Safe Use of HCFC Alternatives in Refrigeration and Air-Conditioning: Flammable Refrigerants

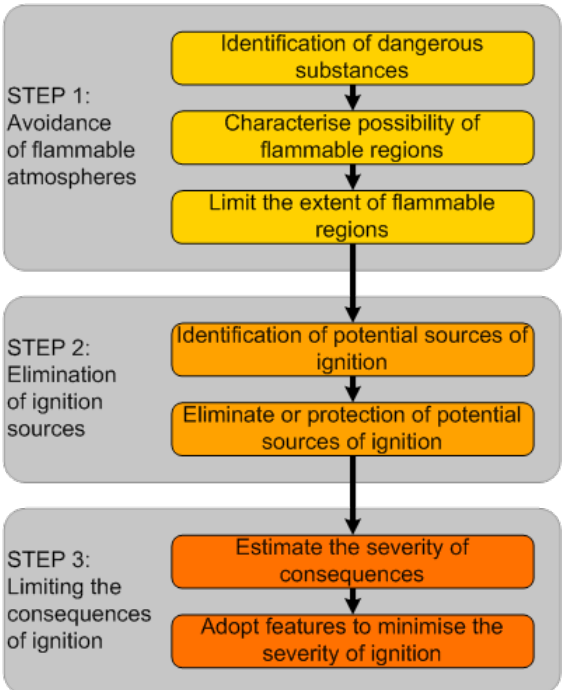
Introduction

As the phase out of hydrochlorofluorocarbons (HCFCs) progresses, it is expected that there will be a considerably higher uptake, in particular in developing countries of 'alternative refrigerants', such as hydrocarbons, ammonia, carbon dioxide, unsaturated hydrofluorocarbons (HFCs) –or HFOs. Many of these alternative refrigerants have particular characteristics in terms of toxicity, flammability and high pressure which are different from those used previously such as chlorofluorocarbons (CFCs) and HCFCs. When refrigeration and air-conditioning equipment is installed, serviced, repaired and dismantled, safety issues need to be carefully evaluated and considered particularly when servicing technicians have to deal with refrigerants with properties that they were previously not familiar with. It is therefore important that the refrigeration and air-conditioning industry adapts to both the technical and safety issues concerning these refrigerants.

There are a number of flammable refrigerants – some old and some recently developed. Although there are many flammable refrigerants the extent of their flammability varies quite widely; it can be seen that some substances have relatively low '*lower flammability limits*' (LFLs). For example HC-290 has an LFLs of 38 g per m^3. Other refrigerants have significantly higher LFLs, for example HFC-1234yf has an LFL of 289 g per m^3). There are other flammability characteristics such as minimum ignition energy, heat of combustion and burning speed that have an impact of the ease with which a substance can be ignited and the severity of the consequence following ignition.

General Risk Assessment

With all flammable refrigerants, the risk arises with the possible ignition of a flammable concentration. Ignition is caused by an unprotected source of ignition – this could be an electric spark, a naked flame, a very hot surface or some other event that creates sufficient energy. Ignition may occur wherever the refrigerant has leaked and mixed with air in dangerous proportions.



Basic steps for flammability risk assessment

Special requirements

For flammable refrigerants, appropriate design requirements – that are over and above what would normally be required for ordinary refrigerants – can be found in regulations, standards, codes of practice and industry guidelines. The main issues described in these sources to be addressed, include:

- Limiting the quantity of refrigerant to an amount that is unlikely to be ignited (i.e., refrigerant charge limits)
- Designing the system and components for smaller refrigerant charge amounts
- Not installing equipment in vulnerable locations (i.e., where there are an excess of potential sources of ignition)
- Ensuring systems have a high level of leak tightness.
- Constructing the system so that there are no potential sources of ignition that could ignite a refrigerant leak (e.g., no sparking components where a leak of refrigerant could accumulate)
- More frequent use of gas detection and ventilation systems to assist with dispersing any leak of refrigerant
- Applying the necessary warnings to accessible parts of the system to ensure that technicians are aware of the hazard (e.g., flammable gas stickers near charging points)
- Including the necessary information relating to flammability in installation and operating documentation

Standards such as EN 1127-1[1] are useful for assisting with the design considerations of systems use flammable refrigerants.

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Electronic manifold gauge set that can be used with flammable refrigerants

Tools and equipment

For technicians and engineers that are working directly with flammable refrigerants, it is essential that workers have available and use the appropriate tools and equipment. Whilst it is often the case that certain tools and equipment are equally applicable to most refrigerants, there are some that may ordinarily compromise safety and some specialised equipment is required.

Flammable gas warning sign that must be on flammable refrigerant recovery cylinders

TOOLS AND EQUIPMENT FOR USE WITH FLAMMABLE REFRIGERANTS

Item	Remarks
Gas detectors	Should be electronic and intended for use with flammable gases and the refrigerant intended
Balance/scales	If electronic, should be suitable for use in an area where flammable refrigerant may be present, as confirmed by the manufacturer.
Manifold/gauge/hose set	Materials should be compatible, be able to withstand the maximum pressure and, if electronic, be suitable for use in the presence of flammable refrigerant
Vacuum gauge	If electronic, be suitable for use in the presence of flammable refrigerant, as confirmed by the manufacturer.
Vacuum pump	Should be suitable for use with flammable gases (e.g., not with a brushed motor) or arranged so that it can be switched on/off in a location where a release of flammable refrigerant cannot reach.
Refrigerant cylinder adapters	Ensure that the correct type of cylinder adapter is present to enable safe removal of refrigerant from the cylinder
Recovery cylinder	Must be rated for the maximum pressure of the refrigerant being used and have the appropriate flammable gas warnings, also proper refrigerant cylinder handling rules must be adhered to
Refrigerant recovery machine	Must be suitable for use with the type of refrigerant under consideration and also be designed appropriately for flammable refrigerants
Venting hose	Due to the negligible environmental impact of direct releases for certain flammable refrigerants, specifically hydrocarbons, venting is sometimes practiced instead of recovering (generally for small refrigerant charges); in this case, a venting hose with sufficient length to allow venting directly to a safe place in the open air is necessary.
Mechanical ventilation	When working with larger charges of refrigerant, it can be beneficial to use a safe mechanical ventilation unit to help dilute refrigerant that has been accidentally released
Personal protective equipment (PPE)	Normally standard items such as goggles, gloves, fire extinguisher

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Refrigerant recovery machine for hydrocarbon refrigerants

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Refrigerant gas detector for hydrocarbon refrigerants

KEY TOPICS FOR TRAINING

Topics
Basic principles
• How to carry out flammability risk assessment for systems and installations
• Awareness of material safety data sheets (MSDS)
• Flammability characteristics ("fire triangle", LFL, ignition energy, heat of combustion, etc)
• Relevant safety standards and regulations that relate to equipment using flammable, higher toxicity and higher pressure gases
• Differences in refrigerant density compared to ordinary refrigerants and the implications on charge size and cylinder filling
• Behaviour of a leak of refrigerant under different circumstances, i.e., the flow of denser-(or lighter-) than-air gas in closed rooms, enclosures, the outside in still or windy conditions and the effect of ventilation
System design and construction
• Classifications within refrigeration safety standard – flammability, toxicity, occupancies, locations, system types
• Requirements of safety standards – determination of charge size limits (or minimum room sizes), need for safety devices (such as pressure limiters, pressure relief, etc), gas detection, ventilation, etc
• Sources of ignition; types of ignition sources, spark energies, temperature effects, etc
• Need for and types of protection appropriate for potential sources of ignition
• Importance of leak minimisation and methods for avoiding leakage
• Information requirements such as equipment marking, labelling and signage
Working practices
• How to carry out a risk assessment for creating and maintaining a safe working area and for carrying out work on a system containing flammable refrigerants
• Selection and use of appropriate tools, equipment and personal protective equipment (PPE) when handling flammable, higher toxicity or higher pressure refrigerants
• Appropriate use of fire extinguishers
• Standard procedures for safe charging, recovery, evacuation, venting, etc
• Emergency response procedures, such as in the event of a major release or a fire or carrying out first aid
• Provision of relevant information for data-plates, equipment documentation and owners/operators
• Selection of appropriate 'like for like' replacement components for electrical devices, electrical enclosures, compressors, etc., and maintaining the integrity of sealed electrical enclosures
• Presence and absence of odorant
• Restriction on relocation of existing systems/equipment

WARNING AGAINST RETROFITTING TO FLAMMABLE OR HIGHER TOXICITY REFRIGERANTS

The introduction of flammable, higher toxicity and/or higher pressure alternatives is strongly discouraged from being used in existing HCFC systems that were not designed for these alternatives. The issue of safety related to retrofitting was specifically considered by the Executive Committee in 2014 and a decision was taken at the meeting (72/17) which stated: "*anyone engaging in retrofitting HCFC-based refrigeration and air-conditioning equipment to flammable or toxic refrigerants and associated servicing, does so on the understanding that they assume all associated responsibilities and risks*".

Footnote:

[1] European Standard, EN 1127-1, 'Explosive atmospheres – explosion prevention and protection. Basic concepts and methodology'

Source:

- UNEP OzonAction - Safe Use of HCFC Alternatives in Refrigeration and Air-conditioning: An overview for developing countries, 2015

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