What You Should Know About Refrigerant Safety

Taking precautions when working with any refrigerant can help avoid dangerous situations and injuries. *By Jim Lavelle*

An HVACR technician is exposed to many personal safety hazards during the course of a normal workday. In addition to the obvious hazards such as sharp metal, electrical wiring and climbing ladders, the technician needs to be aware of the safety hazards that refrigerants pose.

Refrigerant safety is straightforward: If the refrigerant stays contained in the cylinder or in the system then it presents little danger to people. The hazard occurs when the refrigerant comes out of the container or system, often quickly and unexpectedly. Injuries can be avoided if regular safety checks are performed.

Regular checks on containers and systems for holding pressure and preparing safety equipment and procedures to minimize personal exposure after unexpected releases should help avoid any injuries when handling refrigerants. Specific hazards from refrigerant fall into three categories:

1. Toxicity
2. Combustion / flammability / decomposition, and
3. Pressure

Toxicity and Personal Exposure

Most refrigerants have undergone extensive toxicity testing before being released for general refrigeration or air-conditioning use. Testing generally involves a range of exposure levels and times to determine any possible effects on test animals.

- Short-term exposures at high concentrations indicate any acute hazards such as irritation, sensitization of the heart to adrenaline and lethal concentration (LC50 is the amount which kills half the animals in a short amount of time).
- Tests that expose animals for longer periods of time, such as 90 days to two years, are designed to indicate chronic problems. These can include mutagenicity (changes to cells), reproductive problems and effects on organs ocarcinogenicity (cancer-causing).

ASHRAE Standard 34[1] provides a safety classification for refrigerants based on information related to personal exposure. AHSRAE Standard 15[2] uses this safety rating and additional toxicity information to set requirements for machinery rooms and sets limits on the amount of refrigerant allowed in systems outside machinery rooms. Many blends containing these individual components are also classified.

Refrigerants not classified in ASHRAE Standard 34 should be reviewed with suppliers to make sure enough is known about their toxicity properties. Some blends may not be classified, but contain classified components. (Note: Many building codes have adopted the new refrigerants listed in ASHRAE standards. Some building codes have not, and therefore, require special permits. A refrigerant that is not listed will most likely require an engineering study to determine if it can be used safely.)

Exposure levels are values given to refrigerants to indicate how much of the chemical a person can regularly be exposed to without adverse effects. All toxicity test results are considered when setting this level. The American Conference of Government and Industrial Hygienists (ACGIH) sets the TlV-TWA values for chemicals. TLV-TWA stands for Threshold Limit Value-Time Weighted Average, which is the amount of chemical a person can be exposed to for 8 hours a day, 40 hours a week, without adverse effects.

The maximum value for any chemical is 1,000 ppm, though many refrigerants have shown no effects in toxicity testing as values much higher than that. Other organizations and chemical producers have similar exposure level indexes based on the same criteria. These are the *Workplace Environmental Exposure Limit* (WEEL) set by the American Industrial Hygiene Association (AIHA*); Permissible Exposure Limit* (PEL) set by OSHA; and *Acceptable Exposure Limit* (AEL) used by DuPont.

There are also the *Short Term Exposure Limit* (STEL) which is based on a 15-minute exposure time in any given day as well as the value *Immediately*

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Dangerous to Life or Health (IDHL). These are used to give guidance for machinery room requirements, ventilation and alarms in an emergency or escape situation, or in circumstances where short releases of refrigerant are expected, which could include refrigerant transfers or servicing large equipment.

Toxicity data is summarized in great detail on Material Safety Data Sheets (MSDS). What all of this data means to the technician, however, is that commercial refrigerants are safe enough to use provided you don't breathe too much of them. Industry practices for handling refrigerant are intended to minimize personal exposure as well as reduce releases into the atmosphere. General rules to follow are:

- Minimize the amount of refrigerant released. Proper recovery procedures, including clearing hoses, will keep the refrigerant in the containers instead of potentially exposing it to people.
- Never intentionally release refrigerant in a confined space. Even the safest refrigerant can still displace enough oxygen to cause suffocation.
- Set up ventilation equipment, like a portable fan, in areas where possible release would mean high concentrations.
- Refer to AHSRAE Standard 15 and local building codes for additional guidance.

If someone is exposed to refrigerant get him/her to fresh air, give oxygen if needed and get him/her checked by a doctor.

Flammability / Combustion / Decomposition

Flammable refrigerants present an immediate danger when released into the air. The refrigerant can combine with air at atmospheric pressure and ignite, causing a flame and possibly an explosion to occur. Because of the obvious hazards, the use of flammable refrigerants is restricted to controlled environments that have monitors, proper ventilation, explosion-proof equipment and generally few people near the equipment (refineries, storage warehouses, breweries, etc.).

Some refrigerants can burn with oxygen but only at higher pressures or temperatures and never in air at atmospheric conditions. These are called "combustible" refrigerants. Underwriter's Laboratories (UL) lists these refrigerants as "Practically Nonflammable."

R-22 and R-134a fall into this category. R-22 was found to cause a combustion hazard during a pressurized leak test with air. For this reason, most refrigerants should be used only with pressurized nitrogen for leak testing. As long as refrigerant is not mixed with large amounts of air, there should be little hazard from these refrigerants during normal handling and use.

Decomposition can occur with any refrigerant when it gets hot enough (generally above 700˚F). Refrigerant can decompose in systems or containers exposed to fire or other extreme heat, electrical shorts (burnouts), or in refrigerant lines being soldered or brazed without being cleared first. Obviously, refrigerant containers or charged systems should never intentionally be exposed to a flame or torch.

When a refrigerant is decomposed or burned, the primary products formed are acids: Hydrochloric Acid (HCl), if the refrigerant contains chlorine, and Hydrofluoric Acid (HF), if is contains fluorine. These products are certainly formed when hydrogen is present, such as from the breakdown of oil, water or if the refrigerant has hydrogen attached (like R-22 or R-134a). If oxygen is also present (from air or water), then it's possible to form carbon monoxide, carbon dioxide and various unsaturated carbonyl compounds – the most notorious of which is phosgene.

Being extremely toxic in small amounts, phosgene formation was a real concern when traditional refrigerants (R-11, R-12, R-113, R-114) decomposed. Phosgene contains two chlorine atoms and an oxygen atom. It will only form when oxygen is present and only the refrigerants with chlorine attached will produce phosgene (not HFCs). R-22 has only one chlorine atom per molecule, so it is extremely difficult, chemically speaking, to get another one attached to form phosgene.

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Decomposition of R-22 or HFCs may form other carbonyl fluorides, however they are not as toxic as phosgene.

The standard practice for handling decomposed refrigerant is to collect the gas, treat the refrigerant and/or the system for acid contamination, and appropriately dispose of the burnt gas. Please note that any cylinder or system component exposed to high heat or fire should be retested or discarded. Cylinders used to recover burnt gas should be checked and cleaned before being put back into service, especially the valve and/or pressure relief device.

Physical Hazards

The fact that it's a liquified gas under pressure is one of the more obvious hazards of refrigerant. Sudden, unexpected release of pressurized refrigerant can result in personal injury.

- ***Frostbite*.** Liquid refrigerant suddenly released from high pressure to atmospheric pressure will flash and boil to vapor. Naturally, the temperature of the refrigerant will drop quickly to the boiling point and the refrigerant will quickly absorb heat from whatever it is touching. If the refrigerant is touching skin it can cause frostbite. Frostbite damages skin by freezing water inside the skin cells, which can expand and burst the cell walls. To treat frostbite, cover the exposed area with warm (not hot) water or a wet compress. The skin must recover slowly or more damage can occur. Do not rub the affected area to try to warm it as it may inflict more damage. Protective clothing, gloves and eye protection are effective at preventing frostbite by keeping liquid refrigerant away from the skin.

- ***Rupture of tank or system*.** Cylinders or systems without pressure relief devices could break if the refrigerant pressure inside were to exceed the strength of the cylinder or system component. This type of failure can be quite hazardous if the refrigerant is at a high pressure or solid material is blown loose. Containment failures are caused by one of two things: The refrigerant pressure has increased above the pressure rating of the cylinder or system, or something has happened to the cylinder or system so that it will no longer hold normal refrigerant pressure.

Elevated refrigerant pressure can be caused by exposure to heat. Refrigerants with pressures similar to R-12 will develop more than 500 psia at temperatures above 200˚F. Refrigerants with pressures similar to R-502 will achieve the same pressures at about 150˚F. Hydrostatic pressure also can develop quickly in a confined volume that has been completely filled with liquid refrigerant, for example liquid-full hoses between shut valves or an overfilled recovery cylinder. Refrigerant tubing, hoses, system components and some refrigerant cylinders surely would fail at some elevated pressure without certain safety provisions. Various pressure relief devices are used to lower the pressure back to safe limits by releasing some or all of the refrigerant.

Valves on many refrigerant cylinders are fitted with spring-loaded pressure relief valves. These are typically set to release pressure somewhere above typical refrigerant pressures at normal use or transportation temperatures, but below the maximum service pressure of the cylinder. When the pressure is reduced to a safe level the valve should close itself.

Other cylinders or storage vessels are fitted with burst discs as the pressure relief device. These are pieces of metal designed to break at some preset pressure, again lower than the maximum service pressure of the container. In the case of a burst disc, the entire contents of the container will be released. This is also the case with a fusible plug, which is designed to melt at a certain temperature. It is used to relieve the pressure in a tank or system in a fire situation before the pressure gets high enough to burst the tank, tubing or system component.

Damaged or weakened refrigerant cylinders or system components may fail at pressures lower than originally specified. Physical abuse such as dents, scratches, rust, bulges or exposure to excessive heat can reduce the strength of joints or the metal itself. Materials originally designed to hold hundreds or thousands of psi pressure might now fail at typical refrigerant pressures. In the case of damaged cylinders, the pressure relief should not be relied upon for

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protection; the cylinders should be repaired and retested or discarded.

The best way to avoid pressure-related hazards is to always use cylinders and system components that have the correct pressure rating for the refrigerant you are using. *Table 1* lists the typical cylinder service pressures that manufacturers and distributors use for various refrigerants. Pressure ratings for system components must be chosen based on the application and expected service pressures for the intended application. Pressure ratings are also based on the refrigerant chosen. Always check for signs of damage or excessive wear before filling recovery cylinders, picking up new refrigerant cylinders or attaching new parts to a system.

Table 1

Refrigerant	Cylinder Service Pressure
	psig
R-12	260
R-22	260
R-500	260
R-502	260
R-114	260
R-134a	260
R-401A	260
R-401B	260
R-402A	350
R-402B	300
R-404A	300
R-406A	260
R-407A	300
R-407C	300
R-408A	300
R-409A	260
R-410A	400
R-414B	260
R-416A	260
R507	300

Typical test pressure is 2 to 2.5 times the service pressure.
Service pressure is stamped or printed on the cylinder, sometimes preceded by a number and letter such as "3A400" or "3B260"

References

(1) ANSI/ASHRAE Standard 15, "Safety Code for Mechanical Refrigeration", American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc., Atlanta.

(2) ANSI/ASHRAE Standard 34, "Designation and Safety Classification of Refrigerants", American Society of Heating, Refrigerating and Air Conditioning Engineers, Inc., Atlanta.

Refrigerant Handling Checklist

Safe handling of refrigerant is easily achieved for the technician who has been trained on the following practices:

☑ Use proper system components and practices for installation to maintain system pressure rating.

☑ Use cylinders with the right pressure rating and frequently check the condition of any cylinder you are using.

☑ Don't abuse cylinders or misuse a cylinder for unintended purposes.

☑ Avoid creating a flammability or combustion hazard (use nitrogen instead of air for leak testing.)

☑ Recognize decomposition situations and handle the burnt gas appropriately.

☑ Minimize personal exposure to refrigerant gas.

☑ Review and practice safety procedures and use protective equipment.