CCCANZ
CLIMATE CONTROL COMPANIES ASSOCIATION NEW ZEALAND

FLAMMABLE REFRIGERANTS – *BE INFORMED, BE AWARE*

System design considerations

This fact sheet explores the rules for the design of A2L, A2 and A3 flammable refrigerant-based stationary air conditioning and refrigeration systems. Significant consequences may arise if you, as a designer, fail to properly address safety considerations. The content is based on the Australian Institute of Refrigeration, Air Conditioning and Heating (AIRAH) *Flammable Refrigerants Safety Guide* – available from www.airah.org.au.

REFRIGERANT CLASSIFICATION

Flammable refrigerants include A2L, A2, A3, B2L, B2 and B3 classes from AS/NZS ISO 817:2016 *Refrigerants – Designation and safety classification*. Flammability group classification is based on the lower flammability limit (LFL) of the refrigerant. Different design rules apply to each type of refrigerant. Unknown refrigerants should be treated as A3.

	Safety group	
Higher flammability	A3	B3
Flammable	A2	B2
Lower flammability	A2L	B2L
No flame propagation	A1	B1
	Lower toxicity	Higher toxicity

SYSTEM SUITABILITY

If the system is not specifically designed or converted for use with flammable refrigerants, the area is not well ventilated or there are ignition sources in or close to the system, the application would be unsuitable for flammable refrigerants. For systems located below ground, additional limitations apply. The overall safety objective is for any potential release of flammable refrigerant to be contained to a safe concentration. Risks are reduced by limiting refrigerant charge.

SYSTEM CONVERSIONS

Flammable A2L, A2 or A3 refrigerants are not a suitable 'drop-in' replacement for non-flammable A1 refrigerants. System conversion is usually required. When converting an existing A1 refrigerant-based system to use A2L, A2 or A3:

- the designer must be competent in the design rules (including recognising when additional engineering controls are necessary)
- the converted system must comply with all applicable standards and regulations
- the equipment manufacturer and flammable refrigerant manufacturers should be contacted for advice on the application, including advice on warranties.

APPLICABLE STANDARDS

- AS 4343:2014 *Pressure equipment – Hazard levels*
- AS/NZS 5149 *Refrigerating systems and heat pumps – Safety and environmental requirements* series
- AS/NZS 60079 *Explosive atmospheres* series
- AS/NZS 60335 *Household and similar electrical appliances* series

REFRIGERANT CHARGE LIMITATION (RCL)

Refrigerant charge limitation (RCL) is the maximum amount of refrigerant allowed in a product or system to reduce the risks of toxicity, asphyxiation and flammability hazards. AS/NZS 60335 contains charge limitations for particular products, and AS/NZS 5149.1:2016 Table A.2 contains charge limitations for systems. Refrigerant charges are restricted according to the level of risk posed based on the flammability class, the occupancy category, the application (human comfort or other) and whether the system is above or below ground. Practical limits, used for simple calculations, are based on the RCL or historically established charge limitations.

OCCUPANCY CATEGORY

Three categories of occupancy are used to define maximum refrigerant charge:

Category	General characteristics - rooms or parts of buildings	Typical examples
General occupancy a	Where people can sleep or are restricted in their movement or an uncontrolled number of people are present or where people have access without being personally acquainted with the applicable safety precautions	Hospitals, courts, prisons, theatres, supermarkets, schools, lecture halls, public transport terminals, hotels, dwellings, restaurants
Supervised occupancy b	Where only a limited number of people can be assembled, some being necessarily acquainted with the general safety precautions of the establishment	Business or professional offices, laboratories, places for general manufacturing and where people work
Authorised occupancy c	Where only authorised persons have access, who are acquainted with general and special safety precautions of the establishment and where manufacturing, processing or storage of material or products takes place	Manufacturing facilities (for example, for chemicals, food, beverage, ice, ice cream), refineries, cold stores, dairies, abattoirs, non-public areas in supermarkets

Machinery rooms are considered an authorised occupancy in New Zealand.

LOCATION CLASSIFICATIONS

Four system location categories are used to define maximum refrigerant charge:

- Class I: Refrigerant containing parts located in occupied space (for example, self-contained drinks cabinet).
- Class II: Compressors and pressure vessels in machinery room or open air (for example, split systems).
- Class III: Refrigerant containing parts located in machinery room or open air.
- Class IV: Refrigerant containing parts located in ventilated enclosure.

For refrigerating systems, flammable refrigerant charge limits must be in accordance with AS/NZS 5149.1:2016 Table A.2. For room air conditioners and domestic heat pumps, flammable refrigerant charge limits must be in accordance with Annex GG of AS/NZS 60335.2.40.

HUMAN COMFORT APPLICATIONS

Some common flammable refrigerants are heavier than air and can tend to pool at floor level. This means that, even with charge restrictions of 20% of the LFL, flammable zones can still exist in poorly ventilated rooms. This is of special concern for installations that are occupied by sleeping or incapacitated people such as in bedrooms or nursing homes. For this reason, extra conditions on allowable charge limits are applied to air conditioners and heat pumps classified for use as for 'human comfort'. AS/NZS 5149.1:2016 introduces the concept of a cap factor – m_1, m_2 or m_3 – based on the LFL.

For A2L, no restrictions for charges ≤ m_1 x 1.5, for A2/A3, no restrictions for charges ≤ to m_1, otherwise - $m_{max} = 2.5 \times LFL^{5/4} \times h_0 \times A^{1/2}$.

It is the net volume of the space that is used when determining charge limitations. Where AS/NZS 5149.1:2016 allows the use of alternative provisions for A2L refrigerants, the designer can calculate allowable refrigerant charge based on the RCL and the ventilation provided (QLMV/QLAV). A range of system-specific conditions apply to this approach.

$m_1 = 4m^3 \times LFL$

$m_2 = 26m^3 \times LFL$

$m_3 = 130m^3 \times LFL$

	m_1	m_2	m_3
R32	1.22	7.96	39.81
R1234yf	1.16	7.52	37.58
R1234ze	1.21	7.88	39.40
R717	0.46	3.02	15.09
R290	0.15	0.98	4.91
R600a	0.17	1.11	5.56

$$A_{min} = \left[\frac{m}{2.5 \times LFL^{5/4} \times h_0} \right]^2$$

A_{min} = minimum room area (m)

m = refrigerant charge (kg)

h_0 = height of leak

LFL = lower flammability limit

APPLIANCE STANDARDS

For small consumer products (for example, fridges and dryers), the maximum charge size is typically 150 g in each separate circuit. For air conditioners/heat pumps, the maximum charge is 1–5 kg depending on the application. For motor compressors, the maximum charge depends on the appliance it is installed in.

Room air conditioner appliance standard AS/NZS 60335.2.40 requires the installation manual to clearly indicate the minimum floor area of the room that can be served, in the form of a table or single figure. Complicated refrigerant charge calculations should not be required as long as these minimum rules are observed.

FLAMMABLE ATMOSPHERES

Flammable refrigerant, when leaked to atmosphere, can form an explosive gas atmosphere. If the concentration of the flammable gas can exceed 5% of the LFL, that work area must be deemed a hazardous atmosphere under the Health and Safety at Work (HSW) regulations. The requirements for hazardous areas from AS/NZS 60079.10.1:2009 will apply, and additional applicable design standards would include AS 1482-1985 (R2013) *Electrical equipment for explosive atmospheres – Protection by ventilation – Type of protection v* and AS/NZS 60079.14:2017.

SOURCES OF IGNITION

Where flammable refrigerants are used in a system, there must be no potential sources of ignition in or around the equipment that could ignite any leaked refrigerant. Potential sources of ignition to consider include a hot surface, a spark from an electrical source, a naked flame, static electricity or even lightning. Ignition sources within and around the system need to be removed.

PRESSURE RELIEF

AS/NZS 5149.2:2016 specifies which specific type and size of pressure relieving device is permitted for different system types. Discharges must be directed into a safe place where people and property are not endangered by released refrigerant.

HSW REGULATIONS

The HSW regulations require risks to be managed where atmospheres can rise above 5% of the LFL. Because the RCL for refrigerant/system design is based on 20% of the LFL, the implication is that designers need to consider actioning this 5% LFL criterion when designing a system for a specific occupancy. This could include leak detection by odour or electronic sensor or system refrigerant containment strategies.

DETECTION SYSTEMS

AS/NZS 5149.3:2016 clause 9 requires detectors where the practical limit of the refrigerant can be exceeded. Detectors must be refrigerant specific and located where a refrigerant leak will concentrate. Triggers to actuate alarms, shut-off valves and emergency ventilation systems in machinery rooms are specified, including:

- 19.5% oxygen content (for human respiration)
- 25% of the LFL of the refrigerant
- half or less of the AS/NZS ISO 817:2016 RCL concentration of the refrigerant
- specific concentrations for ammonia R717.

LABELLING

The attachment of class labels should be specified for both the units and the interconnecting pipework – see section 9 of the *Flammable Refrigerants Safety Guide.*

TRAINING

Designers should be competent in all safety aspects of flammable refrigerants – see section 10 of the *Flammable Refrigerants Safety Guide.*

These fact sheets have been produced by the Climate Control Companies Association New Zealand (CCCANZ) supported by BRANZ and in association with the Australian Institute of Refrigeration, Air Conditioning and Heating (AIRAH). They provide an overview of the key elements of safe operation for flammable refrigerant-based systems and an introduction to the pathways, plans and processes towards a new cooling environment. The fact sheets cover:

1. Introduction and overview
2. System design considerations (this fact sheet)
3. Installing systems with flammable refrigerants
4. Operating and maintaining flammable refrigerant-based systems

Designers/installers/service providers should access the AS/NZS 5149 *Refrigerating systems and heat pumps – Safety and environmental requirements* series in order to ascertain the precise requirements for an individual installation.