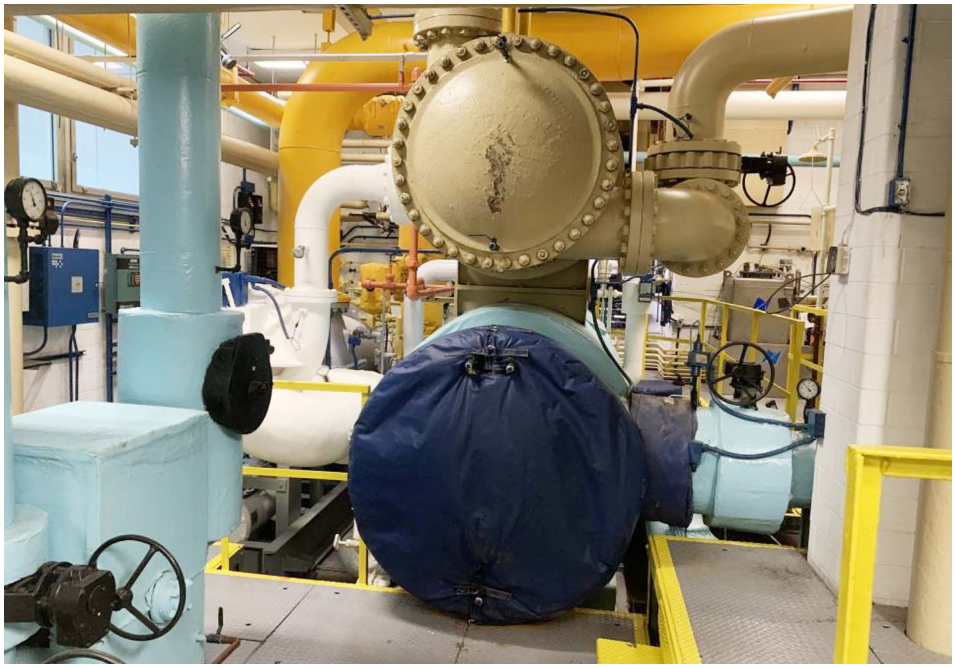
Refrigerant leaks: A cold brew of hazardous materials

By Captain Thomas Delgrosso and Lieutenant James Pirot

In our line of work, situational awareness is imperative. While we're generally good at identifying hazardous materials that we encounter frequently—such as natural gas—sometimes it can be difficult to recognize the ones we don't see as often. In recent years, at least two incidents involving refrigerant leaks have caused in inhalation injuries to FDNY members that resulted in hospitalizations. In one case, members in Staten Island responded to a grocery store for a report of "smoke" in the rear loading area of the store. Members made entry thinking it was a rubbish fire that had been extinguished by the sprinkler system. They noticed a white haze with no odor. After only a few breaths, they began to experience symptoms. As many as six members wound up in the hospital with chest pains and difficulty breathing. To that end, leaking refrigerants are a dangerous hazardous material that can be hard to detect. This article will discuss the nature of refrigerants, the cycle of refrigeration and, most importantly, operations at refrigerant leaks.

Based on the information from the response ticket, a refrigerant leak might not be our initial diagnosis. Often refrigerant leaks come in as "smoke," or simply an odor. When you arrive on scene, you might encounter a white haze in the air or an oily smell. Also, members may notice a coating of oil on surrounding surfaces or a stained ceiling. For smaller window units or mini splits, you might notice a mist blowing out from the copper refrigerant line under pressure. Further, you may encounter ice or oil on the copper line. These conditions indicate a leak. If you find these clues, consider the following objectives (with both home HVAC systems and large commercial HVAC systems, the same general principles and actions apply):



Commercial chiller plant

1. Protect yourself by using your SCBA.
2. Special call Hazmat resources by transmitting a 10-80 code 1.
3. Shut down the affected equipment or have a licensed building engineer perform an "orderly shutdown."
4. Ventilate the affected area.
5. Identify the refrigerant involved, if possible.
6. Isolate the leak, if possible.
7. Determine whether an evacuation is necessary (depending on the amount of refrigerant released, whether the leak can be stopped, the type of refrigerant, the type of occupancy and whether the location can be vented).

About the authors

Captain Thomas Delgrosso is a 25-year veteran of the FDNY. He is currently the captain of Ladder 22. Previous assignments include Ladder 13 as a lieutenant and Ladder 58 as a firefighter. He is a member of Local 638 Steamfitters, with more than 30 years of experience installing, designing and maintaining HVAC systems. Captain Delgrosso holds an EPA 608 Universal Technician Certification, a certification issued by the U.S. Environmental Protection Agency (EPA) under the Clean Air Act for technicians who work with refrigerants.

Lieutenant James Pirot has served in the FDNY since 2006. He is covering in Division 7. Previous assignments include Squad 61, Ladder 18 and Engine 160. He is also a member of the International Union of Operating Engineers Local 94, with experience working with both residential and commercial HVAC systems, including high-tonnage systems. He has completed the Local 94 New York City training program; holds a Q-99 Certification of Qualification for Refrigerating Systems Operating Engineer certificate, issued by the City of New York; and holds an EPA 608 Universal Technician Certification, a certification issued by the U.S. Environmental Protection Agency (EPA) under the Clean Air Act for technicians who work with refrigerants.

Window-unit evaporator coil. This front coil is where the heat is absorbed into the refrigerant.

How refrigeration systems work

Refrigeration systems all work to accomplish the same job: absorb heat from an area in order to create conditioned air. Your refrigerator removes heat from within the box and discharges it outside, which makes it cool inside the refrigerator and warm on the exterior. The same principle applies to home air-conditioning systems, including forced air, mini splits and window units. You are taking the heat from within your home and removing it to the outside by using a refrigerant.

Commercial systems do the same job, just on a significantly larger scale. Although vastly different in size, small window units and large commercial units follow the same refrigeration cycle. In larger units, the system absorbs ambient heat from the space and releases it through a cooling tower. The outdoor unit (condenser) of a residential central-air-conditioning system and the back section of a window unit both release heat from the system, doing the same job as a cooling tower, just on a smaller scale. With each type of cooling system, the general refrigeration loop—and the refrigerants themselves—all follow the same principles. Heat is captured from one area and moved to another.

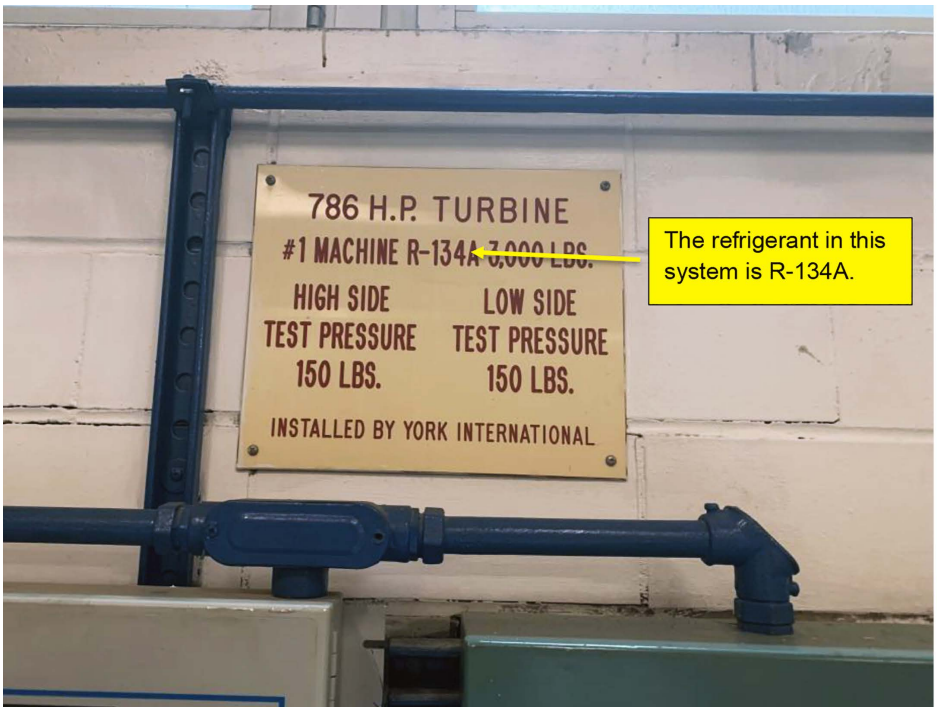
The refrigerant

The words refrigerant, Freon and Puron can be used to describe a wide range of refrigeration products. Some commonly found refrigerants are R-134A, R-410A and R-22, but there are many others. All refrigerants are chemical compounds that should be considered hazardous to your health. Some initial concerns should be the risk of asphyxiation and explosion. In addition, exposure can also cause frostbite if you come in contact with the product. Within the refrigeration loop, the refrigerant's state of matter will cycle from a gas to a liquid and then back to a gas again, depending on what step of the process it is in. They all act in the same manner, absorbing heat during one step of the refrigeration loop and releasing it during another.

What if you are told by an engineer—or read on the nameplate—that the refrigerant in the system is R-717? This means you are dealing with ammonia; all of the associated hazards and risks should be considered. Another number you might encounter is R-290, a highly flammable compressed gas containing propane. But unlike fuel propane, there is no odorant in R-290, making it difficult to detect and presenting additional risks that you might not have considered initially. These hazardous materials present more problems than just a simple refrigeration leak. Therefore, it's important to identify the product in order to assess the potential hazards.

The dangers of inhalation

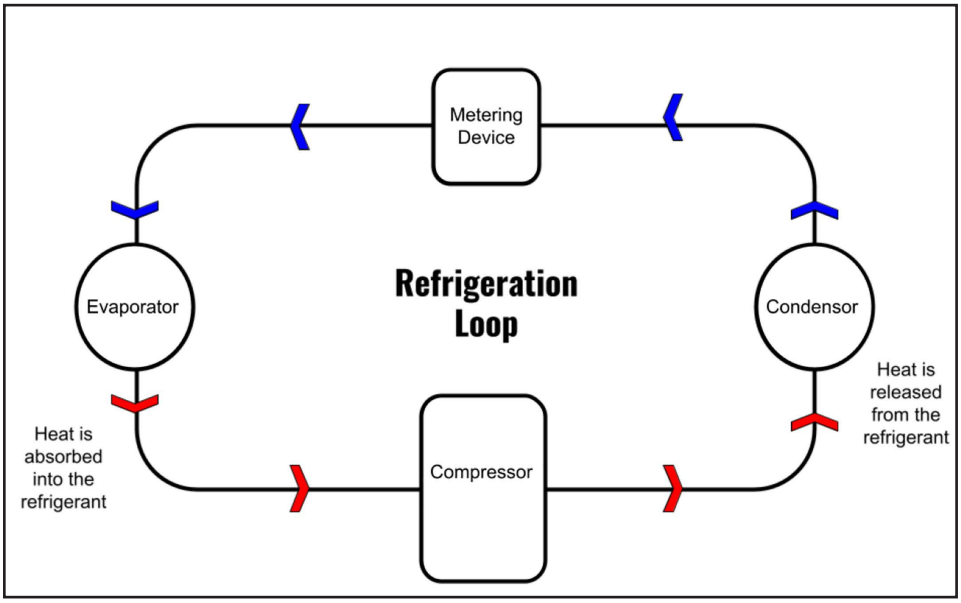
It is critical to keep in mind that a refrigerant is an asphyxiant, meaning it will displace oxygen. There may be no indication that you are entering an oxygen-depleted area. Carry an activated Altair meter, which will warn you of an oxygen-deficient environment. You must also don your SCBA facepiece before entering a compromised area. Doing so will protect you from an oxygen-depleted en-



Nameplate identifying the type of refrigerant in a machine room

vironment and prevent you from inhaling toxic chemicals.

Occasionally, we go to window-unit air-conditioner fires. Aside from the fire situation itself, this is also a Hazmat incident, as the flammable oils in refrigerants can produce phosgene gas. In addition, an air-conditioning unit can explode violently when exposed to fire, as heat can cause a refrigerant in the liquid state to expand to a gas, creating a pressure buildup that leads to an explosion. Once again, you must use your SCBA to protect yourself.



The refrigeration loop

How does the refrigerant move throughout a system? Let's start at the *evaporator*. The evaporator is the coil inside your refrigerator, at the front of a window unit or inside the *air handler*. Warm air passes over these coils, which contain refrigerant, and they absorb heat and return cooled air to the space. The next system component is the *compressor*—the heart of the system. This is what drives the refrigerant. If the compressor is the heart, then the refrigerant is the blood.

Compressors can be powered by a simple wall plug, but in large commercial buildings, these compressors can be driven by high-pressure steam, high-voltage electric or their own engine. The parts within a compressor require a lubricant, which is why oils are found within refrigerants. The oils are what you might see if there is a break in the lines or system. The refrigerant absorbs additional heat from the compressor and continues to the *condenser*, where the refrigerant releases heat that has been absorbed. In a home HVAC system, this is done at the outdoor unit. If you were to put your hand over the fan, you would feel warm air. This is the warmth of your home being released to the outdoor space; it also applies to window and mini split units. In large commercial systems, heat from the space is discharged by means of a *cooling tower* after an additional heat-transfer process. The refrigerant then leaves the condenser and travels through a metering device, finally returning to the evaporator and completing a loop. This basic refrigeration process repeats itself until the desired temperature is reached by gradually absorbing heat from an area and releasing it to another.

Operational considerations for refrigerant leaks

During your size-up at a refrigerant leak, you may initially encounter various clues. In a large commercial system, an oily haze in the air and/or a coating of oil on the floor could be a sign of a leak. Your next step is to determine the source of the leak, such as a break in a refrigerant line above a drop ceiling, a leak within the air handler or a malfunction of the system causing a relief valve to activate. Refrigeration leak detectors should be found in large machine rooms, which can help identify the problem. During a leak, a refrigerant can travel to low spots or get dispersed to various floors in a building via the HVAC vents. The source of the leak may be remote from the location of the haze or odor. To help pinpoint the leak, consider following the ducts back to the refrigeration coils or tracing the refrigeration lines. Hazmat units have meters and tools to pinpoint leaks. Keep in mind that a simple leak can lead to something more serious, like a phosgene gas situation, ammonia leak or propane explosion.

Large systems over a certain tonnage (determined by compressor horsepower) need to have a licensed engineer on site to operate the refrigeration equipment. When trying to identify the refrigerant and mitigate the situation, these engineers are a vital resource. In addition, building information (BIC) cards, along with nameplates on both small and large systems, will contain the type of refrigerant.

Once you realize you are operating at a refrigeration leak, it is critical to don your SCBA facepiece and stay on air. Refrigerants can take the form of both liquids and gases, depending on what step of the loop they are in. Using your mask protects you from not only the oil that has been aerosolized, but also numerous other gases that may harm you. It is also critical to wear all of your PPE,

Refrigeration detector

This is a condenser where the heat is discharged from the refrigerant. The electrical disconnect switch (located on the exterior siding) can be pulled to kill power to the system.

as skin contact with the refrigerant can cause frostbite.

If the unit is not part of a critical system, simply shutting it off will help gain control of the situation. Smaller residential air-conditioning units have a breaker disconnect outside (near the condenser) in order to kill power to the exterior unit, including the compressor. Some units can simply be unplugged from a wall outlet. Shutting off power can slow further discharge of the refrigerant by stopping the compressor, which drives the refrigeration.

In a larger or vital system, ask the building engineer whether they can complete an "orderly shutdown." If a shutdown is called for, a licensed engineer must take certain steps to properly shut it down. Incorrectly shutting down a larger system or critical system will significantly compound the problem. If the building has multiple chiller plants, ask, "Can you swing the plant over?" This means that a separate plant will pick up the work of the compromised system. This should be done for critical systems. As a last resort, an emergency stop button can be found at the entrance to a machine room or other location; this option should be reserved for extreme situations.

Emergency stop button

Take note of your Altair. If the oxygen is not reading the correct level, then something is displacing oxygen in the air. This is a problem, not only because you may be operating in an oxygen-deficient environment, but also because there may be a toxic gas present in the air. It is critical to note that a 0.1 percent change in the 02 reading means that there are 5,000 ppm of an unknown substance in the air, which can be a massive, lethal dose if the substance is toxic. If the Altair was reading 20.8 percent oxygen prior to making entry to the space, but changes to 20.7 percent after making entry, this indicates the presence of 5,000 ppm of another—and potentially toxic—substance. If the 02 reading on your Altair changes, consider how many ppm caused it to move? In addition to keeping members safe, your Altair reading should affect your decision about whether to evacuate civilians from the affected area.

Ventilating the affected area is a key step in making the area safe. This can be done by opening windows and setting up fans. For larger systems, opening the outside air dampers along with the exhaust dampers while closing the mixing dampers will also help. The goal is to get fresh air into the space while exhausting the bad air. The mixing dampers should be closed to reduce the risk of spreading the refrigerant throughout the building.

Members must avoid cutting refrigeration lines, as this could lead to an uncontrolled release of a refrigerant from a high-pressure system. As discussed earlier, the refrigerant could consist of ammonia or propane. This could worsen an already dangerous situation.

Evacuation should be considered for a variety of reasons but may not always be necessary. Hazmat Company 1 can help with this decision by metering the affected area and identifying the type of gas. If a leak cannot be stopped, the area cannot be vented or meter readings are a concern, then you should consider evacuating the area.

If fire is present, we have mentioned the threat of the refrigerant turning into a phosgene gas. In addition, high heat from a fire can also cause over-pressurization, turning the liquid refrigerant into a gas and leading to a catastrophic failure or explosion if the safety features malfunction. Commercial systems have pressure-relief valves. If a pressure-relief valve is venting, it may be doing its job and releasing pressure because of a malfunction or heat-related overpressure. Manually reseating the valve will exacerbate the problem, causing a catastrophic failure in this instance. The relief valve may be venting because it's doing its job and protecting the system. The on-site engineer will be your best source of information when dealing with this.

Can refrigeration leaks occur during the winter? Yes, absolutely! Grocery stores keep their systems in service year-round. Commercial buildings and hospitals contain vital systems that need cooling year-round as well. Do home HVAC systems run during the winter? Yes, these systems still run in the winter by reversing the flow of refrigerant to supply heat to a space. Members should remember that refrigerant leaks can occur at any time of year.

When encountering refrigeration leaks, members should consider these operational steps:

1. Protect yourself by using your SCBA.
2. Special call Hazmat resources by transmitting a 10-80 code 1.
3. Shut down the affected equipment or have a licensed building engineer do so properly.
4. Ventilate the affected area.
5. Identify the refrigerant involved, if possible.
6. Isolate the leak, if possible.
7. Determine whether an evacuation is necessary (depending on the amount of leaking refrigerant, whether the leak can be stopped, the type of refrigerant, the type of occupancy and whether the location can be vented). ■