LEAK TESTING

THE FUNDAMENTALS OF LEAK TESTING

Making your system more efficient by understanding system leaks

By Matt Lindorfer

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AS REGULATIONS AROUND the phase-down of HFC refrigerants and the push for lower-GWP alternatives continue to drive the HVAC/R industry issues like system installation, maintenance and service practices are also changing accordingly. Many of the new low-GWP refrigerants are classified as flammable (A3) or mildly flammable (A2L) and there are special tools and procedures to follow in order to service these systems safely and effectively.

Leak testing is still one of the most fundamental processes of HVAC/R service. Whether installing a new system, replacing a system component, or conducting preventative maintenance, leak testing plays a vital role in system performance and safety.

This procedure is important for many reasons. Systems that are undercharged due to leaks will run less efficiently, putting more stress on the compressor and using more energy than necessary. This can lead to costly repairs and higher energy bills. Refrigerant leaking into the atmosphere can also create environmental and safety issues. Many of the newer low-GWP refrigerants that are less impactful on the environment carry an element of flammability and leaks near ignition sources can create dangerous situations. Finding and addressing leaks early saves time and money. The system repairs are less extensive, and with the system running more efficiently, you can expect fewer service calls and lower risk of downtime.

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Where to find system leaks

Understanding the most common locations for system leaks can make leak testing more effective and efficient. The Institute of Refrigeration is leading a campaign around proper leak testing techniques called the Refrigerant Emissions and Leakage Zero, or REAL Zero Project. The project aims to educate service technicians on the importance of leak testing and outlines processes and tools to ensure effective leak testing. The training documentation provides a comprehensive list of the 13 most common leak locations, providing likely causes and solutions. The training references European F Gas Regulations and is also promoted by the U.S. Environmental Protection Agency (EPA).

Valves and joints make up the top five most common leak locations. Shut-off valves, ball valves and Schrader valves can all deteriorate over time, be damaged by excessive heat during brazing, or may be left uncapped, which can contribute to leaks. The tightening of Schrader cores is also very important. Using a tool that tightens the cores to the manufacturer-recommended torque of 3–5 in.-lb is critical for proper sealing.

Core Removal Tool being used to properly tighten system Schrader core.

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Flare joints and other mechanical joints are also common locations for system leaks. Temperature variation, improper tightening and poor joint preparation are all causes of leaks in these areas. Tightening these joints to the proper torque and following recommended practices for installation are essential for avoiding leaks. *The Real Zero Guide to Good Leak Testing* also points out that the first leak found is usually not the only leak and that it is important to check the whole system.

Understanding the different methods of leak testing is equally as important as knowing where leaks are commonly found. Efficient leak testing includes identifying the process or processes that make the most sense for a given system and the type of service being performed. There are many different methods of leak testing and while many of the tools and processes used for leak testing of conventional systems can be used effectively on newer low-GWP systems as well, there are some important details to note.

Preventive Maintenance Leak Testing

Leak detection and prevention programs are valuable for both contractors and customers alike. In some cases, they are also a required component of preventative maintenance. European F gas regulations require the leak testing of systems containing HCFC and HFC refrigerants (like R-134a, R-407C and R-410A) once every 12 months for systems containing 3–30 kg (6.6–66 lb) and twice every 12 months for systems containing more than 30 kg (66 lb) of refrigerant.

These leak tests and any refrigerant addition or removal must be documented. The United States EPA has established similar leak inspection requirements for systems containing more than 50 lb of ozone depleting refrigerants like R-22. If a system leak rate exceeds the allowable trigger rate, which depends on the type of system, the leak must be repaired and then that system must be leak tested at least once per year until it is evident that the leak rate no longer exceeds the trigger rate.

Soap solutions in conjunction with inspection mirrors and flashlights are still viable options for finding leaks at joints and other exposed areas of the system. However, some soap solutions have limited sensitivity and may not be effective for small leaks. Soap solutions also require application directly to the system plumbing, which may involve more extensive labor to access shrouded components like the system evaporator.

Highly sensitive electronic leak detectors are also great tools for leak detection, but it is important to use the proper leak detector for the system being tested. Systems containing R-290 and R-600a (classified as A3 flammable refrigerants) require the use of a leak detector designed specifically for combustible gases. Traditional halide leak detectors can create a spark and should not be used for A3 systems. Always make sure the leak detector being used is compatible and sensitive to the refrigerant in the system being checked.

Not only can leak detectors find smaller leaks, but they are also more versatile when leak testing system components that are enclosed or difficult to reach. Since refrigerant gas is denser than air, it will flow to the lowest point if it leaks from the system. Placing a leak detector near the base of enclosed components, such as evaporators, can provide an indication of whether leaks are present before removing access panels and ducting to perform more direct leak testing. When using an electronic leak detector, it is important to test the sensitivity on a regular basis to make sure the detector is working properly. Calibrated leak references are offered by many leak detector manufacturers and they provide an effective way to check your leak detector on an annual basis.

Leak check being performed with an IR Leak Detector.

Leak Testing of Systems Being Serviced

When a system has been opened for service, there are a variety of leak testing methods that may be used. Since the system does not contain refrigerant, conventional electronic leak detectors cannot be used until refrigerant is added back into the system. However, there are more effective ways to check for system leaks before charging the system.

Nitrogen pressure testing is a great method for leak testing a system that has been opened. Not only does pressurizing the entire system provide a rudimentary indication of overall system tightness but pushing dry nitrogen through the system will also expel any air, moisture, or residual refrigerant that may be present. This is especially important for A3 systems, where nitrogen purging is required prior to evacuation to avoid passing any flammable residual gas through the vacuum pump. But, it also helps to speed up the evacuation process for all types of systems. A manifold gauge is often used in conjunction with a nitrogen tank and regulator, but specialized nitrogen leak test kits are also available from several manufacturers. These kits often include a leak-testing pressure gauge with a peak pressure indicator that makes it easy to see even small drops in pressure. There are also electronic pressure measurement probes that can track pressure drops and provide pass/fail indications based on user input parameters.

While nitrogen pressure testing provides an indication of overall system tightness, it can be difficult to pinpoint leaks if a pressure drop is found. Tracer gas leak testing is also a useful leak testing method, especially when identifying the locations of smaller leaks. Tracer gas is primarily made up of nitrogen with a smaller percentage, or “trace”, of a leak-detector-sensitive gas such as hydrogen or helium. The 95% nitrogen 5% hydrogen mixture is common for HVAC leak detection. The hydrogen atoms in the gas are very small, which allows them to pass through smaller gaps in the system plumbing. The hydrogen can also be sensed with hydrogen or tracer gas leak detectors—offered by many service tool manufacturers. As with conventional refrigerant leak detectors, it is also important to check these tracer gas leak detectors against a leak reference on a regular basis.

Recovery

If a system leak has been located, or if a system component is to be replaced, it is important to understand the regulations and safety precautions to take when recovering refrigerant from newer low-GWP A2L and A3 systems. Due to their low environmental impact and the dangers of ignition during conventional recovery, A3 refrigerants are exempt from the EPA’s venting prohibition.

Many service procedures recommend moving the equipment outdoors at least 10 ft from any ignition sources and making everyone in the immediate area aware of the release of flammable refrigerant. If temporary containment of the refrigerant is needed before venting, a recovery cylinder that has been charged with Nitrogen and then evacuated can be connected to the system and the pressure differential is used to pull refrigerant out of the system and into the cylinder without the use of any mechanical equipment.

The cylinder can then be vented in a safe place, purged with nitrogen, and re-evacuated for subsequent use until the system has been fully recovered. There are some specialized refrigerant recovery machines that can be used with A3 refrigerants, but it is imperative that the machine be certified for use with flammable refrigerants.

A2L refrigerants like R-32, R-1234yf, and R-454B are covered in the EPA 608 venting prohibition and must be recovered. This can be accomplished by using a recovery machine compatible with these types of refrigerant. A2L-compatible recovery machines have additional safety features to reduce the risk of ignition. This might include sparkless switches and relays, higher air flow and increased machine cabinet venting, and/or longer, locking or hardwired power cords to move possible ignition sources further away from the recovery machine.

Evacuation

Evacuation continues to be an integral part of HVAC/R service for all types of systems. It is the final step before charging a system and is critical for the removal of air and moisture from the system. It also serves as a final verification of system tightness, but other leak testing methods should be performed prior to evacuation. As with recovery, there are some important safety precautions that should be taken when evacuating A2L and A3 systems.

The process for evacuating A2L systems is similar to that of non-flammable systems, but the vacuum pump must be rated for use with these types of systems. As with A2L compatible recovery equipment, vacuum pumps including additional safety features like sparkless components and high airflow to ensure that system evacuation can be performed safely.

Evacuation of A3 systems can be performed with a conventional vacuum pump, but a pre-evacuation nitrogen purge of the system is imperative. This purge ensures that any residual flammable gas in the system has been removed prior to evacuation. This purge commonly takes place after successful nitrogen pressure testing since nitrogen has already been introduced into the system. Be sure to follow the manufacturer recommended evacuation procedure and reach the specified vacuum level.

Recharge

While the procedure for charging flammable and non-flammable refrigerant is similar, A3 systems require special attention. Not only is it important to make sure that no refrigerant is released near ignition sources, but the critical charge amounts in these systems requires some special equipment. Highly precise scales and short length, small diameter hoses ensure accurate measurement and more complete transfer of refrigerant into the system with minimal loss.

Many manufacturers offer charging kits for hydrocarbon (HC) refrigerants like R-290 and R-600a that include the unique tools required for safe and effective charging. Additionally, HC systems are serviced and charged through temporary line tap valves, which require crimping of the system process lines prior to removal from the system. A thorough leak check after the system has been charged is critical to ensure that the system is tight and operating safely.

Conclusion

The HVAC/R industry continues to evolve with new regulations aimed at reducing greenhouse gas emissions through the transition to lower-GWP refrigerants and stricter requirements for system leak testing. Understanding the common locations of systems leaks and the most effective methods for identifying them is becoming increasingly important. Proper training and education around leak testing and other service process changes relating to the newer low-GWP, flammable refrigerants will aid in safe and effective service as these refrigerants become more widely used in HVAC and refrigeration systems.

An example of a hydrocarbon charging kit for safe and effective charging of R-290 and R-600a systems.

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