Safe Use of HCFC Alternatives in Refrigeration and Air-Conditioning: Higher toxicity refrigerants

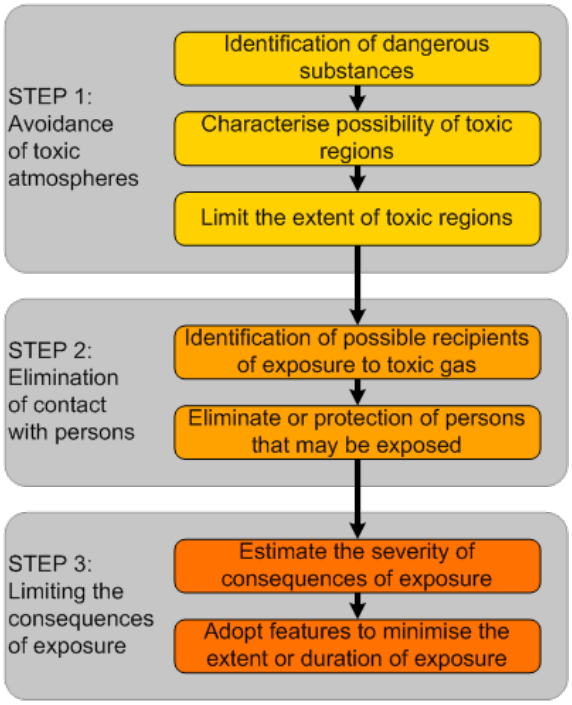
Introduction

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 is primarily one alternative refrigerant that is of higher toxicity, ammonia (or R-717); it is flammable as well as being higher toxicity. Another important consideration for ammonia is that is a powerful corrosive chemical and has an affinity for moisture.

General risk assessment

With higher toxicity refrigerants and specifically ammonia, the primary hazard is the inhalation of leaked refrigerant by persons. Other hazards, albeit less common include direct contact with liquid refrigerant and possible ignition of a flammable concentration. Excessive exposure to a toxic concentration may arise due to an accidental release of refrigerant within an enclosed space – or even an open space if the release is of sufficient magnitude – and the occupants are not in immediate possession of the appropriate Personal Protective Equipment. Particularly with ammonia, adverse reactions can occur even at extremely low concentrations (in the order of tens or hundreds of parts per million in air). The consequences of inhalation can include irritation of eyes and nose with a sore throat, cough, chest tightness, inflammation, lacrimation, photophobia, headache and confusion and eventual fatality. The consequence of direct contact to the skin exposure may result in deep burns whereas inhalation may result in burns to the mouth and throat.



Basic steps for toxicity risk assessment

Special requirements

For higher toxicity 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 pose a toxicity risk (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 large groups of uncontrolled occupants)
- Ensuring systems have a high level of leak tightness.
- More frequent use of gas detection and ventilation systems to assist with dispersing any leak of refrigerant
- Provision of specialist personal protective equipment (PPE), such as respirators, suitable clothing and washing facilities.
- Applying the necessary warnings to accessible parts of the system to ensure that technicians are aware of the hazard (e.g., warning signs near charging points)
- Including the necessary information relating to toxicity effects in installation and operating documentation

Particularly with ammonia, because of its very low acute toxicity exposure limit, the permitted quantities of refrigerant (per refrigerant circuit) are extremely small. Depending upon the occupancy, location and type of system, larger quantities are allowed and furthermore, additional features can be applied to the design of the system so that the amount of refrigerant that would be released is limited. For systems installed outside or in machinery rooms, there are normally no such limitations.

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Refrigerant gas detector for ammonia (R-717)

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Example of respiratory equipment

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Example of protective suit for ammonia

Service tools and equipment for use with ammonia

For technicians and engineers that are working directly with higher toxicity 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.

Item	Remarks
Gas detectors	Should be electronic and intended for use with ammonia
Manifold/gauge/hose set	Materials must be compatible with ammonia, be able to withstand the maximum pressure and, if electronic, be suitable for the characteristics of ammonia
Vacuum gauge	Materials must be compatible with ammonia.
Vacuum pump	Should be suitable for the characteristics of ammonia.
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 ammonia, have the appropriate warnings and be of a material that is compatible with ammonia. Also proper refrigerant cylinder handling rules must be adhered to
Refrigerant recovery machine	Must be suitable for use with ammonia
Personal protective equipment (PPE)	Further to normal Personal Protective Equipment, depending upon the quantity of refrigerant involved, special respiratory protection (canister type self-contained respirators or breathing equipment) shall be provided. In addition, protective clothing including face-shield with transparent visor, gas-tight goggles, gauntlet thermal insulating gloves, protective suit and hood impervious to ammonia and rubber boots shall be available. Also a safety shower or bath and an eye fountain must be present.

R-717 recovery pump set

KEY TOPICS FOR TRAINING

Topics
Basic principles
• How to carry out toxicity risk assessment for systems and installations
• Awareness of material safety data sheets (MSDS)
• Toxicity characteristics (short term, long term, physiological effects, etc)
• Relevant safety standards and regulations that relate to equipment using flammable, higher toxicity and higher pressure gases
• 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
• 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 higher toxicity refrigerants
• Selection and use of appropriate tools, equipment and personal protective equipment (PPE) when handling flammable, higher toxicity or higher pressure refrigerants
• 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
• 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*".

Source:

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

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