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Safety Bulletin
Maximum Refrigerant Quantities per Occupied Space
Derivation of values for Table 1, CSA B52-13 for A1 and B1 Refrigerants

Introduction

This information bulletin serves to provide additional information with respect to the derivation of the refrigerant quantities per occupied space as listed in Table 1, CSA B52-13 *Mechanical Refrigeration Code* for A1 and B1 refrigerants.

Limiting the total quantity of refrigerant permitted in a specified occupied space is a significant health and safety issue. Therefore the listed values are chosen to minimize negative effects (e.g. narcosis, cardiac sensitization or insufficient oxygen to support life) for occupants in the event of refrigerant leakage. These limiting values also have a significant influence on the determination of the overall design of a refrigeration system and the associated space, and for this reason the calculation methodology of the values is further detailed herein under to assist Code users in their review and application of appropriate limits. Code users are also reminded that the maximum quantities of refrigerant per occupied space are subject to approval of the regulatory authority where the refrigeration system is to be installed.

Refrigerant Classifications and Quantities

To note, Table 1 of CSA B52-13 provides a list of some refrigerants, selected by their common usage in installations in Canada. The Table is segregated by refrigerant classifications including, Groups A1, single fluids and blends, A2, A3, B1 and B2. The refrigerant numbers and associated group numbers originate from classifications as set forth by ASHRAE[1].

ASHRAE Standard 34-13, *Safety Standard for Refrigerating Systems* is recognized as establishing the latest and most complete information available for refrigerant technical data for North American refrigeration standards. Designers are provided values as prescribed in Table 1, CSA B52-13, however in a note to the Table it is identified that where conflict occurs with the ASHRAE standard, the latter prevails.

RCL (Refrigeration Concentration Limit)

There are three methods of determining the **RCL (Refrigeration Concentration Limit)** for a given refrigerant;

[1] ASHRAE is the American Society of Heating, Refrigerating and Air-Conditioning Engineers

i. **Acute Toxicity Exposure Limit (ATEL)** as defined in ASHRAE Standard 34-13 section 7.1.1,
ii. **Oxygen Deprivation Limit (ODL)** as defined in ASHRAE Standard 34-13 Section 7.1.2, and
iii. **Flammable Concentration Limit (FCL)** as defined in ASHRAE Standard 34-13 Section 7.1.3

The RCL to be used for an application is the lowest value determined from the three methods (*Note that ODL limits are related to elevation above sea level. It is therefore possible that refrigerants may have an RCL related by ATEL at sea level, and an RCL related by ODL at higher elevations. R-407C is an example).*

For illustration, concentration limits from CSA B52-13 for a few common refrigerants are provided in Figure A. For these same refrigerants, the corresponding RCL values at sea level and the ODL values from ASHRAE Standard 34-13 are provided in Figures B, C and D. To note, flammability is not a consideration for these examples.

Calculation Methodology for CSA B52-13, Table 1

The RCL values provided for in CSA B52-13 Table 1 are derived from both calculated and tabular values for ODL at elevations above 1500m and ATEL at sea level from ASHRAE 34-13.

ODL

All refrigerants heavier than air have a risk of asphyxiation. The molecular mass of air is 28.97 g/mol. The RCL defined by ODL is based on the altitude of the application as defined in ASHRAE 34-13 Clause 7.1.2 and is provided in three altitude categories (refer to Figures B-D):

a. An RCL value of 140,000 ppm v/v shall be used for all refrigerants heavier than air at an altitude below 1000 m.
- *For example, according to this calculation for this altitude, R-410A has an allowable concentration of* ***0.4163 kg/m^3.***

b. An RCL value of 112,000 ppm v/v shall be used for all refrigerants heavier than air at an altitude between 1000 m and 1500 m.
- *For example, according to this calculation for this altitude, R-410A has an allowable concentration of* ***0.3331 kg/m^3****.*

c. An RCL value of 69,100 ppm v/v shall be used for all refrigerants heavier than air at an altitude greater than 1500 m.
- *For example, according to this calculation for this altitude, R-410A has an allowable concentration of* ***0.2055 kg/m^3.***

RCL at Sea Level

The RCL sea level values[2] are presented per ASHRAE Standard 34-13, Tables 4-1 and 4-2 in ppm v/v. The RCL is converted into a mass per unit volume using the calculation method detailed in section 7.4.1 of ASHRAE Standard 34-13 based upon the molecular mass of the refrigerant. The resultant RCL_M is then the basis for concentration limit calculations expressed in kg/m^3 (refer to Figures B-D).

[2] These values are the lowest value as determined by ATEL and ODL. FCL is not a factor for the examples presented.

- *For example, according to this calculation, the R-410A has an RCL at sea level of 140,000 ppm v/v and a resulting allowable concentration at sea level of* ***0.4163 kg/m^3.***

RCL at sea level with Adjustment Based on Altitude

The RCL_M for refrigerants limited by Oxygen Deprivation must be adjusted based upon altitude of an application when expressed as mass per unit volume[3], g/m^3. It shall be adjusted according to ASHRAE Standard 34-13, section 7.4.2 and is represented with rcl_a. It must be noted that the same evaluation at a different altitude may yield different results. Figures B, C and D provide examples at three different specified altitudes, 105m, 250m and 1100m with bolded values indicating where the RCL is selected, that is either RCL at sea level adjusted for height, or the ODL value at the corresponding altitude threshold.

- *For example, the RCL value for R-410A in Figure D at an elevation of 1100m is determined by the ODL value at an altitude between 1000m and 1500m,* ***0.3331 kg/m^3.***

RCL Values in CSA B52-13, Table 1

The maximum refrigerant quantities per occupied space presented in CSA B52-13 for A1 and B1 refrigerants are based on the lesser of two values, RCL at sea level or ODL above 1500m altitude as determined from ASHRAE Standard 34-13. Therefore the ODL may be adjusted to match application specific altitudes. It is not mandatory to use the values corresponding to altitudes above 1500m.

- *For example, the R-410A RCL (kg/m^3), refer to Figures A through D:*

CSA B52-13	***Sea level***	***105m***	***250m***	***1000-1500m***	***Greater than 1500m***
0.2055	*0. 4163*	*0.4128*	*0.4081*	*0.3331*	*0.2055*

Figure A: Refrigeration Concentration Limits, CSA B52-13

	CSA B52-13		
	Based on the lower value of either ASHRAE 34-13 values for ATEL at Sea Level or ODL Above 1500 m Altitude		
Refrigerant	**kg/m^3**	**Vol. %**	**lb/1000ft^3**
R-134a	0.2089	5.00	13.02
R-404A	0.2762	6.91	17.22
R-407C	0.2440	6.91	15.21
R-410A	0.2055	6.91	12.81
R-507A	0.2799	6.91	17.45
R-744	0.0721	4.00	4.49

[3] The RCL is not adjusted when expressed as a volumetric ratio, ppm.

Figure B: Refrigeration Concentration Limits at 105m Elevation

(bold values identify allowable concentrations)

Refrigerant	RCL at Sea Level (1)			Altitude Adjustment for RCL (2) Example @ 105 meters		ODL (Oxygen Deprivation Limit) (3)								
						Altitude less than 1000m			Altitude between 1000m and 1500m			Altitude greater than 1500m		
	RCL ppm v/v	RCL_M (g/m^3)	kg/m^3	rcl_a (g/m^3)	kg/m^3	$RCL_{0\ to\ 1000}$ ppm v/v	RCL_M (g/m^3)	kg/m^3	$RCL_{1000\ to\ 1500}$ ppm v/v	RCL_M (g/m^3)	kg/m^3	RCL_{1500+} ppm v/v	RCL_M (g/m^3)	kg/m^3
R-134a	50,000	208.8960	0.2089	207.1544	**0.2072**	140,000	584.9088	0.5849	112,000	467.9270	0.4679	69,100	288.6943	0.2887
R-404A	130,000	519.7005	0.5197	515.3677	**0.5154**	140,000	559.6774	0.5597	112,000	447.7420	0.4477	69,100	276.2408	0.2762
R-407C	81,000	285.9909	0.2860	283.6066	**0.2836**	140,000	494.3053	0.4943	112,000	395.4442	0.3954	69,100	243.9750	0.2440
R-410A	140,000	416.3174	0.4163	412.8466	**0.4128**	140,000	416.3174	0.4163	112,000	333.0540	0.3331	69,100	205.4824	0.2055
R-507A	130,000	526.6227	0.5266	522.2323	**0.5222**	140,000	567.1322	0.5671	112,000	453.7057	0.4537	69,100	279.9202	0.2799
R-744	40,000	72.0896	0.0721	71.4886	**0.0715**	140,000	252.3136	0.2523	112,000	201.8509	0.2019	69,100	124.5348	0.1245

Note: The values in the table above are sourced or calculated from sections of ASHRAE Standard 34-13 as indicated:

(1) Tables 4-1 and 4.2;

(2) Section 7.4.2; and

(3) Section 7.1.2

Figure C: Refrigeration Concentration Limits at 250m Elevation

(bold values identify allowable concentrations)

Refrigerant	RCL at Sea Level (1)			Altitude Adjustment for RCL (2) Example @ 250 meters		ODL (Oxygen Deprivation Limit) (3)								
						Altitude less than 1000m			Altitude between 1000m and 1500m			Altitude greater than 1500m		
	RCL ppm v/v	**RCL_M (g/m^3)**	**kg/m^3**	**rcl_a**	**kg/m^3**	**$RCL_{0\ to\ 1000}$**	**RCL_M (g/m^3)**	**kg/m^3**	**$RCL_{100\ 0\ to\ 1500}$**	**RCL_M**	**kg/m^3**	**RCL_{1500+}**	**RCL_M (g/m^3)**	**kg/m^3**
R-134a	50,000	208.8960	0.2089	204.7494	**0.2047**	140,000	584.9088	0.5849	112,000	467.9270	0.4679	69,100	288.6943	0.2887
R-404A	130,000	519.7005	0.5197	509.3844	**0.5094**	140,000	559.6774	0.5597	112,000	447.7420	0.4477	69,100	276.2408	0.2762
R-407C	81,000	285.9909	0.2860	280.3140	**0.2803**	140,000	494.3053	0.4943	112,000	395.4442	0.3954	69,100	243.9750	0.2440
R-410A	140,000	416.3174	0.4163	408.0535	**0.4081**	140,000	416.3174	0.4163	112,000	333.0540	0.3331	69,100	205.4824	0.2055
R-507A	130,000	526.6227	0.5266	516.1693	**0.5162**	140,000	567.1322	0.5671	112,000	453.7057	0.4537	69,100	279.9202	0.2799
R-744	40,000	72.0896	0.0721	70.6586	**0.0707**	140,000	252.3136	0.2523	112,000	201.8509	0.2019	69,100	124.5348	0.1245

Note: The values in the table above are sourced or calculated from sections of ASHRAE Standard 34-13 as indicated:

(1) Tables 4-1 and 4.2;

(2) Section 7.4.2; and

(3) Section 7.1.2

Figure D: Refrigeration Concentration Limits at 1100m Elevation

(bold values identify allowable concentrations)

Refrigerant	RCL at Sea Level (1)			RCL_a , Altitude Adjustment for RCL (2) Example @ 1100 meters		ODL (Oxygen Deprivation Limit) (3)								
						Altitude less than 1000m			Altitude between 1000m and 1500m			Altitude greater than 1500m		
	RCL ppm v/v	RCL_M (g/m^3)	kg/m^3	rcl_a	kg/m^3	$RCL_{0\ to\ 1000}$	RCL_M (g/m^3)	kg/m^3	$RCL_{1000\ to\ 1500}$	RCL_M	kg/m^3	RCL_{1500+}	RCL_M (g/m^3)	kg/m^3
R-134a	50,000	208.8960	0.2089	190.6510	**0.1907**	140,000	584.9088	0.5849	112,000	467.9270	0.4679	69,100	288.6943	0.2887
R-404A	130,000	519.7005	0.5197	474.3098	0.4743	140,000	559.6774	0.5597	112,000	447.7420	**0.4477**	69,100	276.2408	0.2762
R-407C	81,000	285.9909	0.2860	261.0125	**0.2610**	140,000	494.3053	0.4943	112,000	395.4442	0.3954	69,100	243.9750	0.2440
R-410A	140,000	416.3174	0.4163	379.9563	0.3800	140,000	416.3174	0.4163	112,000	333.0540	**0.3331**	69,100	205.4824	0.2055
R-507A	130,000	526.6227	0.5266	480.6275	0.4806	140,000	567.1322	0.5671	112,000	453.7057	**0.4537**	69,100	279.9202	0.2799
R-744	40,000	72.0896	0.0721	65.7933	**0.0658**	140,000	252.3136	0.2523	112,000	201.8509	0.2019	69,100	124.5348	0.1245

Note: The values in the table above are sourced or calculated from sections of ASHRAE Standard 34-13 as indicated:

(1) Tables 4-1 and 4.2;

(2) Section 7.4.2; and

(3) Section 7.1.2

This bulletin was published on behalf of the CSA B52 Technical Committee on Mechanical Refrigeration Code. For more information, please contact your local regulatory authority or:

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