Not all refrigeration and air conditioning system types and applications are suitable for flammable refrigerants. While flammable refrigerants are acceptable in some system types, there are other systems in which they should never be used. In all cases, prevention of ignition sources and provision of adequate ventilation to disperse any gas leaks are critical safety factors. Appropriate attention to these factors must be paid in and around any system.

A system may be unsuitable for flammable refrigerants where any of the following apply:

- The system was not specifically designed or modified for use with flammable refrigerants
- The area is not well ventilated
- There are ignition sources or hot surfaces close to the system (i.e. within a region where any gas 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 in below-ground applications.

The requirements for the safe use of flammable refrigerants contained in this Skills Workshop are based primarily on those detailed in the applicable Part 2 Standards of the AS/NZS 60335 series and AS/NZS 1677.2. These requirements outline – by a combination of permissible charge limitations, control of potential ignition sources and/or the provision of mechanical ventilation where applicable – the objective for any potential release of flammable refrigerant to be contained to a safe concentration.

However, system standard AS/NZS 1677.2 has been superseded in the application of these controls by other, more recent standards. Current requirements for the application of these principles can be found in these other standards, including AS/NZS 60079.10.1, AS/NZS 60079.14 and AS/NZS 1482.

Warning: All fluorinated refrigerants, when heated or combusted, release highly toxic gases including hydrofluoric acid and carbonyl halides. These compounds are toxic even at very low levels and can lead to permanent injury or death. A flammable fluorinated refrigerant fire may self-propagate, thereby resulting in higher local concentrations of these toxic compounds compared to non-flammable fluorinated refrigerants. For further information, consult safety data sheets (SDS) for the refrigerant, hydrogen fluoride and carbonyl halides.

SAFE OPERATION

Regular service and maintenance is essential to the safe and reliable operation of a flammable-refrigerant-based refrigeration system. Service and maintenance is covered in AS/NZS 1677.2. The relevant sections of the standard, relating to service and maintenance of stationary flammable refrigerant systems, are detailed below for reference. Specific guidance for system components may also be found in other guides, codes or standards and such guidance should also be followed where relevant, e.g. the requirements for inspection and maintenance of electrical equipment in hazardous areas can be found in AS/NZS 60079.17.

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 due to the fact that the possibility of a release of refrigerant and the presence of potential sources of ignition is greater during service and repair activities. The risk of ignition has been quoted as typically 100 to 1,000 times greater in these circumstances than when the equipment is not subject to human interference (Proklima, 2012).

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

Managing occupant risks

The charge limits for flammable refrigerants are restricted according to the level of risk they pose to those using the equipment or occupying the surrounding area. Risks increase when occupants:

- Are unskilled or untrained on the safety aspects of the equipment
- Are sleeping or are incapacitated
- Might introduce an ignition source (e.g. a room heater) into an area that potentially contains leaked flammable refrigerant.

AS/NZS 1677.1 requires all A3 refrigerants to be odourised. However, not all flammable refrigerants may have odourant added, or the odourant may fade over time. If there is a leak, the flammable refrigerant may not be detected (smelt) by people in the space. Maximum refrigerant charge limits are applied to reduce the risks according to the application.
Assuring compliance
Safety risks are minimised by applying the correct design, installation and maintenance practices: AIRAH’s Flammable Refrigerant Safety Guide, which is available free online, includes an audit tool that allows owners and operators to assess the compliance of any flammable-refrigerant-based installation or service provider against the requirements it outlines.

Sources of ignition
There must be no potential sources of ignition, in or near the equipment, which could ignite any refrigerant that leaks from the system. Flammable materials should not be stored near or around a system containing flammable refrigerants.

Ventilation
Any ventilation provided for the system must remain operable for the life of the system. Keep fans on and vents open as designed/intended.

Fire service notification
The local fire service should be notified of any system that holds 5kg or more of a flammable refrigerant. A notification form should be sent to the appropriate fire service on installation (AIRAH’s FRSG contains a printable notification form). Notification should also be provided when the system is changed, decommissioned or removed.

Gas detection
It is the workplace’s obligation to ensure any gas detection equipment is working. Any level of flammable gas detection (including odour) should be taken as an indicator of dangerous conditions or situations that could quickly escalate to dangerous. Any alarm should be taken seriously and responded to as such.

Emergency planning
Alarm response – including the system’s shut-down procedure and the occupant evacuation procedure – should be explicitly detailed in the site’s emergency plan, which is the written document that details how a workplace and its occupants deal with or manage an emergency.

After a fire
In the event of a fire, burnt fluorinated A2 flammable refrigerants can release highly toxic gases, including hydrofluoric acid and carbonyl halides, resulting in high local concentrations during and immediately after a fire. Avoid any area where decomposition products may be present, consult SDS, which should be available at a site where flammable refrigerants are used.

Maintenance imperative
Regular service and maintenance is essential to the safe and reliable operation of a flammable-refrigerant-based refrigeration or air conditioning system. All detection systems require regular servicing and operator training to ensure correct operation into the future.

Training
Someone who oversees the day-to-day operations of a business should be aware of the safety risks involved with the operation of any equipment containing a flammable refrigerant installed on their premises. Service providers maintaining systems must also be trained in their correct handling and use.

Maintenance
Service and maintenance is covered in AS/NZS 1677.2 Section 5 on Testing, Inspection, Documentation and Marking, and in Section 6 on Operation and Maintenance. If servicing a refrigeration system at a commercial premises, technicians must prepare, maintain and implement an emergency plan dealing with the work they are undertaking.

Maintenance risk
The risk of fire or explosions is higher when systems are being worked on, compared to when they are operating normally. The potential for refrigerant release and for sources of ignition to be present is typically 100 to 1000 times greater during service and repair activities than at any other time.

Pre-service safety
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 – as it is deemed a temporary flammable zone – and the appropriate precautions are in place. In particular, prior to beginning work on systems containing flammable refrigerants, safety checks are necessary to ensure that the risk of ignition is minimised.

An assessment should be completed prior to any service, maintenance, or repair of the system to confirm the type and classification of the installed refrigerant. In the event that the system uses a flammable refrigerant, or the refrigerant is unknown, the following 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 must be instructed on the nature of the work being carried out
- The area around the workspace must 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 (CO2 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 externally to the outside
- Suitable flammable gas detectors are present and operating to warn workers of a dangerous concentration of refrigerants
- The gas detection equipment being used is suitable for use in hazardous areas
- Erect appropriate signage, including “no smoking” and “do not enter the area” signs
- All appropriate and necessary tools, PPE and equipment are available.

Temporary flammable zones
Temporary flammable zones are areas where at least some emission of refrigerant is anticipated to occur during normal working procedures. These areas would be classified as Zone 2 Hazardous Areas under AS/NZS 60079.10.1.

For these 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 zone to be installed as suitable for a hazardous area. The distance from the potential leak point that should be considered as a temporary flammable zone is a minimum of 2m in all directions (refer to AS/NZS 60079.10.1). The actual dimensions of the temporary flammable zone should be determined, taking account of the charge in the system and whether it is located indoors or in a well-ventilated area (e.g. outdoors). For a domestic fridge it would be a minimum of 2m, for larger systems greater distances could be required.

Safe system access
Never break into a system containing refrigerant under pressure by cutting or breaking pipework. A number of aspects must be considered when gaining access to a system:

- It is preferable to remove the entire refrigerant charge in case of unexpected failures
- When the refrigerant has been removed, flush the system with oxygen-free dry nitrogen (OFDN). Flushing with OFDN can eliminate the risk of flash-fire by diluting residual refrigerant below the lower explosive limit (LEL). Depending on the charge size and purging method, this may need to be repeated several times
If brazing operations are to take place, OFDN must be purged through the system during the brazing process.

Never use compressed air or oxygen for flushing, pressure testing or filling, due to the explosion possibility.

It is preferable to use cold-connection technologies instead of brazing when performing system repairs where it is likely that residual flammable refrigerant is present.

Refrigerant recovery

System charges greater than 150g should be recovered.

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.

The recovery cylinder must be suitable for the refrigerant used, specifically, in terms of the pressure rating and the compatibility of valve seals, etc., and with a Class 2.1 label (diamond). Refrigerants of different safety group classifications (e.g. A1, A2, and A3) must not be mixed in recovery cylinders.

Container(s) must be carefully weighed during the transfer of the refrigerant and the permissible fill weight of refrigerant in the container at a reference temperature of 45°C must not be exceeded. All containers are required to be marked with a tare weight and 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. Reference should be made to cylinder standards such as AS/NZS 1596, AS 4332 and NZS 5807.

Because odourant could be lost in the recovered refrigerant due to odourant fade, recovered refrigerant must not be transported in enclosed vehicles, nor stored in an enclosed space, and not be used for charging systems unless it is re-odourised.

Refrigerant venting

Venting may only be carried out for refrigerants that are not covered by the Ozone Protection and Synthetic Greenhouse Gas Management Act 1989. Under certain circumstances, it may be considered acceptable to vent hydrocarbon refrigerants. However, this can only be considered if the following local and national rules and regulations permit including:

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

A risk assessment process must be adopted, 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 gas detection and alarms, the availability of fire protection, the extent of any hazardous areas generated, and the resulting requirements for equipment within that space.

Normally, venting is only carried out with systems that contain a small quantity of refrigerant, typically less than 150g; larger quantities should be recovered. If venting is to be carried out, a set of special procedures is required to ensure that it is done safely, by following the general safety procedures discussed within this section, and through appropriate use of a suitable hose:

- Venting to inside a building is not permissible under any circumstances
- Venting must not be to a public area, or where people are unaware of the procedure taking place
- The hose must be of sufficient length such that it will extend to at least 3m beyond the outside of the building
- The venting should only take place on the certainty that the refrigerant will not get blown back into any adjacent buildings, and that it will not migrate to a location below ground-level
- The hose is made of material that is compatible for use with the refrigerants and oil
- A device is used to raise the hose discharge at least 1m above ground level and so that the discharge is pointed in an upwards direction (to assist with dilution)

Ideally, there should be a type of rose on the end of the hose so that the vented refrigerant can discharge in different directions, with fairly small outlet orifices (to assist with dilution)

There must be no sources of ignition near the hose discharge

Flammable gas warning sign must be positioned close to the hose discharge.

Tools and equipment

Electrical and electronic tools used on systems containing flammable refrigerant should be rated for use in a hazardous area, or be used with a gas detector and suitable procedures to prove safety.

A flammable gas detector should be used to monitor the air in the work area. A dry-powder or CO₂ fire extinguisher must be available at the location.

A suitable ventilation fan should be used when working inside, if there is insufficient natural ventilation, or when working in a confined space.

If an electronic leak-detector is used, it must be suitable for detecting the particular type of flammable refrigerant. Most HFC-only leak detectors do not meet this requirement. As an alternative, leak-detection fluid may be used.

Note: Battery hand drills, screw drivers, heat guns, hair dryers and the like should never be used inside confined compartments, such as those of a domestic freezer or provision compartments. The brush-type motors used, or heat produced from the element, introduces an ignition source into a very confined space.

Charge accuracy

Very accurate scales are necessary when charging small, critically-charged systems with some flammable refrigerants, such as hydrocarbon refrigerants. A scale accuracy that is suitable to the system refrigerant type and charge size is necessary. Many scales traditionally used for HFC refrigerant service may not be sufficiently accurate for use with hydrocarbon refrigerants.

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

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

TICKING BOXES

In order to guide technicians and installers, conversion/installation checklists have been provided in AIRAH’s Flammable Refrigerants Safety Guide (FRSG) to outline the issues that need to be addressed when applying flammable refrigerant based systems. Checklists are provided for the following typical applications:

- High-wall split system
- Cool room refrigeration system
- Plant-room-based refrigeration system.

The FRSG is available free online at www.airah.org.au

MORE INFORMATION

The information in this Skills Workshop was adapted from AIRAH’s Flammable Refrigerants Safety Guide, which is available free online. Hard copies can be purchased for $25 in AIRAH’s online store at www.airah.org.au.

For more information, visit the “Useful Documents” section of the AIRAH website, at www.airah.org.au, where the Flammable Refrigerants Safety Guide, factsheets, videos and slides from the recent seminar series on safe use of flammable refrigerants are all available free.

An ARCtick licence is required for anyone to work with HCFC or HFC refrigerants.

Significant consequences may arise if you, as a designer, fail to properly address safety considerations.