1]	326.6[1]	Neither
452A	R-32/125/1234yf (11.0/59.0/30.0)	(±1.7/±1.8/+0.1, –1.0)	**790**	A1	**100,000**	27	440				Neither
452B	R-32/125/1234yf (67.0/7.0/26.0)	(±2.0/±1.5/±2.0)	870	A2L	30,000	**4.8**	**77**	119,000	19.3	310.5	Neither
452C	R-32/125/1234yf (12.5/61.0/26.5)	(+0.5, –1.5/±1.0/+0.5, –1.5)	**810**	A1	100,000	27	430				Neither
453A	R-32/125/134a/227ea/600/601a (20.0/20.0/53.8/5.0/0.6/0.6)	(±1.0/±1.0/±1.0/±0.5/+0.1, –0.2/+0.1, –0.2)	1000	A1	34,000	7.8	120				Neither
454A	R-32/1234yf (35.0/65.0)	(+2.0/–2.0, +2.0/–2.0)	690	A2L	16,000	**3.2**	**52**	63,000[1]	18.3[1]	293.9[1]	Neither

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.

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. 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.

f. *Highly toxic*, *toxic*, or *neither*, where *highly toxic* and *toxic* are as defined in the *International Fire Code*, *Uniform Fire Code*, and OSHA regulations, and *neither* identifies those refrigerants having lesser toxicity than either of those groups [1,2,3].

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

h. The OELs are eight-hour TWAs as defined in Section 3 unless otherwise noted; a "C" designation denotes a ceiling limit.

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

j. LFL is based on WCF @23°C (73.4°F) unless otherwise noted.

k. WCFF LFL @60°C (140°FF)

l. WCFF LFL @23°C (73.4°F)

m. WCF LFL @100°C (212°F)

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Table 4-2 Data and Safety Classifications for Refrigerant Blends *(Continued)*

Refrigerant Number	Composition (Mass%)	Composition Tolerances	OEL[h], ppm v/v	Safety Group	RCL[a] (ppm v/v)	RCL[a] (lb/Mcf)	RCL[a] (g/m^3)	LFL (ppm v/v)	LFL (lb/Mcf)	LFL (g/m^3)	Highly Toxic or Toxic[f] Under Code Classification
454B	R-32/1234yf (68.9/31.1)	(+1.0/–1.0, +1.0/–1.0)	850	A2L	19,000	**3.1**	**49**	77,000[l]	22.0[l]	352.6[l]	Neither
454C	R-32/1234yf (21.5/78.5)	(±2.0/±2.0)	620	A2L	19,000	**4.4**	**71**	62,000[l]	18.0[l]	289.5[l]	Neither
455A	R-744/32/1234yf (3.0/21.5/75.5)	(+2.0, –1.0/+1.0, –2.0/±2.0)	650	A2L	**22,000**	**4.9**	**7.9**	118,000	26.9	432.1	Neither
456A	R-32/134a/1234ze(E) (6.0/45.0/49.0)	(±1.0/±1.0/±1.0)	900	A1	77,000	20	320				Neither
457A	R-32/1234yf/152a (18.0/70.0/12.0)	(+0.5, –1.5/+0.5, –1.5/+0.1, –1.9)	650	A2L	15,000	**3.4**	**54**	60,000	13.5	216.3	Neither
458A	R-32/125/134a/227ea/236fa (20.5/4.0/61.4/13.5/0.6)	(±0.5/±0.5/±0.5/±0.5/±0.1)	1000	A1	76,000	18	280				Neither
459A	R-32/1234yf/1234ze(E) (68.0/26.0/6.0)	(+0.5, –1.5/±2.0/+1.5, –0.5)	870	A2L	27,000	**4.3**	**69**	107,000	17.4	278.7	Neither
459B	R-32/1234yf/1234ze(E) (21.0/69.0/10.0)	(+0.5, –1.0/±2.0/±1.0)	640	A2L	**25,000**	**5.8**	**92**	99,000	23.3	373.5	Neither
460A	R-32/125/134a/1234ze(E) (12.0/52.0/14.0/22.0)	(±1.0/±1.0/±1.0/±1.0)	**950**	A1	92,000	24	380				Neither
460B	R-32/125/134a/1234ze(E) (28.0/25.0/20.0/27.0)	(±1.0/±1.0/±1.0/±1.0)	950	A1	120,000	25	400				Neither
460C	R-32/125/134a/1234ze(E) (2.5/2.5/46.0/49.0)	(±0.5/±0.5/±1.0/±1.0)	900	A1	73,000	20	310				Neither
461A	R-125/143a/134a/227ea/600a (55.0/5.0/32.0/5.0/3.0)	(±1.0/ ±0.5/±1.0/±0.5/+0.1, –0.4)	1000	A1	61,000	17	270				Neither
462A	R-32/125/143a/134a/600 (9.0/42.0/2.0/44.0/3.0)	(+1.5, –1.0/±2.0/±1.0/±2.0/±1.0)	1000	A2	16,000	3.9	62	105,000[k]	16.6[k]	265.8[k]	Neither

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.

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. 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.

f. *Highly toxic*, *toxic*, or *neither*, where *highly toxic* and *toxic* are as defined in the *International Fire Code*, *Uniform Fire Code*, and OSHA regulations, and *neither* identifies those refrigerants having lesser toxicity than either of those groups [1,2,3].

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

h. The OELs are eight-hour TWAs as defined in Section 3 unless otherwise noted; a "C" designation denotes a ceiling limit.

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

j. LFL is based on WCF @23°C (73.4°F) unless otherwise noted.

k. WCFF LFL @60°C (140°FF)

l. WCFF LFL @23°C (73.4°F)

m. WCF LFL @100°C (212°F)

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Table 4-2 Data and Safety Classifications for Refrigerant Blends *(Continued)*

Refrigerant Number	Composition (Mass%)	Composition Tolerances	OEL[h], ppm v/v	Safety Group	RCL[a] (ppm v/v)	RCL[a] (lb/Mcf)	RCL[a] (g/m^3)	LFL (ppm v/v)	LFL (lb/Mcf)	LFL (g/m^3)	Highly Toxic or Toxic[f] Under Code Classification
463A	R-744/32/125/1234yf/134a (6.0/36.0/30.0/14.0/14.0)	(+2.0, –1.0/±2.0/±2.0/±2.0/±2.0)	990	A1	98,000	19	300				Neither
464A	R-32/125/1234ze(E)/227ea (27.0/27.0/40.0/6.0)	(±1.0/±1.0/±1.0/±0.5)	930	A1	120,000	27	430				Neither
465A	R-32/290/1234yf (21.0/7.9/71.1)	(+0.5, –1.5/+0.1, –0.9/±1.0)	660	A2	12,000	2.5	40	98,000	10.0	160.9	Neither
Azeotropes[b]											
500	R-12/152a (73.8/26.2)		1000	A1	**29,000**	**7.4**	120				Neither
501	R-22/12 (75.0/25.0)[c]		1000	A1	54,000	13	210				Neither
502[g]	R-22/115 (48.8/51.2)		1000	A1	73,000	21	330				Neither
503	R-23/13 (40.1/59.9)		1000								Neither
504[i]	R-32/115 (48.2/51.8)		1000		140,000	28	450				Neither
505	R-12/31 (78.0/22.0)[c]										Neither
506	R-31/114 (55.1/44.9)										Neither
507A[d,i]	R-125/143a (50.0/50.0)		1000	A1	130,000	32	**510**				Neither
508A[d]	R-23/116 (39.0/61.0)		1000	A1	55,000	14	220				Neither
508B	R-23/116 (46.0/54.0)		1000	A1	52,000	13	200				Neither
509A[d,g]	R-22/218 (44.0/56.0)		1000	A1	75,000	24	**380**				Neither

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.

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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. 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.

f. *Highly toxic*, *toxic*, or *neither*, where *highly toxic* and *toxic* are as defined in the *International Fire Code*, *Uniform Fire Code*, and OSHA regulations, and *neither* identifies those refrigerants having lesser toxicity than either of those groups [1,2,3].

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

h. The OELs are eight-hour TWAs as defined in Section 3 unless otherwise noted; a "C" designation denotes a ceiling limit.

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

j. LFL is based on WCF @23°C (73.4°F) unless otherwise noted.

k. WCFF LFL @60°C (140°FF)

l. WCFF LFL @23°C (73.4°F)

m. WCF LFL @100°C (212°F)

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Table 4-2 Data and Safety Classifications for Refrigerant Blends *(Continued)*

Refrigerant Number	Composition (Mass%)	Composition Tolerances	OEL[h], ppm v/v	Safety Group	RCL[a] (ppm v/v)	RCL[a] (lb/Mcf)	RCL[a] (g/m^3)	LFL (ppm v/v)	LFL (lb/Mcf)	LFL (g/m^3)	Highly Toxic or Toxic[f] Under Code Classification
510A	R-E170/600a (88.0/12.0)	(±0.5/±0.5)	1000	A3	7300	0.87	14	29,000	3.5	56.1	Neither
511A	R-290/E170 (95.0/5.0)	(±1.0/±1.0)	1000	A3	5300	0.59	9.5	21,000	2.4	38.0	Neither
512A	R-134a/152a (5.0/95.0)	(±1.0/±1.0)	1000	A2	11,000	1.9	31	45,000[l]	7.7[l]	123.9[l]	Neither
513A	R-1234yf/134a (56.0/44.0)	(±1.0/±1.0)	650	A1	72,000	20	320				Neither
513B	R-1234yf/134a (58.5/41.5)	(±0.5/±0.5)	640	A1	74,000	21	330				Neither
514A	R-1336mzz(Z)/1130 (E) (74.7/25.3)	(+1.5, –0.5/+0.5, –1.5)	320	B1	2400	0.86	14				Neither
515A	R-1234ze(E)/227ea (88.0/12.0)	(+1.0, –2.0/+2.0, –1.0)	810	A1	**63,000**	19	300				Neither
516A	R-1234yf/134a/152a (77.5/8.5/14.0)	(±1.4/+0.5, –1.5/+0.1, –1.9)	590	A2L	**13,000**	**3.2**	**52**	50,000	13.1	210.1	Neither

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.

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. 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.

f. *Highly toxic*, *toxic*, or *neither*, where *highly toxic* and *toxic* are as defined in the *International Fire Code*, *Uniform Fire Code*, and OSHA regulations, and *neither* identifies those refrigerants having lesser toxicity than either of those groups [1,2,3].

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

h. The OELs are eight-hour TWAs as defined in Section 3 unless otherwise noted; a "C" designation denotes a ceiling limit.

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

j. LFL is based on WCF @23°C (73.4°F) unless otherwise noted.

k. WCFF LFL @60°C (140°FF)

l. WCFF LFL @23°C (73.4°F)

m. WCF LFL @100°C (212°F)

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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.

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Founded in 1894, ASHRAE is a global professional society committed to serve humanity by advancing the arts and sciences of heating, ventilation, air conditioning, refrigeration, and their allied fields.

As an industry leader in research, standards writing, publishing, certification, and continuing education, ASHRAE and its members are dedicated to promoting a healthy and sustainable built environment for all, through strategic partnerships with organizations in the HVAC&R community and across related industries.

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