AIRAH

HVAC&R FOR A BETTER WORLD

Flammable Refrigerants

SAFETY GUIDE

2026

Flammable Refrigerants

SAFETY GUIDE

Preface

This industry guide helps users manage the health and safety risks associated with the safe design, manufacture, supply, installation, conversion, commissioning, operation, maintenance, decommissioning, dismantling and disposal of refrigeration, air conditioning and heat pump equipment and systems that use flammable refrigerants. It was developed because of the increasing demand for flammable refrigerants due to their lower global warming potential (GWP). This includes hydrocarbons, ammonia and various flammable synthetic refrigerants.

This edition of the guide incorporates the changes highlighted in the 2018 amendments and has been further updated to reflect the current regulations, standards and practices that apply to flammable refrigerants. It applies to anyone who has a duty of care in the circumstances described. Like regulations, industry guides deal with particular issues and do not cover all hazards or risks which might arise. Duty holders must consider all risks associated with work, not only those for which regulations, codes of practice, and industry guides exist.

Australian and international standards related to the use of flammable refrigerants are constantly revised and amended based on new research and technology changes. This guide is based on standards current at the time of publication; users should ensure that the application of any standards-related information remains current.

About AIRAH

AIRAH is the peak body representing the HVAC&R industry in Australia. Our mission is to lead an Australian HVAC&R industry that is highly skilled, safe and sustainable.

DISCLAIMER

The information or advice contained in this document is intended for use only by persons who have had adequate technical training in the field to which the Safety Guide relates. The document has been compiled as an aid only and the information or advice should be verified before it is put to use by any person. Reasonable efforts have been taken to ensure that the information or advice is accurate, reliable and accords with current standards as at the date of publication. To the maximum extent permitted by law, the Australian Institute of Refrigeration Air Conditioning and Heating Inc., its officers, employees and agents

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arbsfoundation.com.au

This industry guide was originally developed by a Flammable Refrigerants Taskforce made up of stakeholder industry organisations, and was developed and reviewed by a wide range of individual experts.

The following organisations were represented during the preparation of the 2013 edition:

- Air conditioning and Refrigeration Equipment Manufacturers Association (AREMA)
- Australian Institute of Refrigeration, Air conditioning and Heating (AIRAH)
- Australian Refrigeration Wholesalers Association (ARWA)
- Australasian Fire and Emergency Service Authorities Council (AFAC)
- Climate Control Companies Association New Zealand (CCCA)
- Department of Natural Resources and Mines Qld (DNRM)
- Department of Sustainability, Environment, Water, Population and Communities (DSEWPaC)
- E-OZ Energy Skills Australia
- Electrical Regulatory Authorities Council (ERAC)
- Fire and Rescue NSW
- Gas Technical Regulators Committee (GTRC)
- Institute of Refrigeration Heating and Air Conditioning Engineers (IRHACE) New Zealand
- Queensland Fire and Rescue Service (QFRS)
- Road Transport and Warehouse Association (RWTA)
- Standards New Zealand
- Technical And Further Education TAFE NSW
- WorkCover NSW
- Work Health and Safety Queensland
- WorkSafe Victoria

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How to use this guide

The word should is used in this guide to indicate a recommended course of action. May is used to indicate an optional course of action. Shall, must, requires or mandatory indicate a mandatory requirement that exists under applicable legislation, regulation or referenced standards.

Acronyms used in this guide

The acronyms and initialisms used in this guide have the following meaning:

ADG	Australian dangerous goods
CFC	Chlorofluorocarbon
CO_2e	Carbon dioxide equivalent
DG	Dangerous goods
FR	Fill ratio
GHS	Globally Harmonized System
GWP	Global warming potential
HC	Hydrocarbon
HCFC	Hydrochlorofluorocarbon
HFC	Hydrofluorocarbon
HFO	Hydrofluoroolefin
HVAC&R	Heating, ventilation, air conditioning and refrigeration
LFL	Lower flammability limit
NATA	National Association of Testing Authorities
OFN	Oxygen-free nitrogen
OH&S	Occupational health and safety
OPSGGM	Ozone protection and synthetic greenhouse gas management
PCBU	Person conducting a business or undertaking
PPE	Personal protective equipment
PS	Maximum system allowable pressure
QLAV	Quantity limit with additional ventilation
QLMV	Quantity limit with minimum ventilation
RACHP	Refrigeration, air conditioning and heat pump
RCL	Refrigerant concentration limit
RHL	Refrigerant handling licence
RTA	Refrigerant trading authorisation
SDS	Safety data sheet
SFC	Safe fill capacity
SGG	Synthetic greenhouse gas
SME	Small to medium enterprise
SOI	Source of ignition
VCE	Vapour cloud explosion
WHS	Work health and safety

Contents

1. SCOPE AND APPLICATION

1.1 Introduction

Many refrigerants used in refrigeration and air conditioning systems in Australia in the past were non-flammable, lower toxicity, synthetic greenhouse gases (SGGs) that have a high global warming potential (GWP). These were typically chlorofluorocarbon (CFC), hydrochlorofluorocarbon (HCFC) and hydrofluorocarbon (HFC) synthetic refrigerants. Due to the concern regarding the atmospheric effects of SGGs and other environmental impacts, the use of alternative low-GWP refrigerants is increasing. Many of these low-GWP refrigerants are flammable.

Flammable refrigerants are now widely used in domestic refrigerators, small integral commercial cabinets, heat pumps and air conditioners, fluid chillers or heaters, and industrial refrigeration. Their use is expected to continue to grow in commercial and industrial refrigeration applications as well as commercial and residential air conditioning and heat pumps. This represents a significant change for the refrigeration, air conditioning and heat pump industry. It is therefore critical that the flammability of refrigerants be addressed by an industry resource that recognises their flammability and provides guidance on their safe use throughout the product lifecycle. That is the purpose of this guide, as well as the complementary fact sheets and online resource.

All refrigerants are dangerous if misused or applied incorrectly. Although they have less impact on the environment, flammable refrigerants are significantly more easily combusted. The increased flammability risk can lead to significant consequences if a person conducting a business or undertaking (PCBU) fails to:

- Follow appropriate servicing and maintenance or repair practices
- Follow appropriate installation or decommissioning practices
- Properly address safety considerations if converting or modifying a system where a flammable refrigerant is involved.

Any of these failures could result in fires, explosions, injury to people, damage to property, and legal action that is otherwise avoidable. To keep these risks as low as is reasonably practical, equipment and systems designed for use with flammable refrigerants require additional safety features, beyond those normally required when using non-flammable refrigerants.

Mandatory charge restrictions apply to the use of flammable refrigerants in many safety standards. Designers, manufacturers, importers and suppliers must ensure, so far as is reasonably practicable, that the equipment they design, manufacture, import or supply is safe before it is introduced to the marketplace. Installing contractors and service technicians must ensure, so far as is reasonably practicable, that the equipment they install and service is safe and that any work onsite is carried out in a safe manner.

Flammable refrigerants (i.e. A2L, A2 or A3) are not suitable drop-in replacements for non-flammable (A1) refrigerants. Conversion is often required and any conversion typically requires design competence and new or different legal compliance obligations, before the equipment can be re-commissioned, (refer to Clause 1.5).

1.2 Application

This guide gives people with health and safety duties practical guidance on how to manage health and safety risks associated with the design, manufacture, installation, commission, service, use, repair, decommission, dismantle and disposal of refrigeration, air conditioning and heat pump equipment using flammable refrigerants at a workplace, in a public building, or in a residential/domestic setting.

This guide applies to all stationary refrigeration, air conditioning and heat pump (RACHP) equipment and systems that are to be charged with flammable refrigerants with a refrigerant safety group classification of A2L, A2 or A3. It also covers non-stationary applications of flammable refrigerants that fall under the scope of AS/NZS 5149, including transport refrigeration (road, rail, air, marine) and mobile or portable air conditioning and refrigeration systems and appliances.

1.3 What this guide does not cover

This guide does not cover applications of flammable refrigerants in vehicle air conditioning systems (cars, trucks, buses, trains, boats, aircraft).

It does not cover the storage and handling of ammonia (NH_3, R717), a B2L refrigerant covered in AS/NZS 2022. Ammonia refrigeration systems may be applied in accordance with the AS/NZS 5149 series.

It does not cover the application of A1 refrigerants.

This guide is not applicable to major hazard facilities, large chemical storage facilities, and large industrial plants such as natural gas liquids (NGL) extraction and liquid natural gas (LNG) processing plants. These facilities can contain large inventories of flammable hydrocarbons as refrigerants and are already covered by existing legislation and national/international standards for major hazard facilities (refer to Guide for major hazard facilities – Emergency plans | Safe Work Australia).

1.4 Refrigerant GWP and flammability

Historically, refrigeration and air conditioning systems in Australia have mainly used non-flammable and lower toxicity refrigerants with high global warming potential (GWP), primarily CFC, HCFC, and HFC A1 refrigerants. Alternative refrigerants with lower GWP are now increasingly being used. For synthetic HFC, HCFC and hydrofluoroolefin (HFO) refrigerants, a lower GWP is typically achieved by reducing chemical stability, resulting in a shorter atmospheric lifetime. This chemical instability is associated with increased reactivity, often manifesting as an increase in flammability.

A3 refrigerants such as hydrocarbons, are low GWP and chemically stable but are highly flammable.

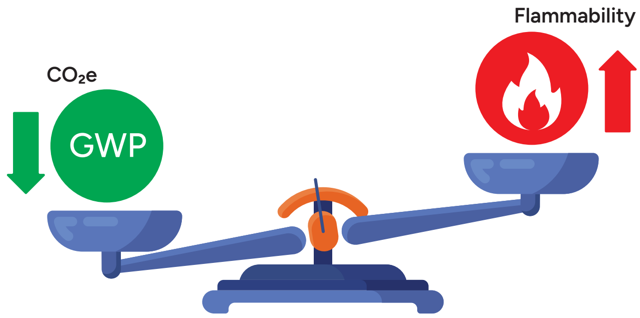


Figure 1.1 Weighing up synthetic refrigerant GWP and flammability

Non-flammable low-GWP refrigerants include air (R729), water (R718) and CO_2 (R744).

As the industry moves towards a greater use of low- and reduced-GWP flammable refrigerants, the safety practices for refrigeration design, installation, service, and repair are also changing. The safety objectives for flammable refrigerants (over and above those for non-flammable refrigerants) include:

- Minimising the possibility of any refrigerant leaks, and conversely, air entering the refrigerant circuit
- Minimising the possibility of ignition of any leaked refrigerant
- Minimising the severity of the consequences of any ignition
- Integrating mitigation measures where appropriate, such as gas detection, airflow and means to limit the amount of refrigerant released, to minimise the formation of flammable mixtures
- Providing marking and information to warn of flammability hazards.

1.5 Refrigerant safety hazards

Specific hazards from refrigerant and refrigerant handling fall into the following seven categories:

1. **Flammability hazard** – Flammable refrigerants can present an immediate hazard when released into the air, by forming an explosive atmosphere.
2. **Combustion hazard** – Mixtures of refrigerant, lubricant and air/oxygen, under pressure in systems or when filling cylinders, can also create an explosion hazard due to a variety of mechanisms such as adiabatic heating (diesel

type compression ignition) or mechanical heat.

3. **Toxicity hazard** – Toxic refrigerants can present an immediate acute or chronic toxicity hazard when released into the air. Toxicity data is summarised in Safety Data Sheets (SDS).
4. **Decomposition hazards** – When synthetic refrigerant is decomposed or burned, the byproducts released can be extremely toxic, even at very low concentrations. Many flammable refrigerants can also create carbon monoxide or carbon dioxide when burned.
5. **Asphyxiation hazard** – Refrigerants, whether they are heavier or lighter than air, can cause suffocation by oxygen displacement if the concentration is high enough or if released in a confined space.
6. **Pressure hazard** – Sudden unexpected release of pressurised refrigerant can result in personal injury.
7. **Temperature hazard** – Liquid refrigerant, when released from high to low pressure, will flash and boil to vapour. This leads to very low temperatures that can cause cold burns or frostbite if it comes into contact with skin.

1.6 Converting systems and equipment

1.6.1 General

This guide applies to the use of all flammable refrigerants with a safety group classification A2L, A2 or A3. It covers appliances and systems specifically designed for their use and to the conversion of appliances and systems not specifically designed for their use, provided the conversion is consistent with applicable legislation, standards, and safety requirements.

Equipment originally designed for use with non-flammable (A1) CFC, HCFC, or HFC refrigerant is generally not intended for use with flammable refrigerants. Converting such systems to use flammable refrigerants requires careful consideration to ensure safety and legal compliance.

1.6.2 WHS advice

Work health and safety (WHS) regulators advice for flammable refrigerants is that conversion should only be undertaken if:

- The person performing the conversion is demonstrably competent in all relevant aspects of handling flammable refrigerants and safe operation of systems. Conversion typically requires relevant system design competencies. *See Section 8.*
- The converted system meets all applicable legal requirements, including regulations and referenced standards.
- The flammable refrigerant manufacturer, the original equipment manufacturer or a competent person is consulted and requested to advise on the equipment suitability for the refrigerant type change.
- The competent person provides written confirmation on the suitability of the refrigerant and the conversion.

Under WHS regulation, a person changing a refrigerant to a more flammable refrigerant takes on a role similar to that of a designer of a refrigeration system. For example, for a stationary system a refrigeration engineer must assess the suitability of the system for use with the flammable refrigerant, and ensure compliance with relevant standards including AS/NZS 5149, AS/NZS 3000 and other electrical standards (e.g. AS/NZS 60079.14).

Consider should also be given to any effects a conversion might have on manufacturers' warranties, registered trademarks and property insurance disclosures.

1.6.3 Electrical safety advice

Electrical safety regulators advice on converting systems and equipment is:

1. If equipment has not been confirmed as being designed, manufactured and tested to be compliant to relevant electrical safety standards for use with the proposed refrigerant then conversion of the equipment or use of the proposed refrigerant should not occur.
2. All domestic electrical appliances should be shown to comply with the relevant electrical safety product standard for use with the proposed refrigerant.
3. For commercial and industrial situations, all equipment used and the complete installation should (and for larger systems, might be required to) have appropriate certification, assessment and evidence of compliance with electrical safety standards for hazardous areas.

Common types of domestic and light commercial equipment, including domestic air conditioners, refrigerators and heat pumps, are subject to mandatory outcome-orientated safety criteria, with compliance demonstrated via referenced standards such as the AS/NZS 60335 series for electrical compliance, and AS 4343 for pressure equipment compliance where design and plant registration is required.

Compliance with these outcome-orientated safety criteria is mandatory for the sale, installation, modification or repair of the equipment. Compliance is demonstrated by an approved laboratory test report and independent certification. In practice, this means that a legal conversion of individual appliances from a non-flammable to a flammable refrigerant might not be technically or economically feasible. For household air conditioners, the referenced appliance safety standard AS/NZS 60335.2.40 specifies a range of additional compliance tests where a flammable refrigerant is used. These tests can only be carried out under controlled laboratory conditions; full compliance with AS/NZS 60335.2.40 cannot be determined by inspection alone.

Conversion of a system to flammable refrigerants should not be carried out unless the modifier possesses:

- ✔ Competence in the design of refrigerating equipment (competence to carry out routine service and maintenance alone is usually insufficient)
- ✔ Knowledge of the additional or changed legal requirements that might be engaged as a result of using flammable refrigerants in the particular application
- ✔ The competence to recognise when additional engineering controls are necessary and how to implement them
- ✔ Knowledge of the electrical safety standards applicable to the system.

As with any modification that deviates from the original manufacturer's instructions, the modifier is responsible for continued compliance with legislation and is obliged to inform the end-user and/or owner of the system of any considerations, e.g. health and safety, changes to operating procedures.

National Association of Testing Authorities (NATA)-accredited test facilities exist for the independent testing of new or modified refrigeration and air conditioning equipment. This is one pathway for demonstrating compliance to the relevant standards and legislation. Depending on the system other specialists might also be needed, e.g. for large systems and hazardous area assessments.

1.6.4 Meanings of key terms

Many alternative terms with alternative definitions are used by different sectors of industry. For the purposes of this guide, the following meanings apply:

A person conducting a business or undertaking (PCBU) can be a PCBU whether they are in business alone or with others (e.g. partnerships, joint ventures and unincorporated associations) and whether the business is for profit or not for profit. Persons include individuals and bodies corporate; it is a broad concept used to capture all types of modern working arrangements.

The phrase "business or undertaking" is intended to be read broadly and covers businesses or undertakings conducted by people including employers, principal contractors, head contractors, franchisors and the Crown.

Under the terms of the *Work Health and Safety Act 2011* and regulations, and in the context of a refrigeration and air conditioning system, a PCBU with a duty of care could include the following:

- The person responsible for operating the system
- The person responsible for servicing or maintaining a system
- A person installing a system or part of a system
- A person supplying a system or part of a system
- A person designing or manufacturing a system or part of a system.

Competent person is a person who has acquired through training, qualification or experience the knowledge and skills to carry out the task.

Conversion is the term used when changing a system from one refrigerant to another, where the new refrigerant has a higher flammability or toxicity refrigerant safety group classification than the original refrigerant, and where modifications to the system and/or the surroundings are necessary to achieve regulatory compliance (e.g. change of electrical contacts, thermal overloads and similar).

Drop-in is the term used when changing from one refrigerant to another, where the new refrigerant has the same flammability and toxicity refrigerant safety group classification as the original refrigerant, and only minor adjustments to the system are necessary to achieve the required performance (e.g. adjustment of the thermostatic expansion valve superheat).

Flammable refrigerant is any refrigerant with a flammability classification of Class 2L, Class 2 or Class 3 in accordance with AS/NZS ISO 817.

Lower flammability limit (LFL) is the minimum concentration of the refrigerant that is capable of propagating a flame through a homogeneous mixture of refrigerant and air measured at 23°C and 101kPa.

Major components and sub-assemblies means equipment including compressors, air/water cooled condensers, liquid receivers, chilled and heated water heat exchangers, evaporators and air/water cooled condensing units.

Maximum allowable pressure (PS) is the maximum pressure which a system or component is designed for, as specified by the designer in accordance with AS/NZS 5149.2.

Must when used for a provision, indicate a mandatory requirement that exists under applicable legislation, regulation or referred standards.

Non-flammable refrigerant is any refrigerant with a flammability classification of Class 1 (no flame propagation) in accordance with AS/NZS ISO 817.

Practical limit for any refrigerant, is the limit of refrigerant charge in kilograms per metre cubed of the space served and as specified by AS/NZS 5149.2. It is the concentration used for simplified calculation to determine the maximum acceptable amount of refrigerant in an occupied space. Refrigerant concentration limit (RCL) is determined by toxicity or flammability tests, but practical limit is derived from the RCL or historically established charge limits.

Primary duty of care is a legal obligation imposed on an individual or company requiring that they exercise a reasonable standard of care while performing any acts that could foreseeably harm others.

Duty of care may be considered a formalisation of the implicit responsibilities held by an individual towards another individual within society. Duty of care statements can be found in each jurisdiction's (Commonwealth/state/territory) current Work Health and Safety or Occupational Health and Safety Acts.

The *Model Work Health and Safety Act* can be found at: www.safeworkaustralia.gov.au.

Qualification means evidence of a certain level of training, professional knowledge, skill and experience. Nationally recognised vocational education and training Australian Qualifications Framework (AQF) qualifications are provided through endorsed training packages and accredited courses containing units of competency.

RACHP equipment (refrigeration, air conditioning and heat pump equipment) is equipment used for cooling or heating of anything and that uses a refrigerant.

Referenced standard A standard referenced in legislation or regulation, thereby making compliance mandatory within the scope of that particular law and reference.

Note: When standards are published, compliance is normally voluntary. When compliance with a standard, or part of a standard, is required by an act or regulation, compliance becomes mandatory. Standards are also regularly referred to as compliance pathways in outcome-based regulations. In these cases, regulatory compliance is achieved by demonstrating compliance with the relevant referenced standards.

Refrigerant classification is the AS/NZS ISO 817 system of classifying refrigerants into safety groups according to health and safety risks assessed on the basis of flammability and toxicity (refer Clause 3.2). The safety group classification system is used when designing equipment, determining maximum refrigerant charge sizes and defining the applications and locations that they can be used in.

Refrigerant concentration limit (RCL) is the maximum refrigerant concentration, in air, determined and established in accordance with AS/NZS ISO 817, to reduce the risks of acute toxicity, asphyxiation and flammability hazards.

Scheduled refrigerant is a refrigerant containing a substance with an ozone depletion potential and/or a global warming potential that is listed under Schedule 1 of the *Ozone Protection and Synthetic Greenhouse Gas Management Act 1989*. These are generally fluorinated synthetic chemicals including CFCs, HCFCs and HFCs, but not HFO.

Units of competency are nationally agreed statements of the skills and knowledge required for effective performance in a particular job or job function.

Upper flammability limit (UFL) is the maximum concentration of the refrigerant that is capable of propagating a flame through a homogeneous mixture of refrigerant and air measured at 23°C and 101kPa.

2. LEGISLATIVE FRAMEWORK

2.1 General

This section provides an overview of the regulations, codes and standards that apply to flammable refrigerants.

Laws and regulations, standards, codes, guidelines and certification schemes are continuously under review and are revised and updated from time to time. For example, Australian standards are amended and revised over time and interpretations or amendments are occasionally issued by Standards Australia. Users of this guide must have the latest updates available and be aware of all relevant changes they contain. New and amended regulations also often have a "bedding in" period, so the date of enforcement of a regulation is an important aspect to consider.

At the time of publication, the information in this section was considered to be both current and accurate. Users of this guide must ensure they check all of the information provided, particularly in regard to regulations and Australian Standards for any updates, changes or amendments.

2.2 Acts and regulations

An act sets out general duties of care applying to employers, employees, self-employed persons, occupiers, designers, manufacturers, importers and suppliers. An act enables regulations to be made in relation to the safety, health and welfare of people at work.

An act will usually contain a specific power for a minister to make regulations to outline the basic administrative requirements not specifically outlined in the act. Regulations set out specific duties and the detail of what is required to comply with the corresponding act. More detail is sometimes provided for specific situations and settings in referenced standards or codes of practice. Industry guides, fact sheets and online tools provide additional compliance information.

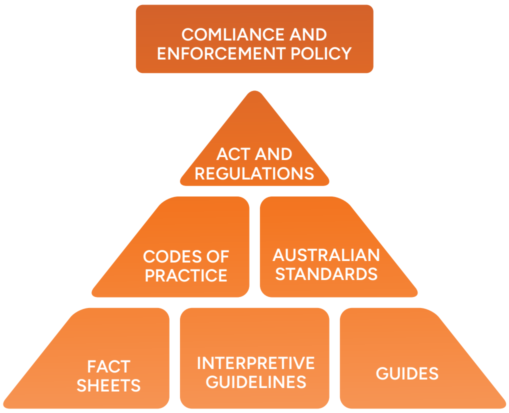


Figure 2.1 Information hierarchy

There are a wide range of laws and other instruments that regulate flammable refrigerants in Australia and there is no single legal framework or act that governs their use. Instead, flammable refrigerants are regulated by a range of acts, primarily related to WHS/OHS, electrical safety, dangerous goods, and environmental impact. While there is a significant amount of consistency in the applicable laws around the country, there are also significant variations between jurisdictions and circumstances (e.g. refrigerant storage or transport or use).

For an overview of the regulatory and quasi-regulatory instruments that control the use and handling of flammable refrigerants in the different Australian jurisdictions refer to Refrigerants-Australia-Final-Report-16-December-2020.pdf

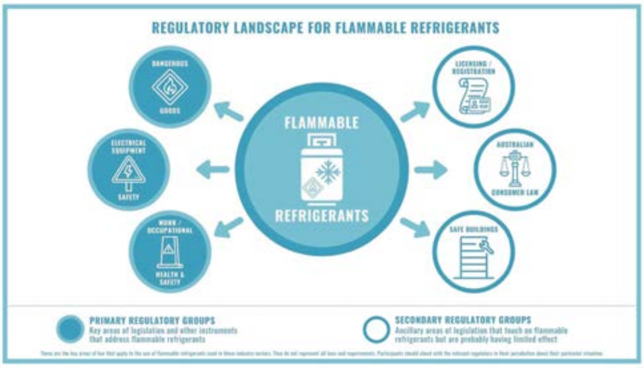


Figure 2.2 Overview of the regulatory landscape for flammable refrigerants

2.3 WHS/OH&S legislation

2.3.1 General duties

All states and territories have adopted harmonised work health and safety (WHS) legislation, except for Victoria which has retained its own occupational health and safety (OH&S) legislation.

WHS/OH&S regulations specify duties to ensure that any identified safety risk has been eliminated or minimised so far as is reasonably practicable. The term "reasonably practicable" means what is reasonably able to be done, taking into account and weighing up all matters including:

- The likelihood of the hazard or the risk occurring
- The degree of harm that might result from the hazard or the risk
- What the person concerned knows, or ought reasonably to know, about the risk and ways to eliminate it
- The availability and suitability of ways to mitigate (eliminate or minimise) the risk
- The cost associated with mitigating the risk, including whether the cost is proportionate to the risk.

2.3.2 Position on flammable refrigerant

The Heads of Workplace Safety Authorities (HWSA) produced a Flammable refrigerant gases – position paper that provides information on the obligations of work health and safety duty holders with respect to the use of flammable refrigerant gases at workplaces. Duty holders identified in the paper include:

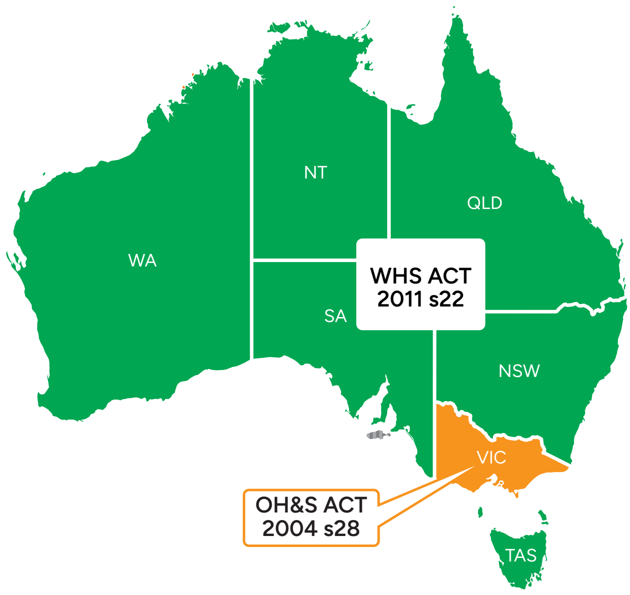
- Manufacturers, importers and suppliers of refrigerants and refrigeration equipment
- Designers, installers and maintainers of equipment and systems
- PCBU, employers and people with management or control of workplaces
- People involved in the storage and reclamation or disposal of refrigerants.

Some of the essential duties identified in the paper include:

- Classification of the refrigerant must be in accordance with the Globally Harmonized System (GHS) and a compliant safety data sheet (SDS) and label must be used
- For transport, compliance with the Australian Dangerous Goods (ADG) Code is required
- Any installation, operation and maintenance risks associated with the system must be eliminated, so far as is reasonably practicable
- Relevant standards (such as AS/NZS 5149 series or AS/NZS 60335.2 series) should be adhered to, for measures to prevent the release of refrigerants and other controls
- Any flammability hazards and risks and any other hazards or risks associated with the refrigerant must be controlled
- Duty holders must have relevant experience and training and ensure that only competent workers work on refrigerating and air conditioning systems containing flammable refrigerants
- The refrigerant gas quantity (charge size) must be appropriate and refrigerants can be odourised to aid in their detection
- Refrigerant detection equipment, where required, must be installed in compliance with AS/NZS 5149 or IEC TS 63542 (as applicable)
- Information should be provided on:
  - All refrigerants that are compatible with the system
  - Any hazardous area classification associated with the system (refer to AS/NZS 60079.10.1)
  - The safe use and maintenance of the system (refer to AS/NZS 5149 and AS/NZS 60335 series)
- Refrigeration systems must include labelling or signage specifying the refrigerant used and any hazards.

The compatibility of any alternative refrigerant with the system must be assessed and documented by a competent person before any substitution. A person changing a refrigerant to a more flammable refrigerant takes on a role similar to that of a designer of a refrigeration system.

Click on the links in *Figure 2.3* for individual state and territory regulator positions and information on flammable refrigerants.



NSW	NT	SA	QLD
TAS	VIC	WA	Commonwealth

Figure 2.3 WHS/OH&S regulator positions

2.3.3 The GHS – Globally Harmonized System

The Globally Harmonized System of Classification and Labelling of Chemicals (GHS) is an internationally agreed system that sets criteria for the classification of chemical hazards and offers protective measures through labels and safety data sheets (SDS). Australian WHS/OH&S regulations have transitioned to the seventh revised edition of the GHS (GHS 7).

Classification

Classification is a process used to determine if a chemical can cause harm to human health or safety. It involves the identification and evaluation of the physical properties of a chemical, along with its health effects. It is the classification of a hazardous chemical that determines what information is communicated on the label and the SDS.

Note: The GHS flammable gas classification system is different from the AS/NZS ISO 817 flammable refrigerant classification system that is used in refrigerating system design.

For the purposes of GHS classification, a Class 2 flammable gas is defined as a gas having a flammable range with air at 20°C and a standard pressure of 101.3kPa. Category 1A flammable gases are categorised as H220 Extremely Flammable Gas. Category 1B flammable gases are categorised as H221 Flammable Gas. The same pictograms and signal word is used for these gases, *see Figure 2.4*, but the hazard statements and prevention precautionary statements are different.

Category 1A are gases that at 20°C and a standard pressure of 101.3 kPa:

- Are ignitable when in a mixture of 13% or less by volume in air, or
- Have a flammable range with air of at least 12 percentage points regardless of the LFL unless data show they meet the criteria for Category 1B.

Category 1A also includes pyrophoric gases and chemically unstable gases, which are not typically relevant to refrigerants.

Category 1B are gases that meet the flammability criteria for Category 1A, but are not pyrophoric, nor chemically unstable, and have at least either:

- An LFL of more than 6% by volume in air, or
- A fundamental burning velocity of less than 10 cm/s.

Feature	GHS Class 2 Category 1A	GHS Class 2 Category 1B
Hazard level	Higher hazard	Lower hazard
Chemical stability	May be chemically unstable or pyrophoric	Must not be chemically unstable or pyrophoric
Lower flammable limit (LFL)	Can have an LFL of 13% or less in air	Must have an LFL of more than 6% in air
Fundamental burning velocity	Can have a burning velocity of 10cm/s or greater	Must have a burning velocity of less than 10cm/s

Table 2.1 GHS classification – Class 2 flammable gas

GHS Class 2 Category 2 flammable gases are exempt from classification under WHS regulations.

Information

The GHS establishes requirements for harmonised communication by standardising:

- Pictograms for nine physical, health and environmental hazards, e.g. GHS02 Flammable gas, GHS04 Gas under pressure
- Signal words for hazards – either **Danger** or **Warning**
- Hazard statements and codes to describe the nature of the hazard e.g. H221 Flammable gas.

Note: GHS labelling requirements do not apply to the marking of individual appliances and systems within scope of AS/NZS 60335.2 series and AS/NZS 5149 series that are marked with the ISO Flammable material symbol, see Section 7.

Classification		Labelling			
Hazard		Pictogram code(1)	Signal word	Hazard statement	
Class	Category			Code(1)	Text
Flammable gases(2)	Category 1A	 GHS02	Danger	H220	Extremely flammable gas
	Pyrophoric gas			H232	May ignite spontaneously if exposed to air
	Chemically unstable gas A			H230	May react explosively even in the absence of air
	Chemically unstable gas B			H231	May react explosively even in the absence of air at elevated pressure and or temperature
	Category 1B			H221	Flammable gas

(1)The code for the Pictogram and Hazard statement should not be included on the label.
(2)Pyrophoric and Chemically unstable gases must always be classified as flammable gases Category 1A in addition to these hazard categories

Figure 2.4 GHS Classification and labelling – Flammable gases

Flammable gases in cylinders also need to display the pictogram code, warning and hazard statements for gases under pressure, *see Figure 2.5*.

Classification		Labelling			
Hazard		Pictogram code(1)	Signal word	Hazard statement	
Class	Group(2)			Code*	Text
Gases under pressure(2)	Compressed gas	 GHS04	Warning	H280	Contains gas under pressure; may explode if heated
	Liquefied gas				
	Dissolved gas			H281	Contains refrigerated gas; may cause cryogenic burns or injury.
	Refrigerated liquefied gas				

(1)The code for the Pictogram and Hazard statement should not be included on the label.
(2)The hazard class "Gases under pressure" is subdivided into 'Groups' (not 'Categories')

Figure 2.5 GHS Classification and labelling – Gases under pressure

Where there is an equivalent ADG dangerous goods pictogram available, that is an acceptable alternative to a GHS pictogram.

SDS are used to provide more detailed hazard and use information to professional users of chemicals. The GHS gives guidance on how to prepare the SDS. The SDS should not contradict information on the label.

Safety data sheets (SDS)

SDS are the main tool for ensuring that manufacturers and importers communicate enough information along the supply chain to allow safe use of their substances and mixtures. SDS must be prepared in accordance with the GHS and include information about the properties of the substance, its hazards, instructions for handling, disposal and transport, and also first-aid, fire-fighting and exposure control measures.

> **Note**: SDS were previously called material safety data sheets (MSDS) or product safety data sheets (PSDS).

SDS must be made available at a site where flammable refrigerants are stored or handled. These SDS must be current and supplied with an expiry date. The correct SDS for the actual refrigerant that is used must be available, as it contains important information including personal protective equipment (PPE) and first aid chemical safety information.

The manufacturer or importer is responsible for the preparation and supply of the SDS, and for supplying it to any person who might be affected by the chemical, or to any person who requests it. SDS must be reviewed by the importer or manufacturer every five years.

2.4 Environmental legislation

2.4.1 Scheduled refrigerants

Certain refrigerants that have ozone depleting or global warming potential are scheduled substances under the Commonwealth's *Ozone Protection and Synthetic Greenhouse Gas Management Act 1989* (OPSGGM Act).

Regulations made under this act make provision for the following:

- Regulating the distribution, purchase, acquisition or disposal of scheduled refrigerants
- Regulating the storage, use or handling of scheduled refrigerants
- Regulating the recovery, recycling or destruction of scheduled refrigerants.

A person must not, except in limited circumstances, discharge a scheduled refrigerant if it is likely to enter the atmosphere. Any person who handles scheduled refrigerant, or carries out work on RACHP equipment containing or designed to contain scheduled refrigerant, must hold a national ARCtick Refrigerant Handling Licence (RHL).

Apprentices and other trainees working with scheduled refrigerant and equipment must hold a trainee licence and work under the supervision of a fully qualified licence holder. A person or company must also be appropriately authorised to acquire, possess, or dispose of bulk scheduled refrigerant by holding a Refrigerant Trading Authorisation (RTA).

The use of refrigerants other than those scheduled in the Commonwealth legislation, such as HFOs or natural refrigerants (hydrocarbon, ammonia, CO_2), does not require an ARCtick RHL or RTA.

2.4.2 HFC phase-down

The OPSGGM Act 1989 was amended in June 2017 to introduce a phase-down of HFC imports from January 1, 2018. The phase-down targets refrigerants with high GWP and applies to all HFCs covered by the Montreal Protocol, including refrigerant blends containing those HFCs. Hydrofluoroolefins (HFOs) are not included in the phase-down unless a HFC is part of a HFO blend.

As part of the regulations, certain air conditioning equipment with a refrigerant charge of 2.6kg or less and designed to use a refrigerant with a GWP over 750 are banned from manufacture and import. Also, refrigeration and air conditioning equipment cannot be charged with a higher GWP refrigerant than the design refrigerant.

2.4.3 ARCtick licensing

The ARCtick Refrigeration and Air Conditioning (RAC) permit scheme is the national licensing scheme for scheduled refrigerants administered on behalf of the Commonwealth Government by the Australian Refrigeration Council (ARC). A Refrigerant Trading Authorisation (RTA) is required when a business or individual wishes to acquire, possess or dispose of a scheduled CFC, HCFC or HFC, refrigerant or a refrigerant blend containing a scheduled refrigerant. An RTA is subject to conditions and auditing processes designed to minimise the risk of emissions while the refrigerant is in the business or individual's possession.

Anyone wanting to install, service, repair or decommission an air conditioner, or any other piece of refrigeration and air conditioning equipment containing or designed to contain a scheduled refrigerant must be a licensed technician under the OPSGGM Regulations. The holder of a Refrigerant Handling Licence (RHL) is an individual who is qualified in their field of activity and has met the licensing requirements under the regulations.

A current RHL is required when converting a system containing scheduled refrigerant to a non-scheduled flammable refrigerant.

An ARCtick licence is not required for the purchase or use of non-scheduled flammable refrigerants, including hydrocarbons and HFO refrigerants. The voluntary ARC Green Scheme Accreditation program incorporates key refrigerants not covered by the current ARCtick licence scheme, such as hydrocarbons, carbon dioxide (R744), ammonia (R717) and HFOs.

For further information on ARCtick licensing visit the Australian Refrigeration Council: www.arctick.org

A condition of the ARCtick licence is the commitment to follow the Australian and New Zealand Refrigerant Handling Code of Practice (Parts 1 and 2 as applicable). Codes of Practice | ARC Industry Site

2.5 Electrical safety regulations

2.5.1 Electrical equipment safety

All states and territories have a regulatory framework aimed at increasing consumer safety when interacting with household electrical equipment. Regulations prescribe the minimum standards of safety for electrical equipment. AS/NZS 3820 is called up in all electrical regulations, and this standard prescribes outcome-orientated safety criteria for electrical equipment.

The AS/NZS 60335 series of standards is listed in Appendix B of AS/NZS 3820 as being representative of suitable product safety standards. AS/NZS 60335 product standards provide measurable criteria, and compliance with the AS/NZS 3820 safety criteria can generally be achieved by demonstrating compliance with the relevant specific AS/NZS 60335.2 product standards. The AS/NZS 3100 standard is applicable to electrical equipment used in a variety of settings but does not apply to appliances that are already covered by the AS/NZS 60335 series of standards.

An Inter-Governmental Agreement (IGA) on the governance of a harmonised Electrical Equipment Safety Scheme (EESS) has been signed by Queensland, Victoria, Western Australia and Tasmania. Other jurisdictions are currently progressing or considering implementation of the EESS. All suppliers of "in scope" electrical equipment must register as responsible suppliers on the EESS database and make a declaration that the electrical equipment offered for supply is electrically safe and complies with the relevant electrical safety standards. The EESS stipulates three levels of equipment types with different registration and certification requirements for each level, based upon the assessed risk of that equipment type.

Household air conditioners using an A2 or A3 refrigerant are classified as level 3 equipment and require a "Certificate of Conformity" from an accredited certification body to be lodged on the EESS before the air conditioner can be legally sold. Household air conditioners using an A2L or A1 refrigerant are classified as Level 2 equipment.

It is important to note that if a modification is made to an electrical product, such as the use of a different refrigerant during the recharging process, the person making the modification must take responsibility for the electrical safety of the appliance. For example, if a flammable refrigerant (A2L, A2 or A3) is used in an electrical product designed for a non-flammable refrigerant (A1), the electrical product might become non-compliant with the electrical safety product standard. As with any modification, the modifier is responsible for this non-compliance.

Electrical safety regulators would treat this level of modification as creating a new electrical appliance (i.e. the modifier has become the equipment manufacturer). For "in-scope" electrical equipment, this would require the modifier to be a registered responsible supplier; and if level 2 or level 3 equipment, to register the equipment; and to have:

- Certification if level 3 equipment
- Compliance folder if level 2 equipment
- Evidence of compliance to relevant electrical safety standard if level 1 equipment.

Further information on electrical safety regulations and product compliance can be found at the ERAC website: www.erac.gov.au.

2.5.2 Electrical installation safety

In addition to the product electrical safety standards, the requirements of AS/NZS 3000 apply to all installations and to the detailed design of all systems.

Where the system falls under the scope of AS/NZS 3000, the person in control of the installation must ensure that any hazardous areas are assessed and classified in accordance with Clause 7.7 (which invokes the hazardous area classification standard AS/NZS 60079.10.1). As a guide, most large stationary systems using flammable refrigerants in most jurisdictions might need to comply with AS/NZS 60079.10.1 and AS/NZS 60079.14. The AS/NZS 60079 series of standards are not applied to domestic premises or systems, where the quantity of flammable gas is small, although small quantities in small spaces can still pose a hazard. The flammable refrigerant requirements specified in the AS/NZS 60335 series are intended to prevent a hazardous area greater than "negligible extent" from occurring.

For electrical equipment associated with hazardous areas, the equipment must normally be certified according to the IECEx scheme (International Electrotechnical Commission System for Certification to Standards Relating to Equipment for Use in Explosive Atmospheres). However, alternative options are provided for where IECEx certified equipment is not available, see AS/NZS 60079.14.

Hazardous area installations in Victoria and Queensland are also subject to mandatory inspections by licensed or accredited auditors before initial energisation.

2.6 Transport of dangerous goods

When transporting dangerous goods, it is a requirement to comply with the Australian Dangerous Goods (ADG) Code and relevant state and territory dangerous goods transport regulations for road and rail. The ADG Code sets out the rules for safely transporting dangerous goods, including how to classify dangerous goods and how they should be packed, labelled and documented.

Dangerous goods are substances and articles listed in the ADG Code that have explosive, flammable, toxic, infectious or corrosive properties. For the purposes of the regulations, a flammable refrigerant is a dangerous good if its flammability properties fall within the criteria for Class 2 (Gases) Division 2.1 (Flammable gases) GHS Category 1A or 1B (i.e. Class 2.1A or Class 2.1B), see Section 9.

The ADG Code is consistent with the "UN Recommendations on the Transport of Dangerous Goods - Model Regulations", which is used by many countries as the basis for their road and rail dangerous goods transport codes. The UN recommendations are also internationally accepted as the principal technical standards underpinning the air and sea dangerous goods transport codes.

Each state and territory implements the updated ADG Code and updates their transport regulations separately. The ADG Code is updated every two years, with a one-year transition period for each edition. The Australian Dangerous Goods Code (edition 7.9, 2024) has been compulsory from October 1, 2025. The ADG Code is published by the National Transport Commission.

Australian Dangerous Goods Code | National Transport Commission

2.7 Queensland legislation for hydrocarbon refrigerants

2.7.1 Licensing and approvals

In Queensland, the use of hydrocarbon refrigerants is regulated under the Petroleum and Gas (Production and Safety) Act 2004. This includes approval of the RACHP device and licence to undertake gas work on the device.

- A device that uses hydrocarbon refrigerants is a Type B gas device and is required to be approved before it is sold, installed or used. An appliance such as a refrigerator or an air conditioner that uses A3 hydrocarbon refrigerants e.g. R600a, must be approved by a recognised Type B approving authority or the Chief Inspector Petroleum and Gas, before it is sold, installed or used in Queensland.
- Anyone installing, removing, altering, repairing, servicing, testing or certifying the gas system of a device (i.e. charging, discharging or breaking into the refrigeration system that uses hydrocarbon refrigerants) must hold a Gas Work Licence (Hydrocarbon Refrigerants).

Full details of how to make an application for a licence are provided in the Apply for a new gas work licence or authorisation, online portal. Guidelines on the use of hydrocarbon refrigerants (guidelines) are also provided.

2.7.2 Unodourised flammable refrigerants

In Queensland, Section 628 of the *Petroleum and Gas (Production and Safety) Act 2004* requires that fuel gas must be odourised unless the supply is to an industrial installation with appropriate gas detectors and shut-down systems, and a risk analysis has been carried out by an appropriately qualified person showing the supply is safe. The term "appropriately qualified person" is defined in Section 628 as being a person who is independent of the person supplying the fuel gas; and the chief inspector considers:

- Is appropriately qualified, and
- Has access to information to carry out the risk analysis.

A number of organisations have submitted evidence to the Chief Inspector and are currently considered by the Chief Inspector to be appropriately qualified persons. Others who wish to qualify as an "appropriately qualified person" should submit relevant evidence for the Chief Inspector's consideration.

Guidelines for the use of unodourised gas (guidelines) are provided to assist those conducting risk analyses or organisations wishing to use unodourised refrigerant in meeting risk criteria.

2.8 Australian standards

Standards Australia develops Australian standards through an open process of consultation and consensus. Committees of experts from industry, government, consumers and other interests prepare standards that reflect the latest scientific and industry experience. Australian standards are kept under continuous review after publication and are updated regularly.

Standards play an important role in helping PCBUs, as well as designers, manufacturers and installers of plant to discharge their safety duties under the WHS/OHS legislation. While this guide is limited to fundamental safety requirements and does not provide detailed design guidance, such guidance can be found in relevant Australian standards. Referring to Australian standards will further assist duty holders to gain knowledge about a hazard or risk, and any ways to eliminate or control the risks of flammable refrigerants so far as is reasonably practicable.

This section provides a list of the main Australian standards that apply to flammable refrigerants, including standards on refrigeration, handling, storage, electrical safety and explosive atmospheres. In all cases, the latest edition of the standard (including any amendments) should be applied.

2.8.1 Refrigeration-related standards

- AS/NZS ISO 817 – Refrigerants – Designation and safety classification
- AS/NZS 5149 Refrigerating systems and heat pumps – Safety and environmental requirements
- AS/NZS 5149.1 – Part 1: Definitions, classification and selection criteria
- AS/NZS 5149.2 – Part 2: Design, construction, testing, marking and documentation
- AS/NZS 5149.3 – Part 3: Installation site
- AS/NZS 5149.4 – Part 4: Operation, maintenance, repair and recovery.

2.8.2 Handling and storage standards

- AS 1216 – Class labels for dangerous goods
- AS/NZS 1596 – The storage and handling of LP Gas
- AS 2030.1 – Gas cylinders Part 1: General requirements
- AS 2030.5 – Gas cylinders Part 5: Filling, inspection and testing of refillable cylinders

- AS 4332 – The storage and handling of gases in cylinders
- AS 4484 – Gas cylinders for industrial, scientific, medical and refrigerant use – Labelling and colour coding.

2.8.3 Product safety standards

- AS/NZS 60335 – Household and similar electrical appliances – Safety
- AS/NZS 60335.2.11 – Particular requirements for tumble dryers
- AS/NZS 60335.2.24 – Particular requirements for refrigerating appliances, ice-cream appliances and ice makers
- AS/NZS 60335.2.34 – Particular requirements for motor compressors
- AS/NZS60335.2.40 – Particular requirements for electrical heat pumps, air-conditioners and dehumidifiers
- AS/NZS 60335.2.75 – Particular requirements for commercial dispensing appliances and vending machines
- AS/NZS 60335.2.89 – Particular requirements for commercial refrigerating appliances with an incorporated or remote refrigerant condensing unit or compressor.

2.8.4 Pressure equipment standards

- AS 4343 – Pressure equipment – Hazard levels.

2.8.5 Electrical-related standards

- AS/NZS 3000 – Electrical installations (known as the Australian/New Zealand Wiring Rules)
- AS/NZS 3100 – Approval and test specification – General requirements for electrical equipment
- AS/NZS 3820 – Essential safety requirements for electrical equipment
- AS/NZS 4761.1 – Competencies for working with electrical equipment for hazardous areas (EEHA) – Competency Standards
- AS/NZS 60079.10.1 – Explosive Atmospheres – Classification of Areas – Explosive gas atmospheres
- AS/NZS 60079.13 – Explosive atmospheres – Equipment protection by pressurized room ‘p’ and artificially ventilated room “v”
- AS/NZS 60079.14 – Explosive atmospheres – Electrical installations design, selection and erection
- AS/NZS 60079.17 – Explosive atmospheres – Electrical Installations inspection and maintenance
- AS/NZS 60079.29.2 – Explosive atmospheres – Gas detectors – Selection, installation, use and maintenance of detectors for flammable gases and oxygen.

For further information on Australian standards visit the Standards Australia website: Explore Standards | Standards Australia Store

2.9 Codes of practice

2.9.1 Environmental COP

Under environmental legislation, any person who carries out work including the manufacturing, installation, servicing, modifying, or dismantling of any RACHP equipment that contains, will be charged with, or will be manufactured incorporating, any scheduled refrigerant, must ensure that they and/or any of their employees who handle scheduled refrigerant are provided with a copy of the Australian and New Zealand Refrigerant Handling Code of Practice (Parts 1 and 2 as applicable) and work to the standards it sets out.

Codes of Practice | ARC Industry Site

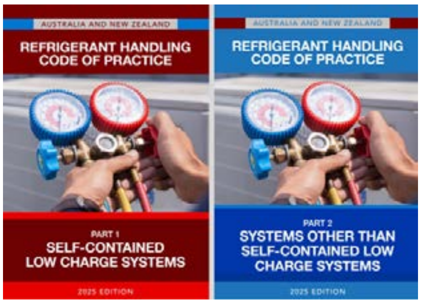


Figure 2.6 AS/NZ RHCOP Parts 1 and 2 2025

2.9.2 Health and safety COP

Under WHS legislation, a code of practice applies to anyone who has a duty of care in the circumstances described in the code. In most cases, following an approved code of practice would achieve compliance with the health and safety duties in the WHS Act, in relation to the subject matter of the code. Like regulations, codes of practice deal with particular issues and do not cover all hazards or risks that might arise. The health and safety duties require duty holders to consider all risks associated with work, not only those for which regulations and codes of practice exist.

Codes of practice are admissible in court proceedings under the WHS Act and Regulations. Courts can regard a code of practice as evidence of what is known about a hazard, risk or control and might rely on the code in determining what is reasonably practicable in the circumstances to which the code relates.

Compliance with the WHS Act and Regulations can be achieved by following another method, such as a technical or an industry standard, if it provides an equivalent or higher standard of work health and safety than the code.

An inspector can refer to an approved code of practice when issuing an improvement or prohibition notice.

For further information on the codes of practice that have been approved by SafeWork Australia go to [Model Codes of Practice.](#)

Figure 2.7 Some SafeWork Australia - model codes of practice

3. CLASSIFICATION AND APPLICATION OF FLAMMABLE REFRIGERANTS

3.1 AS/NZS ISO 817 safety group classification

Flammable refrigerants are classified differently depending on the context. This section is relevant to flammable refrigerants in an RACHP system and the immediate vicinity. For other contexts, such as transport and storage, flammable refrigerants are classified according to the ADG Code and the GHS (see Sections 9 and 10).

AS/NZS ISO 817 classifies refrigerants into safety groups according to their flammability and toxicity. Lower toxicity refrigerants are prefixed A, while higher toxicity refrigerants are prefixed B. The prefixes are followed by a number indicating increasing flammability: 1, 2L, 2, or 3.

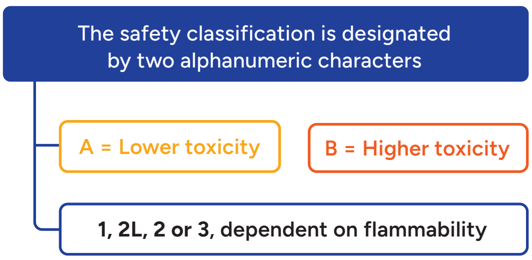


Figure 3.1 AS/NZS ISO 817 alpha numeric safety group classification

With two levels of toxicity and four levels of flammability, there are eight separate refrigerant safety group classifications defined in AS/NZS ISO 817.

A3	B3	Higher Flammability
A2	B2	Flammable
A2L	B2L	Lower Flammable
A1	B1	No Flame Propagation
Lower Toxicity	Higher Toxicity	

Figure 3.2 The eight refrigerant safety group classifications of AS/NZS ISO 817

Refrigerants are designated R numbers through AS/NZS ISO 817 (and ASHRAE 34) which establishes a simple means of referring to common refrigerants rather than by their chemical name, formula, or trade name. For pure compounds, the numbers are based on chemical formula; for blends, the numbers are assigned sequentially.

Table 3.1 provides the safety classification and designated R numbers of some common refrigerants.

Safety group[1]	Typical refrigerants
A1	R134a, R404A, R410A, R407C, R449A, R513A, R744 (CO_2), R1233zd(E)
A2L	R32, R143a, R444A, R454B, R454C, R1234yf, R1234ze(E)[2]
A2	R152a, R419B, R439A, R440A, R512A
A3	R170 (ethane), R290 (propane), R600a (isobutane), R1270 (propylene)
B1	R245fa, R514A
B2L	R717 (ammonia)

Note 1: B2 and B3 refrigerants are currently uncommon.

Note 2: R1234ze(E) is classed as a mildly flammable A2L refrigerant by AS/NZS ISO 817 but is classed as a non-flammable gas by the Australian Dangerous Goods code (ADG) and the GHS.

Table 3.1 Safety group classification and designated R numbers

AS/NZS ISO 817 does not include some refrigerants that have come to market after its publication. However, the ISO version of 817 is regularly updated by an ISO maintenance agency and the revised refrigerant tables are published at ISO Standards Maintenance Portal 817. Where there is doubt about which safety group a refrigerant is classified in, it must be classified in the safety group requiring the most stringent precautions.

The application of the AS/NZS ISO 817 refrigerant classification system is based on the presumption that:

- Refrigeration system or appliance safety standards are applied to prevent the decomposition or ignition of refrigerants, and
- Refrigerant handling standards are applied to prevent more general exposure to refrigerant.

3.2 AS/NZS ISO 817 classification criteria

3.2.1 Toxicity classification

Refrigerants are assigned to one of two classes, A or B, based on the following exposure:

- **Class A** (lower chronic toxicity) signifies refrigerants that have a mortality toxic concentration factor (TCF) ≥ 2,500ppm and a cardiac sensitisation TCF, central nervous system TCF or permanent injury TCF ≥ 10,000ppm, and an occupational exposure limit ≥ 150ppm.
- **Class B** (higher chronic toxicity) signifies refrigerants that do not meet the criteria for Class A.

3.2.2 Flammability classification

Refrigerants are assigned to one of four flammability classes - 1, 2L, 2 or 3 - based on the flammability potential, the probability of ignition and the potential impact of ignition, *see Figure 3.3*.

Flammability potential is determined based on LFL.

The probability of ignition is determined based on:

- Autoignition temperature, and
- Minimum ignition energy.

The impact or damage potential (severity) of an ignition is determined based on:

- Heat of combustion, and
- Burning velocity.

Class 1 (no flame propagation)

Single compound refrigerants or refrigerant blends that do not exhibit flame propagation when tested in air at 60°C and 101.3kPa.

Examples: R22, R134a, R404A, R410A, R744.

Class 2L (lower flammability)

Single compound refrigerants or refrigerant blends that meet all the following conditions:

- Exhibit flame propagation when tested at 60°C and 101.3kPa
- Have an LFL > 3.5% by volume
- Have a heat of combustion < 19,000kJ/kg
- Have a maximum burning velocity of < 10cm/s when tested at 23°C and 101.3kPa.

Examples: R32, R1234yf, R1234ze, R717.

Class 2 (flammable)

Single compound refrigerants or refrigerant blends that meet all the following conditions:

- Exhibit flame propagation when tested at 60°C and 101.3kPa
- Have an LFL > 3.5% by volume
- Have a heat of combustion < 19,000kJ/kg.

Examples: R152a, R439A.

Class 3 (higher flammability)

Single compound refrigerants or refrigerant blends that meet all the following conditions:

- Exhibit flame propagation when tested at 60°C and 101.3kPa
- Have an LFL ≤ 3.5% by volume
- Have a heat of combustion that is ≥ 19,000kJ/kg.

Examples: R290, R600, R601, R1270.

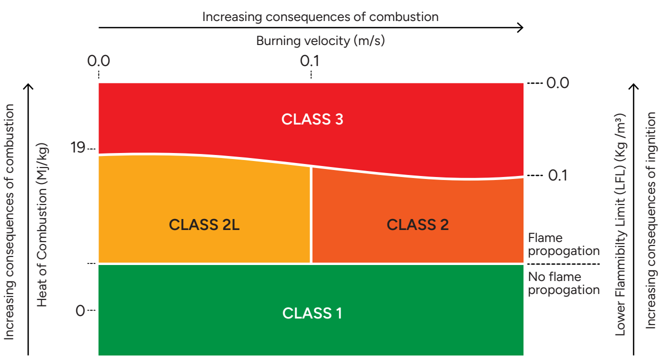


Figure 3.3 AS/NZS ISO 817 flammability classification

3.2.3 Classification of mixtures

The safety classification system of AS/NZS ISO 817 does not consider the behaviour of lubricants or mixtures of refrigerants and oils/lubricants.

Refrigerant/oil/air mixtures at elevated pressures or temperatures can be flammable or explosive and air must not be allowed to mix with refrigerant, in systems or in cylinders.

3.2.4 Classification of decomposition products

The safety classification system of AS/NZS ISO 817 does not consider the toxicity of products of refrigerant combustion or decomposition, see Clause 4.8.

3.3 Flammable refrigerants

As noted above, under the AS/NZS ISO 817 system there are the six possible flammable refrigerant classifications: A2L A2, A3, B2L, B2, B3.

The three most common flammable refrigerant classifications encountered in refrigeration and air conditioning in Australia are A2L, A3, and B2L.

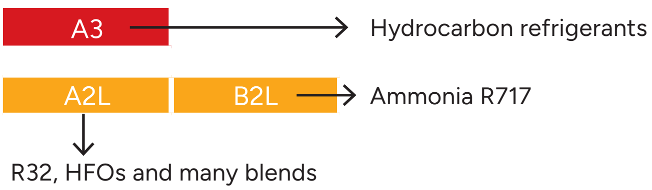


Figure 3.4 Three most commonly encountered flammable refrigerant safety groups

If there is any doubt as to the safety group classification to apply to a refrigerant not listed in AS/NZS ISO 817, the refrigerant should be treated as though it were an A3 refrigerant.

3.4 Flammability limits

A flammable refrigerant gas can only burn at concentrations between the lower flammability limit (LFL) and the upper flammability limit (UFL). The LFL is the minimum concentration of gas in air that is required for the product to become potentially combustible. Combustion is not possible at any concentration less than the LFL.

The UFL is the minimum concentration of gas in air above which combustion is not possible. The refrigerant cannot combust with air at any concentration greater than UFL. Concentrations between the LFL and UFL present the greatest probability of combustion.

LFL and UFL can be expressed as a concentration of kilograms of gas per metre cubed air (kg/m³) or as a percentage of air by volume.

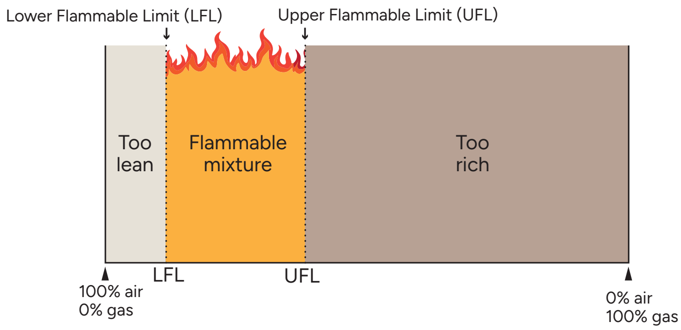


Figure 3.5 Lower and upper flammability limits

The combustion range between LFL and UFL increases with temperature until the temperature reaches autoignition temperature where the gas-air mixture spontaneously combusts, *see Figure 3.6* example for Propane.

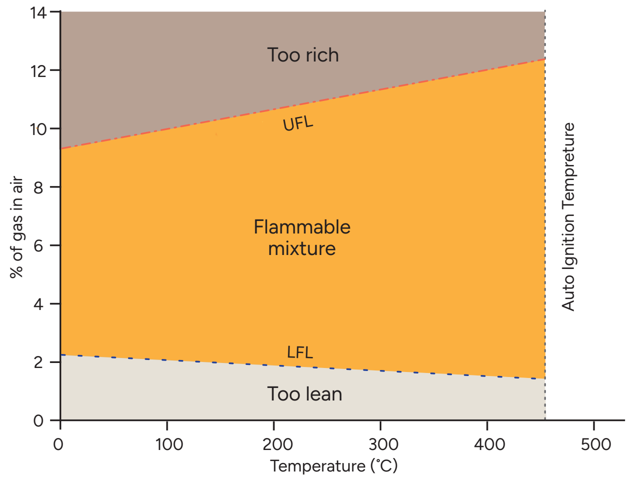


Figure 3.6 Example - Temperature effect on LFL and UFL – Propane

No flammable refrigerant (Class 2L, 2 or 3) will ignite if the concentration level in a room stays below their LFL.

Australian safety standards such as AS/NZS 5149 and the AS/NZS 60335 series define technical requirements to help ensure that rooms remain below the LFL in case of a refrigerant leakage. This is achieved primarily through refrigerant charge limits. If the charge could result in an atmosphere that reaches the LFL, control and mitigation measures need to be in place to reduce the likelihood of ignition.

3.5 Refrigerant concentration limit (RCL)

As part of the refrigerant classification and designation process, safety limits for each refrigerant are established (by test) for the respective risks:

- Toxicity exposure limit (acute toxicity, mortality and cardiac sensitization)
- Oxygen deprivation limit (ODL), and
- Lower flammability limit (LFL).

The lowest of these safety limits is adopted as the refrigerant concentration limit (RCL). This limit, in parts per million by volume, feeds into the safety standards for systems AS/NZS 5149 and AS/NZS 60335 series. The RCL for each refrigerant is listed in Tables 5, 6 and 7 from AS/NZS ISO 817 with a range of other data.

Refrigerant number	Composition designating prefix	Chemical name[b]	Relative molar mass[a] g/mol	Normal boiling point[a] C°	Safety group[d]	LFL (ppm by volume)	ATEL (ppm by volume)	RCL (ppm by volume)

Figure 3.7 Refrigerant data headings from Table 5 AS/NZS ISO 817

AS/NZS 5149 Parts 1 to 4 impose more stringent requirements as toxicity and flammability increase from A1 to B3. It also places restrictions on flammable A2L, A2 and A3 refrigerants that do not apply to A1 refrigerants.

One of the main restrictions imposed is the maximum charge of refrigerant allowed to be used in specific circumstances. For example, AS/NZS 5149.1 sets a charge limit (called the practical limit) on the amount of refrigerant permitted in a space.

3.6 Flammable refrigerant charge limits

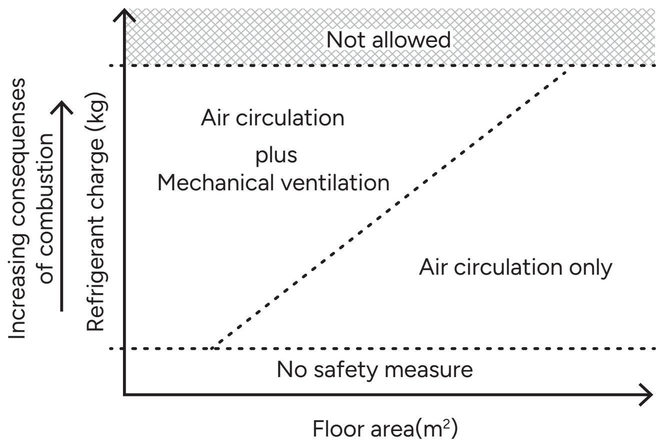
The charge limits for flammable refrigerants are restricted according to the level of hazard they pose to the occupants or people using the refrigeration equipment or in the surrounding area, see Section 4 of this guide. This level of hazard increases when the occupants:

- Are unskilled or untrained on the safety aspects of the equipment
- Are sleeping or incapacitated
- Might introduce an ignition source into an area which has potentially leaked flammable refrigerant.

Refrigerant charge limit is the maximum amount of refrigerant allowed in a product or system to reduce the hazards due to toxicity, asphyxiation and flammability. AS/NZS 60335 series contains charge limits for particular products, and AS/NZS 5149.1 Table A.2 contains charge limits 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.

Under AS/NZS 5149.1 the designer can choose (for some or all the occupied spaces served by equipment using A2L refrigerant) to calculate the allowable refrigerant charge using the RCL, QLMV (quantity limit with minimum ventilation) or QLAV (quantity limit with additional ventilation) values given in the standard, instead of the practical limit values provided. The maximum charge of refrigerant in a circuit can be modified to an allowable refrigerant charge by the application of ventilation (natural or mechanical), safety shut-off valves, and refrigerant detection and alarm in accordance with Annex A.



Note: Provisions are dependent on room height, unit height and LFL of installed refrigerant.

Figure 3.8 Modifying refrigerant charge by the application of ventilation or air circulation

Under AS/NZS 60355.2.40 the appliance design can be based on the releasable charge of flammable refrigerant for systems protected with shut-off valving designed to limit refrigerant release. Releasable charge is determined using the methods outlined in Annex QQ.

Annex GG outlines requirements for charge limits and adjustments for specified design provisions. Some of the relaxation provisions are specific to the refrigerant safety group (i.e. A2L, A2 or A3) and may include natural ventilation, mechanical ventilation, enhanced tightness refrigeration requirements and leak detection.

3.7 Unodourised flammable refrigerants

Fuel gases such as LPG (hydrocarbon gas) used in barbeques and the natural gas used in cooking and heating equipment must have an odourant added so that it can be smelled in the event of a leak and the area evacuated.

AS/NZS ISO 817 does not require A2L, A2 or A3 flammable refrigerant to be odourised. Many flammable refrigerants do not have odourant added or, if they do, materials and components used in the refrigeration or air conditioning system might absorb or react with the odourant over time, causing the strength of the odour to fade. This means that in the event of a leak the flammable refrigerant might not be smelled by people in the vicinity. This is one of the reasons maximum charge limits are applied to flammable refrigerants.

Some jurisdictions might not accept the use of unodourised flammable refrigerant. Queensland legislation requires the addition of odourant to A3 refrigerant in some circumstances. The use of unodourised gas imposes a considerable risk to the safety of personnel and public during transport to the site, system installation and ongoing maintenance interventions. Although refrigerant odourant can fade over time, the initial refrigerant charge and any refrigerant used for recharging should be odourised. Special arrangements need to be made for the handling, storage and transport of recovered refrigerant that has lost its odourant.

Note: Refer to Clause 2.7.2 for specific requirements relating to the use of unodourised hydrocarbon refrigerant in Queensland.

3.8 Safe application of flammable refrigerants

Hazardous area assessments might be required for flammable refrigerant systems, particularly for larger refrigerant charges. The flammable refrigerant requirements specified in AS/NZS 60335 series are intended to prevent a hazardous area greater than "negligible extent" from occurring. Hazardous area assessment is not normally applied to domestic appliances.

Safe application of flammable refrigerants includes ensuring that:

- The system has been specifically designed or converted for use with flammable refrigerants
- The area is well ventilated, and
- There are no ignition sources or hot surfaces close to the system (i.e. within a region where any refrigerant leak has not had sufficient opportunity to safely disperse).

For systems located below ground level or in poorly ventilated spaces, additional requirements and limitations apply due to the increased risk of pooling of the refrigerant.

The requirements for the safe use of flammable refrigerants contained in this guide are based primarily on those detailed in the applicable Part 2 standards of the AS/NZS 60335 series and AS/NZS 5149. These requirements outline, by a combination of maximum charge limitations, control of potential ignition sources, refrigerating system tightness and/or the provision of mechanical ventilation where applicable, the objective for any potential release of flammable refrigerant to be restricted to a safe concentration.

In order to guide technicians and installers, Appendix A of this guide provides conversion/installation checklists to outline the issues that need to be addressed when applying flammable refrigerant based systems. Checklists cover the following typical applications:

- High wall split system
- Ducted split system air conditioner
- Coolroom refrigeration system
- Plantroom-based refrigeration system.

Note: The checklists in Appendix A can be used as a basic guide for system designers and installers; however, they must also have access to and a thorough working knowledge of the standards covered in this guide to ensure full compliance is achieved.

4. SAFETY REQUIREMENTS FOR DESIGN AND INSTALLATION

4.1 Applicable design standards

This section provides information about flammable refrigerants, sources of ignition and refrigerant charge size limits with respect to the location of the refrigerating equipment. It provides a guide to the design and manufacturing standards for refrigerating appliances, refrigeration systems, plantrooms and installation sites where flammable refrigerants are to be used.

Notes:

1. This guide is limited to fundamental safety requirements and does not purport to provide detailed design guidance, which is included in the referenced standards
2. This guide is based on the assumption that refrigeration systems are designed, constructed, installed, inspected, and maintained by competent personnel.

The maximum charge of flammable refrigerant allowed in any specific application is calculated in accordance with the procedures of the applicable design standard. There is an electrical safety appliance standard and a refrigerating system safety standard as follows:

- Appliance: AS/NZS 60335 Part 2 product safety standard series for household and similar use, e.g. AS/NZS 60335.2.40 for air conditioners and heat pumps, and
- System: Annex A of AS/NZS 5149.1 for all other refrigerating and air conditioning systems.

Maximum charge refers to the largest quantity of refrigerant that can be contained in the system. The maximum releasable charge is the maximum quantity of refrigerant that can be released into an occupied space. Each individual system or independent refrigerant circuit is considered separately. Simultaneous failure of multiple systems/circuits is not considered.

Note: Charge calculations outlined in this guide are based on the Australian standards. It should be noted that State regulator guidance, local council policy, building rating requirements, site or facility carbon accounting and corporate sustainability policies can all have an impact on refrigerant selection and can vary or limit the standard charge calculations.

It is important to know where each standard is to be applied. For refrigerating systems and appliances, AS/NZS 5149 is the general standard used, unless a specific AS/NZS 60335 Part 2 product safety standard applies. Where an AS/NZS 60335 Part 2 product standard (such as AS/NZS 60335.2.40 or AS/NZS 60335.2.89) specifies design or safety requirements, including flammable refrigerant charge limits, these requirements take precedence over any conflicting clauses in AS/NZS 5149.

For example, charge limits for room, split, multi-split, and VRF air conditioner appliances using flammable refrigerants are defined in AS/NZS 60335.2.40 Annex GG. In these cases, AS/NZS 5149 Annex A and Clause A.5 do not apply. Where no applicable AS/NZS 60335 Part 2 product standard exists, system design must comply with AS/NZS 5149.

Note: For appliances using A1 refrigerants, charge limits are calculated in accordance with AS/NZS 5149.1.

4.2 Electrical appliance charge limitations

Electrical legislation in Australia and New Zealand references the AS/NZS 60335 series for electrical appliances, making compliance mandatory when under the jurisdiction of that legislation. These product-specific standards take precedence over horizontal and generic system standards covering the same subjects such as AS/NZS 5149.

The AS/NZS 60335 product standards in Table 4.1 (non-exhaustive) contain flammable refrigerant charge limits. Compliance with these product standards is a common regulatory compliance pathway under the various state electrical regulations. Compliance is shown via a safety test report from an accredited testing laboratory.

STANDARD	APPLICATION	A2L CHARGE LIMITS	A3 CHARGE LIMITS
Product standards			
AS/NZS 60335.2.11 **Tumble dryers**	Tumble dryers that use a refrigerating system incorporating sealed motor compressors for carrying out the drying process	Up to 150g of flammable refrigerant in each separate refrigerant circuit	Up to 150g of flammable refrigerant in each separate refrigerant circuit
AS/NZS 60335.2.24 **Refrigerating appliances, ice-cream appliances and ice makers**	Domestic and similar uses, including caravans, camping, boating	Up to 150g of flammable refrigerant in each separate refrigerant circuit	Up to 150g of flammable refrigerant in each separate refrigerant circuit
AS/NZS 60335.2.40 **Electrical heat pumps, air conditioners and dehumidifiers**	Any air conditioning and heat pump application for a normal household, or used by laypeople in shops, light industry and farms	Charge limit depends on floor area, height/type of air conditioner, ventilation and risk mitigation devices (e.g. detectors, sensors, alarms).	Charge limit depends on floor area, height/type of air conditioner, ventilation and risk mitigation devices (e.g. detectors, sensors, alarms)- up to 1kg inside and 5kg outside, depending on the application
AS/NZS 60335.2.34 **Motor compressors**	Motor compressors that are intended for use in household and similar appliances, excluding industrial uses	Charge limit depends on the appliance it is fitted in.	Charge limit depends on the appliance it is fitted in.
AS/NZS 60335.2.75 **Commercial dispensing appliances and vending machines**	Commercial dispensing or vending machines such as cold beverage vending, ice-cream and whipped cream dispensers, ice dispensers, and refrigerated merchandisers	Up to 150g of flammable refrigerant in each separate refrigerant circuit	Up to 150g of flammable refrigerant in each separate refrigerant circuit
AS/NZS 60335.2.89 **Commercial refrigerating appliances with an incorporated or remote refrigerant condensing unit or compressor**	Refrigeration appliances used for commercial situations, e.g. refrigerated display cabinets, storage cabinets, service counters, water coolers	Up to 13 times the LFL or a maximum 1,200g of flammable refrigerant in each separate refrigerant circuit for self-contained systems and up to 150g for remote condensing units or compressors	Up to 13 times the LFL of flammable refrigerant (e.g. 500g for R290) in each separate refrigerant circuit for self-contained systems and up to 150g for remote condensing units or compressors
System standards			
AS/NZS 5149.1 Refrigerating systems and heat pumps – Safety and environmental requirements Part 1: Definitions, classification and selection criteria	All refrigeration, air conditioning and heat pumps, domestic, commercial, industrial	Variable depending on application, see Clause 4.3.	Variable depending on application, see Clause 4.3.

Table 4.1 Charge limits from applicable appliance standards

The electrical compliance requirements of the AS/NZS 60335 series product standards must not be confused with the electrical installation requirements of the Australian Wiring Rules as detailed in AS/NZS 3000. The Wiring Rules only apply up to the general purpose outlet (GPO) or supply connection terminal block located within the appliance; they do not apply to the internal wiring or components of the appliance itself.

For split systems, any interconnecting wiring other than control wires carrying extra low voltage must be installed in accordance with AS/NZS 3000.

4.3 AS/NZS 5149 system charge limitations

Refrigerant charge limitations in AS/NZS 5149 are based on the refrigerant safety group and:

- **Occupancy classification** – as defined by AS/NZS 5149.1 – (Category a, b, c)
- **System classification** – as defined by AS/NZS 5149.1 – (Direct or Indirect)
- **Location classification** – as defined by AS/NZS 5149.1 – (Class I, II, III, IV).

Note: Industry charge calculators are a useful online resource to help understand the interaction between the occupancy, system and location classifications as they apply to a variety of scenarios (see Appendix C for an example).

4.3.1 AS/NZS 5149.1 – Occupancy classification

An occupancy is a room or space that is occupied by people. Three categories of occupancy are defined in AS/NZS 5149.1 as follows:

- General occupancy a
- Supervised occupancy b
- Authorised occupancy c.

CATEGORIES	GENERAL CHARACTERISTICS	EXAMPLES
General occupancy -a	**Rooms, parts of buildings, buildings where:** ▸ Sleeping facilities are provided ▸ People are restricted in their movement ▸ An uncontrolled number of people are present, or ▸ To which any person has access without being personally acquainted with the necessary safety precautions.	Hospitals, courts or prisons, theatres, supermarkets, schools, lecture halls, public transport termini, hotels, dwellings and restaurants.
Supervised occupancy -b	Rooms, parts of buildings, buildings where only a limited number of people can be assembled, some being necessarily acquainted with the general safety precautions of the establishment.	Offices, laboratories, places for general manufacturing, workplaces.
Authorised occupancy -c	Rooms, parts of buildings, buildings where only authorised persons have access who are acquainted with the general sand specialised safety precautions of the establishment and where manufacturing, processing, or storage of material or products take place.	Manufacturing facilities, for example, for chemicals, food, beverage, ice and ice-cream. Refineries, cold stores, dairies, abattoirs, and non-public areas in supermarkets

Figure 4.1 Occupancy categories from AS/NZS 5149.1

In broad terms, occupied spaces are differentiated on the basis of the occupant's awareness and access authorisation including their understanding of the safety precautions of the site. An example of general occupancy would be visitors to a hotel, library or other publicly accessible building – the general public – where they might not necessarily be aware of the building's safety precautions. This category includes places where people sleep.

An example of supervised occupancy would be people in a workplace like a general office – the workers – some of whom would be aware of the building's safety precautions and emergency plans.

An example of authorised occupancy would be workers in a manufacturing facility or back of house in a supermarket – trained workers – where they are specifically acquainted with the building's safety precautions.

Machinery rooms are considered as an authorised occupancy in Australia and New Zealand. This recognises the fact that occupants of refrigerating equipment plantrooms are generally acquainted with the safety precautions.

Many buildings will contain multiple occupancy categories. For example, in a typical supermarket, the public retail area might be general occupancy (category a), the storage and staff areas 'back-of-house' might be supervised occupancy (category b) and the plant room, with authorised access only, might be authorised occupancy (category c).

4.3.2 AS/NZS 5149.1 – System classification

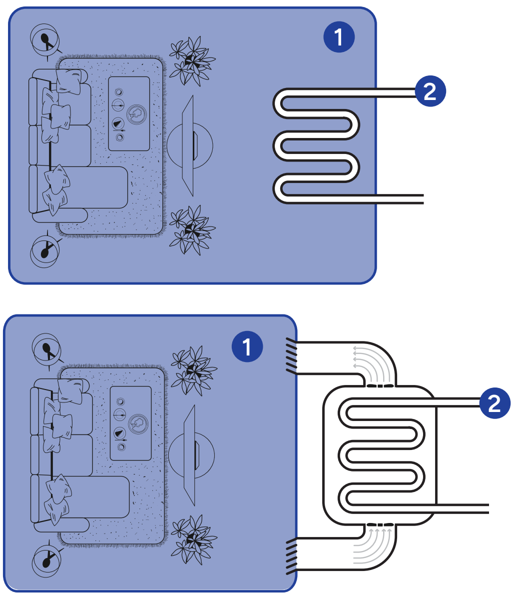
Refrigerating system types are classified as "direct releasable" or "indirect" systems according to:

- The method of extracting heat from the atmosphere (cooling)
- The method of adding heat to the atmosphere (heating)
- The substance to be treated, and
- The refrigerant leak entering the occupied space.

The fundamental criterion is the existence of a pathway for the leaked refrigerant to enter the occupied space. For direct releasable systems, a direct pathway exists, whereas for indirect systems no direct pathway exists.

The following system arrangements are classified as **direct releasable systems**:

- **Direct systems** where a single rupture of the refrigerant circuit results in a refrigerant release to an occupied space
- **Open spray systems** where the heat-transfer medium is in direct communication with the refrigerant-containing parts of the circuit and the indirect circuit is open to an occupied space
- **Direct ducted systems** where the conditioned air is in direct communication with the refrigerant-containing parts of the circuit and is supplied to an occupied space
- **Open vented spray system** where the heat-transfer medium is in direct contact with refrigerant-containing parts of the circuit and the indirect circuit is open to an occupied space.

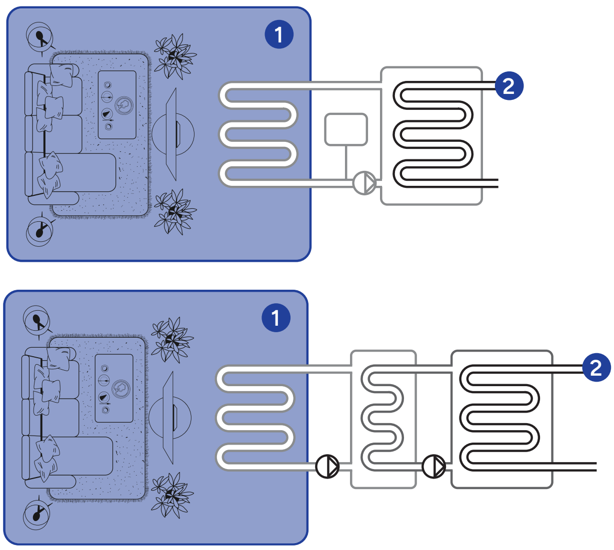


1 = occupied space, 2 = refrigerant containing parts

Figure 4.2 Direct system and direct ducted system

The following system arrangements are classified as **indirect systems**:

- **Indirect closed system** where the heat-transfer medium is in direct communication with an occupied space, and a refrigerant leak into the indirect circuit can enter the occupied space only if the indirect circuit also leaks.
- **Indirect vented system** where the heat-transfer medium is in direct communication with an occupied space, and a refrigerant leak into the indirect circuit can vent to atmosphere outside the occupied space.
- **Indirect vented closed system** where the heat-transfer medium is in direct communication with an occupied space and a refrigerant leak into the indirect circuit can vent to atmosphere through a mechanical vent, outside the occupied space.
- **Double indirect system** where a refrigerant leak cannot enter the occupied space because the heat-transfer medium is in contact with refrigerant-containing parts, and the heat is exchanged with a second indirect circuit that passes into an occupied space.
- **High-pressure indirect system** where the heat-transfer medium is in direct communication with an occupied space and the indirect circuit is maintained at a higher pressure than the refrigerant circuit at all times, so that a rupture of the refrigerant circuit cannot result in a refrigerant release to the occupied space.



1 = occupied space, 2 = refrigerant containing parts

Figure 4.3 Indirect closed and double indirect systems

4.3.3 AS/NZS 5149.1 - Location classification

Refrigerating systems are also classified in AS/NZS 5149.1 by their location class. There are four location classes specified, Class I to Class IV:

- **Class I:** Refrigerating system or refrigerant-containing parts are located within the occupied space (e.g. self-contained drinks cabinet)
- **Class II:** Compressors and pressure vessels are either located in a machinery room or in the open air, while heat exchangers and pipework, including valves, can be located in an occupied space. (e.g. split system)
- **Class III:** All refrigerant-containing parts are located in a machinery room or open air
- **Class IV:** All refrigerant-containing parts are located in ventilated enclosures.

4.4 Maximum charge calculations – AS/NZS 5149.1

For refrigerating systems, the refrigerant charge calculation procedures are detailed in AS/NZS 5149.1 Annex A. For air conditioning and heat pump appliances, the refrigerant charge calculation procedures are detailed in AS/NZS 60335.2.40.

4.4.1 Annex A charge calculation procedures

Annex A of AS/NZS 5149.1 outlines how to calculate the refrigerant charge limit using Table A.1 for toxicity-based limits and Table A.2 for flammability-based limits.

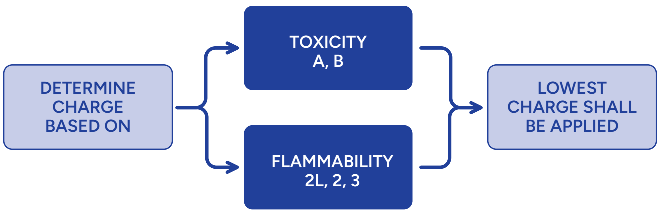


Figure 4.4 Charge calculation procedure

The following process is specified to calculate refrigerant charge limits for any particular application:

1. Define the occupancy category (and location class) for the system
2. Define the toxicity class of the refrigerant
3. Determine the charge limit for the refrigerating system based on Table A.1
4. Define the flammability class of the refrigerant
5. Determine the charge limit for the refrigerating system based on Table A.2
6. The lowest refrigerant charge obtained according to 3) and 5) is applied.

Define the occupancy category (a, b, or c) and location class (I, II, III, or IV)

↓

Define the toxicity class (A or B)

↓

Determine the charge limit based on toxicity (higher of ATEL/ODL or practical limit)

↓

Define the flammability class (1, 2L, 2 or 3)

↓

Determine the charge limit based on flammability (from LFL)

↓

Lowest charge limit applies

Figure 4.5 Charge calculation process

For spaces above 250m² floor area, the charge limit calculations must use 250m² as the floor area.

4.4.2 Calculating room volumes

The room volume calculation must only consider the "free" volume of a room. Any substantial volume taken up by fixtures, fittings, equipment or stored produce is not included in the calculation. The volume of stored products is subtracted from the total room volume to produce the free volume.

Spaces above false ceilings are not included in the volume calculation unless the ceiling has more than 50% openings to the space below.

4.4.3 Applying AS/NZS 5149.1 charge limit tables

The refrigerant charge limit calculations are outlined in Annex A of AS/NZS 5149.1, Tables A.1 and A.2. (For air conditioner and heat pump appliances refer to AS/NZS 60335.2.40 Annex GG). Table A.2 of AS/NZS 5149.1 Appendix ZZ applies to flammable refrigerant. Note that the original tables have been amended in Appendix ZZ for use in Australia and New Zealand.

These tables show the refrigerant charge limit for different system types, locations and applications, based on the specific flammability characteristics (and toxicity where relevant) of the refrigerant used.

The methodology for calculating charge limits for a system depends on the following three characteristics:

- Refrigerant properties: toxicity (Table A.1) or flammability (Table A.2)
- Occupancy categories: a, b or c
- Location classification: Class I, II, III or IV.

There are different limits set for human comfort (air conditioning) applications and for other refrigeration applications, and there are exceptions for above or below ground applications.

The charge limit, or how to calculate it, for each refrigerant application scenario is provided in the body of the table. Systems in location classifications I and II have charge limits applied, whereas systems in location classification III have no charge limitations applied, except for Class 3 flammable refrigerants (A3 and B3 refrigerants). For location classification IV ventilated enclosures, the flammable refrigerant cap factor m_3 applies and there is no charge limit in terms of room size, as it is assumed that the refrigerant will not directly enter an occupied space. The tables are laid out as shown.

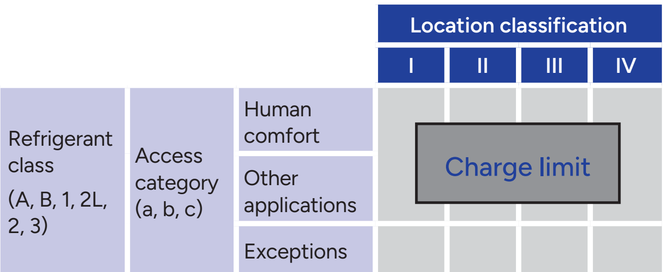


Figure 4.6 Charge limit table layout

4.4.4 Charge limits due to flammability

There are no restrictions on the maximum refrigerant charge size of Class 1 refrigerants due to flammability. For Class 2L, 2 and 3 flammable refrigerants, the total mass of refrigerant is limited to the maximum values listed in Table A.2 – Charge limit requirements for refrigerating systems based on flammability.

As an additional restriction for flammable refrigerants (Class 2L, 2 and 3), the charge limits of Table A.2 are capped to a limit based on the LFL of the refrigerant. The basic cap factors applied are m_1, m_2, and m_3.

Some common flammable refrigerants are heavier than air and can 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, nursing homes etc. 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 applies the concept of a "charge cap factor" m_1, m_2, and m_3 based on the LFL.

For Class 2L flammable refrigerants, the basic cap factor is increased by a factor of 1.5, recognising that the lower burning velocity of these refrigerants leads to a reduced risk of ignition and consequence. This represents a reduced stringency for 2L refrigerants.

The cap factor limits used in Table A.2 can be increased where occupants are familiar with the safety requirements for the building (for example, occupancy categories b or c), or where the risk of leakage is reduced.

The cap factor refrigerant charge limits (in kg) given in Table A.2 are calculated as follows:

$m_1 = 4m^3 \times LFL$

$m_2 = 26m^3 \times LFL$

$m_3 = 130m^3 \times LFL$

where LFL equals the lower flammability limit in kg/m³.

Refrigerant	LFL (kg/m³)		m_1 = (kg)	m_2 = (kg)	m_3 = (kg)
R32	0.307	1.5	1.84	11.97	59.87
R1234yf	0.289	1.5	1.73	11.27	56.36
R1234ze	0.303	1.5	1.82	11.82	59.09
R717	0.116	1.5	0.70	4.52	22.62
R290	0.038	1	0.15	0.99	4.94
R600a	0.043	1	0.17	1.12	5.59

Table 4.2 AS/NZS 5149.1 Refrigerant cap factors and limits

There are no room volume restrictions for refrigerants of flammability Class 2L for refrigerant charges less than or equal to $m_1 \times 1.5$. There are no room volume restrictions for refrigerants of flammability Classes 2 and 3 for refrigerant charges less than or equal to m_1.

When the charge of refrigerant with flammability Class 2L is greater than $m_1 \times 1.5$, or the charge of refrigerants with flammability Classes 2 and 3 is greater than m_1, the allowable maximum charge in the room must be calculated in accordance with the Formula A.4.

The required minimum floor area A_{min}, in square metres, to install a system with refrigerant charge m, in kilograms, is calculated in accordance with formula A.5.

$$m_{max} = 2.5 \text{ x } LFL^{5/4} \text{ x } h_0 \text{ x } A^{1/2}$$

AS/NZS 5149.1 Formula A.4

$$A_{min} = \left(\frac{m}{2.5 \text{ x } LFL^{5/4} \text{ x } h_0} \right)^2$$

AS/NZS 5149.1 Formula A.5

Figure 4.7 AS/NZS 5149.1 Calculations

4.4.5 Extending A2L charge limits

Where design charge limits for A2L refrigerants are exceeded in a space, the system can still comply if special alternative provisions are made within the system to ensure at least an equivalent level of safety is achieved. Where the combination of location classification and occupancy classification shown in Table A.2 allow the use of the alternative provisions, the designer can choose (for some or all of the occupied spaces served by the equipment) to calculate the "allowable refrigerant charge" using the RCL (refrigerant concentration limit), QLMV (quantity limit with minimum ventilation), or QLAV (quantity limit with additional ventilation) values given in A.5.2 instead of the practical limit values given in AS/NZS 5149.1 Tables B.1 and B.2.

These alternative provisions are detailed in paragraph A5 of Annex A where the refrigerant charge is assessed against the RCL, QLMV or QLAV.

If the value of the total charge of the system divided by the room volume exceeds the QLMV or RCL, appropriate measures such as ventilation (natural or mechanical), safety shut-off valves, and safety alarm, in conjunction with a gas detection device, need to be taken.

Where the value is more than the QLMV but less than or equal to the QLAV value, at least one of the measures is required. Where the value exceeds the QLAV, at least two of the specified measures are required.

Refrigerant	Allowable concentration kg/m³ RCL	QLMV kg/m³	QLAV kg/m³
R22	0.21	0.28	0.50
R134a	0.21	0.28	0.58
R407C	0.27	0.28	0.50
R410A	0.39	0.46	0.42
R744	0.072	0.42	0.18
R32	0.061	0.074	0.16
R1234yf	0.060	0.062	0.15

Table 4.3 – Allowable refrigerant concentration

$$\text{QLMV} \quad \frac{T\,x\,m}{V} \qquad (A.6)$$

Figure 4.8 RCL, QLMV and QLAV for A2L refrigerants

4.4.6 AS/NZS 5149.1 variations

Variations have been made to ISO 5149.1:2014 to make it suitable for use in Australia and New Zealand as AS/NZS 5149.1:2016. These are listed in AS/NZS 5149.1 Appendix ZZ.

Appendix ZA has been added to provide worked examples of the determination and calculation of allowable refrigerant charge limits for several different refrigerant scenarios. Calculation of allowable charge limits can be complex given the many variables involved. A range of examples has been provided to assist users of the standard including:

- A machinery room for refrigerant R290
- A supermarket medium temperature rack system using R134a – public area
- A supermarket medium temperature rack system using R134a – plantroom
- Self-contained refrigerated display cabinet using R290
- Coolroom with a remote condensing unit for refrigerant safety group A1 – no public access
- Coolroom with a remote condensing unit for refrigerant safety group A1 – with public access
- Coolroom with a remote condensing unit for refrigerant safety group A3 – with public access.

Stepping through these example calculations gives the user a good appreciation of the logic behind the charge limit requirements and the steps involved in the calculation process.

4.5 Appliance charge limits – AS/NZS 60335.2.40 Annex GG

4.5.1 Compliance standard

AS/NZS 60335.2.40 is the electrical safety standard that covers air conditioners and heat pumps. Annex GG applies where flammable refrigerants are used in the appliance.

Flammable refrigerant charge limits for room, split, multi-split and VRF split system air conditioners and hot water heat pumps are defined in AS/NZS 60335.2.40 Annex GG. The use of Annex A (and paragraph A.5) of AS/NZS 5149.1 is not applicable to air conditioner appliances using flammable refrigerant that fall under the scope of the appliance standard.

Essentially these are air conditioning appliances intended for domestic and light commercial use. Any split system air conditioner installed in Australia must comply with the requirements of AS/NZS 60335.2.40 and AS/NZS 5149. Where any contradiction between the two standards exists, AS/NZS 60335.2.40 will take precedence.

4.5.2 Annex GG charge calculations

Considering the number of variables and the complexity of the required calculations for air conditioners that use flammable refrigerants, AS/NZS 60335.2.40 mandates that the manufacturer performs the calculations and that the installation instructions clearly show the resulting minimum floor area into which the air conditioner can be installed.

For portable air conditioners with a flammable refrigerant charge greater than m_1, the minimum floor area must be marked on the outside of the appliance so that it is visible in normal use.

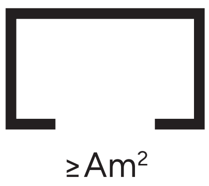


Figure 4.9 Portable air conditioner – Minimum floor area label

Where a flammable refrigerant is used, the minimum room area required and the ventilation requirement for an AS/NZS 60335.2.40 appliance are determined according to:

- The refrigerant charge used on the appliance – actual charge m_c
- The safety group of the refrigerant
- The LFL of the refrigerant
- The releasable charge – m_{rl} determined by Annex QQ
- The installation location – height of release (distance of indoor unit above floor level)
- The type of ventilation – of the location or the appliance.

Where the releasable charge is greater than m_1, the refrigerating system must comply with at least one of the mitigation measures specified in Annex GG.

A2L refrigerants have less stringent requirements than A2 and A3 refrigerants, which have the same requirements. AS/NZS 60335.2.40 requires marking of the refrigerant designation and charge.

The AS/NZS 60335.2.40 maximum allowable charge calculations take into consideration variables such as the room floor area, height of the air conditioner, type of air conditioner, characteristics of the particular refrigerant, the level of ventilation and the application of risk mitigation devices (e.g. detectors, sensors, alarms etc).

For installation of split system ducted air conditioners, the maximum charge limits are particularly important. The smallest room the system serves dictates the maximum refrigerant charge in the system that can be safely installed (except where the indoor fan operates continuously or is activated by a leak detection system). Ducted indoor units pose an additional hazard if the indoor unit is located in a confined space or underfloor area where, if a refrigerant leak occurs, the refrigerant could pool or become trapped, exceeding RCL levels. An underfloor ducted calculation would likely require countermeasures such as detection, compressor stop, zone opening and air circulation.

4.6 Hazardous areas – explosive gas atmosphere

4.6.1 Hazardous atmosphere

WHS regulations in most jurisdictions state that an atmosphere is a hazardous atmosphere if:

- The atmosphere does not have a safe oxygen level, or
- The concentration of oxygen in the atmosphere increases the fire risk, or
- The concentration of flammable gas, vapour, mist or fumes exceeds 5% of the LFL for the gas, vapour, mist or fumes, or
- Combustible dust is present in a quantity and form that would result in a hazardous area.

A PCBU at a workplace must manage risks to health and safety associated with an ignition source in a hazardous atmosphere at the workplace. Note that toxicity conditions that are harmful to humans might occur at less than 5% of the LFL for some refrigerants.

Flammable gas, when released to atmosphere, can form an explosive gas atmosphere. If the concentration of the flammable gas exceeds 5% of the LFL (during normal use) then that work area must be considered a hazardous atmosphere under the WHS regulations.

4.6.2 Hazardous area classification

The classification of hazardous areas for explosive gas atmospheres is defined under AS/NZS 60079.10.1. The AS/NZS 60079 series standards do not apply to domestic premises or small refrigerant systems where the quantity of flammable gas is small.

A hazardous area is defined as an area in which an explosive atmosphere is present or might be expected to be present. The standard defines three levels of hazardous area classifications: Zone 0, Zone 1 and Zone 2 as follows:

- **Zone 0:** An area in which an explosive gas atmosphere is present continuously or for long periods or frequently

- **Zone 1:** An area in which an explosive gas atmosphere is likely to occur in normal operation occasionally
- **Zone 2:** An area in which an explosive gas atmosphere is not likely to occur in normal operation but, if it does occur, it will exist for a short period only.

The hazardous area classification and electrical equipment requirements will vary according to the specific flammable gas used and the application details. Should the proposed installation result in a "hazardous area" classification, additional applicable standards would include AS/NZS 60079.14 for electrical installations and AS/NZS 60079.13 for the use of mechanical ventilation as a control measure.

Australian standards on hazardous area classification typically use values of 25% of the LFL (or higher depending on the level of certainty) as the trigger for hazardous area mitigation measures. Reference should be made to the applicable standards such as AS/NZS 60079.10.1 and rulings on this subject issued by Standards Australia. See AS/NZS 60079.10-1-2022-rul-1-2024 and AS/NZS 60079.14:2022 Rul 1:2024.

4.6.3 Temporary hazards

This guide makes reference to a "temporary flammable zone" that arises during system installation and maintenance activities (see Clause 6.7). A temporary flammable zone that is not part of normal operations can be equated to a hazardous area classification of Zone 2. These are areas where at least some emission of refrigerant is anticipated to occur during common working procedures, such as refrigerant charging, recovery, and the like - typically where hoses can be connected or disconnected.

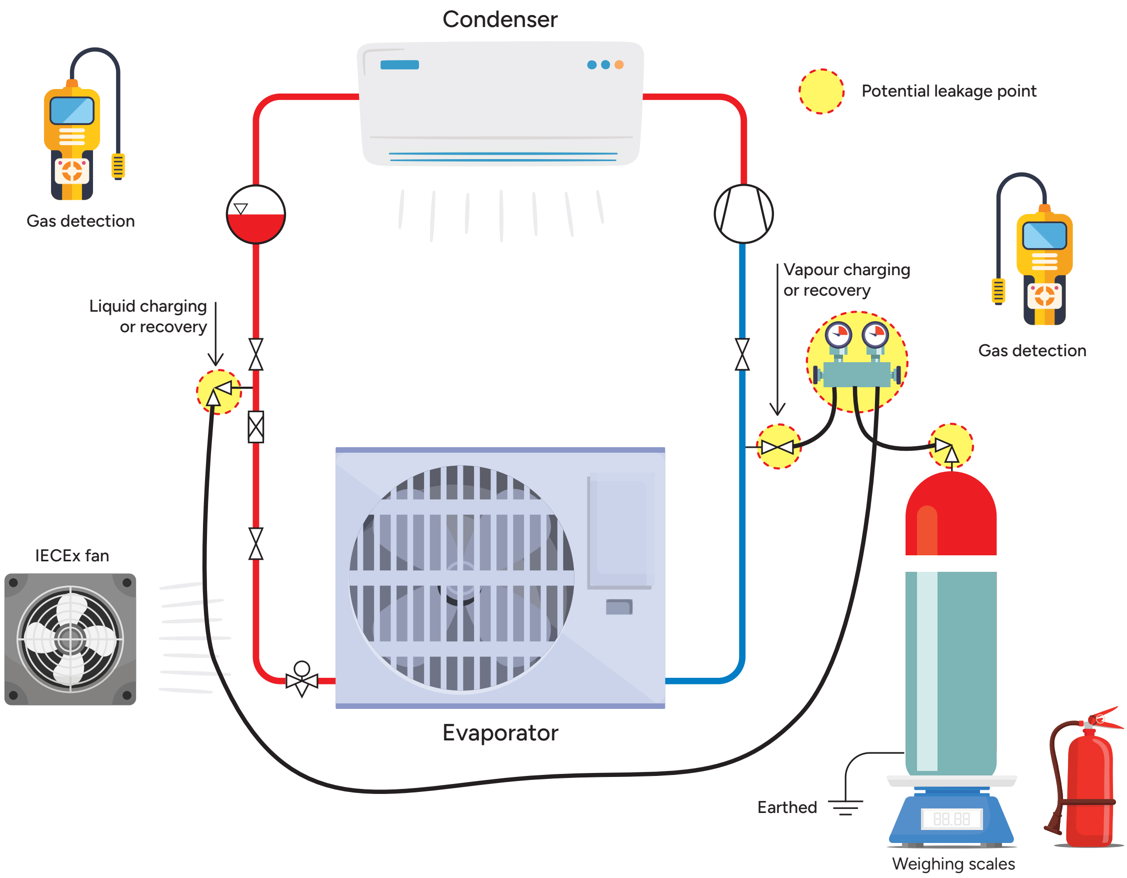


Figure 4.10 Potential leakage points during refrigerant charging and recovery

In this case, the requirements for Zone 2 in AS/NZS 60079.14 apply. Where a release of flammable gas could occur in poorly ventilated spaces, a Zone 1 hazardous area classification is commonly applied.

Technicians and contractors need to action this when charging or recovering refrigerant during installation or maintenance procedures, including the creation of a temporary flammable zone and the use of refrigerant detection before, during and after the work.

4.7 Sources of ignition

4.7.1 General

Where flammable refrigerants are used in a system, there must be no potential sources of ignition associated with or in the vicinity of the equipment that could ignite any refrigerant that leaks from the system. The assessment of Class 2L, 2 and 3 flammable refrigerants and associated ignition sources should be in accordance with AS/NZS 60079.10.1, including electrical compliance with AS/NZS 60079.14 where applicable.

Note: Class 2L refrigerants would have much lesser hazardous areas when compared to areas for class 2 and class 3 refrigerants. These lesser requirements reflect the differences in ignition and combustion characteristics between the different classes of flammable refrigerants.

Examples of potential sources of ignition include:

- A hot surface
- A spark from an electrical source
- An open or naked flame
- Static electricity
- Lightning
- Mechanical equipment.

Note: Flammable materials should not be stored near or around a refrigeration system containing flammable refrigerants.

For air conditioners within scope of AS/NZS 60335.2.40, that standard specifies requirements for the identification and treatment of sources of ignition within the appliance.

4.7.2 Hot surfaces

All parts of equipment should be checked to ensure that the temperature of any surface that might be exposed to leaked refrigerant cannot exceed:

- The maximum allowable surface temperature specified in Annex BB of AS/NZS 60335.2.40 or, where the maximum allowable surface temperature is not specified
- The autoignition temperature of the A3, B2L and B3 flammable refrigerant, reduced by 100K. This temperature equates to about 350°C for many hydrocarbon refrigerants, or
- 300°C for A2L and A2 halogenated refrigerants.

Condensate tray heaters and defrost heaters are prime candidates for hot surfaces within refrigeration and air conditioning equipment. Unless a maximum surface temperature is stated by the manufacturer, the temperature should be checked by testing as specified in AS/NZS 5149 and/or the applicable AS/NZS 60335.2 product safety standard.

Note: Some refrigerants and lubricants decompose when heated and emit toxic compounds, refer to Clause 4.8.

4.7.3 Electrical sources of ignition

RACHP equipment using flammable refrigerant must be designed and constructed so that any leaked refrigerant will not flow or stagnate where electrical components are fitted, as these could be a source of ignition. Typical electrical components that form part of the refrigeration system and could be a source of ignition include:

- On/off, isolator switches or contactors
- Start relays and potential relays
- Switches – pressure, defrost, flow, oil differential, liquid level, fan delay or time
- Thermal overloads
- Fan motors
- Thermostats
- Condensate pumps
- Miniature circuit breakers
- Defrost heaters
- Condensate tray heaters
- Fan speed controller
- Programmable controllers
- Lights
- Gas detectors that are not rated for hazardous areas.

Electrical equipment such as fans, heaters, electrical sockets, power outlets, motors and any other electrical equipment installed or likely to be used near systems containing flammable refrigerant should also be considered, particularly equipment mounted below the refrigeration system and at or near floor level.

According to AS/NZS 3000, all electrical equipment installed in a hazardous area that could act as a source of ignition must be both selected and installed in accordance with the requirements of AS/NZS 60079.19.

Options for dealing with sources of ignition within a potentially flammable zone/hazardous area classification include the following:

- Move the source of ignition outside the hazardous area (potentially flammable zone), or
- Replace the source of ignition with a suitable device as noted above, or
- Increase the uncontaminated airflow and/or maintain a permanent airflow to reduce the potentially flammable zone by applying AS/NZS 60079.13 (in conjunction with AS/NZS 60079.10.1).

Note: The application of AS/NZS 60079.13 might also require the use of fixed gas detection equipment. Where there is a "jet" release, the use of ventilation might not eliminate a hazardous area close to any potential source of a jet. Uncontaminated air is typically drawn in from high level and discharged at low level.

If equipment is installed according to AS/NZS 60079.14, the requirements of AS/NZS 60079.19 for the maintenance and inspection of this equipment would also apply.

4.7.4 Naked flame ignition sources

RACHP equipment charged with flammable refrigerant should not be installed or located where refrigerant could leak to areas that have naked flames present. This can include areas with gas cooktops and ranges, gas water heaters and gas or wood-fired room or space heaters.

4.7.5 Static electricity and lightning

In order to avoid static electricity or lightning introducing a potential ignition source, metal structures around a system should be electrically earthed and bonded.

Static electricity hazards include static electricity from personnel clothing and activities that can ignite A2 and A3 flammable refrigerants. Precautions should be applied to the selection of PPE and work control measures accordingly.

Informative guidance on common issues related to static electricity that would be relevant to A2 and A3 flammable refrigerants can be found in industry guides (see resources in Appendix C).

Further technical information on these factors can be found in standards such as AS/NZS 60079.14 for electrical installations, AS/NZS 1020 and SA TS 60079.32.1 for static electricity, and AS 1768 for lightning protection.

4.7.6 Mechanical equipment

Mechanical equipment might introduce other sources of ignition (e.g. sparks) that should be considered in the design of the system. Examples include:

- Static electricity from belts
- Frictional sparking risks from different metals, including any rotating parts
- Sparks from welding or grinding.

4.8 Thermal decomposition

Some refrigerants and lubricants decompose and emit toxic compounds when heated. This means a toxicity hazard can develop (even if ignition does not occur) as a result of refrigerant escape.

The thermal decomposition process is the breakdown of a refrigerant molecule into smaller, compounds due to high temperatures. This process can be triggered by overheating within a refrigeration system, refrigerant combustion in a fire, or exposure of leaked refrigerant to heat sources. In many cases that process produces highly toxic substances.

All flammable refrigerants that contain carbon can decompose to carbon dioxide and, in the case of incomplete combustion, carbon monoxide. Depending on the conditions, other toxic substances may also be released. Decomposition of A1, A2L and A2 fluorinated refrigerants can produce highly toxic substances such as hydrogen fluoride (hydrofluoric acid) and carbonyl halides. Some decomposition products can be harmful on contact with the skin, even if not airborne. Workplace exposure standards set maximum exposure limits for these chemicals.

CHEMICAL NAME	EXPOSURE STANDARD	SHORT-TERM LIMITS
Carbon dioxide	30,000ppm (3.0%)	Short-term exposure limit (15 min)
Carbon monoxide	200ppm (0.2%)	(Guideline) short-term exposure limit (15 min). Short term excursions should never exceed 400ppm
Carbonyl fluoride	5ppm (0.005%)	Short-term exposure limit (15 min)
Hydrogen fluoride	2ppm (0.002%)	Peak limit, should never be exceeded, even momentarily

Table 4.4 Workplace exposure standards for some decomposition products

Note: For further information, consult the SDS for the refrigerant, hydrogen fluoride and carbonyl fluoride.

Because A3 refrigerants lack chlorine and fluorine atoms, there is no possibility of acid formation in the presence of moisture and therefore salt formation and subsequent blockage in circuits is unlikely.

Each flammable refrigerant has a thermal decomposition temperature, beyond which the refrigerant molecule will break apart (decompose) and recombine with surrounding atoms. In the presence of lubricants and other contaminants, decomposition of refrigerants at lower temperatures is possible. Mixtures of refrigerant and lubricant might start to decompose at the autoignition temperature of the lubricant.

For repairs and maintenance, all refrigerant and lubricant should be removed from the circuit, which should be flushed with oxygen-free nitrogen (OFN) before any brazing, welding or other hot work is undertaken.

4.9 Materials compatibility

All lubricants used should be compatible with the refrigerant and equipment, as indicated by the refrigerant/equipment manufacturer's specifications. Designers should have regard to manufacturer's documentation of the system components.

The refrigerant and lubricants must be compatible with system materials such as plastics, elastomers, metals, etc.

Virtually all common elastomer and plastic materials used as O rings, valve seats, seals and gaskets are compatible with A2L, A2 or A3 refrigerants.

Materials such as EPDM, natural rubbers and silicone rubbers are not compatible with A3 refrigerants and therefore should not be used. Chloroprene (neoprene) products are not compatible with chemically unsaturated A2L, A2 or A3 refrigerants (i.e. R1270, R1150, etc).

A2L, A2 or A3 refrigerants do not react with steel, copper, aluminium and brass in dry refrigerating systems. Alloys containing more than 2% magnesium will react with fluorine and chlorine atoms in A2L and A2 blends and should only be used with pure A3 refrigerants. In the presence of moisture, zinc and galvanised steel are particularly susceptible to corrosive attack.

Care should be taken with larger plastic items that can increase the hazards due to static electricity and where light metals such as aluminium could come into moving contact with ferrous metals (either as a result of faults or during handling) and introduce other sparking hazards.

4.10 System construction standards

4.10.1 Tools and equipment

Tools and equipment used during the installation process (including, but not limited to, portable detectors, vacuum pumps, tools, cylinders and gauges) must be suitable for use with the appropriate refrigerant flammability class (2, 2L or 3) and be in serviceable condition.

New or existing installation tools should be assessed individually to ensure either:

- They conform with relevant International/ Australian/New Zealand Standards, or
- The manufacturer's manual/specification states that it is designed for use with flammable refrigerants.

4.10.2 AS/NZS 60335.2.40 requirements

AS/NZS 60335.2.40 Annex DD outlines the safety-critical information that must be included in manuals for installation, servicing, maintenance, and decommissioning for technicians working with appliances that use flammable refrigerants.

For installation technicians, the annex emphasizes the importance of understanding the refrigerant charge and how it relates to the room size and ventilation requirements. Technicians must ensure that pipework is installed securely and with minimal length, avoiding unventilated spaces unless specific conditions are met. If additional refrigerant charge is required during installation, the manual must clearly explain how to calculate and label the total charge, including any field-installed components.

The annex also requires technicians to be aware of the location and function of safety shut-off valves and leak detection systems. These components are critical for limiting the amount of refrigerant that could be released into a space in the event of a leak. Technicians must follow instructions for placing these devices correctly and verifying their operation. In cases where remote refrigerant sensors are used, the manual must specify their installation location and how to test them to ensure proper function.

For matched units that have been factory tested, it is only the interconnecting pipework, joints and fittings installed onsite that must be leak tested.

4.10.3 AS/NZS 5149.2 requirements

AS/NZS 5149.2 covers system installation including construction requirements, testing and marking. It can be applied to new systems and to modifications of existing systems (including the conversion of a system to another refrigerant type), but not to systems that are relocated.

Class 3 (A3, B3) flammable refrigerants attract the highest stringency requirements. Class 2L refrigerants must comply with the same requirements as class 2 refrigerants unless specifically excluded or varied and relaxed in the standard. There are several areas in AS/NZS 5149.2 where these stringency reductions have been amended (removed) for Australian/New Zealand use.

AS/NZS 5149.2 contains all the technical detail in relation to the design and construction of the system including:

- Pipes
- Piping components and fittings
- Component and system testing
- Marking and documentation.

It also contains the requirements for assemblies of components.

4.10.4 Refrigerant leakage

Worn, poorly aligned and out of balance machinery can cause excessive vibration and premature failure of piping and components, with possible release of refrigerant.

A compressor is designed to compress refrigerant gas and not to pump liquid. If excess liquid enters any type of compressor, by way of faulty valves or refrigerant overcharge, damage can result in potential release of refrigerant.

Care should be taken to ensure that liquid refrigerant is not trapped in pipelines or fittings between shut off valves. Due to its high coefficient of thermal expansion, trapped liquid refrigerant might expand when ambient temperature rises, generating excess pressure sufficient to rupture components and resulting in release of refrigerant.

Corrosion on the external surfaces of steel piping and vessels, brazed copper, brass and aluminium joints, can reduce the strength of the containment resulting eventually in release of refrigerant.

4.11 Installation procedures

Installation procedures must comply with AS/NZS 5149.2 and AS/NZS 5149.3.

Installation work must only be undertaken by competent personnel, or trainee personnel working under appropriate supervision.

Equipment should be sourced from manufacturers capable of providing spare parts and technical backup.

4.12 Installation of piping

The installer should ensure that all piping used is selected and applied in accordance with AS/NZS 1571 and AS 4041 as applicable and is delivered clean and sealed from the ingress of foreign matter.

Copper pipe may be hard-drawn or soft-drawn. Pipes should be clean, burr free and not out-of-round, before assembly. Refrigerant pipelines should be as short and direct as possible. Joints should be carefully made.

Where it is not possible to install copper pipework in a location where it will not be exposed to potential mechanical damage, it must be enclosed within a protective covering or otherwise protected against mechanical damage.

Flexible pipe elements must be protected against mechanical damage.

All mechanical joints should be double-checked for tightness.

All pipe insulation must conform to the requirements of the National Construction Code.

4.12.1 Piping location

Refrigerant pipe should not be exposed to external sources of excessive heat such as furnace rooms or boilers.

The exposure of refrigerant pipe or insulation to direct sunlight should be minimised.

Refrigerant pipe must not be installed where it can be walked on or mechanically damaged, unless protected from mechanical damage.

Piping with detachable joints not protected against disconnection must not be located in public hallways, lobbies, stairways, stairway landings, entrances, exits, or in any duct or shaft that has unprotected openings to these locations.

4.12.2 Pipe penetrations

The position of any equipment, cables or piping that might already be in place should be ascertained before any holes are drilled or penetrations made in the building to avoid possible damage and leakage of refrigerant.

All penetrations must conform to the requirements of the National Construction Code.

4.12.3 Pipe cutting

Pipe should be cut with a pipe cutter and de-burred using the correct tool. When cutting pipe, the opening should be facing down.

Metal filings should not be left in pipework after cutting, as they can cause damage to shaft seals, compressor bearings and windings in hermetic and semi-hermetic compressors.

4.12.4 Pipe bending

All copper pipes should be bent with the correct-sized pipe bender or bending spring.

When pre-insulated pipe is bent (e.g. pair coil pipes) the following procedure should be used:

1. Split the insulation and cut away from around the pipe.
2. Bend the pipe using the correct-sized bender or insert a copper elbow using brazed connections.
3. Replace the insulation, or insulate the bend, and seal the joins using adhesive and tape.

4.12.5 Brazing and soldering

After pipework has been fixed in position, OFN should be passed through the system to remove any oxygen before brazing or silver soldering joints.

OFN should be purged continuously through the system during the operation to eliminate oxidation (scaling), a common cause of choked dryers, blocked expansion valve strainers, dirty oil and compressor failure. A purging tool can be used to ensure nitrogen flow during brazing.

The OFN pressure should be at minimal gauge pressure during brazing, to eliminate the possibility of pinhole leaks forming in the solder. Wet rags and water spray can be used for controlling the surrounding surface temperatures.

4.12.6 Flare connections

The use of flare connections must be kept to the practical minimum.

For AS/NZS 60335.2.40 split system air conditioners, flare joints may only be used indoors for the final connections to the indoor unit. All other joints indoors must be either a permanent mechanical joint or brazed. The use of flare joints is also restricted by AS/NZS 5149.2 for some refrigerant/system types.

Flared joints must only be used with annealed pipe and on pipe sizes not exceeding 20mm outside diameter. Care should be taken not to flare piping that has been work hardened.

Flaring of joints is not a simple task and the correct tool, suitable for the refrigerant type and pipe wall thickness being applied, should be used.

A suitable refrigerant-compatible lubricant should be used on the flare threads, flare sealing surfaces and between the back of the flare and the nut to avoid tearing the flare when tightening the nut.

For single-flare connections of copper tubes, the torque and conditions outlined in AS/NZS 5149.2 Table 4 should be applied, or the manufacturer's instructions used.

Nominal outside diameter			Minimum wall thickness	Tightening torque
Metric series	Millimetre/ Inch series			
mm	mm	In	mm	Nm
6			0.80	14–18
	6.35	1/4	0.80	14–18
	7.94	5/16	0.80	33–42
8			0.80	33–42
	9.52	3/8	0.80	33–42
10			0.80	33–42
12			0.80	50–62
	12.7	1/2	0.80	50–62
15			0.80	63–77
	15.88	5/8	0.95	63–77
18			1.00	90–110
	19.06	3/4	1.00	90–110

Table 4.5 AS/NZS 5149.2 Table 4 – Standard tightening torque

The flare nut should be tightened with the designated torque by means of an appropriate torque wrench and spanner. The torque used to tighten the nut should not exceed the manufacturer's instructions.

4.12.7 Welded connections

Stainless welds for refrigerant lines should be purged with an appropriate inert gas (nitrogen or argon) during the process to prevent internal contamination.

Any welded pipework connections should be completed in accordance with AS 4041 and AS 3992.

4.12.8 Flanged connections

The use of flanged connections must be kept to the practical minimum.

The correct type and grade of gasket material must be used, that is:

- Suitable for the operating temperatures and pressures in the relevant part of the system
- Compatible with the relevant refrigerant and oil.

Flanged connections must be arranged so that the connected parts can be dismantled with minimum distortion stress of the piping.

Flanges should be evenly tightened, applying the "opposites" rule in three, or more gradual passes until the flange is seated correctly.

4.12.9 Compression/crimped fittings

Compression/crimped fittings should be installed following the manufacturer's preparation and fitting instructions.

All burrs should be removed from pipe ends before connecting.

4.12.10 Schrader valves

The use of Schrader valves should be kept to the practical minimum and they should be sealed with a cap when not in use.

Valve cores should be tightened to the manufacturer-recommended torque using a purpose designed tool.

Valve cores should be removed when brazing the fitting.

4.12.11 Piping supports

Pipework and fittings must be adequately supported according to their size and service weight, to prevent movement and failure.

The selection of pipework support materials should take into account surrounding atmospheric conditions to prevent premature wear and corrosion.

Where galvanised clamps are used, copper pipe should be protected from chafing and corrosion.

Pipework must be fixed at regular intervals according to the outside diameter. The maximum spacing for supports should not exceed the recommendations of AS/NZS 5149.2 Table 5 and 6.

Outside diameter (mm)	Support spacing (m)
15–22	2
>22–<54	3
>54–67	4

Table 4.6 AS/NZS 5149.2 Table 5 – Recommended maximum spacing for copper pipe supports

Nominal bore (DN)	Support spacing (m)
15–25	2
32–50	3
65–80	4.5
100–175	5
200–350	6
400–450	7

Table 4.7 AS/NZS 5149.2 Table 6 – Recommended maximum spacing for steel pipe supports

These are recommended maximum spacings. Additional support might be needed to account for components, vibration and thermal expansion, as specified by the designer or manufacturer.

Good support throughout the system means not only fewer leakage problems, but better operation. It also offers the following advantages:

- No pipework sagging and eventual cracking
- Good oil-handling characteristics
- No bad effects from vibration
- Longer service life for the piping
- Less chance of liquid hammer damage.

4.12.12 Piping clearance

The clearance around the piping must be sufficient to allow:

- Routine maintenance of insulation, vapour barrier, and components
- Checking of pipe joints
- Repairing of leaks.

4.12.13 Pipework testing

Pipework should undergo visual and non-destructive testing after installation in accordance with AS 4041 to verify its integrity.

4.13 Compressor installation

4.13.1 Cleanliness

Compressors should be in a clean, dry and serviceable condition when installed.

The technician should ensure that no foreign matter enters the suction side of the compressor during the initial run-in period.

4.13.2 Shafts and drives

Shaft alignment should be within the compressor manufacturer's specifications.

Compressor drive belts, when fitted, should not be over tensioned, as this can lead to premature bearing wear and shaft seal failure.

4.13.3 Condensing units

Condensing units should be secured in accordance with the manufacturer's instructions to prevent any movement.

4.14 Protection against excess pressure

Exposure to heat (including fire) and various fault conditions can give rise to elevated pressures inside an AS/NZS 5149 refrigeration or air conditioning system. The system must therefore contain means for safely preventing or relieving over-pressure at pressures at or below the design pressure of the system.

AS/NZS 60335.2.40 appliances must have over pressure protection (e.g. HP cut out switch), but do not need pressure relief devices.

4.14.1 Pressure relief devices

A pressure relief device refers to any device designed to protect a system from overpressure, including pressure relief valves, bursting discs and fusible plugs. AS/NZS 5149.2 specifies which specific types of pressure relieving devices are permitted for particular system types.

To determine which specific requirements apply, the assemblies must be categorised into one of four AS/NZS 5149.2 risk categories: I, II, III, or IV. The risk category depends on:

a. The GHS classification of the refrigerant
b. The phase of refrigerant in the assembly (gas/liquid)
c. The strength pressure (PS), and
d. The volume of the vessel or diameter of pipe/fitting.

The risk category of the "assembly" is determined based on the highest risk category of its components.

Pressure relief devices must be mounted on, or in proximity to, a pressure vessel or other parts of the system that require protection. They must be easily accessible and connected above the level of liquid refrigerant.

4.14.2 Pressure relief vent

Discharges must be directed into a safe, well-ventilated place. Discharge vents or piping can be employed to direct discharges appropriately, taking care not to restrict the discharge flow rate in accordance with AS/NZS 5149.2 Annex F. Flammable refrigerants should never be discharged into an occupied or enclosed space where the maximum charge size for the room volume could be exceeded. Where practicable, flammable refrigerant pressure relief should always be vented to outdoors.

Careful consideration should be given to potential hazards that can arise in the event of a discharge. In the case of flammable refrigerants, this requires particular attention to the location of any potential sources of ignition in the area surrounding the discharge release point. A flammable concentration can occur around the relief point before the release disperses to below the LFL.

Wherever practical, discharges should be directed upwards and discharge points should be clearly identifiable from a safe distance, alerting persons to the potential release of flammable gases. Special care should be taken to ensure that the vented refrigerant cannot re-enter an occupied or enclosed space, pool in low areas, or enter drainage systems. Consideration should be given to the potential for accumulation of ice, dirt or debris in discharge pipes, inhibiting proper functioning.

Shut-off valves must not be fitted between the apparatus being protected and the pressure relief device. Never bypass or in any other way hinder a pressure relief device from performing its function.

4.14.3 Conversion and pressure relief

If a system is being converted from a non-flammable A1 refrigerant to a flammable refrigerant, pressure relief valves need to be considered. The hazard level classification of the relief devices might not be appropriate; also, the location of the pressure relieving devices outlets might need to be changed.

Special care also needs to be made for small systems with vessels less than 230mm diameter that are converted from non-flammable to flammable refrigerants. These small systems designed for group A1 refrigerants typically do not have pressure relief devices but rely on the failure of a soldered joint in case of fire. This is not acceptable for a flammable refrigerant, as it could result in the sudden release of the refrigerant at an elevated pressure, potentially resulting in a vapour cloud explosion (VCE). For these small systems, the use of a suitable pressure relief device will ensure a more controlled release of the refrigerant at a lower pressure that greatly reduces the risk of a VCE event.

Note: It is recommended that service providers carry their own calibrated pressure gauges because the pressure gauges fixed to the refrigerating system might become inaccurate over time (i.e. accuracy drift due to wear and tear).

4.14.4 Conversion and design/plant registration

If a system is being converted from a non-flammable A1 refrigerant to a flammable refrigerant, pressure vessel approvals need to be considered.

Under WHS regulations, pressure equipment (e.g. hermetic compressors, receivers and accumulators) categorised as hazard level A, B, C or D according to AS 4343, require design registration. In a conversion from an A1 to an A2L, A2 or A3 refrigerant, the hazard level classification of the pressure equipment will likely change to a higher level as a result of the conversion, necessitating the registration of an "altered plant design". If the pressure equipment is categorised as hazard level A, B or C it can also require plant registration.

4.15 Machinery rooms

Under AS/NZS 5149.3, machinery rooms or special enclosures can have certain requirements if flammable refrigerants are used. These include number and opening of doors, fire resistance of walls, tightness, refrigerant detection and alarm, and minimum airflow or ventilation rates.

4.16 System testing

4.16.1 General

Before any refrigerating system is put into service, all the individual components, or the whole refrigerating system, must undergo the following tests:

- Strength-pressure test, in accordance with AS/ NZS 5149.2
- Leak tightness test, in accordance with Clause 4.18
- Functional test of safety switching devices for limiting the pressure, in accordance with AS/NZS 5149.2
- Conformity test of the complete installation, in accordance with AS/NZS 5149.2.

Joints must be accessible for inspection while the strength-pressure testing and leak tightness testing are in progress.

After strength-pressure testing and leak tightness testing, the functional testing of all the electrical safety circuits is carried out. All tests must be documented.

For onsite strength and tightness tests in AS/NZS 5149.2, the test pressures are based on a multiplier of the maximum system allowable pressure (PS).

4.16.2 Maximum allowable pressure (PS)

The system components must be designed for a pressure higher than the saturated refrigerant pressure corresponding to the maximum expected system temperatures.

The maximum allowable pressure (PS) in the different parts of the system is determined by the system designer by calculation and/or testing It takes into account the maximum ambient temperature for the installation site, the potential for build-up of non-condensable gases in the system, the system application characteristics and the method used for defrosting. PS can be determined either:

a. By calculation verified by testing (where the minimum temperature difference between ambient temperature and condensing temperature is calculated), or
b. By calculation using the default minimum temperatures from AS/NZS 5149.2 Table 2 (where the temperature difference between ambient temperature and condensing temperature is taken from Table 2).

In both cases the maximum allowable pressure is determined by the saturated refrigerant pressure at no less than the specified temperatures. When the evaporators can be subject to high pressure, e.g. during hot gas defrosting or reverse cycle operation, the temperature specified for the high-pressure side is used.

The maximum system operating pressure cannot be greater than the maximum system allowable pressure (PS). The maximum allowable pressure (PS) for each component must not be less than the maximum allowable pressure (PS) of the system or part of the system.

AS/NZS 5149.2, AS/NZS 60355.2.40 and AS/NZS 60335.2.89 all require that the maximum allowable pressure (PS) for the high- and low-pressure sides of the system is stated on the system or appliance identification plate.

4.17 Strength-pressure testing

Under AS/NZS 5149.2 Clause 4.4.2, all components of a refrigeration system must be strength-pressure tested, either at 1.43 x PS for individual testing or at 3 x PS for type testing. These hydrostatic pressure tests are carried out by manufacturers of components, pipes, fittings and assemblies and are not required to be carried out onsite.

Under AS/NZS 5149.2 Clause 5.3.2, where a system is installed with piping and piping joints that have not been strength-pressure tested by the manufacturer or supplier, that system (or section of the system) must be strength-pressure tested onsite.

Onsite strength-pressure tests use oxygen-free non-hazardous gas (e.g. OFN) pressurisation at test pressures of either 1.43 x PS or 1.1 x PS depending on the category of the system (as defined in Annex C) and the level of inspection and non-destructive testing applied to the piping and piping joints.

4.18 Leak tightness testing

The system must be leak tested in whole or in part either at the factory or onsite using the tightness test before the plant is charged with refrigerant. Refrigerant must not be put into a system for the purposes of onsite tightness testing.

Major components and sub-assemblies that have already been factory tested for tightness in accordance with the applicable standard do not need to be retested onsite.

4.18.1 General

This test applies to site assembled systems and not to manufactured systems or components.

> **Warning:** When pressure testing at high pressures with OFN, the pressures are high enough to cause serious injury or death. Nitrogen is an asphyxiant.

4.18.2 When to test

Systems or parts of systems must be leak tightness tested to ensure they are leak free before being charged with refrigerant. The leak tightness test must be completed:

- At initial system commissioning
- After the system is moved, altered, or a change in use has occurred
- After the system is repaired
- After a change in refrigerant type
- When a refrigerant leak or low refrigerant charge is known or suspected
- After system standstill for longer than two years.

4.18.3 Test equipment

OFN (oxygen free nitrogen) – high purity <10ppm moisture content.

> **Note:** The use of standard grade nitrogen is unsafe because of the possibility of sufficient oxygen to cause an explosion at high pressure. Refrigerant, oxygen or compressed air cannot be used as the test medium for onsite tightness tests.

Tracer gas – OFN with a small percentage of <5% hydrogen (tracer) or 10–30% helium (tracer) gas added, to improve the sensitivity of detection. Specific detectors for hydrogen or helium are used to pinpoint the leak. Warning: For safety reasons 5% hydrogen must not be exceeded.

> **Note**: With the use of a suitable electronic gas detector, using tracer gas (hydrogen or helium) offers far more sensitive and accurate leak detection than when using pure OFN.

Gas and leak detectors – A variety of technology is available for gas or leak detection:

- **Electronic gas detector** – gas detector designed and calibrated for the gas being detected (recommended)
- **Ultrasonic leak detector** – electronic detectors designed to detect the sound of leaking gas
- **UV additives** – fluorescent additives than can be detected where they leak by a UV light
- **Proprietary leak detection spray/fluid** – commercial non–corrosive spray purpose-designed for leak testing.

All equipment should be used in accordance with the manufacturer's instructions. The use of an electronic gas detector is recommended, with leak detection spray/fluid limited to point source leak verification.

4.18.4 Test pressure

For initial system commissioning the test pressure must be at the system maximum allowable pressure (PS) for that section and:

- Lower than any pressure limiting device setting and any pressure relief device setting
- Never greater than the maximum allowable pressure (PS).

When testing a repair or component replacement the test pressure must be:

- Above 25% and below 90% of the maximum system allowable pressure (PS)
- Lower than any pressure limiting device setting and any pressure relief device setting.

4.18.5 Test procedure

The leak-detection procedure should take into account the response time of the equipment and the maximum distance between the leak and the leak-testing equipment. The following steps are recommended:

1. Recover all refrigerant where applicable.
2. Evacuate the system.
3. Connect the OFN cylinder to the system or isolated section under test.
4. Pressurise the system in stages.
5. Check for leakage and pressure loss at every pressure increment increase. Repair any leaks found.
6. When the maximum system allowable pressure has been reached, isolate the system from the nitrogen cylinder and record the system pressure and ambient temperature.
7. Monitor the system pressure for the required test duration, 1 hour up to 24 hours (see below).

8. If there is any drop in pressure (pressure adjusted for changes to ambient conditions in accordance with the ideal gas laws) then all leaks must be identified.
9. While the system is holding the test pressure, all potential leakage points should be tested with a leak detector. Check the whole system. The first leak found might not be the only leak.
10. If a leak is identified, the OFN must be vented, the leak repaired and the leak tightness test procedure repeated.

The detection equipment should be used in accordance with the manufacturer's instructions. It is best practice to use a combination of techniques e.g. an electronic detector to test an area and leak detection spray to identify and verify the exact location of the leak.

When the system has met the acceptance criteria the OFN must be removed, the system evacuated and then charged with refrigerant in accordance with Clause 6.12.

When the system has not met the acceptance criteria, and a leak has not been found, the test should be repeated using more sensitive leak detection, e.g. using a tracer gas to improve detection or a specialised UV leak detection dye.

4.18.6 Test duration

Leak tightness test pressure should be held for:

- Up to 24 hours for initial system commissioning tests, and
- At least 1 hour when testing a repair or component replacement.

4.18.7 Acceptance criteria

The system should be observed over a period of time, relative to the size of the system, to ensure that no pressure drop (due to leakage) occurs, having due regard to ambient temperature and temperature variation throughout the system.

For joints, equipment and components assembled at the installation site, all potential leakage points must be tested with detection equipment, with the equipment in standstill and under operation or under a pressure of at least the standstill or operational conditions.

For refrigerants with GWP > 150, the AS/NZS 5149 acceptance criterion for this test is that no leaks are detected when using detection equipment with a capability of 10^{-6} Pa·m³/s or better, for example, a helium sniffer.

For refrigerants with GWP < 150, the AS/NZS 5149 acceptance criterion for this test is that no leaks are detected when using detection equipment with a capability of 10^{-3} Pa·m³/s or better, for example, application of a leak detection spray to the outer surface.

Any leak detected at this level of sensitivity must be repaired and retested.

5. RISK ASSESSMENT, CONTROLS AND DETECTION SYSTEMS

5.1 General

This section provides information on risk management and gas detection, for use by technicians, contractors and SMEs.

5.2 Risk assessment

5.2.1 Hazard identification and assessment

Hazard identification and risk assessment enables a site to control risks associated with any product, process or plant that has the ability to cause injury or harm to people on the site.

This process can be simple or complex depending on the number of hazards and the association of those hazards present on the site. In some instances a hazard identification and risk assessment flow diagram can be used. More complex hazards might require a WHS specialist with specific knowledge to provide assistance.

Risk assessment determines whether there is a direct risk of injury or damage to property from the identified hazards. The purpose of the risk assessment is to:

- Determine those risks that need to be controlled, and
- Assist in making decisions about the order in which risks should be controlled.

5.2.2 Risk management

Risk management is the process of determining and implementing appropriate measures to control the risks associated with hazards identified for a site. PCBUs have a duty to ensure that any risks associated with their premises or activities are controlled. The primary duty is to eliminate these risks. If this is not possible, the risks must be reduced as far as is practicable.

The risk management process involves the following steps:

1. **Establish the context** – this helps to define the scope and identify key stakeholders.
2. **Identify hazards** – find out what could cause harm.
3. **Assess the hazards** – understand the nature of the harm that could be caused by the hazard, identify the risk factors.
4. **Evaluate the risks** – how serious the harm could be and how likely it is to happen; can the risk be controlled (avoided, reduced or transferred).
5. **Control risks** – implement the most effective control measures that are reasonably practicable in the circumstances, and monitor performance.
6. **Review control measures** to ensure they are working as planned.

Figure 5.1 Steps in risk management

The consistent, auditable recording of the reasons for decisions on risk should help in the long-term development of more effective decisions on risk.

5.2.3 Hazard identification

Some of the hazards that need to be considered include:

- **Chemical hazards:** safety data sheet (SDS) information such as flammability characteristics, toxicity, asphyxiation, etc., for refrigerants and oils
- **Plant hazards:** component failures, over-pressurisation and releases, corrosion, confinement and enclosed areas, collateral damage or impacts, thermal hazards (burns or frostbite)
- **Task hazards:** monitoring tasks such as visual inspections and pressure readings, maintenance tasks such as "breaking in" to a system
- **Work environment hazards:** indoor versus outdoor work, enclosed areas and confined spaces, ventilation, refrigerant transfer.

5.2.4 Hazard mitigation

Some of the controls that could be applied to individual hazards include:

- **Elimination or substitution** – of the hazard for a non-hazardous alternative
- **Enclosure** – of the hazard to contain the risk
- **Ignition sources** – remove potential ignition sources
- **Ventilation** – reduces contaminant by dilution or exhaust
- **Detection** – Odourisation of refrigerant, installation of fixed gas detection, use of portable gas detection
- **Charge minimisation** – reducing the quantity of refrigerant required
- **Charge retention** – the use of valves, receivers and automatic controls, to minimise potential leak quantities
- **Information and administration** – Education and awareness, emergency procedures, alarms
- **Personal protective equipment** – lowest on the risk control hierarchy.

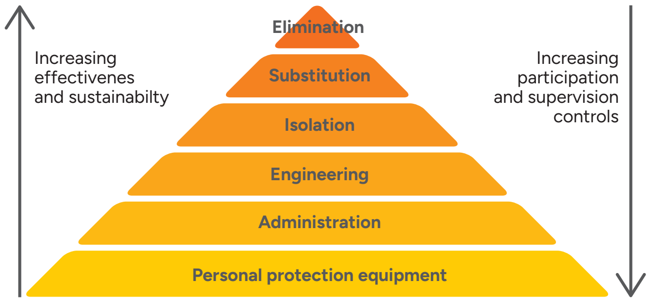


Figure 5.2 Hierarchy of control measures

Further specific information and guidance relating to hazard identification, risk assessment and control processes can be obtained from AS/NZS 60079.14 and AS/NZS 60079.10.1, and the following resource documents:

- AS/NZS ISO 31000 – Risk management – Principles and guidelines
- HB 158 – Delivering assurance based on ISO 31000:2009 Risk management – Principles and guidelines
- Managing risks of hazardous chemicals in the workplace Code of Practice (SafeWork Australia)
- Managing the risks of plant in the workplace Code of Practice (SafeWork Australia).

5.3 Gas detection systems

5.3.1 Gas detection

Gas detection is the act of locating a gas hazard and characterising the nature of the hazard during a leak condition. This could be a toxic, asphyxiant or flammable condition. It shows the nature of the atmosphere that workers and the public might be exposed to and supports the selection of other risk control measures such as respiratory protection. In the context of this guide there are two common situations when detection is considered. They are:

- Under common working conditions, and
- In an emergency response.

During common working conditions, detection is intended to provide information about the presence and concentration of airborne hazards to ensure a safe environment. In particular, it provides warning in the event of a leak from the refrigeration or air conditioning system or some other change to the nature of the atmosphere.

During emergency conditions, detection is intended to identify the nature of the airborne contaminant and the extent of the hazard to assure the safety of any onsite response team or emergency responders (police, fire, and ambulance officers) and the community. This activity plays a crucial role during the emergency response.

5.3.2 Monitoring and trigger levels

Detecting gas levels over time, i.e. monitoring, is necessary to check the state of the hazard and hazardous area over time. With any gas detection system, triggers to undertake specific actions should be specified. The accepted trigger criteria for action levels for gas detectors include:

- 19.5% oxygen content (for human respiration)
- 5% of the LFL (for WHS regulations)
- 25% of the LFL for alarm activation and isolation of electrical equipment that is not rated for hazardous areas, and
- National exposure standards (for community and occupational exposures).

For all applications, any level of gas detection should be taken as an indicator of likely dangerous conditions or situations that could quickly escalate to dangerous. It should be taken seriously and be treated with appropriate caution.

5.3.3 Operation

It is the workplace's obligation to ensure the detection equipment is serviceable and functioning, given its vital importance to warn workers and the community. Matters to be addressed include:

- Selection and assessment
- Policy and procedures
- Calibration
- Maintenance and servicing
- Use – criteria and action levels
- Review and audits.

5.3.4 Selection

There are two categories of gas detection systems: fixed systems and portable systems. Regardless of the system category there are basic selection factors to consider, these include:

- Appropriate certification for hazardous area use, for example intrinsic safety
- Robustness, design and construction
- Operating range, selectivity, and sensitivity
- Calibration, maintenance (such as mean time between failures (MTBF)) and servicing
- Alarms, power requirements, and data logging
- Operation.

Detailed information on gas detection system selection, use, training and maintenance is available in AS/NZS 60079.29.2.

5.4 Refrigerant detection

Refrigerant detectors provide early detection to help prevent significant refrigerant loss and limit the exposure of people to hazardous atmospheres generated by a leak of flammable refrigerant. Cylinder storage areas can also be protected by detectors.

Refrigerant detection systems can be used to:

- Initiate mechanical emergency ventilation
- Actuate audible and visual alarms
- Automatically shut down any combustion processes in the area
- Shut down the refrigerating system components (chillers, pumps etc.).
- Alarms can be set at levels to provide a sequence of operation.

Portable refrigerant detectors are suitable to monitor for hazardous atmospheres and for in-service leak detection.

5.4.1 AS/NZS 5149 requirements

Appropriate refrigerant detectors must be provided when the allowable charge specified in AS/NZS 5149.1 can be exceeded for the installation. This can commonly occur in plantrooms (machinery rooms).

Detectors must at least actuate an alarm and start the emergency mechanical ventilation of a machinery room. They must be protected to prevent tampering and located to allow access for checking, repair, or replacement.

A refrigerant detector for flammable refrigerant (except for R717) must activate at a concentration as low as practical and not exceeding 25% of the LFL of the refrigerant and continue to activate at higher concentrations.

5.4.2 AS/NZS 60355.2.40 requirements

The output signal from the detection system must initiate the actions required to comply with Appendix GG of the standard (close valves, start ventilation, raise alarm etc). For multiple units in the same room that share the output signal from a single detector, all units must initiate the required actions.

The refrigerant detection system must comply with IEC TS 63542.

The detection system must generate an output signal within 30s when the refrigerant concentration exceeds 25% of the LFL.

5.5 Fixed detection systems

Fixed detection systems are intended to monitor the atmosphere and provide warning about a leak or change to the composition of the atmosphere. Such systems could include oxygen detectors, flammable gas detectors and toxic gas sensors. All systems require regular servicing and operator training to ensure ongoing operability.

A fixed gas detection system could be installed for any system where refrigerant leakage could cause a hazard. This includes any systems installed in areas such as open air where the practical limit can be exceeded in the vicinity or where there is risk of pooling occurring in low lying areas. A risk assessment should be undertaken for systems with a large refrigerant charge to determine if a fixed gas detection system is required.

Fixed detection systems should be installed at suitable locations that take into account the types of activities and vulnerable points of the system where leaks might be expected to occur (and affect the workforce or the public), such as around the installation or loading areas and public spaces. The ideal detector locations are also influenced by the physical and chemical properties of the airborne contaminant (the refrigerant) and the application, for example:

- The density – is the refrigerant heavier than air?
- Any effect of ventilation on gas movement?
- The safety characteristics – is the flammable refrigerant toxic or an asphyxiant?
- What is the likely operating and release temperature of any leaked refrigerant?

Procedures relating to responding to an alarm from a fixed detection system, including the systems shutdown procedure and occupant evacuation procedure. should be explicitly detailed in the site's emergency plan.

Note: Some types of gas detection is of limited value in coolrooms and freezer rooms due to the condensing nature of the thermal environment. In addition, detection equipment will have ongoing maintenance and verification requirements, to ensure correct operation.

5.6 Hand-held or portable detection systems

Hand-held or portable gas detection systems are intended to be used by workers during everyday activities such as refrigerant leak detection, repairs, confined space entry, and also in emergency response scenarios. They are also used to inform workers of the selection of appropriate PPE required to undertake a task.

Hand-held or portable systems require regular servicing and operator training. If the facility intends to use hand-held or portable gas detectors during emergency response activities it should consider the following:

- Are there enough calibrated instruments available within the facility?
- Are staff trained and resourced to use them?
- Will the instrument detect the airborne contaminant over the entire range of measurement interest?
- Do testing procedures adequately address the range of conditions and site-specific issues associated with a release (e.g. gas layering, topographical issues, confinement, etc.)?

5.7 Personal protective equipment (PPE)

PPE is a risk control measure (see SafeWork Australia Code of Practice Managing the risk of hazardous chemicals in the workplace); however, it is generally only used as a last resort measure where other risk control measures have failed. Within the context of the WHS Act and Regulation, the PCBU must ensure suitable PPE is provided to the worker.

The selection of PPE is based on several factors. These include:

- The type and nature of the hazards – such as flammability, electrical, and airborne contaminants
- Location of the work or tasks – such as open area, confined space, working at heights
- The type of tasks e.g. hot work, manual tasks or decanting chemicals
- Suitability of PPE for hazard– static electricity characteristics, fire performance, chemical protection, heat dissipation

- Suitability of the operator – fitness, age, heat and psychological stress.

In addition to the selection of the PPE, work policies and other factors should be considered. These include communication, work methodology, safety risk (such as for a rescue team), and refrigerant detection. Providing appropriate PPE for the workplace is critical, and considerations should include:

- Selection and assessment
- Policy and procedures
- Training
- Maintenance and servicing
- Use and decontamination
- Review and audits.

5.8 Protective clothing

All PPE should be maintained in accordance with the relevant standards. All wearers of the PPE should be trained in its use. Considerations in selecting appropriate PPE should include:

- Eye protection should conform to AS/NZS 1336 and the appropriate part(s) of the AS/NZS 1337(series)
- Eye wash – An eye fountain should be a fountain designed to effectively irrigate both eyes for a period of at least 30 min; an eye irrigator should be an eyecup or other device to irrigate the eyes
- Gauntlet gloves should have separate fingers and thumb and should protect the hands and forearms
- Clothing – Cotton drill long trousers and long-sleeve shirts or full-length or seamless coveralls (synthetic and woollen clothing should not be used due to the risk of static electricity becoming a source of ignition). Also, long-sleeve jackets provide protection from the cold (refrigerant leak).
- Safety boots: Should conform to AS/NZS 2210.3 Type 1 and Type 4 (waterproof), and be elastic sided boots or sewn tongue. Safety footwear is available with static electricity dissipative ratings, which assists with the management of static electricity when used on most floor surfaces. Examples include footwear that is marked according to AS 2210.3 or ISO 20345 as Class I or II and marked with codes A, S1, S2, S3, S4 or S5, and ASTM F2413 and marked with code SD.

Procedures for the safe disposal and/or re-use of contaminated PPE (after use) should also be considered.

5.9 Emergency planning

The WHS Regulations require an emergency plan to be prepared, maintained and implemented in the event of an emergency for every workplace. These obligations extend to a contractor working on a refrigeration system. The requirements imposed on fulfilling these obligations are generally limited to the scope of work and authority.

For example, a contractor servicing a refrigeration system at a large commercial premises must prepare, maintain and implement an emergency plan dealing with the work they are undertaking; however, they do not necessarily have the authority to evacuate the premises. This function should be dealt with in the site emergency plan. Consequently, the PCBU with the authority for the site should be consulted in the development of the contractor's own emergency plan.

While this guide focuses on flammable refrigerants, emergency planning must adopt an "all hazards" approach covering the whole premises, in which flammable refrigerants are a single component of a refrigeration system within a facility. In addition, the emergency planning should consider which flammable refrigerant is in use, as some flammable refrigerants can be either toxic or produce toxic products of combustion.

Refer to the checklist for Emergency Plans from SafeWork Australia

http://www.safeworkaustralia.gov.au/sites/swa/about/publications/pages/emergency-plans-fact-sheet

6. SERVICE AND MAINTENANCE

6.1 General

This section covers the maintenance and associated requirements for flammable refrigerant-based refrigeration systems. This section also includes information on pre-service safety, temporary flammable zones, refrigerant recovery, refrigerant venting, refrigerant top-up, and tools and equipment.

Regular service and maintenance are essential to the safe and reliable operation of a flammable refrigerant-based refrigeration system. Service and maintenance are covered in AS/NZS 5149.4. The provisions of the standard relating to service and maintenance of flammable refrigerant systems are detailed in this section.

Specific guidance for system components can also be found in other guides, codes or standards and such guidance should also be followed where relevant. For example, the requirements for inspection and maintenance of electrical equipment in hazardous areas can be found in AS/NZS 60079.17.

6.1.1 Service risk

It is generally recognised that the risk of fire or explosions is higher when systems are being worked on, compared to when they are operating normally. This is because the possibility of a release of refrigerant mixing with oxygen and the presence of potential sources of ignition is greater during service and repair activities.

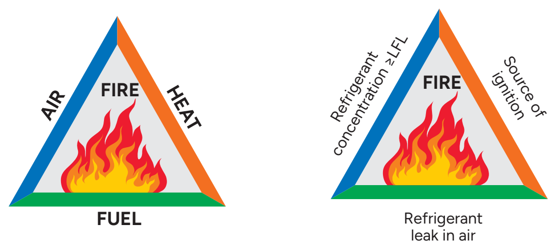


Figure 6.1 Leakage-induced fire conditions

Persons working on such systems must be competent, which includes meeting specified training and licensing requirements if the jurisdiction requires it (e.g. ARCtick licensing requirements or Queensland state regulations).

Warning: All fluorinated refrigerants, when heated or combusted, release highly toxic gases including hydrofluoric acid and carbonyl halides, see Clause 4.8. This means that a toxicity hazard can develop (even if ignition does not occur) as a result of refrigerant escape due to a leak or servicing procedure.

6.1.2 Tools and equipment

Tools and equipment used during service and maintenance (including, but not limited to, portable detectors, vacuum pumps, tools, cylinders and gauges) must be rated for use with the appropriate refrigerant flammability class (2, 2L or 3) and be in serviceable condition.

New or existing servicing tools and equipment should be assessed individually to ensure either:

- They conform with relevant International/Australian/New Zealand standards, or

- The manufacturer's manual/specification states that it is designed for use with flammable refrigerants.

Note: Mains-powered hand drills, screwdrivers, heat guns, hair dryers and the like should never be used inside confined compartments, such as those of a domestic freezer or provision compartments. Brush-type motors or heat produced from the element introduces an ignition source into a very confined space. Battery tools with brushless motors can be used.

6.1.3 Labelling flammable refrigerant

There are three different but similar labels or pictograms that will be encountered when dealing with flammable refrigerants.

1. The ISO 7010 W021 Flammable material symbol is used on appliances and systems.
2. The GHS Flammable Gas GHS02 Pictogram is used in the SDS and for product storage placarding and manifest purposes at workplaces.
3. The ADG Flammable Gas Class 2 Division 2.1 label is used for packaging and placarding for transport. GHS labelling is suitable on internal packaging for goods in transit; however, an ADG symbol may be substituted for a GHS pictogram where the ADG class symbol represents the same hazard.

An equivalent ADG dangerous goods pictogram is an acceptable alternative to a GHS pictogram.

ISO 7010 W021 symbol | GHS02 Pictogram | ADG Division 2.1 label

Figure 6.2 Flammable Refrigerant Labels

6.2 AS/NZS 5149.4 maintenance provisions

6.2.1 Preventative maintenance

Leak tests, inspections and checking of the safety equipment should be carried out regularly.

The system instruction manual (see AS/NZS 5149.2 or AS/NZS 60335.2.40 Annex DD) must include the maintenance instructions for the entire system with a time schedule for preventive maintenance with respect to leakage.

AS/NZS 5149.4 requires that preventive maintenance be carried out in accordance with the system instruction manual.

6.2.2 Inspection

All systems should be regularly inspected in accordance with AS/NZS 5149.4, Section 5.2 Maintenance and AIRAH's DA19 – HVAC&R maintenance – Compliance level maintenance.

The general operating conditions should be checked regularly, including system pressures where readings are displayed, refrigerant sight glass, etc. The condition of condensing equipment should also be checked regularly. For air-cooled equipment, the condition of the condenser coil should be observed.

A regular inspection program should ensure that the protection offered by the sacrificial anode or other protection where fitted is maintained and that the heat exchangers stay clean and scale-free.

6.3 AS/NZS 60335.2.40 maintenance provisions

Under AS/NZS 60335.2.40, for appliances using flammable refrigerants, a service, maintenance and repair manual must be available that includes at least the information required by Annex DD of the standard.

The manual must contain specific safety information for service personnel including:

- Safety checks to the area to ensure the risk of ignition is minimised
- Using controlled work procedures (e.g. safe work method statements)
- Instructing all staff and people in the area and avoiding work in confined spaces
- Checking for presence of refrigerant with an appropriate refrigerant detector, before, during and after the work
- Having appropriate fire extinguishers if any hot work is done
- Controlling ignition sources before, during and after the work
- Ensuring adequate ventilation.

The manual must specify the parts of the refrigeration system to be checked, including checks to the refrigerating equipment, refrigerant charge, ventilation arrangements, marking and corrosion, and electrical devices and cabling.

During servicing and maintenance, technicians must follow procedures that minimise the risk of ignition. This includes using appropriate leak detection methods and ensuring that electrical components are handled safely. The annex stresses the need for proper ventilation during any work on the refrigerant circuit and requires that technicians be trained and competent in handling flammable refrigerants.

Manuals must also provide clear instructions for safely removing refrigerant, purging systems with inert gas, and recharging them without contamination.

When decommissioning an appliance, technicians must follow procedures that ensure all refrigerant is safely removed and the system is properly labelled. Disposal must comply with local regulations, and any components that could pose a hazard must be handled with care.

6.4 In-service leakage inspection

Including in-service leak inspections as part of a preventative maintenance program allows the technician to find and fix small leaks before they lead to complete loss of refrigerant charge.

The in-service leak inspection is carried out with the refrigerant in place and the system operating as normal.

"Inspected for leakage" means that the equipment or system is examined primarily for leakage using direct or indirect measuring methods, focusing on those parts of the equipment or system most likely to leak.

For an in-service leakage inspection, the technician should complete:

1. A visual inspection of the system.
2. A diagnostic analysis of the system operating parameters.
3. A leak inspection of the system, including common leakage points.

6.4.1 Visual inspection

The technician should review the maintenance records to identify where leaks have been found previously. The technician should complete a visual inspection of the operating system including, but not limited to, identifying any:

- Visible oil or dust stains on joints, components or insulation
- Movement or stresses due to vibration or thermal expansion
- Signs of corrosion, thermal stress, wear or metal to metal contact points
- Unusual level of noise or vibration from the system.

6.4.2 Diagnostic analysis

The technician should assess the system/refrigerant operating temperatures and pressures and compare against the manufacturer's data and operation instructions to determine whether the refrigerant charge is low.

For systems with fixed-speed compressors, technicians can assess charge levels against manufacturer data by measuring pressure readings coupled with air and refrigerant temperatures.

For systems with variable speed compressors, diagnostic analysis can involve running the system at maximum output and measuring temperature difference (TD) and change in temperature (ΔT) across the heat exchangers at steady state, or measuring delivered capacity, which requires measuring enthalpy change (ΔH) and fluid flow rate.

Some systems have on-board diagnostics for automatic leak detection.

Where diagnostic analysis indicates a low refrigerant charge, a leak tightness test should be performed.

6.4.3 Leak inspection

Various methods may be used for leak inspection, e.g. electronic gas detectors, ultrasonic leak detectors, proprietary leak detection spray, or ultraviolet fluorescent additives. Electronic gas detectors should be specific to the refrigerant type.

- Using a gas or leak detector, assess all joints and components on the system for leakage, with a focus on common leakage points and any areas identified in the visual survey
- Follow the gas or leak detector manufacturer's instruction for detection
- The results of the in-service inspection should be recorded.

Where a leak is detected, all refrigerant must be removed from the system or affected section, and the leak repaired. When isolating an affected section and removing refrigerant using pump-down, care must be taken to avoid negative pressure, which could lead to air entering the system.

Where a leak is suspected but not detected, all refrigerant must be removed, and the system (or affected section) should be leak tightness tested.

6.4.4 Portable leak detectors

Portable refrigerant leak detectors are used for verification of hazardous atmospheres, personal safety, and in-service leak inspection programs – see Clause 5.6.

Technologies used include:

- **Electronic gas detectors** identify the refrigerant and detect the actual refrigerant concentration in the air. These are suitable for detecting hazardous atmospheres and leak testing systems and components.

- **Ultrasonic detectors** detect the ultrasonic noise created by the leak of any gas. These are suitable for leak testing systems and components.
- **Fluorescent additive detection** identifies leaks by the use of a UV light that causes a substance added to the refrigerant to visibly fluoresce, showing the leak. This is suitable for leak testing systems and components.
- **Proprietary leak detection spray/fluid** verifies point source leaks with a commercial non-corrosive spray/fluid purpose-designed for leak testing.

All equipment should be used in accordance with the manufacturer's instructions. The use of an electronic gas detector is recommended for in-service leak inspection, with leak detection spray limited to point source leak verification.

Systems containing flammable refrigerants require the use of a gas detector designed specifically for flammable gases. Traditional halide leak detectors that rely on an open flame should never be used for flammable refrigerants.

The detection equipment should be calibrated periodically. The sensitivity of portable gas detection devices should be at least 5g per year.

6.4.5 Common leakage points

The following areas should be individually assessed with a gas or leak detector:

- **Joints** – flare joints, mechanical joints and flanges, brazed joints, catalyst cured joints
- **Valves** – Schrader valves, service valves, manual valves, pressure relief valves/devices, expansion valves, line tap valves
- **Evaporators and condensers** – corroded areas, return bends, valves and joints
- **Seals** – shaft seals (open compressor), compressor gaskets, seals on replaceable driers and filters, seals on gauge points, seals on caps
- **Other** – capillary tubes, control bellows, O rings and pressure switches.

Access valves should have their caps refitted.

6.4.6 Testing the low-pressure side

The low-pressure side of a system should be placed under a positive pressure before leak testing the evaporator, heat exchanger, expansion valve, solenoid valve, and other components.

Pressure in the low-pressure side of the system during testing should not exceed the maximum design conditions.

6.4.7 Leakage inspection frequency

Mandatory leak inspection frequency

AS/NZS 5149.4 requires that each refrigerating system be subjected to preventive maintenance with respect to leakage in accordance with the system instruction manual, including the frequency of in-service leakage inspections.

Recommended leak inspection frequency

In the absence of instructions in the operating manual, the recommended frequency of in-service leakage inspections of AS/NZS 5149.4, shown below, should be followed.

SYSTEM TYPE /REFRIGERANT CHARGE	INSPECTION FREQUENCY
Self-contained systems, unitary systems	After repair or when leakage is suspected
Hermetic systems ≤ 6kg refrigerant charge	Every 12 months
All other systems ≤ 3kg refrigerant charge	After repair or when leakage is suspected
All other systems > 3kg ≤ 30kg refrigerant charge	Every 12 months
All other systems > 30kg ≤ 300kg refrigerant charge	Every 6 months
All other systems > 300kg refrigerant charge	Every 3 months
Stored refrigerant in cylinders	Every 3 months

Table 6.1 AS/NZS 5149.4 Recommended in-service leakage inspection frequency

Best practice leakage inspection frequency

The best practice approach to in-service leakage inspections is currently reflected in the European Union (EU) F-Gas regulations, where the frequency is based on tonnes of CO_2 equivalent of the refrigerant charge, and whether a fixed refrigerant leak detection system is fitted.

The tonnes of CO_2 equivalent (tCO_2e) of a refrigerant charge is calculated by multiplying the mass of refrigerant charge in tonnes by the GWP of that refrigerant.

The EU regulations also mandate inspection frequencies for HFO refrigerants, based on refrigerant charge mass.

Refrigerant type	Refrigerant charge (tonnes CO_2e or kg refrigerant)	Leak inspection frequency (months)	
		No fixed leak detection	With fixed leak detection
HFC and HFC/HFO Blends	▸ 5t $CO_2e \leq$ refrigerant charge < 50t CO_2e ▸ 50t $CO_2e \leq$ refrigerant charge < 500t CO_2e ▸ Refrigerant charge ≥ 500t CO_2e	12 6 3	24 12 6
HFO	▸ 1kg ≤ refrigerant charge < 10kg ▸ 10kg ≤ refrigerant charge < 100kg ▸ Refrigerant charge ≥ 100kg	12 6 3	24 12 6

Table 6.2 European Union (EU) F-Gas regulation – Leak inspection frequency

6.5 Maintenance competency

6.5.1 AS/NZS 5149.4 competence

AS/NZS 5149.4 states that the personnel charged with the operation, supervision and maintenance of the refrigerating system must be adequately instructed and competent with respect to their tasks. A competent person is required for all the following tasks:

- All maintenance service and testing
- Leak detection and repair
- Replacement or changes to equipment
- Refrigerant recovery, reuse, recycling, reclamation and disposal
- Draining oil from systems
- Welding and brazing.

Other trades working on the system (e.g. electricians or controls technicians) must be supervised by a competent person.

ISO 22712 defines the activities related to working on ISO 5149 type refrigerating systems and the associated competence profiles. It also establishes competence criteria for persons who carry out these activities. ISO 22712 provides a matrix of skills and knowledge versus tasks for all required activities and provides for four levels of assessment:

- BA – Basic appreciation level
- WK – Working knowledge level
- FO – Fully operational level
- LE – Leading edge level.

6.5.2 AS/NZS 60335.2.40 competence

Annex HH of AS/NZS 60335.2.40 details the competence expected for service personnel working on in-scope equipment (i.e. air conditioning and heat pump appliances). The qualifications required should be listed in the appliance instruction manual.

Under AS/NZS 60335.2.40, every maintenance, service and repair procedure that involves safety must only be carried out by a competent person. This includes:

- Breaking into the refrigerating circuit
- Opening of sealed components
- Opening of ventilated enclosures
- Decommissioning systems.

Special training is required for servicing equipment with flammable refrigerant, including information on:

- Consequences of explosions
- Potential ignition sources
- Protection by ventilation
- Protection by sealing enclosures or components
- Correct working procedures for commissioning, maintaining, repairing, decommissioning and disposal of systems containing flammable refrigerant.

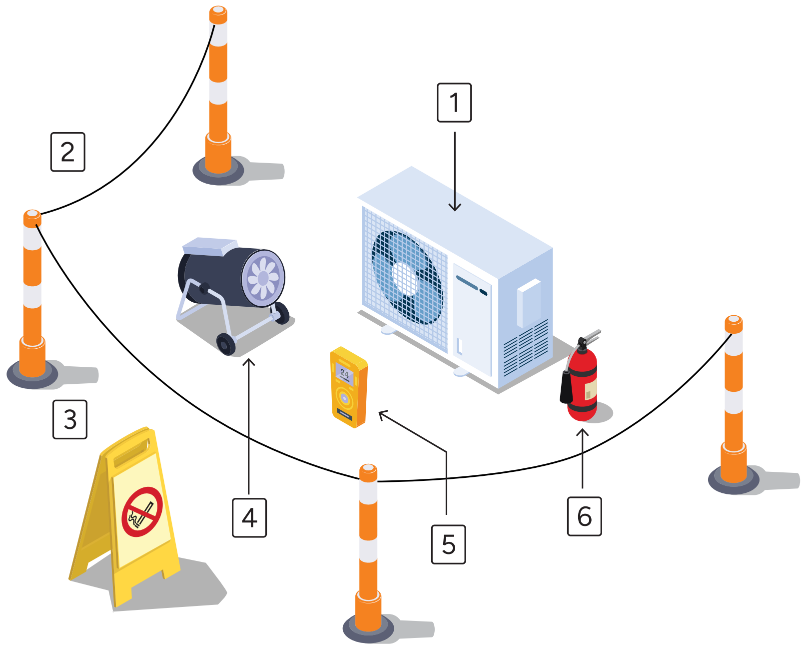
6.5.3 AS 4761.1 competence

AS 4761.1 includes competencies for all types of personnel who might carry out work associated with hazardous areas including classification, design, installation of electrical systems and maintenance of electrical equipment.

6.6 Pre-service safety

A technician should be aware of the possibility that the system might have been incorrectly charged or incorrectly labelled.

Before carrying out any work on a refrigerating system or associated equipment, it is essential to ensure that the immediate area is suitable for working safely and the appropriate precautions are in place, as it is deemed a temporary flammable zone. In particular, before working on systems containing flammable refrigerants, safety checks are necessary to ensure that the risk of ignition is minimised.



1. Unit being worked on – containing flammable refrigerant
2. Temporary flammable zone – safety exclusion zone
3. Safety warning signs – Warning, Danger, Restricted Access, No Smoking, No Mobile Phones
4. Ventilation fan – IECEx Certified fan or equivalent
5. Refrigerant gas detector – suitable for use with flammable refrigerants
6. Fire extinguisher – CO_2 or powdered dry type

Figure 6.3 Example of pre-service safety for flammable refrigerant systems

An assessment should be completed before any service, maintenance, or repair of the system to confirm the type and classification of the installed refrigerant. If the system uses a flammable refrigerant, or the refrigerant is unknown, the following safety precautions should be taken before working on the refrigerant circuit:

- Identify the refrigerant being worked with; if identification is not possible, treat it as an A3 refrigerant
- All staff and others working in the local area should be instructed on the nature of the work being carried out
- The area around the workspace should be sectioned off
- Obtain permit for hot work (if required)
- Working within restrictive spaces should be avoided. When this cannot be avoided, additional safe working practices should be employed including working with a buddy and appropriate PPE
- No flammable materials are stored in the work area
- No ignition sources are present anywhere in the work area
- Suitable fire extinguishing equipment (CO_2 or dry powder type) is available within the immediate area
- The work area is properly ventilated before working on the refrigerant circuit or before brazing or handling electrics
- Ventilation should safely disperse any released refrigerant and preferably expel it outside
- Suitable flammable gas detectors are present and operating to warn workers of a dangerous concentration of refrigerants
- The gas detection equipment used is suitable for hazardous areas
- Erect appropriate signage, including “no smoking” and “do not enter the area” signs, *see Figure 6.4*
- All appropriate and necessary tools, PPE and equipment are available

Figure 6.4 Appropriate signage

6.7 Temporary flammable zones

When working on systems using flammable refrigerants, the technician should consider certain locations as “temporary flammable zones” (refer Clause 4.6.3). These are normally regions where at least some emission of refrigerant is anticipated to occur during working procedures, such as recovery, charging, and so on, typically where hoses can be connected or disconnected. These areas may be classified as Zone 2 Hazardous Areas under AS/NZS 60079.10.1.

For such zones, procedural controls, including isolation of all electrical equipment, may be accepted in accordance with AS/NZS 60079.14, rather than requiring all electrical equipment in the temporary flammable zone to be installed as suitable for a hazardous area.

In anticipation of the maximum quantity of refrigerant that might be released during such a procedure (such as disconnecting a hose while it is full of liquid refrigerant), the distance from this point that should be considered as a temporary flammable zone is a minimum of two metres in all directions, refer to AS/NZS 60079.10.1. The size of the temporary flammable zone should be determined from the refrigerant charge in the system, the refrigerant discharge rate, and whether the system is indoors or in a well-ventilated area (e.g. outdoors). For example, for a domestic fridge it could be a minimum of two metres, for a small air conditioner or heat pump it could be three metres, for a larger system with a larger refrigerant charge, greater distances could be required.

Under no circumstances should the system be broken into by means of cutting or breaking pipework if it contains any flammable refrigerant or any other gas under pressure.

6.8 Gaining access to a system

A number of other aspects should be considered when gaining access to a system:

- In the absence of servicing ports, tube piercing valves can be used to gain access. This should be followed by leak detection to ensure refrigerant does not leak around the pierced tubing. Tube-piercing valves should be removed prior to the completion of service.
- It is generally preferable to remove the entire refrigerant charge in case of unexpected failures. When isolating an affected section without removing all refrigerant, such as in the case of a pump down, care must be taken to ensure that air does not leak into the system (via leakage points), creating a mixture of refrigerant, oil and air, and an associated explosion or flammability hazard.
- If refrigerant has been removed, the system should be flushed with OFN. Although there will always be some residual flammable refrigerant left in the system, flushing with nitrogen can eliminate the risk of flash fire by diluting residual refrigerant below the LFL. Depending on the circumstances (e.g. charge size and specific purging method), this process might need to be repeated several times.
- If brazing or de-brazing operations are to take place on the pipework, OFN should be purged through the system both before and during the process.
- Due to the possible explosion hazard, compressed air or oxygen must not under any circumstances be used for flushing, pressure testing or filling the system.

Where possible, it is preferable to use cold connection technologies instead of brazing when performing system repairs where there is a likelihood that residual flammable refrigerant is present.

6.9 Refrigerant recovery

The machine used for refrigerant recovery must be suitable for use with flammable refrigerants. In particular, it should not have any potential sources of ignition; the requirements are the same as those for a refrigerating system (see Section 4).

Refrigerants of different safety group classifications (e.g. A1, A2L, A2, and A3) must not be mixed in recovery cylinders.

Cylinders must be carefully weighed during the transfer of the refrigerant and the permissible fill weight of refrigerant in the cylinder at a reference temperature of 65°C must not be exceeded, see Clause 9.4. All cylinders are required to be marked with a tare weight. Some may have an indication of the weight of refrigerant that can safely be contained. If there is any doubt, the weight of the refrigerant which can be contained should be checked. Refer to cylinder standards such as AS/NZS 1596, AS 2030.1, AS 2030.5 and AS 4332.

Prior to recovery, all hose connections should be leak-tested before permanently opening the valves. Care must be taken to ensure that air does not get into the cylinder (via leakage points), creating a potential explosion or flammability hazard.

6.9.1 Scheduled refrigerant

It is an offence to act in a way that results in the unlawful discharge of scheduled refrigerants. Recovery and disposal of refrigerant at the end of its useful life, using appropriate recovery equipment or recovery/recycling equipment, is mandatory. All scheduled refrigerant removed from equipment must be recovered and reclaimed, recycled or disposed of. Any person who handles a scheduled refrigerant must hold a Refrigerant Handling Licence.

6.9.2 Non-scheduled A2L/A3 refrigerant

It is not illegal to vent non-scheduled A2L and A3 refrigerants, see Clause 6.11; however, with the right equipment, these refrigerants can readily be recovered.

When recovering or venting these refrigerants from an RACHP system, a means to safely shut off the refrigerant flow should be available, e.g., a spring-loaded dead-man valve. This is consistent with the LPG decanting procedure set out in AS 1596.

6.9.3 Mixtures that include A3 refrigerant

The correct classification of mixtures generally requires knowledge of the ingredient substances, their concentration, and individual classifications. Classification of mixtures for physical hazards requires testing of the mixtures using a refrigerant analyser.

Scheduled A1 refrigerants mixed with flammable refrigerants should be treated as A3 refrigerants with safe fill capacity of the recovery cylinder dictated by the refrigerant with the lowest fill ratio. Under environmental law, scheduled refrigerants in mixtures must be recovered by a licensed technician and it is an offence to knowingly vent them to atmosphere.

When recovering flammable A2L, A2 or A3 refrigerant mixtures, recovery equipment specifically designed and rated for the refrigerant mixture should be used. A separate recovery cylinder suitable for storing flammable refrigerant mixtures is also required.

6.10 Recovery equipment

6.10.1 Tools and equipment

Tools and equipment must be suitable for use with the appropriate flammability class. Flammable A2L, A2 and A3 refrigerants might not be compatible with the following servicing tools used to work with A1 refrigerants:

- Vacuum pumps
- Recovery units
- Refrigerant cylinders.

A suitable ventilation fan should be used when working inside if there is insufficient natural ventilation, or when working in a confined space. A dry powder or CO_2 fire extinguisher should be available at the location.

An electronic flammable refrigerant detector should be used to monitor the air in the work area. It must be suitable for detecting the particular type of flammable refrigerant in the system.

6.10.2 Recovery units

Portable equipment is available for recovery of refrigerant in the field. Hoses, fittings and procedures used during recovery should minimise the loss of refrigerant.

Refrigerant recovery equipment and recovery/recycling equipment should conform to AS 4211.3, ISO 11650 or AHRI 740. Refrigerant recovery units must be appropriately rated for the flammability safety group of the refrigerant being recovered. Recovery equipment should be used and maintained in accordance with the manufacturer's instructions.

6.10.3 Recovery cylinders

Cylinders used for recovery must conform with AS 4484, AS 2030.5 and AS/NZS 1200. Cylinders must only be used within the application they are designed for and the recovery cylinder must be appropriate for the refrigerant being recovered. Cylinders should be clearly labelled to identify the type and quantity of refrigerant in the cylinder.

A2L, A2 and A3 refrigerant must be recovered into refrigerant-specific cylinders with the correct design pressure ratings and with valves and seals that are compatible with a flammable gas. Flammable refrigerant recovery cylinders are fitted with a left-hand valve (tighten anticlockwise) and red ring around the collar, whereas non-flammable A1 refrigerant cylinders are fitted with right hand valves (tighten clockwise). Refrigerants of different safety group classifications (e.g. A1, A2L, A2, and A3) must not be mixed in recovery cylinders.

Ammonia (R717) B2L refrigerant should never be recovered into cylinders designated for A1, A2L, A2 or A3 refrigerants, as these cylinders typically have brass valves. Ammonia reacts with brass fittings, leading to corrosion and potential cylinder failure.

Refrigerant must not be recovered into an out-of-date recovery cylinder. The current date must not be more than 10 years later than the cylinder test date stamp.

> **Note**: Refrigerant/oil mixtures have a lower density than refrigerant alone, so the carrying capacity of refrigerant cylinders will be reduced for refrigerant/oil mixtures compared to pure refrigerants.

The designed maximum safe working pressure of a refrigerant recovery cylinder determined in accordance with AS 2030.5 must not be exceeded in any filling operation, no matter how temporary.

Particular care should be taken when recovering modern high-pressure refrigerants – their ambient pressures can be much higher than previous generation refrigerants.

6.10.4 Recovered refrigerant

There are four pathways for recovered refrigerant. Refrigerant reuse, recycling, reclaim or disposal as detailed in AS/NZS 5149.4.

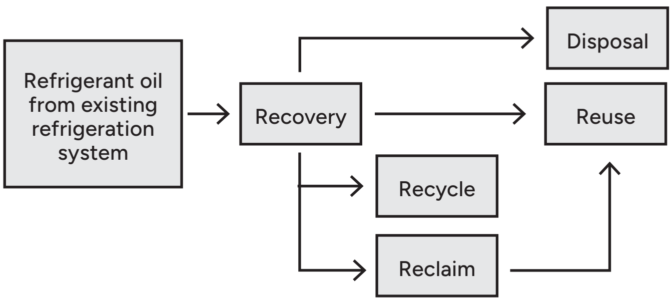


Figure 6.5 Relationship between refrigerant recycle, reclaim, reuse and disposal

6.11 Refrigerant venting

6.11.1 Scheduled refrigerants

Venting of scheduled refrigerants is prohibited.

6.11.2 Non-scheduled refrigerants

Controlled venting of non-scheduled refrigerants may be permitted when complying with applicable legislation, such as:

- Legislation relating to waste material
- Environmental legislation
- WHS/OH&S legislation
- Legislation related to hazardous substances.

A risk assessment process should be adopted (see Clause 5.2), with control measures determined and implemented, before the venting of a system is conducted.

Key issues to be considered include

- The amount of gas to be vented (volume/ discharge rate)
- Where it will go and any ability for accumulation of the released gas
- The implications to public safety
- The application of refrigerant detection and alarms
- The availability of fire protection
- The extent of any temporary hazardous areas generated and the resulting requirements for equipment within that space.

6.11.3 Venting non-scheduled A2L refrigerants

Although it is not illegal to vent non-scheduled A2L refrigerants, they are readily recoverable and AS/ NZS 5149.4 requires that venting any refrigerant to atmosphere be avoided, with the exception of R744 (CO_2). Some A2L refrigerants are linked to persistent environmental pollutants such as tri-fluoro acetic acid (TFA) and per- and polyfluoroalkyl substances (PFAS). Venting of any refrigerant that degrades to TFA should be avoided.

Indoor venting of A2L refrigerant is not recommended, as the formation of a large hazardous area can occur, in which there might be ignition sources.

If outdoor venting of A2L refrigerant is unavoidable, the controlled venting procedures of Clause 6.11.4 should be followed.

6.11.4 Venting A3 Hydrocarbon refrigerants

Indoor venting of A3 refrigerants is extremely hazardous and should be avoided. It is unlikely that indoor venting can be carried out without creating a hazardous explosive atmosphere.

Venting of flammable refrigerants outdoors can create an explosive atmosphere in the immediate vicinity of the discharge point. The extent of the danger area depends on the amount of refrigerant released and the effect of air movement in the vicinity of the release point.

The following procedures for controlled venting should be applied:

- Venting must only be done outdoors, above ground level, in a well-ventilated location with a discharge point that is at least 3m away from buildings and other obstructions
- Venting should be carried out at a refrigerant discharge rate that ensures a hazardous explosive atmosphere will not be generated within 3m of the discharge point
- Make sure no ignition sources are present or in electrical equipment used during venting operations
- Use a hose compatible with the refrigerant and oil to vent the refrigerant at least 1m above ground level to help it disperse and dilute in the air
- Beware of hazardous areas near hose connections and make sure all connections are tight before starting work
- Ensure that the refrigerant will not be blown into any adjacent buildings, and that it has no way of sinking below ground level (such as into drains and basements) or migrating into confined spaces
- Do not vent to a public area or an area where people are not aware of what you are doing - appropriate signage must be positioned close to the hose discharge.

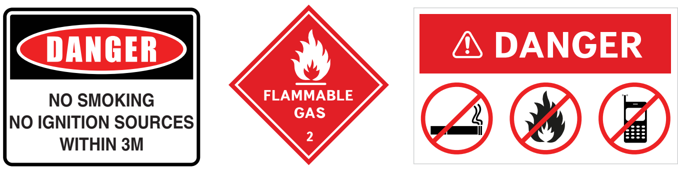


Figure 6.6 Examples of safety signage

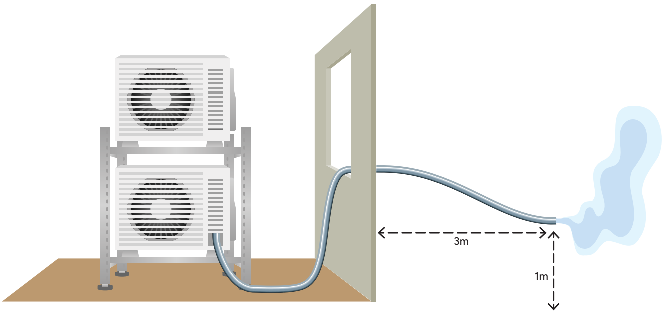


Figure 6.7 Example of non-scheduled flammable refrigerant venting to outdoors

6.12 Refrigerant charging

6.12.1 Safety checks

Before charging a refrigerating system with a flammable refrigerant, it is essential to ensure that the immediate area (deemed a temporary flammable zone) is suitable for working safely and the appropriate precautions are in place. This should include an assessment of the area for ventilation, sources of ignition, fire hazards and fire safety equipment. It should include the use of refrigerant detection equipment and PPE.

6.12.2 Charging procedures

The system and cylinder must be earthed before charging with flammable refrigerant to prevent the risk of electrostatic discharge while charging. This is particularly important when the cylinder is electrically isolated by the scales, or any other insulating materials.

The system refrigerant charge limits must not be exceeded, see Clause 4.4 or 4.5.

All charging must be carried out in accordance with AS/NZS 5149.4, Section C.2 Handling. Note that pure refrigerants can be charged as a vapour or liquid, but refrigerant blends can only be charged as a liquid.

Hoses, fittings and procedures used during charging should be those which minimise the loss of refrigerant. Hoses should be as short in length and small in diameter as possible, with suitable fittings. Connections should be leak-tested before permanently opening the cylinder valve.

Refrigerant must be weighed into and out of the system. Refrigerant cylinders should not be connected to a system that is at a higher pressure or temperature, to prevent refrigerant backflow.

6.12.3 Refrigerant charge accuracy

The refrigerant charge is an important risk factor and the scales used to measure refrigerant weight should provide the appropriate accuracy to ensure installed charges are correct.

Very accurate scales are necessary when charging small, critically charged systems, with some flammable refrigerants such as hydrocarbon A3 refrigerants. Scale accuracy must be suitable to the system refrigerant type and charge size. Many scales traditionally used for HFC A1 refrigerant service might not be sufficiently accurate for use with hydrocarbon A3 refrigerants.

Note: “Dial a charge” cylinders, with a sight glass in the cylinder, should not be used to charge systems with flammable refrigerant.

6.13 Topping up a system

A system with one type of refrigerant should never be topped up with another type of refrigerant, particularly a flammable refrigerant.

A system known to be leaking must not be topped up with refrigerant until all leaks are fixed. A technician should not do other work on leaking equipment without repairing the leak.

7. SYSTEM MARKING, LABELLING AND DOCUMENTATION

7.1 General

The information provided in this section is to ensure that refrigeration systems and appliances are adequately marked, labelled and documented. This ensures that employees, maintenance personnel, emergency services personnel and others are aware of the type of refrigerant contained in the system or unit, in accordance with the requirements of WHS/OH&S regulations.

7.2 Marking and labelling of systems and units

All RACHP systems and appliances containing flammable refrigerant must be marked and labelled with an ISO 7010 W021 Flammable material symbol as shown in *Figure 7.1*.

AS/NZS 60335.2.40 requires a minimum triangle height of 30mm in colour. Only the unit containing the compressor needs to display the flammable symbol and AS/NZS ISO 817 safety group.

AS/NZS 5149 requires a minimum triangle height of 10mm and label does not need to be in colour.

Figure 7.1 ISO 7010 W021 Flammable material symbol

For appliances using flammable refrigerants, AS/NZS 60335.2.40 also requires the ISO 7000-0790 symbol to “read operators manual” and the ISO 7000-1659 symbol “service indicator: read technical manual” to be placed on the appliance in locations visible to the person required to know the information. Symbol height must at least 10mm.

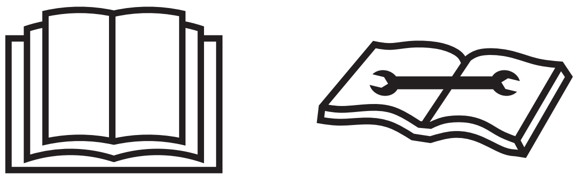


Figure 7.2 ISO 7000 manual symbols

The installing contractor must ensure that the labelling requirements are satisfied. The labels must be visible and clearly identifiable when the equipment is installed and operating.

7.3 AS/NZS 60335 appliance marking

7.3.1 AS/NZS 60335 marking requirements

Manufactured systems, equipment, major components and sub-assemblies that are manufactured, assembled and tested before being delivered to site must be labelled and marked in accordance with the applicable appliance standard.

Appliances complying with AS/NZS 60335.2.11, AS/NZS 60335.2.24, and commercial refrigerating appliances with an incorporated motor-compressor complying with AS/NZS 60335.2.89 or AS/NZS 60335.2.75, are delivered to the user pre-charged with refrigerant and must have the international symbol ISO 7010 W021 warning label applied.

The unit or system must also have a permanently attached identification plate as per the relevant standard. The installing contractor must ensure that the name plate has the correct refrigerant "R" number designation marked on it.

7.3.2 AS/NZS 60335 identification plate

A clearly readable identification plate must be located on the appliance. The identification plate must contain at least the following data:

- The name or identification of the supplier or manufacturer
- The model, serial number, or reference number
- The R number designation of the installed refrigerant in accordance with AS/NZS ISO 817
- The refrigerant charge
- The maximum allowable pressure (PS), high- and low-pressure sides
- When flammable refrigerants are used, the Flammable material symbol (ISO 7010 W021) on all units that contain a compressor
- For portable air conditioning units with a flammable refrigerant charge greater than m_1, the minimum floor area symbol (IEC 60417 – 6412).

ISO 7010 – W021 Label   IEC 60417 – 6412 Label

Figure 7.3 Typical Identification plate symbols

7.3.3 AS/NZS 60355.2.40/89 marking

For appliances, marking must be in accordance with Section 7 Marking and instructions of the applicable standard: AS/NZS 60335.2.24, AS/NZS 60335.2.40 or AS/NZS 60335.2.89.

Warning symbols

For AS/NZS 60335.2.40 portable air conditioning appliances using flammable refrigerants with a refrigerant charge greater than m_1, the minimum floor area symbol is required. For AS/NZS 60335.2.89 appliances, the minimum floor area symbol is required if the flammable refrigerant charge exceeds 4 x LFL for A2 and A3 refrigerants, or 6 x LFL for A2L (equivalent to m_1 in AS/NZS 60335.2.40).

Where AS/NZS 60355.2.40 and AS/NZS 60335.2.89 require the minimum floor area (IEC 60417 – 6412 Label) to be marked on the appliance, information must be supplied warning that the appliance must be installed, operated and stored in a room with a floor area not less than the minimum room area indicated.

AS/NZS 60355.2.40 also requires that the flammable material symbol (ISO 7010-W021 Label) with a minimum height of 30mm, including the AS/NZS ISO 817 safety group of the refrigerant (i.e. A2L, A2 or A3), must be placed within sight of where the refrigerant R number designation is marked on the appliance.

Flammable material/refrigerant group label   Minimum floor area label

Figure 7.4 AS/NZS 60355.2 parts .40 and .89 warning symbols

Marking and labelling of pipework

Interconnecting refrigerant pipework - that is, pipework external to the unitary components - should be marked with a flammable material label every two metres where the pipework is visible. This includes pipework located in a ceiling space or any void a person can access for maintenance or repair work within that space.

7.4 AS/NZS 5149 system marking

7.4.1 Identification plate

For systems assembled onsite, the system marking must comply with AS/NZS 5149.2. For AS/NZS 5149.2 compliance a clearly readable identification plate must be located near or on the refrigerating system. The identification plate must contain at least the following data:

- The name or identification of the installer or manufacturer
- The model, serial number, or reference number
- The year of manufacture

> **Note**: The year of manufacture can be part of the serial number, and all information can be part of the identification plate of the equipment and can be coded.

- The R number designation of the installed refrigerant type, in accordance with AS/NZS ISO 817
- The refrigerant charge
- The maximum allowable pressure (PS), high- and low-pressure sides
- When flammable refrigerants are used, the Flammable material symbol (ISO 7010 W021).

7.4.2 Component marking

Pipe markers should be used in accordance with AS 1345, accurately indicating refrigerant, especially for refrigerant lines external to plantroom. Piping must be marked with the flame symbol near valves and fittings and where walls are penetrated. The pressure relief valve discharge piping should be marked, and all isolation valves should be marked.

Service access points to equipment operating with flammable refrigerants must be marked with the ISO flame symbol. Shut off devices and the main control devices should also be marked.

7.5 Marking a change of refrigerant or lubricant

Whenever the type of refrigerant and/or lubricant in a system is changed, the technician must clearly label the system with:

- The number designation of the new replacement refrigerant, in accordance with AS/NZS ISO 817
- The refrigerant charge
- The maximum allowable pressure (PS), high- and low-pressure sides
- When flammable refrigerants are used, the Flammable material symbol (ISO 7010 W021)
- Name of technician, licence number and service organisation
- Date of service
- Whether any ultraviolet dye has been added.

Whenever the type of lubricant in a system is changed (other than when it has been pre-charged into a replacement compressor by its manufacturer), the technician must also clearly label the system with:

- The lubricant type.

7.6 Documentation

7.6.1 Installation and operation instructions

Installation, operation and maintenance instructions must be provided in accordance with the applicable standard:

- AS/NZS 5149.2 – Clause 5.4 Marking and documentation
- AS/NZS 60335.2.24, AS/NZS 60335.2.40, AS/NZS 60335.2.89 – Section 7 Marking and instructions
- AS/NZS 60335.2.40 – Annex DD Requirements for installation, service, maintenance and repair, and decommissioning manuals of appliances using flammable refrigerants.

7.6.2 AS/NZS 5149.2 Site documentation

The system installer must provide documentation for the operating site that contains at least the following information:

- The name, address, and telephone number of the installer, the installer's service department
- The person responsible for the refrigerating system, and the addresses and telephone numbers of fire department, police, hospitals, and burn centres
- The nature of the refrigerant by indicating its chemical formula and its R number designation
- The instructions for shutting down the refrigerating system in case of emergency
- The maximum allowable pressures
- The details of the flammable refrigerant used (group A2L, A2 or A3 refrigerant).

7.6.3 AS/NZS 5149.2 Operation and maintenance information

The manufacturer or installer must supply an adequate number of instruction manuals and provide safety instructions. The instruction manual should at least contain the following information in accordance with AS/NZS 5149.2.

General information

The manual should include:

- The purpose of the system and a description of the machinery and equipment
- Aa refrigerating system schematic diagram and electrical circuit diagram
- Instructions concerning the starting, stopping, and standstill of the system
- Instructions concerning the disposal of operating fluid and equipment
- Precautions to be taken to prevent freezing at low ambient temperatures or by normal reduction in the system pressure/temperature
- Precautions to be taken when lifting or transporting the systems or parts of the systems

Safety information

The manual must include:

- A reference to protective measures, first aid provisions, and procedures to be followed in the event of emergencies, e.g. leakage, fire, explosion
- Instructions concerning the handling of refrigerant and the hazards associated with it
- Instructions concerning the function and maintenance of safety, protective, and first aid equipment, alarm devices, and pilot lamps.

Maintenance and refrigerant leakage information

The manual must include:

- The causes of the most common defects and measures to be taken, e.g. instructions concerning leakage detection by authorised personnel and the need to contact competent technicians in the event of leakage or breakdown
- Maintenance instructions for the entire system with a time schedule for preventive maintenance with respect to leakage
- Instructions concerning the charging and discharging of refrigerant
- The logbook and guidance for the use of the logbook, where applicable.

7.6.4 AS/NZS 5149.2 Logbook

For all systems with a refrigerant charge over 3kg, AS/NZS 5149.2 requires that the manufacturer or installer supply a logbook with the system documentation.

The following information must be able to be recorded in the logbook:

- The details of maintenance and repair works carried out
- The quantities and kind of (new, reused, recycled) refrigerant that have been charged or transferred from the system on each occasion
- The source and the results of any analysis of any reused refrigerant
- All changes and replacements of components of the system
- The results of all periodic routine tests
- Significant periods of non-use.

7.6.5 Hazardous area documentation

Where a hazardous area has been identified or where mechanical ventilation is used to reduce a hazardous area, the AS/NZS 60079 series standards require documentation to be provided and maintained. This suite of documentation is commonly called a "hazardous area dossier", but various forms of record keeping can be applied under this term. The hazardous area documentation requirements include:

- Hazardous area assessment records according to AS/NZS 60079.10.1
- Electrical installation and electrical equipment records according to AS/NZS 60079.14
- Information relevant to any mechanical ventilation controls that are used to mitigate the hazardous areas to AS/NZS 60079.13
- Records of electrical maintenance activities according to AS/NZS 60079.17.

7.6.6 AS/NZS 60335.2.40 Documentation

AS/NZS 60335.2.40 Annex DD outlines the safety-critical information that must be included in manuals for installation, servicing, maintenance, and decommissioning for appliances that use flammable refrigerants.

8. TRAINING

8.1 General

Flammable refrigerants are used in many different system configurations, sizes and types of facilities. Personnel responsible for the design, installation, commissioning, service, repair, and maintenance of these refrigeration or air conditioning systems (referred to as technicians, engineers, mechanics or contractors) should be competent. Training is an excellent means to attain competence.

Formalised training identifies the specific knowledge, skills, and learning objectives to be attained. A family of training modules facilitates the development of competence across the required domains. When deployed widely, these modules help eliminate confusion and enable companies and individuals to systematically and uniformly understand and attain the necessary competence, aligning with relevant legislation, codes, standards, and guides. This section identifies the key competencies expected of various categories of persons working with flammable refrigerants and defines the training available to be a "competent person".

8.2 Competent person training

WHS regulations and AS/NZS 5149 define a competent person as someone who has acquired through training, qualifications, or experience the knowledge and skills necessary to perform the task safely.

The training of persons working on refrigeration and air conditioning systems containing flammable refrigerant should include:

- Knowledge of legislation, regulation and standards relating to flammable refrigerants
- Detailed knowledge of and skill in handling flammable refrigerants, PPE, refrigerant leakage prevention, handling of cylinders, charging, leak detection, recovery and disposal
- Knowledge of the properties and hazards of flammable refrigerants.

ISO 22712 defines the activities related to working on AS/NZS 5149 type refrigerating systems and the associated competence profiles. It also establishes competence criteria for persons who carry out these activities. ISO 22712 provides a matrix of skills and knowledge versus tasks for all required activities and provides for four levels of assessment:

- **BA** – Basic appreciation level
- **WK** – Working knowledge level
- **FO** – Fully operational level
- **LE** – Leading edge level.

The competent person should undertake continuing skills and knowledge development, education or training to ensure their knowledge of standards, regulations, procedures and technologies remain up to date.

8.3 Worker training

This guide distinguishes three general levels of training that are relevant to ensuring safe working practices.

1. **Workplace induction training** – Awareness training provided to all workers when first employed, for all personnel working in an environment containing flammable refrigerants.

2. **WHS supervisor training** – Specific safety awareness training for building WHS/OH&S officers and building supervisors and managers working in an environment containing commercial/industrial AS/NZS 5149 refrigeration or air conditioning systems with a charge of 3kg or more of flammable refrigerants.
3. **Technical service provider training** – Specific training of personnel working on refrigeration/ air conditioning systems containing flammable refrigerants.

All the above training levels should be reviewed where applicable and when there are changes to a site or procedures. In addition, ongoing professional development and regular refresher training for any people working with flammable refrigerants should also be undertaken.

8.4 Flammable refrigerant training

Any person working on refrigeration or air conditioning systems using flammable refrigerants should undertake training to achieve competence in safety aspects of using flammable refrigerants. This includes site supervisors and managers, maintenance personnel, refrigeration and air conditioning mechanics, appliance service mechanics, contractors and engineers.

The competence of a person using flammable refrigerants is established by either:

- Assessment by an approved Registered Training Organisation (RTO) against the relevant unit of competence, or
- Demonstrating that the skills, knowledge and experience have been acquired that are to an equivalent or comparable standard to (a) above.

It is recommended that people continuously maintain their skills and competence, for example by the study of relevant updated literature and industry publications, short courses and practical work experience, as appropriate.

8.5 Hazardous areas training

For persons working in or with electrical equipment for hazardous areas, the competencies outlined in AS/NZS 4761.1 apply. Managers, technicians, and designers should be competent to this standard, with relevant units of competence appropriate for the role and equipment. For a definition of hazardous areas refer to Clause 4.6.

8.6 Specific training requirements

8.6.1 Technicians, mechanics, and contractors

A qualified technician, mechanic, or contractor should complete the following recommended minimum formal training requirements (or equivalent):

- Certificate III or IV in Air Conditioning and Refrigeration, or
- Diploma of Air Conditioning and Refrigeration Engineering
- Certificate III in Appliance Service, and
- National Restricted Electrical License (NREL) – (also known as Restricted Workers Electrical License and various other titles, refer to Clause 8.7).

In addition to these, the following specific flammable refrigerant units of competency should be completed. They are from the electrotechnology training package and are available through TAFE and other RTOs:

- UEERA0007 Apply safety awareness and legal requirements for flammable refrigerants
- UEERA0048 Install and commission flammable refrigerant air conditioning and refrigeration systems
- UEERA0084 Service and repair self-contained flammable refrigerants air conditioning and refrigeration systems
- 11412NAT Course in Refrigeration and Air Conditioning – Minimum Australian Context Gap

In Queensland, the use of hydrocarbon refrigerants is regulated under the *Petroleum and Gas (Production and Safety) Act 2004*. This includes approval of the refrigerating device and licence to undertake gas work on the device. Anyone installing, removing, altering, repairing, servicing, testing or certifying a hydrocarbon refrigerant based system or device (i.e. charging, discharging or breaking into a refrigeration system that uses hydrocarbon refrigerants) must hold a Gas Work Licence (Hydrocarbon Refrigerants) to do so.

8.6.2 Design and application engineers

A person that is responsible for the design of a refrigeration or air conditioning system carries a duty of care, and as such should be aware of the safety risks, standards and regulations involved with the design, installation and operation of any refrigeration or air conditioning equipment intended to operate with a flammable refrigerant charge.

Design and application engineers should complete the following recommended minimum formal training requirements (or equivalent):

- Recognised Bachelor of Mechanical or Electrical Engineering or Diploma in Refrigeration and Air Conditioning

And the following units of competency (or equivalent) from the electrotechnology training package, which are available through TAFE and other RTOs:

- UEERA0007 Apply safety awareness and legal requirements for flammable refrigerants
- UEERA0023 Design hydrocarbon refrigerated systems.

8.6.3 Owners, site supervisors and managers

A person that oversees the day-to-day operations of a business carries a duty of care, and as such should be aware of the safety risks involved with the operation of any AS/NZS 5149 refrigerating or air conditioning system containing a flammable refrigerant installed on their premises.

Owners, site supervisors and managers should complete the following unit of competency from the electrotechnology training package, which is available through TAFE and other RTOs:

- UEERA0007 Apply safety awareness and legal requirements for flammable refrigerants.

8.7 National Restricted Electrical Licence (NREL)

The following state and territory arrangements apply for training and competencies for restricted electrical licensing for personnel that work on refrigeration and air conditioning systems.

ACT – Restricted Electrical Licence

Construction licences – City and Environment Directorate – Planning

NSW – Disconnection and reconnection of fixed electrical equipment

Disconnection and reconnection of fixed electrical equipment | NSW Government

Apply for a qualified supervisor certificate | Service NSW

NT – Restricted Electrical Licence

Application for restricted electrical work licence | NT WorkSafe

Queensland – Restricted Electrical Licence

Restricted electrical work licences/permits (other than apprentices) | WorkSafe.qld.gov.au

SA – Restricted electrical workers registration

SA.GOV.AU – Plumbing, gas fitting and electrical registration and contractors' licences

Tasmania – Restricted Electrical Workers Licence

Apply for an electrical restricted licence | Service Tasmania

Victoria – Restricted Electrical Workers Licence

Restricted Electrical Worker's licence (REL) | Energy Safe Victoria

WA – Restricted Electrical Licence

Restricted electrical licence

9. STORAGE

9.1 General

This section is intended for persons involved in the refrigeration and air conditioning industry, particularly technicians, contractors and SMEs who store flammable refrigerants at a premises. Specific information is provided on small-scale storage applications for use by small and medium-sized PCBUs. For large-scale storage applications, refer to the specific standards and regulations.

The applicable standards include AS 4332 and AS/NZS 1596. Many jurisdictions mandate compliance with these standards. The GHS and ADG Code are also referenced.

> **Note**: Not all ADG classes of gases are included in this section, which focuses on Division 2.1 flammable gas. Where premises store more than one class of gas, e.g. Divisions 2.2 or 2.3, additional requirements will apply.

Many of the general safety aspects previously covered in this guide, such as the classification of hazardous areas and the use of appropriate PPE, will also apply to the storage of larger quantities of flammable refrigerants in cylinders and to activities such as cylinder filling.

9.2 Flammable refrigerant gas cylinders

For flammable refrigerants, technicians must take the relevant safety measures for the correct transport, storage, and handling of a flammable gas. This includes ensuring that the refrigerant is not exposed to open flames or other ignition sources.

Appropriate cylinders must be used for flammable refrigerants. Cylinders must conform with AS 4484, AS 2030.1 and AS/NZS 1200, with the correct design pressure ratings, valves and seals that are compatible with a flammable gas. The cylinders should have collars to protect valving and relief valves, and appropriate marking and labelling.

> **Note**: The marking and labelling requirements for flammable refrigerant gas cylinders are covered in Section 10 of this guide.

Figure 9.1 Gas cylinder GHS pictograms

9.3 Handling of refrigerant gases in cylinders

Technicians should make reference to refrigerant manufacturers' safety data sheets (SDS) when handling refrigerant cylinders. Wear eye protection, safety shoes and gloves in gas cylinder storage and handling areas. Gauges should be removed from the cylinder for storage and transport.

The refrigerant cylinder and its valve should be handled carefully to avoid mechanical damage. When a refrigerant cylinder is not in use, its valve should be closed, the valve outlet sealing cap put in place and the valve protected.

Cylinders should be leak tested every three months. Refrigerant leak detectors can be used for this purpose. The contents of a leaking cylinder must be transferred to a recovery cylinder and the leaking cylinder should be returned to the supplier.

9.4 Cylinder filling

Cylinder filling involves the consideration of a number of factors:

- Maximum gross weight
- Safe fill capacity
- Fill ratios.

As well as factors like cylinder design and storage temperature, AS 2023.5 specifies the requirements for the filling, inspection and testing of refillable gas cylinders.

9.4.1 Maximum gross weight

The maximum gross weight must not be exceeded when filling refrigerant cylinders. The cylinder must not be used if the maximum gross weight is not marked on the cylinder. The cylinder supplier should determine the maximum gross weight in accordance with AS 2030.5.

The maximum gross weight is a function of the internal volume of the cylinder, refrigerant composition and oil content and temperature.

9.4.2 Safe fill capacity

The safe fill capacity (SFC) is the quantity of liquid refrigerant that can be safely added to a storage cylinder without causing undue stress on the cylinder. The SFC, expressed in kilograms, is determined by multiplying the water capacity (WC) stamped on the cylinder, expressed in litres, by the maximum fill ratio (FR) specified for the refrigerant in accordance with AS 2030.5:

$$SFC = FR \times WC$$

9.4.3 Fill ratio

The FR is a number that is based on the refrigerant properties, cylinder material and design, temperature considerations and the safety factor or ullage (the vacant space between the top of the liquid refrigerant and the top of the cylinder). AS 2030.5 requires a minimum ullage of 3% at the mean bulk liquid temperature of 57°C for refrigerants, except high-pressure refrigerants such as carbon dioxide (R744). The FR can therefore be obtained from refrigerant's specific gravity or liquid density (ρ_{liquid}) expressed in kg/L at 57°C:

$$FR = 0.97 \times \rho_{liquid@57\,°C}$$

Calculated FR based on AS 2030.5 Clause 7.1.3 and tabulated FR from AS 2030.5 Table 4 for some flammable refrigerants are listed in Table 9.1.

Refrigerant	Tabulated FR taken from AS 2030.5 Table 4	Calculated FR based on AS 2030.5 Clause 7.1.3 (a), with liquid density* at 57°C
R32	0.78	0.77
R290	0.42	0.42
R600a	0.49	0.49
R717	0.53	0.53
R1270	0.44	0.43
R1234yf	0.79	0.79
R454B	–	0.82
R454C	–	0.89
* Liquid density predicted by NIST REFPROP software		

Table 9.1 Common flammable refrigerant fill ratios (FR)

9.4.4 Recovery cylinder SFC

For recovered and recycled refrigerants, the SFC formula from AS 4211.3 requires a minimum ullage of 20%, so the SFC calculation becomes:

$$SFC = 0.80 \times FR \times WC$$

A cylinder should only be refilled with the permission of the cylinder owner.

Note: The mixing of flammable and non-flammable refrigerants during recovery should be avoided. Should this occur, a recovery cylinder appropriate for flammable refrigerants must be used, see Clause 9.2.

9.4.5 Cylinder warming

Warming of the discharging cylinder is permissible under controlled conditions to increase the rate of discharge of refrigerant during transfer. A risk assessment should be conducted for the processes used, see Clause 5.2.

Refrigerant cylinders must not be directly heated by flame, radiant heat or uncontrolled direct contact heat. Heating of cylinders using indirect forms of heating, e.g. controlled temperature air flow, should only be conducted where the control system is designed to be fail safe.

9.5 Refrigerant transfer between cylinders

Losses of refrigerant to the atmosphere can occur during the transfer of refrigerant to and from cylinders. Competent technicians can minimise such losses. Where a refrigerant is transferred to or from a cylinder, refrigerant vapour vented to atmosphere must be minimised.

The factors of Clause 9.4 also apply to refrigerant transfer between cylinders.

Where refrigerant is to be transferred from one cylinder to another, a pressure or height difference must be established between the cylinders. This may be achieved by means of a pump or temperature differential. In addition, the cylinders should be electrically connected to mitigate any risk of electrostatic discharge.

Refrigerant cylinders should not be manifolded together if there is a possibility of temperature differences between the cylinders, since this will result in refrigerant transfer and the danger of overfilling the cold cylinder. Where cylinders are manifolded together:

- Care should be taken to ensure all the cylinders are at the same height to avoid gravity transfer between cylinders
- It is recommended that single direction flow or check valves be installed at each cylinder.

9.6 Storage of refrigerant gases in cylinders

Flammable refrigerant cylinder storage should be located outdoors, preferably in a secure cage protected from sunlight. Storage indoors is not recommended unless the building has been designed for that purpose with appropriate fire-rated walls and ventilation. Refrigerant must be stored securely with appropriate signage to provide ready identification by attending emergency services.

AS 4332 sets out the requirements for the storage of gases, and Section 2 of the standard deals with the storage of gases in minor storage. Storage of Division 2.1 (Category 1A) flammable gases in cylinders, which includes refrigerants of safety group A2L, A2 or A3, in quantities not exceeding 200 litres maximum aggregate water capacity, may be classified as minor storage.

Where gases of other classes (Division 2.2 or 2.3) are kept in minor storage, they must be separated and segregated from the flammable refrigerant cylinders. For information on cylinder sizes and water capacity, *see Table 9.2*.

If the quantities of stored gases exceed the quantity criteria of Section 2 of AS 4332 for classification as a minor storage, the requirements of subsequent sections of the standard will be applicable.

9.7 Storage at residential premises

The maximum quantity of gas cylinders stored at a residential premises must not exceed 50 litres (water capacity of cylinders). For information on cylinder sizes and water capacity, *see Table 9.2*.

The following precautions should be observed when storing gas cylinders in residential premises:

- Ensure the storage area is well ventilated
- Do not store the gas cylinders near sources of ignition such as electrical power points, lights and switches, electric motors etc.
- Keep the gas cylinders out of the sun and away from sources of heat
- Keep the cylinder upright and prevent the gas cylinder from falling or being knocked over
- The storage area must be free of combustible or waste materials.
- All gas cylinders must be secured to prevent theft or tampering with.

Note: Check with the property insurance provider to see if they have any additional requirements regarding the storage of gas cylinders.

GAS CLASSIFICATION	CYLINDER SIZE	WATER CAPACITY
 2.1 1A	ACETYLENE	
	D size	10 litres
	E size	24 litres
	G size	50 litres
 2.1 1A	LPG	
	N	11 litres
	P (9kg)	22 litres
	Q/T (18 kg)	44 litres
	R	65 litres
	S (45 kg)	108 litres
	90 kg	200 litres
 2.1 1A	FLAMMABLE REFRIGERANT GASES	
	Includes most A2L, and all A2 and A3 refrigerants	
	N	11 litres
	P (9kg)	22 litres
	Q/T (18 kg)	44 litres

Table 9.2 Gas cylinder sizes and water capacity

9.8 Storage at commercial premises

Buildings used for storing flammable refrigerants should be constructed out of non-combustible materials and compliant with the applicable edition of the National Construction Code.

If located on bushfire prone land or within direct sight of a bushfire hazard, the storage area for refrigerants should be kept clear of vegetation to a distance of 10 metres and shielded on the hazard side of the installation. All external fittings should be metal.

Storage must be in accordance with AS 4332. Stored cylinders should be protected from the weather. *Figures 9.2* and *9.3* provide some examples of ideal gas storage situations.

Brick building with four compartments with lockable gates for security

Figure 9.2 Ideal multi-gas cylinder storage

The layout of this gas cylinder storage is ideal, as it allows the flammable gases to be stored at one end (right-hand end), the non-flammable gases in the next compartment, and the oxidising gas (oxygen) in the next compartment or in the fourth (end) compartment.

The separation distance required for Division 2.1 (Category 1A) Flammable gases to be at least three metres from the oxygen is easily achieved in this scenario.

Division 2.1/Category 1A Flammable gases in metal storage cage

Figure 9.3 Ideal single gas cylinder storage

By storing only Division 2.1 (Category 1A) Flammable gases, there is no need for segregation provided there is no oxygen or toxic gases within three metres or any other dangerous goods within three metres.

Any ignition source must also be at least three metres away.

9.9 Indoor storage areas

The requirements for indoor storage areas can be found in Section 2 of AS/NZS 4332. This details the requirements for storing and handling Class 2 Division 2.1 (Category 1A) dangerous goods (gases), including the need to:

- Secure cylinders upright
- Protect them from damage and impact
- Separate incompatible gases
- Store them away from ignition sources
- Ensure proper ventilation.

It also covers the importance of clear labelling, regular inspections, and training for workers on hazards, safe handling, and emergency response procedures.

Flammable gas cylinders should be stored in a location that:

- Is of fire resisting construction
- Is suitable for the quantity stored
- Is secure
- Is well ventilated
- Is suitably separated from potential sources of ignition
- Is not in an area where people congregate
- Has portable fire extinguishers available
- Has an emergency response plan and hazardous substance warning signage in place.

Further guidance is available in AS 4332 and AS/NZS 1596.

9.10 Minimum fire protection for minor storage areas

The minimum fire protection for gas storage facilities, where the aggregate water capacity of the gas cylinders is less than 1,000 litres, is a water hose *see Figure 9.4*, connected and ready for use.

Figure 9.4 Water hose

For a gas storage area where the aggregate water capacity of the gas cylinders is between 1,000 and 2,000 litres, the minimum fire protection facilities is one of two options (*see Figure 9.5*)

Option 1:	a hose reel 	
Option 2:	A 2A 60B (E) fire extinguisher 	and a water hose 

Figure 9.5 Fire protection options – 1,000 to 2,000 litre storage

9.11 Placarding requirements

SafeWork Australia has provided a guide to placard and manifest quantities, refer to:

Placard and manifest threshold quantities | Safe Work Australia

Individual state and territory requirements might differ. The SafeWork Australia guide applies to those states and territories that use harmonised WHS legislation. Victoria has separate OH&S laws.

Legislation	Flammable gas	Placardable quantity	GHS pictogram class label required
All states and territories except Victoria ***Work Health and Safety Regulations***	Category 1A, 1B	200 litres	
Victoria ***Dangerous Goods (Storage and Handling) Regulations 2022***	Division 2.1	500 litres	

Table 9.4 Requirements for placarding storage areas

Placards are important for workers, contractors, and emergency services personnel because they identify:

- Where flammable refrigerant is stored in bulk (including cylinders)
- Significant quantities of flammable refrigerant in packages
- The dangers of the flammable refrigerant at the workplace
- The required emergency actions for the flammable refrigerant.

Placarding helps emergency services personnel take the appropriate action when responding to an emergency situation.

9.12 Other signs

Areas storing flammable gasses should display danger signage as illustrated in *Figure 9.6.*

Figure 9.6 Storage – danger signs

10. TRANSPORT

10.1 General

The information provided in this section is intended for persons involved in the refrigeration and air conditioning industry, particularly persons who service, maintain, repair or install refrigeration units and transport refrigerants as part of those services.

For persons engaged in the commercial transport of dangerous goods, there are other requirements within relevant state or territory legislation. The state or territory legislation covering the transport of dangerous goods can usually be found on the applicable agency's website.

There is a Model Act and Model Regulations for the transport of dangerous goods in Australia. Although there are minor variations in state and territory legislation, all jurisdictions adopt the Australian Code for the Transport of Dangerous Goods by Road or Rail (ADG Code). This ensures that the transport requirements across Australia are consistent.

10.2 ADG Code for transport by road and rail

The purpose of the Australian Code for the Transport of Dangerous Goods by Road and Rail (ADG Code) is to ensure uniformity and consistency in technical requirements across jurisdictions applying to the land transport of dangerous goods. The ADG Code adopts the structure, format, definitions and concepts of the United Nations Recommendations on the Transport of Dangerous Goods Model Regulations while retaining Australian specific provisions.

Figure 10.1 ADG Code Parts 1 and 2

https://www.ntc.gov.au/codes-and-guidelines/australian-dangerous-goods-code

The ADG Code provides detailed technical specifications and recommendations applicable to the transport of dangerous goods in Australia by road and rail. It covers the requirements for classification, packaging, marking and labelling of substances and articles that meet the United Nations classification criteria for dangerous goods.

10.3 ADG definitions and general provisions for gas transport

The ADG defines a **gas** as a Class 2 substance which:

a. At 50°C has a vapour pressure greater than 300kPa, or
b. Is completely gaseous at 20°C at a standard pressure of 101.3kPa.

The transport condition of a gas is described according to its physical state as:

- **Compressed gas** – a gas that when packaged under pressure for transport is entirely gaseous at -50°C; this category includes all gases with a critical temperature less than or equal to -50°C; or
- **Liquefied gas** – a gas which when packaged under pressure for transport is partially liquid at temperatures above -50°C. A distinction is made between:
  - **High-pressure liquefied gas** – a gas with a critical temperature between 50°C and +65°C, and
  - **Low-pressure liquefied gas** – a gas with a critical temperature above+65°C; or
- **Refrigerated liquefied gas** – a gas that when packaged is made partially liquid because of its low temperature; or
- **Dissolved gas** – a gas that when packaged under pressure for transport is dissolved in a liquid phase solvent.

The class comprises compressed gases, liquefied gases, refrigerated liquefied gases, dissolved gases, mixtures of one or more vapours of substances of other classes, articles charged with a gas and aerosols.

NOTE: Flammable aerosols are not dealt with in this Guide, for aerosol requirements see the ADG Code.

10.4 ADG Class 2 divisions

Substances of Class 2 are assigned to one of three divisions in the ADG based on the primary hazard of the gas during transport. These divisions are designated:

- Division 2.1 Flammable gases
- Division 2.2 Non-flammable, non-toxic gases, and
- Division 2.3 Toxic gases.

Flammable refrigerants A2L, A2 and A3 are all covered under Division 2.1.

Note: R1234ze(E) is classed as a mildly flammable A2L refrigerant by AS/NZS ISO 817 but is classed as a non-flammable gas by the Australian Dangerous Goods (ADG) code and the GHS.

Division 2.1 Flammable gases are gases which at 20°C and a standard pressure of 101.3 kPa:

- Are ignitable when in a mixture of 13% or less by volume with air, or
- Have a flammable range with air of at least 12 percentage points regardless of the lower flammable limit. Flammability should be determined by tests or by calculation in accordance with methods adopted by ISO (see ISO 10156). Where insufficient data are available to use these methods, tests by a comparable method recognised by the competent authority may be used.

Gas mixtures, including vapour substances from other classes, are classified in one of the three divisions. Division 2.1 takes precedence over Division 2.2. Division 2.3 takes precedence over all other divisions. Information on gas mixtures can be found in the ADG Code.

10.5 ADG class labels

For transportation purposes, A2L, A2 and A3 flammable refrigerants in cylinders are classified as a Class 2 Dangerous Goods Division 2.1 flammable gas under the ADG Code and therefore require additional handling and storage safeguards compared to Division 2.2 non-flammable gases (A1 refrigerant).

Cylinders for transport should be marked with the ADG Flammable Gas Division 2.1 Class Label (red diamond), see *Figure 10.2*. Note that WHS regulations allow GHS pictograms to be substituted by the correct ADG class labels.

Minimum label size:

- ≤ 0.5kg of refrigerant – is 15mm x 15mm
- > 0.5 ≤ 5.0kg of refrigerant – is 20mm x 20mm
- > 5.0 ≤ 25.0kg of refrigerant – is 50mm x 50mm
- > 25.0kg of refrigerant – is 100mm x 100mm

Note: These are minimum label dimensions. For safety reasons the actual label dimensions should be as large as is reasonably practical and at least 100mm x 100mm.

Figure 10.2 ADG flammable gas class label sizes

10.6 Packaging for transport

The ADG Code covers how dangerous goods must be marked and labelled when packaged for transport. This includes requirements for displaying the following on the outside of each package:

- The United Nations (UN) number
- Shipping name
- Hazard class symbols.

Markings are the written identifiers – such as "UN XXXX" or a product name – that help identify the contents. Labels are the diamond-shaped hazard signs that indicate the type of risk, such as flammable, toxic, or corrosive. Both must meet size, visibility, and durability standards to ensure they remain clear during handling and transport.

The ADG Code also covers when and how placards – the large hazard signs displayed on trucks, containers, and bulk tanks – must be used during dangerous goods transport. Placards are required on vehicles or containers when the load meets certain thresholds.

10.7 ADG gas cylinder marking and labelling

Gas cylinders must be marked with:

- The proper shipping name for the dangerous goods
- The United Nations number, preceded by the letters "UN", and
- a class label (diamond)

Example: UN *3252 DIFLUOROMETHANE (REFRIGERANT GAS R32)*

The gas cylinder labelling must include the class label (primary risk) and, if applicable, a class division label identifying the subsidiary risk. *Figure 10.3* shows example labels.

Division 2.1
Flammable gases

Division 2.2
Non-flammable,
Non-toxic gases

Division 2.3
Toxic gases

Figure 10.3 Example gas cylinder class labels

10.8 GHS – Marking and labelling of gas cylinders

In the case of gas cylinders labelled in accordance with the GHS as shown in Figure 10.4, these labels are accepted for storage, but not for transport. AS/NZS ISO 817 refrigerant classifications are also not used for cylinder marking and labelling, see Clause 2.3.2.

For transport, the marking and labelling requirements of the ADG must be applied.

Note: The ADG requirements apply to placarding for transport and not product marking.

United Nations Globally Harmonised System – Label elements

Classification		Labelling			
Hazard		Pictogram code[1]	Signal word	Hazard statement	
Class	Category			Code[1]	Text
Flammable gases[2]	Category 1A	 GHS02	Danger	H220	Extremely flammable gas
	Pyrophoric gas			H232	May ignite spontaneously if exposed to air
	Chemically unstable gas A			H230	May react explosively even in the absence of air
	Chemically unstable gas B			H231	May react explosively even in the absence of air at elevated pressure and or temperature
	Category 1B			H221	Flammable gas
	[1]The code for the Pictogram and Hazard statement should not be included on the label. [2]Pyrophoric and Chemically unstable gases must always be classified as flammable gases Category 1A in addition to these hazard categories				

Classification		Labelling			
Hazard		Pictogram code[1]	Signal word	Hazard statement	
Class	Group[2]			Code*	Text
Gases under pressure[2]	Compressed gas	 GHS04	Warning	H280	Contains gas under pressure; may explode if heated
	Liquefied gas				
	Dissolved gas			H281	Contains refrigerated gas; may cause cryogenic burns or injury.
	Refrigerated liquefied gas				
	[1]The code for the Pictogram and Hazard statement should not be included on the label. [2]The hazard class "Gases under pressure" is subdivided into 'Groups' (not 'Categories')				

Figure 10.4 United Nations Globally Harmonised System (GHS) – Label elements

EQUIVALENT ADG/DANGEROUS GOODS LABELS	
GHS Category 1A and 1B Flammable Gases 	GHS Chemically unstable gases 
are Division 2.1 Flammable Gas ADG/ Dangerous Goods  Division 2.1	will fall into one of three Divisions of a Class 2 ADG/Dangerous Goods and they are:  2.1 2.2 2.3

Figure 10.5 GHS and ADG gas labels

10.9 Transport requirements – "Tool of trade" vehicles

The following are the minimum requirements for the transport of refrigerant gas cylinders of less than 250 litres (water capacity of cylinders) in "tool of trade" vehicles:

- Gas cylinders must not be stored on the transport vehicle near a source of heat
- The cylinder must be restrained and stowed upright to ensure the pressure release device communicates with the vapour space
- The main cylinder valve must always be shut and any regulator removed before loading
- Ventilation is required to prevent the build-up of flammable gas in the event of a leak
- For enclosed vehicles like vans, station wagons, and utilities with a canopy or cover, one means of providing ventilation is to stow the gas cylinders in a cabinet that is vented externally only, i.e. not into the vehicle
- Security of the gas cylinders while on the vehicle must be maintained; in the case of a tray truck or utility, gas cylinders would need to be in a locked cage to prevent theft
- The vehicle should be fitted with a fire extinguisher, preferably with a rating of at least 30B.

This 250-litre limit is based on cylinder volume, the water capacity (in litres) of the cylinder, not the quantity of gas held in the cylinder. Empty or partially filled cylinders are considered full for the purpose of calculating the total storage quantity limit. For quantities in excess of 250 litres (water capacity of cylinders) additional requirements apply, refer to the ADG.

10.10 Transport vehicle – self-assessment tools

To assist the technician, contractor, and small business assess their flammable gas cylinder transport arrangements for compliance, two self-assessment tools are provided in Appendix B:

- Self-assessment for the transport of refrigerants in an open vehicle such as a tray truck or utility
- Self-assessment for the transport of refrigerants in an enclosed vehicle or a utility with a canopy or cover.

For quantities greater than 250 litres of Division 2.1 Flammable gases, the full requirements of the Australian Code for the Transport of Dangerous Goods by Road and Rail (ADG 7) apply. Refer to the ADG for specific requirements.

APPENDIX A – Checklists

A1 High wall split system checklist

The following is a checklist of issues that need to be addressed by the installer to install a typical AS/NZS 60335.2.40 high wall split system air conditioner using a flammable A2L, A2 or A3 refrigerant in a domestic dwelling or in a light commercial application such as a restaurant, café or small office.

Note: This checklist covers the most common types of installation. In some cases, the allowable refrigerant charge may be increased (or the minimum allowable floor area decreased) if additional mitigation practices, as described within Annex GG of AS/NZS 60335.2.40, are applied.

HIGH WALL SPLIT SYSTEM CHECKLIST	Yes? No? or N/A
1. Have you received the appropriate training and are you **competent** to install a high wall split system using a flammable A2L, A2 or A3 refrigerant? – *Refer Section 8.*	
2. Have you prepared an **emergency plan** for the work area?	
3. Determine the **maximum refrigerant charge:** a. Refer to the appliance instruction manual, which will list the minimum floor area of the room that can be served by the unit. b. Alternatively, calculate the maximum mass of refrigerant charge limit in accordance with Annex GG of AS/NZS 60335.2.40 based on: i. The amount of refrigerant used in the appliance or the releasable charge as determined by Annex QQ of AS/NZS 60335.2.40 ii. The installation location, and iii. The type of ventilation of the location or of the appliance. c. Calculate m_1, m_2 and m_3 and compare these quantities with the maximum mass of refrigerant M as per Table GG.1. d. Measure the room area that is to be air conditioned by the system. Calculate the allowable charge (maximum mass of refrigerant) using the formula in Annex GG.	

HIGH WALL SPLIT SYSTEM CHECKLIST	Yes? No? or N/A
4. Identify **potential sources of ignition** (SOI) -– Refer Clause 4.7: a. Is the split system designed and approved for flammable refrigerants? b. Check for SOI in the location the system is to be installed. Do not locate the system near open fireplaces, gas heaters or other SOI.	
5. Does the system have any **non-permanent joints** within the occupied space, excepting the final connection to the unit? These should be removed and replaced by brazed or permanent mechanical joints.	
6. Does the system have the appropriate pressure equipment **ratings and approvals** for flammable refrigerants? – Refer Clause 4.14.	
7. Installation of a **new** system or replacement of an **existing** system: a. Check the work area is safe and setup a **temporary flammable zone,** refer Clause 6.7. b. Ensure you have the appropriate tools and equipment, refer Clause 4.10/6.10. c. Do you have the appropriate PPE? Refer SDS d. If the system is a replacement, recover the HCFC or HFC refrigerant. An ARCtick licence is required for this work. e. Apart from final connections to the indoor unit, remove all non-permanent type joints (e.g. flare joints) from the occupied space and replace with either a permanent mechanical joint or braze – refer AS/NZS 60335.2.40. f. Eliminate all potential SOI – refer Clause 4.7. g. Pressure and leak test the system. h. Commission the system and provide written operating and maintenance instructions – refer AS/NZS 60335.2.40. i. Instruct the operator on the correct operation and maintenance of the system.	
8. Marking and labelling of the system: Ensure that the outdoor unit is labelled with an **ISO 7010 W021 Flammable material symbol and AS/NZS ISO 817 refrigerant safety group**, refer Section 7. The name plate or serial plate must also be appropriately marked, refer to AS/NZS 60355.2.40. Interconnecting pipework should also be labelled with a **flammable gas symbol**, near valves and where walls are penetrated, refer Clause 7.4.	

A2 Ducted split system air conditioner

The following is a checklist of issues that need to be addressed by the installer to install a typical ducted split system air conditioner with zone air controller using a flammable A2L, A2 or A3 refrigerant in a domestic dwelling.

Note: This checklist covers the most common types of installation. In some cases, the allowable refrigerant charge may be increased (or the minimum allowable floor area decreased) if additional mitigation practices, as described within Annex GG of AS/NZS 60335.2.40, are applied.

DUCTED SPLIT SYSTEM AIR CONDITIONER CHECKLIST	Yes? No? or N/A
1. Have you received the appropriate training and are you competent to install a ducted split system air conditioner using a flammable A2L, A2 or A3 refrigerant? – Refer Section 8.	
2. Have you prepared an **emergency plan** for the work area?	
3. Determine the **maximum refrigerant charge**: a. Refer to the appliance instruction manual, which will list the <u>minimum</u> floor area of the room that can be served by the unit. The area of the smallest room served is used. b. Alternatively (for A2L systems) calculate the maximum A2L refrigerant charge limit based on the total area of the conditioned space (TA) connected by ducts in accordance with Annex GG Clause GG.9 of AS/NZS 60335.2.40 ensuring that: i. The supply and return air is ducted directly to the space ii. The indoor unit circulation airflow complies with GG9.2 or GG9.3, and iii. Where no refrigerant detection system is provided, the spaces where airflow can be limited by zoning dampers are not included in the determination of TA. c. Calculate the minimum airflow in accordance with Formula GG.24 and verify that the airflow is achieved. d. Is the system located above ground or below ground? If below ground, special consideration should be given to the risk of pooling of leaked refrigerant. An underfloor ducted AS/NZS 60335.2.40 calculation would likely require countermeasures such as detection, compressor stop, zone opening and air circulation. e. Verify that the indoor fan either runs continuously or is operated by a refrigerant detection system, to provide at least the minimum airflow. f. For appliances with continuous ventilation, verify that the user is warned and the compressor is disabled when the flow rate falls below the minimum airflow. g. For appliances with refrigerant leak detection, verify from manufacturer documentation that detection of refrigerant in the supply air will: i. Energise the indoor fan to provide at least the minimum airflow ii. Disable the compressor iii. Fully open all zone dampers, and iv. Activate any additional required ventilation. h. Calculate the **maximum refrigerant charge** using formula GG.25. i. Calculate the required minimum **total conditioned area TAmin** for the installed unit, with a refrigerant charge of mc, using formula GG.26.	
4. Identify **potential sources of ignition** (SOI) -– Refer Clause 4.7: a. Is the ducted split system designed and approved for flammable refrigerants? b. Check for SOI in the location the system is to be installed. Do not locate the system near open fireplaces, gas heaters or other SOI.	
5. Does the system have any **non-permanent joints** within the occupied space, excepting the final connection to the unit? These should be removed and replaced by brazed or permanent mechanical joints.	
6. Does the system have the appropriate pressure equipment **ratings and approvals** for flammable refrigerants? – Refer Clause 4.14.	
7. Installation of a **new** system or replacement of an **existing** system: a. Check the work area is safe and setup a **temporary flammable zone**, refer Clause 6.7. b. Ensure you have the appropriate tools and equipment, refer Clause 4.10/6.10. c. Do you have the appropriate PPE as per the SDS? d. If the system is a replacement, recover the HCFC or HFC refrigerant. An ARCtick licence is required for this work. e. Apart from final connections to the indoor unit, remove all non-permanent type joints (e.g. flare joints) from the occupied space and replace with either a permanent mechanical joint or braze – refer AS/NZS 60335.2.40. f. Eliminate all potential SOI – refer Clause 4.7. g. Pressure and leak test the system. h. Commission the system and provide written operating and maintenance instructions – refer AS/NZS 60335.2.40. i. Instruct the operator on the correct operation and maintenance of the system.	
8. Marking and labelling of the system: a. Ensure that the outdoor unit is labelled with an **ISO 7010 W021 flame symbol and AS/NZS ISO 817 refrigerant safety group**, refer Section 7. b. The name plate or serial plate must also be appropriately marked, refer AS/NZS 60355.2.40. c. Interconnecting pipework should also be labelled with a **flammable gas symbol**, near valves and where walls are penetrated, refer Clause 7.4.	

A3 Coolroom refrigeration system checklist

The following is a checklist of issues that need to be addressed by the installer, to install or convert a typical coolroom refrigeration system using a flammable A2L, A2 or A3 refrigerant with a ceiling-mounted evaporator and a condensing unit mounted inside the occupied space of the building in a light commercial application such as a restaurant, fast food outlet, butcher shop or convenience store:

COOLROOM REFRIGERATION SYSTEM CHECKLIST	Yes? No? or N/A
1. Have you received the appropriate training and are you **competent** to install or convert a commercial refrigeration system with this refrigerant? – refer Section 8.	
2.. Conduct a **risk assessment** – refer Clause 5.2: a. If the installation is to be a ”conversion”, is the current system in good condition and leak tight? b. Is the owner of the system aware that it will be charged with flammable refrigerant and have they given permission to convert? Refer Clause 1.5. c. Conduct a hazardous area assessment in accordance with AS/NZS 60079.10.1.	
3. Have you prepared an **emergency plan** for the work area as the contractor working on a flammable system? The site's emergency plan will have to also be updated if it does not account for a refrigeration system that has flammable refrigerant.	
4. Determine the **maximum refrigerant charge**: a. Refer Clause 4.4 – the allowable charge limit is calculated by the RCL for the refrigerant multiplied by the room net volume, where RCL is 20% of the LFL. This is then compared to the maximum charge limit restrictions of Table A.2, which are capped based on the LFL of the refrigerant. b. Identify the occupancy category a or b or c – see AS/NZS 5149.1. In this example it will be General Occupancy a, (note the inside of the coolroom is not considered as occupied space if only used for storage). c. Identify where the refrigerant containing parts will be located and determine the location classification I, II, III, or IV – see AS/NZS 5149.1. In this example the system is Class I: Refrigerant containing parts located in occupied space. d. Determine charge cap factors m_1, m_2 and m_3 and the appropriate multiplier for the refrigerant flammability class in use (e.g. 1.5 for 2L refrigerants). e. Determine charge limits from AS/NZS 5149.1 Table A.2 using the flammability class 2L, 2 or 3 as appropriate, the occupancy category a, and the location classification I. f. For A2L refrigerants there are no room volume restrictions for refrigerant charges below or equal to m_1 x 1.5. For A2 and A3 refrigerants there are no restrictions for refrigerant charges below m_1. g. If the system is using A3 refrigerant, is it located above ground or below ground? If above ground the maximum charge is 1.5 kg for other applications in General Occupancy a. If below ground, the maximum charge is 1kg and special consideration should be given to the risk of pooling of leaked refrigerant. h. Measure smallest room that has refrigerant containing parts of the system. Calculate the allowable charge using the formula: 20% x LFL x room net volume. The allowable charge must not exceed the charge limits calculated above. The smallest room with refrigerant containing parts might not be the coolroom. Check the volume of the space that the condensing unit is located in, unless it is mounted outdoors.	
5. Identify potential **sources of ignition** (SOI) – Refer Clause 4.7: a. Is the refrigeration system designed and approved for flammable refrigerants? b. If the system is to be converted from a non-flammable to a flammable refrigerant, can all of the SOI within the system be eliminated? c. Check the location the system is to be installed in for SOI. Do not locate the system near open fireplaces, gas heaters or other SOI.	
6. Does the system have any **non-permanent joints** within the occupied space (apart from final connections to the units), including both inside the coolroom and the condensing unit if it is located indoors? These must be removed and replaced by brazed or permanent mechanical joints – Refer Clause 4.12.	
7. Does the system have the appropriate pressure equipment **ratings and approvals** for flammable refrigerants? – Refer Clause 4.14: If the system is to be converted, does it have a pressure relief valve? Refer Clause 4.14.	

COOLROOM REFRIGERATION SYSTEM CHECKLIST	Yes? No? or N/A
8. Installation of a **new** system or conversion of an **existing** system: a. Check the work area is safe and setup a **temporary flammable zone** – refer Clause 6.7. b. Ensure you have the appropriate tools and equipment – refer Clause 4.10/6.10. c. Do you have the appropriate PPE? Refer SDS. d. If the system is a conversion, recover the HCFC or HFC refrigerant. An ARCtick licence is required for this work. e. Remove all non-permanent type joints (e.g. flare joints) from the occupied space (excluding final connections) and replace with either a permanent mechanical joint or braze – refer AS/NZS 5149.2. f. Eliminate all potential SOI – refer Clause 4.7. g. Pressure and leak test the system. h. Commission the system and provide written operating and maintenance instructions – refer AS/NZS 5149.4. i. Instruct the operator on the correct operation and maintenance of the system.	
9. Marking and labelling of the system: a. Ensure that the condensing unit, the evaporator and all service access points are labelled with an **ISO 7010, W021 Flammable material symbol.** b. The identification plate must also be appropriately marked, refer AS/NZS 5149.2. c. Interconnecting pipework should also be labelled with a **flammable gas symbol**, near valves and where walls are penetrated – refer Clause 7.4.	

A4 Plantroom-based refrigeration system checklist

The following is a checklist of issues that need to be addressed by the installer, to install or convert a typical plantroom-based refrigeration system to use flammable A2L, A2 or A3 refrigerant in a commercial application:

PLANTROOM-BASED REFRIGERATION SYSTEM CHECKLIST	Yes? No? or N/A
1. Have you received the appropriate training and are you **competent** to install or convert a plantroom-based refrigeration system? Refer Section 8.	
2. Conduct a **risk assessment** – refer Clause 5.2: a. If the installation is to be a "conversion", is the current system in good condition and leak tight? b. Is the owner of the system aware that it will be charged with flammable refrigerant and have they given permission to convert? Refer Clause 1.5. c. Conduct a hazardous area assessment in accordance with AS/NZS 60079.10.1.	
3. Have you prepared an **emergency plan** for the work area as the contractor working on a flammable system? The site's emergency plan will have to also be updated if it does not account for a refrigeration system that has flammable refrigerant.	
4. Determine the **maximum refrigerant charge:** a. Refer Clause 4.4 – the allowable charge limit is calculated by the RCL for the refrigerant multiplied by the room net volume, where RCL is 20% of the LFL. This is then compared to the maximum charge limit restrictions of Table A.2 which can be capped based on the LFL or practical limit of the refrigerant. b. Identify the occupancy category a or b or c – see AS/NZS 5149.1. In this example it will be Authorised Occupancy c. c. Identify where the refrigerant containing parts will be located and determine the location classification I, II, III, or IV – see AS/NZS 5149.1. In this example the system is a direct system with compressors and pressure vessels in a plantroom, and only evaporators as refrigerant containing parts located in the coolroom. Note that neither plantroom nor coolroom is considered General occupancy a in AS/NZS 5149.1. d. Determine charge limits from AS/NZS 5149.1 Table A.2 using the flammability class 2L, 2 or 3 as appropriate, other applications, the occupancy category c, the location classification III and above or below ground, all as applicable to your installation. e. For A2L and A2 refrigerants there are no charge restrictions. For A3 refrigerants there are no restrictions for above ground plantrooms and a maximum charge limit of 1kg for below ground plantrooms. f. Measure the smallest plantroom that has refrigerant containing parts of the system in it. g. In all cases, if the practical limit for the refrigerant can be reached or exceeded in the plantroom, the requirements of AS/NZS 5149.3 for special machinery rooms apply, including ventilation and refrigerant detection and alarm. h. Any piping containing flammable refrigerant passing through any areas of occupancy category I or II must be appropriately protected – refer AS/NZS 5149.2.	

5. Identify **potential sources of ignition** (SOI) – refer Clause 4.7: a. Is the refrigeration system designed and approved for flammable refrigerants? b. If the system is to be converted from a non-flammable to a flammable refrigerant, can all the SOI within the system be eliminated? This includes electrical equipment not verified as suitable for operation in a flammable atmosphere. c. Confirm that both the plantroom and coolroom are fitted with flammable refrigerant detectors that will raise an alarm, initiate emergency ventilation, and cause isolation of power apart from emergency lighting and ventilation etc. d. Confirm that any electrical equipment intended to continue operating after detection of flammable gas is suitable for operation in a flammable atmosphere. Notes: i. Refrigerant detectors should detect gas with the highest possible sensitivity and well before the atmosphere becomes flammable (e.g. 5% of the LFL). ii. Isolation of power includes all sources, including control systems, and must take place at a point before the power enters the room. e. Check the plantroom for SOI. Do not locate the system near gas-fired boilers or other SOI.	
6. Does the system have any **non-permanent joints**, both inside the coolroom or the plantroom? If so, can they be replaced? Apart from the final connection to the unit, non-permanent joints/flare joints in the internal space are not allowed by AS/NZS 5149.2 for flammable refrigerants.	
7. Does the system have the appropriate pressure equipment **ratings and approvals** for flammable refrigerants? – refer Clause 4.14: a. If the system is to be converted, does it have a pressure relief valve? Refer Clause 4.14.	
8. Does the installation have the **appropriate ventilation** for flammable refrigerants? Refer AS/NZS 5149.3 Clause 5. a. Does the plantroom ventilation system draw from an appropriate location? For heavier-than-air refrigerants, the extraction ventilation system should draw in at low level in the plantroom and coolroom. b. Do the ventilation system and relief valves discharge to outdoors at high level, well away from potential SOI and well away from fresh air intakes to air conditioning or ventilation systems? c. Does the ventilation system include alarms and/or cause isolation of power on loss of airflow according to the requirements of the hazardous area classification of the room? d. If the plantroom contains switchboards with ventilation fans, the switchboard ventilation air intakes should draw in fresh air from outside the plantroom.	
9. Installation of a **new** system or conversion of an **existing** system: a. Check the work area is safe and setup a **temporary flammable zone** – refer Clause 6.7. b. Ensure you have the appropriate tools and equipment – refer Clause 4.10/6.10. c. Do you have the appropriate PPE? Refer SDS. d. If the system is a conversion, recover the HCFC or HFC refrigerant. An ARCtick licence is required for this work. e. Remove non-permanent type joints (e.g.: flare joints) as far as practical from the plantroom, coolroom and interconnecting piping (excluding final connections) and replace with either a permanent mechanical joint, weld or braze – refer AS/NZS 5149.2. f. Eliminate all potential SOI – refer Clause 4.7. g. Pressure and leak test the system. h. Commission the system and provide written operating, maintenance and safety instructions – refer AS/NZS 5149.4. Note: Instructions include those relevant to the safeguarding systems such as the ventilation and refrigerant detection systems (e.g. the applicable testing and calibration protocols for the gas detection system).	
10. Marking and labelling of the system: a. Ensure the condensing unit and the evaporator and all service access points are labelled with an ISO 7010, W021 Flammable material symbol. b. The identification plate must also be appropriately marked, refer AS/NZS 5149.2. c. Interconnecting pipework should also be labelled with a flammable gas symbol, near valves and where walls are penetrated, refer Clause 7.4.	

APPENDIX B – Self-assessment tools / refrigerant cylinder transport

B1

This appendix outlines two tools for assessing the arrangements for refrigerant cylinder transport of up to of 250 litres of Division 2.1 Flammable gases, as follows:

- Self-assessment for the transport of cylinders containing refrigerants in an open "tool of trade" vehicle such as a tray truck or utility, in B2
- Self-assessment for the transport of cylinders containing refrigerants in an enclosed "tool of trade" vehicle or a utility with a canopy or cover, in B3.

For quantities greater than 250 litres of Division 2.1 Flammable gases, the full requirements of the Australian Code for the Transport of Dangerous Goods by Road and Rail (ADG 7) apply. Refer to the ADG 7 for requirements.

Note: This 250 litre Division 2.1 flammable gas quantity limit includes all flammable refrigerants, plus other flammable gases that are being transported, such as acetylene or other brazing gases.

The 250 litre limit is based on cylinder volume (the water capacity (in litres) of the cylinder), not the quantity of gas held in the cylinder. Empty or partially filled cylinders are considered full for the purpose of calculating the total storage quantity limit.

B2 Transport of refrigerants in an open "tool of trade" vehicle – self-assessment

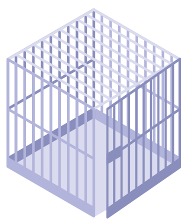
TRANSPORT ASSESSMENT For a tray truck or utility (without a canopy or cover)	
	

This self-assessment document is for the transport of gas cylinders up to a quantity of 250 litres of Division 2.1 Flammable gases in open vehicles such as tray trucks or utilities and should be read in conjunction with Section 10 of this guide.

For quantities greater than 250 litres of Division 2.1 Flammable gases, the full requirements of the Australian Code for the Transport of Dangerous Goods by Road and Rail (ADG 7) apply. Refer to the ADG 7 for requirements.

TRAFFIC LIGHT ASSESSMENT SYSTEM FOR THE TRANSPORT OF CLASS 2.1 DANGEROUS GOODS IN A "TOOL OF TRADE" VEHICLE

	Red	MANDATORY ACTION ITEM
	Yellow	CONSIDER
	Green	SATISFACTORY

				Comment and/or action required
1.	**Flammable gas** Will Division 2.1 Flammable gases be transported 			If NO, see assessment for other gases
2.	What is the maximum quantity of flammable gases to be transported? Quantity is determined by the water capacity (in litres) of the cylinder.	Litres		
3.	Is the maximum quantity of flammable gases less than 250 litres?	Yes	No	If the quantity is ≥250 litres, full compliance with the ADG 7 is required
4.	Are the gas cylinders stored in lockable cages to prevent unauthorised access and is the cage securely attached to the vehicle?  	Yes	No	If NO, provide a lockable cage and secure it permanently to the vehicle.
5.	Are warning signs displayed on the cage?  	Yes	No	If NO, provide warning signs for the cage
6.	Are the gas cylinders stored in an upright (vertical) position and restrained to ensure they cannot move during transport?	Yes	No	If NO, ensure the cylinders are vertical and restrained.
7.	Have the regulators been removed from all cylinders and the ports capped, before transport?	Yes	No	If NO, remove the regulator and cap all ports.
8.	**Fire extinguisher** Is the vehicle fitted with a fire extinguisher of at least a 10B rating? A 30B fire extinguisher is recommended. 	Yes	No	For vehicles transporting Division 2.1 Flammable gases (acetylene, LP gas, hydrogen and other flammable gases), it is recommended that the vehicle be fitted with a minimum size 10B fire extinguisher A 30B fire extinguisher is the minimum size for placard loads.

ADDITIONAL INFORMATION – CLASS 2.1 DANGEROUS GOODS	
9.  **Safety data sheets (SDS)** SDS are available, on request from your refrigerant supplier	A safety data sheet for the specific gas will provide additional useful information such as: ▸ First aid measures ▸ Fire fighting measures ▸ Spillage, leaking cylinders ▸ Storage and handling ▸ Personal protective equipment (PPE) ▸ Transport information ▸ Other information
10.  Australian Code for the Transport of Dangerous Goods by Road and Rail Seventh Edition	For the transport of refrigerant cylinders in placardable quantities, refer to the Australian Dangerous Goods Code.

B3 Transport of refrigerants in an enclosed vehicle – self-assessment

This self-assessment tool is for the transport of gas cylinders up to a quantity of 250 litres of Division 2.1 Flammable gases in enclosed "tool of trade" vehicles such as vans and wagons. It should be read in conjunction with Section 10 of this Guide.

For quantities greater than 250 litres of Division 2.1 Flammable gases, the full requirements of the Australian Code for the Transport of Dangerous Goods by Road and Rail (ADG 7) apply. Refer to the ADG 7 for requirements.

TRANSPORT ASSESSMENT FOR AN ENCLOSED VEHICLE

ENCLOSED VEHICLES INCLUDE:

Utility with an enclosed compartment

Utility with a cover over the tray

When the covers are down, the vehicle is deemed an enclosed vehicle

Utility with a canopy

Enclosed trailer

TRAFFIC LIGHT ASSESSMENT SYSTEM FOR THE TRANSPORT OF CLASS 2.1 DANGEROUS GOODS IN A "TOOL OF TRADE" VEHICLE

		MANDATORY ACTION ITEM
		CONSIDER
		SATISFACTORY

TRANSPORT OF GAS CYLINDERS IN AN ENCLOSED VEHICLE

Transport of gas cylinders in an enclosed vehicle	Yes	No	Action required
1. Is the vehicle that is to be used to transport the gas cylinder(s) an enclosed vehicle? That is to say the luggage area of the vehicle is not open to the elements (open air) and includes such vehicles as: ▸ A van (with or without windows) ▸ A panel van ▸ A station wagon ▸ A utility with a canopy over the tray or luggage/ storage area ▸ A utility with a tonneau cover over the tray ▸ Other type of vehicle whereby the luggage/storage compartment is part of the inside of the vehicle			If the answer to this question is YES, consider a vehicle with an open luggage/storage space such as a tray truck. For vehicles with a canopy over the tray of the vehicle, install a vent that aids the circulation of air to negate the build-up of any flammable gases in the storage area of the vehicle.
2. Is the water capacity of all gas cylinders transported less than 250 litres?			If the answer to this question is NO, the (relaxed) conditions for a "tool of trade" vehicle do not apply.
3. Are the gas cylinders stored in a cabinet inside the vehicle?			
4. Is the cabinet sealed whereby any gas escape cannot enter the inside of the enclosed vehicle?  			**Note:** As an example, the seal around the door of the cabinet should be similar to a door on a household refrigerator. The cold air in the refrigerator is held in by the door seal.
5. Is there a pipe or tube in the cabinet vented to the outside?			The pipe or tube allows any leaking gases to be discharged to outside atmosphere.
6. Are there appropriate markings on the door of the cabinet, to indicate its contents?			
7. Are the gas cylinders stored in an upright (vertical) position and restrained to ensure they cannot move during transport?			 Flammable gas cylinders must be stored and used upright at all times.
8. Have the regulators been removed from all cylinders and the ports capped before transport?			If NO, remove the regulator and cap all ports.
9. **Fire extinguisher** Is the vehicle fitted with a fire extinguisher of at least a 10B rating? 			For vehicles transporting Division 2.1 Flammable gases (acetylene, LP gas, hydrogen etc) it is recommended that the vehicle be fitted with a minimum size 10B fire extinguisher. A 30B fire extinguisher is the minimum size for placard loads.

ADDITIONAL INFORMATION – CLASS 2.1 DANGEROUS GOODS	
Safety data sheets (SDS)  SDS are available, on request from your refrigerant supplier	A safety data sheet for the specific refrigerant will provide additional useful information such as: ▸ First aid measures ▸ Fire fighting measures ▸ Spillage – leaking cylinders ▸ Storage and handling ▸ Personal protective equipment (PPE) ▸ Transport information ▸ Other information
 Australian Code for the Transport of Dangerous Goods by Road and Rail Seventh Edition	For the transport of refrigerant cylinders in quantities above "tool of trade" quantities, refer to the ADG 7 for requirements

APPENDIX C – References and resources

The following Standards are referenced in this guide:

AS/NZS ISO 817	Refrigerants – Designation and safety classification
AS/NZS 1020	The control of undesirable static electricity
AS 1216	Class labels for dangerous goods
AS/NZS 1596	The storage and handling of LP Gas
AS/NZS 2022	Anhydrous ammonia – Storage and handling
AS 2030.1	Gas cylinders - General requirements
AS/NZS 3000	Electrical installations (known as the Australian/New Zealand Wiring Rules)
AS 4211.3	Gas recovery or combined recovery and recycling equipment – Fluorocarbon refrigerants from commercial/domestic refrigeration and air conditioning systems
AS 4332	The storage and handling of gases in cylinders
AS 4343	Pressure equipment – Hazard levels
AS 4484	Gas cylinders for industrial, scientific, medical and refrigerant use – Labelling and colour coding
AS/NZS 4761.1	Competencies for working with electrical equipment for hazardous areas (EEHA) – Competency Standards
AS/NZS 5149	Refrigerating systems and heat pumps – Safety and environmental requirements
AS/NZS 5149.1	Part 1: Definitions, classification and selection criteria (ISO 5149-1:2014, MOD) (incorporating Amd 1 and Amd 2)
AS/NZS 5149.2	Part 2: Design, construction, testing, marking and documentation (ISO 5149-2:2014, MOD)
AS/NZS 5149.3	Part 3: Installation site (ISO 5149-3:2014, MOD)
AS/NZS 5149.4	Part 4: Operation, maintenance, repair and recovery (ISO 5149-4:2014, MOD)
AS/NZS ISO 31000	Risk management – Principles and guidelines

AS/NZS 60079.10.1	Explosive Atmospheres – Classification of areas – Explosive gas atmospheres
AS/NZS 60079.13	Explosive atmospheres – Equipment protection by pressurized room 'p' and artificially ventilation room 'v'
AS/NZS 60079.14	Explosive atmospheres – Electrical installations design, selection and erection
AS/NZS 60079.17	Explosive atmospheres – Electrical Installations inspection and maintenance
AS/NZS 60079.29.2	Explosive atmospheres, Part 29.2: Gas detectors – Selection, installation, use and maintenance of detectors for flammable gases and oxygen
AS/NZS 60335	Household and Similar Electrical Appliances – Safety
AS/NZS 60335.2.11	Particular requirements for tumble dryers
AS/NZS 60335.2.24	Particular requirements for refrigerating appliances, ice-cream appliances and ice makers
AS/NZS 60335.2.34	Particular requirements for motor compressors
AS/NZS60335.2.40	Particular requirements for electrical heat pumps, air-conditioners and dehumidifiers
AS/NZS 60335.2.75	Particular requirements for commercial dispensing appliances and vending machines
AS/NZS 60335.2.89	Particular requirements for commercial refrigerating appliances with an incorporated or remote refrigerant condensing unit or compressor
HB 158	Delivering assurance based on ISO 31000:2009 Risk management – Principles and guidelines
IEC TS 63542	Technical Specification - Refrigerant detection systems for flammable refrigerants
ISO 7010	Graphical symbols – Safety colours and safety signs – Registered safety signs
ISO 22712	Refrigerating systems and heat pumps — Competence of personnel
ASHRAE 34	Designation and Safety Classification of Refrigerants

Store | Standards Australia Store

The following SafeWork Australia approved Codes of Practice are referenced in this guide:

- Managing risks of hazardous chemicals in the workplace
- Managing the risks of plant in the workplace

Model Codes of Practice

The following documents were referred to when drafting this guide:

- Refrigerant Handling Code of Practice 2025 Part 1 – Self-contained low charge systems
- Refrigerant Handling Code of Practice 2025 Part 2 – Systems other than self-contained low charge systems

Resource Library | AIRAH

Codes of Practice | ARC Industry Site

Code of Practice | HVAC&R Centre

Organisation websites – Links to organisations

Resource Library | AIRAH
Flammable refrigerant resources and technical publications

Store | Standards Australia Store
Australian and international standards

Welcome | Safe Work Australia
WHS Act, Regulations and Codes of Practice

https://hcis.safeworkaustralia.gov.au
Hazardous substances information system

www.erac.gov.au
Electrical regulations and mandatory electrical product standards

EESS – Electrical Equipment Safety Scheme
Electrical equipment safety system

www.arctick.org
Refrigerant handling licences and refrigerant trading authorisations Australian Refrigeration Council (ARC)

arcltd.azurewebsites.net/support/green-scheme-accreditation
Green Scheme Accreditation Australian Refrigeration Council (ARC)

Training and online tools

AIRAH Professional Development. Courses for the HVAC&R industry – airah.org.au/site/education/courses

Flammable Refrigerants Safety Guide online resource – An online resource to improve participants' awareness of how to best manage health and safety risks associated with the use and management of flammable refrigerants in refrigeration, air conditioning and heat pump equipment.

VET training http://training.gov.au/ database on vocational education and training in Australia

UN Environment OzonAction Quick Guide on Good Servicing Practices for Flammable Refrigerants Good Servicing: Flammable Refrigerants Quick Guide | Ozonaction

BOC online training –
Gas Safety e-Learning

A2L refrigerant charge calculator –
Climalife – A2L refrigerant calculator

Origin Energy LPG static electricity safety guide –
LPG-Safety-Static-Electricity-Guideline.pdf

ARC training resources –
Industry Training a2-a2l-resource-learning-manual.pdf

ARC information –
R32 Refrigerant information for technicians | ARC Industry Site

Fact sheets produced by –
Refrigerants Australia

Fact sheets produced by –
CCCANZ

IIR informatory note on flammable refrigerants –
Flammable refrigerants. 54st Informatory Note on Refrigeration Technologies. - IIF-IIR - 2023/08

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