Service Guide

HVAC/R Leak Test Best Practices

Leak Testing Low-, Medium-, High-, and Very High-Pressure Equipment

⚠SAFETY WARNING

Only qualified personnel should install and service the equipment. The installation, starting up, and servicing of heating, ventilating, and air-conditioning equipment can be hazardous and requires specific knowledge and training. Improperly installed, adjusted or altered equipment by an unqualified person could result in death or serious injury. When working on the equipment, observe all precautions in the literature and on the tags, stickers, and labels that are attached to the equipment.

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Introduction

Read this manual thoroughly before operating or servicing this unit.

Warnings, Cautions, and Notices

Safety advisories appear throughout this manual as required. Your personal safety and the proper operation of this machine depend upon the strict observance of these precautions.

The three types of advisories are defined as follows:

⚠WARNING	Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.
⚠CAUTION	Indicates a potentially hazardous situation which, if not avoided, could result in minor or moderate injury. It could also be used to alert against unsafe practices.
NOTICE	Indicates a situation that could result in equipment or property-damage only accidents.

Important Environmental Concerns

Scientific research has shown that certain man-made chemicals can affect the earth's naturally occurring stratospheric ozone layer when released to the atmosphere. In particular, several of the identified chemicals that may affect the ozone layer are refrigerants that contain Chlorine, Fluorine and Carbon (CFCs) and those containing Hydrogen, Chlorine, Fluorine and Carbon (HCFCs). Not all refrigerants containing these compounds have the same potential impact to the environment. Trane advocates the responsible handling of all refrigerants-including industry replacements for CFCs and HCFCs such as saturated or unsaturated HFCs and HCFCs.

Important Responsible Refrigerant Practices

Trane believes that responsible refrigerant practices are important to the environment, our customers, and the air conditioning industry. All technicians who handle refrigerants must be certified according to local rules. For the USA, the Federal Clean Air Act (Section 608) sets forth the requirements for handling, reclaiming, recovering and recycling of certain refrigerants and the equipment that is used in these service procedures. In addition, some states or municipalities may have additional requirements that must also be adhered to for responsible management of refrigerants. Know the applicable laws and follow them.

Note: *Refer to* *Table 1, p. 13* *for examples of refrigerants by pressure ranges (i.e., low-, medium-, high-, and very high-pressure).*

Important: *The examples of refrigerants listed in* *Table 1, p. 13* *do NOT represent a comprehensive listing of all refrigerants. Refrigerants used in the field change over time and it is imperative that field technicians thoroughly research the refrigerant(s) used on the particular job prior to beginning work on the equipment.*

⚠WARNING

Proper Field Wiring and Grounding Required!

Failure to follow code could result in death or serious injury. All field wiring MUST be performed by qualified personnel. Improperly installed and grounded field wiring poses FIRE and ELECTROCUTION hazards. To avoid these hazards, you MUST follow requirements for field wiring installation and grounding as described in NEC and your local/state electrical codes.

⚠WARNING

Personal Protective Equipment (PPE) Required!

Failure to wear proper PPE for the job being undertaken could result in death or serious injury. Technicians, in order to protect themselves from potential electrical, mechanical, and chemical hazards, MUST follow precautions in this manual and on the tags, stickers, and labels, as well as the instructions below:

- **Before installing/servicing this unit, technicians MUST put on all PPE required for the work being undertaken (Examples; cut resistant gloves/sleeves, butyl gloves, safety glasses, hard hat/bump cap, fall protection, electrical PPE and arc flash clothing). ALWAYS refer to appropriate Safety Data Sheets (SDS) and OSHA guidelines for proper PPE.**
- **When working with or around hazardous chemicals, ALWAYS refer to the appropriate SDS and OSHA/GHS (Global Harmonized System of Classification and Labeling of Chemicals) guidelines for information on allowable personal exposure levels, proper respiratory protection and handling instructions.**
- **If there is a risk of energized electrical contact, arc, or flash, technicians MUST put on all PPE in accordance with OSHA, NFPA 70E, or other country-specific requirements for arc flash protection, PRIOR to servicing the unit. NEVER PERFORM ANY SWITCHING, DISCONNECTING, OR VOLTAGE TESTING WITHOUT PROPER ELECTRICAL PPE AND ARC FLASH CLOTHING. ENSURE ELECTRICAL METERS AND EQUIPMENT ARE PROPERLY RATED FOR INTENDED VOLTAGE.**

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⚠WARNING

Confined Space Hazards!

Failure to follow instructions below could result in death or serious injury.

Do not work in confined spaces where refrigerant or other hazardous, toxic or flammable gas may be leaking. Refrigerant or other gases could displace available oxygen to breathe, causing possible asphyxiation or other serious health risks. Some gases may be flammable and or explosive. If a leak in such spaces is detected, evacuate the area immediately and contact the proper rescue or response authority.

⚠WARNING

Follow EHS Policies!

Failure to follow instructions below could result in death or serious injury.

- **All Trane personnel must follow the company's Environmental, Health and Safety (EHS) policies when performing work such as hot work, electrical, fall protection, lockout/tagout, refrigerant handling, etc. Where local regulations are more stringent than these policies, those regulations supersede these policies.**
- **Non-Trane personnel should always follow local regulations.**

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TRANE

Overview

The following process is followed in service bulletin:

- Recover, Reclaim and Recycle
- Leak detection basics
- Leak testing process

Recover, Reclaim, Recycle

The “three Rs” (recover, reclaim, recycle) are the basic tenets of refrigerant management. It is vital to follow all laws governing the release of refrigerant into the atmosphere, and the “three Rs” describe these fundamental processes in brief:

Recover. Remove refrigerant (in any condition) from system; store in external container (without testing or processing the refrigerant).

Reclaim. Process used refrigerant to new product specifications; ensure that product meets AHRI Standard 700 for purity via chemical analysis; generally implies using processes or procedures available only at reprocessing or manufacturing facility.

Recycle. Reduce contaminants in used refrigerants—separate oil, remove non-condensables, and use devices such as filter-driers to reduce moisture, acidity, and particulate matter; generally uses procedures implemented in the field or a service shop.

The Environmental Protection Agency (EPA) defines the standards for the only types of refrigerant releases that are permitted under the Clean Air Act.

Definitions from the Clean Air Act (in the United States)

Section 608 of the Clean Air Act[1]

Important: *Compliance with The Prohibition on Venting as outlined in Section 608 of the Clean Air Act must be assured. The four types of releases that are permitted under this prohibition are referenced below; the third type is applicable to leak testing.*

Effective July 1, 1992, Section 608 of the Act prohibits individuals from intentionally venting ozone-depleting substances used as refrigerants (generally CFCs and HCFCs) into the atmosphere while maintaining, servicing, repairing, or disposing of air-conditioning or refrigeration equipment (appliances). Only four types of releases are permitted under the prohibition:

1. “De minimis” quantities of refrigerant released in the course of making good faith attempts to recapture and recycle or safely dispose of refrigerant.
2. Refrigerants emitted in the course of normal operation of air-conditioning and refrigeration equipment (as opposed to during the maintenance, servicing, repair, or disposal of this equipment) such as from mechanical purging and leaks. However, EPA requires the repair of leaks above a certain size in large equipment.
3. Releases of CFCs or HCFCs *that are not used as refrigerants*. For instance, mixtures of nitrogen and R-22 that are used as holding charges or as leak test gases may be released.
4. Small releases of refrigerant that result from purging hoses or from connecting or disconnecting hoses to charge or service appliances will not be considered violations of the prohibition on venting. However, recovery and recycling equipment manufactured after November 15, 1993, must be equipped with low-loss fittings.

Leak Detection Basics

- **Check the surrounding environment**

  For safety purposes, assure that the room is adequately ventilated, and that fans or wind is not blowing directly where the leak test is being performed. Air blowing in the direction of the leak test could obscure the leak; drifting refrigerant could also give false indications of where the leak is located.

- **Clean the area surrounding the suspected leak before testing**

  Refrigerant vapor can flow under layers of paint, flux, rust, slag, and pipe insulation. Often the refrigerant gas may show up quite a long distance from the actual leak. This is why it is important to clean the leak site by removing loose paint, slag, rust, or flux. Where possible, remove any pipe or other insulation on the unit. Oil and grease must also be removed from the site because of the risk of contamination to the delicate sensor tips of electronic detectors.

- **HVAC/R system residues can hide leaks**

  Sludge and residues can coat the interior of system components and temporarily seal corrosion pits, fissures, seams, seals, O-rings, and other small leak points. These residues include—but are not limited to—refrigeration oils, acids, desiccant, pulverized metal, Loctite®, pipe dope, brazing fluxes, and dye particles.

  – *Overcoming residue surface tension*

    Leaks are harder to find because leak testing is typically performed with the system turned off. The benefits of an operating system are lost:

[1] Complying With The Section 608 Refrigerant Recycling Rule, Ozone Layer Protection - Regulatory Programs (U.S. Environmental Protection Agency, 2010). <http://www.epa.gov/ozone/title6/608/608fact.html>

i. constant washing of interior surfaces of components
ii. higher side operating pressures that encourage leaks
iii. vibration and system temperatures changes

With a system at rest, the undisturbed residues mentioned above are able to coat the insides of the evaporator, condenser, compressor, piping, and other components. If residue surface tension is greater than the interior pressures, leaks are very difficult to find.

Classes of Leaks

Important: *Before testing for leaks, always refer to the specific unit* Installation, Operation, and Maintenance *manual for safe leak test pressures.*

1. **Standing leaks** can be detected while the unit is at rest (or off) and high- and low-side pressures are fully equalized. The most common leaks are found during a standing leak test.
2. **Pressure-dependent leaks** can only be detected when the system is above atmospheric pressure. For low-pressure refrigerants when all of the refrigerant is properly removed and a trace gas is added, nitrogen can be used to increase the system pressure. Refer to "Using Nitrogen and Trace Gas to Leak Test a System," p. 15 for more information.
3. **Temperature-dependent leaks** are associated with thermal expansion and contraction. They can sometimes occur from high- and low-temperature changes to the metal and system components (e.g., during a system's defrost period).
4. **Vibration-dependent leaks** occur only during unit operation. The mechanical strains of motion, rotation, refrigerant flow, or valve actuation are all associated with vibration-dependent leaks.
5. **Combination-dependent leaks** are flows that require two or more conditions in order to cause leaks (e.g., temperature, vibration, increased pressure and temperature can cause the discharge manifold on a semi-hermetic compressor to expand and seep refrigerant gas).
6. **Cumulative microleaks** are all the individual leaks that are too small to detect with standard tools. The total loss from cumulative microleaks over many years of operation slightly reduces the initial gas charge. In practice, the greater the number of fittings, welds, seams, O-rings, or gasket flanges in a system, the greater the amount of cumulative microleaks.

Leak Detection Methods

⚠WARNING

Explosion Hazards!

Failure to follow safe leak test procedures below could result in death or serious injury or equipment or property-only-damage.

Never use an open flame to detect gas leaks. Use a leak test solution for leak testing.

There are two essential fundamentals for leak detection in the HVAC/R industry: the correct use of the proper tools and adequate training. Patience is also applicable to all leak testing processes. At times, leak testing can be tedious and frustrating. Experience and patience are vital to getting the job done right.

Ways to identify leaks

- **Visual inspection**

  Refrigeration oil leaks frequently accompany refrigerant leaks. Leaking oil stains the area surrounding the leak's location. An easy way to search for a leak is to visually inspect lines, flanges, and fittings for signs of oil. It may not pinpoint the exact location of a leak, but it can narrow down the search area.

  This method works well in cases where a technician can visually inspect all of the piping with ease. However, it is often difficult—or even impossible—to visually inspect all areas of a system. In these cases, additional leak detection methods are required.

- **Electronic leak detectors**

Important: *When selecting an electronic leak detector for a job, assure that the electronic leak detector can "sense" the refrigerant type in the particular system.*

Most modern electronic leak detectors do an adequate job of locating leaks. However, a technician should always verify the proper operation of an electronic leak detector before relying on it.

Note: *It is recommended that technicians test or calibrate the electronic leak detector periodically during the leak test process to ensure it is working properly. Refer to the literature provided by the manufacturer of the electronic leak detector for specific instructions to assure that the detector is in accurate, working order.*

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Figure 1. Electronic leak detector (photograph courtesy of Bacharach®, Inc.)

Important: *Trane recommends that all field electronic leak detectors meet or exceed SAE-J1627 Standard Performance Criteria for Electronic Leak Detectors.*

Electronic leak detectors are the most sensitive type of leak detector and many designs are on the market. Some respond to an ion source, and others to a change of temperature (thermistor), and the dielectric type is based on the conductivity of different gases. These instruments are AC-powered and/or dry-cell battery operated. Regularly inspect the sensor or sensing tip for cleanliness and always keep tips free from dirt and lint. Also change filters regularly, because a contaminated filter could cause the instrument to respond in error, as if a leak was detected.

Electronic leak detectors normally respond to atmospheric air by providing a blinking light or an audio signal at approximately one signal per second. When a halogenated refrigerant contacts the sensor, the signal accelerates depending upon the degree of vapor leaking—a large leak could produce a continuous signal or oscillation.

When using electronic leak detectors, air movement must be minimized (i.e., all fans should be switched off and drafts excluded). Because refrigerant vapor is heavier than air, apply the sensing tip below the joint and then move it slowly around the area.

When using electronic leak detectors on a leak that is suspected to be very small, enclose the area around the potential leak—if possible—and allow the leaking refrigerant time to accumulate. This improves the detector's capacity for sensing the leak.

Note: *One method for enclosing suspected leak is to wrap the leak and area around it in cellophane or tape and leaving it pressurized with a refrigerant charge for a period of time. Next, operate the electronic leak detector near the bottom of the wrapped area and cut the cellophane or tape so that the leak detector can detect any refrigerant that may have accumulated.*

A disadvantage of electronic leak detectors is that because of the sensitivity of the instruments, they respond to minute volumes of refrigerant vapor which could prevent actual pinpointing of a leak. Electronic leak detectors also respond to other chemicals, complicating detection of leaks on pipework and insulated sections of the system; these chemical include, but are not limited to, chemicals used to expand foam insulation, chemicals in glue, and chemicals used in water treatment.

- **Bubble test**

  The most common and inexpensive test is the bubble test, which uses soap specifically manufactured for the HVAC/R industry. Apply the soap solution around the joint or component that is suspected of leaking; either brush on the solution or spray. The leak then produces bubbles as it passes through the solution.

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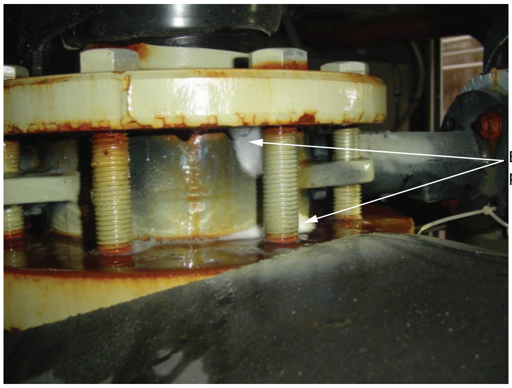
Figure 2. Bubble test



Note: *It is recommended that proprietary product specifically formulated for leak testing be used rather than homemade solutions. Homemade soap bubbles can be weaker and are normally short-lived, making them generally less effective for leak testing.*

This method works well if the area of the leak is known and if the system is adequately pressurized. Also, bubbles can provide the technician a visual indication of how small or large the leak is.

If the system does not contain sufficient pressure for leak detection, the refrigerant can be recovered from the system and the system re-pressurized with dry nitrogen to increase the pressure, making it easier and less time-consuming to pinpoint the leak. Refer to "Using Nitrogen and Trace Gas to Leak Test a System," p. 15 for instructions.

In cases in which there is a repaired leak, replaced component, knowledge that the system has a leak somewhere, and/or observe an area of the system that is oil-coated, a bubble test applied in the suspect area would be a good choice to pinpoint a leak. However, without an indication of where the leak might be, the bubble test may not be appropriate as it could take excessive time to locate the leak.

A disadvantage to the bubble test is that a large leak can blow right through the solution without producing bubbles. However, in most cases, a large leak would be audible.

- **Superior sensing devices**

  State-of-the-art leak detectors are able to identify all CFCs, (those containing chlorine), HCFCs (those containing fluorine) and HFCs (non-ozone-depleting refrigerants and compounds), as well as bromine gas (found in HBFCs) and halogens. A superior portable leak detection tool will accurately detect and may identify the smallest of leaks. The ability to target the gases and the severity of the leak is the key to a great detection device. Reliability, longevity, serviceability, and cost should also be considered, yet initial cost alone may not be the best deciding factor.

  Detector sensing devices to consider include:

  – *Corona*

    This charged electrode causes a charged "corona" or "corona arc." As refrigerant contacts the corona or arc, the charge is broken, and the response is indicated on the detector. This detector can be easily contaminated by dust, dirt, oils, and moisture; false signals can also be caused by these contaminates as well as by high hydrocarbon exposure, smoke, and electrical interference.

  – *Heated diode*

    A heated diode uses a heated sensor. When it is exposed to refrigerant gases, electrical resistance is interrupted, which sends a signal to the instrument. The reading indicates the severity of the leak. Heated diode sensors have an enhanced sensitivity to HFC and HCFC gases; they are built to withstand high concentrations of refrigerant gases, and they clear quickly.

    This unit typically works well on all refrigerants and blends.

  – *Infrared detectors*

    Infrared detectors are moderate- to higher-priced, yet they have a longer sensor life, and pose minimal problems. These detectors emit infrared light energy through a chamber towards an infrared detection target. A filter produces a unique light spectrum. Gases are drawn across the spectrum and energy is absorbed by the chemical, decreasing the amount of light reaching the end of the chamber. At the end of the chamber, an infrared detector senses a temperature change.

    This type of detector works well on all refrigerants and blends with minimal false indications.

Leak detection methods NOT recommended for field use

Trane does NOT recommend dyes for field use due to their potential to leave residues and dye deposits.

Leak Testing Process

⚠WARNING

Refrigerant Vapor Hazard!

Refrigerant vapors may collect and concentrate in confined spaces or low lying areas which will result in the displacement of air. This poses a potential health risk due to suffocation. Failure to follow proper handling guidelines could result in death or serious injury.

Refer to the appropriate MSDS or SDS sheets and OSHA/GHS guidelines for information referring to allowable personal exposure levels and handling guidelines.

⚠WARNING

Explosion Hazard!

Failure to follow safe leak test procedures below could result in death or serious injury or equipment or property-only-damage.

Never use an open flame to detect gas leaks. Use a leak test solution for leak testing.

⚠WARNING

Explosion Hazard!

Failure to follow these instructions could result in death or serious injury or equipment or property-only damage.

Use only dry nitrogen with a pressure regulator for ressurizing unit. Do not use acetylene, oxygen or compressed air or mixtures containing them for pressure testing. Do not use mixtures of a hydrogen containing refrigerant and air above atmospheric pressure for pressure testing as they may become flammable and could result in an explosion. Refrigerant, when used as a trace gas should only be mixed with dry nitrogen for pressurizing units.

⚠WARNING

Explosion Hazards!

Failure to properly regulate pressure could result in a violent explosion, which could result in death, serious injury, or equipment or property-only-damage.

When using dry nitrogen cylinders for pressurizing units for leak testing, always provide a pressure regulator on the cylinder to prevent excessively high unit pressures. Never pressurize unit above the maximum recommended unit test pressure as specified in applcable unit literature.

⚠WARNING

Prevent Contact Between Oxidizing Gases and Oil or Grease!

Do not permit oil or grease to come in contact with cylinders or their valves, especially cylinders containing oxidizing gases. Contact between pressurized oxidizers and oil or grease could cause an explosion and result in death or serious injury.

Introduction

This section details standard procedures for leak testing. Note that procedure details vary depending on the refrigerant used in the equipment that is being tested; refer to Table 1 in Appendix chapter for examples of refrigerants by pressure.

Important: *The examples of refrigerants listed in* Table 1 in Appendix chapter *do NOT represent a comprehensive listing of all refrigerants. Refrigerants used in the field change over time and it is imperative that field technicians thoroughly research the refrigerant(s) used on the particular job prior to beginning work on the equipment.*

Before beginning, the technician has determined that the unit is leaking. The technician must establish a plan for safety, personal protective equipment, required leak testing of equipment, and recovery equipment if necessary for the project.

Test for leaks using an electronic leak detector (see "Electronic leak detectors," p. 6), soap bubble test (see "Bubble test," p. 7), or standing vacuum test (see "Standing Vacuum," p. 17).

Important: *Document all actions as performed, including venting of test charge.*

Low-Pressure Equipment—Standard Procedures

⚠WARNING

Refrigerant under High Pressure!

Failure to follow instructions below could result in an explosion which could result in death or serious injury or equipment damage.

System contains refrigerant under high pressure. Recover refrigerant to relieve pressure before opening the system. See unit nameplate for refrigerant type. Do not use non-approved refrigerants, refrigerant substitutes, or refrigerant additives.

Unit contains refrigerant

- Isolate purge unit from system.

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Note: *Low-pressure equipment can operate in a vacuum and the system pressure has to be brought above atmospheric pressure to perform a proper leak test. If the machine is operating, a leak check may be performed on components at a positive pressure relative to atmosphere.*

- If no leak is found, shut down the unit to perform a more extensive test.
- Increase pressure within the unit using a controllable external heat source specifically designed for pressurizing low-pressure refrigerant equipment, such as a heating blanket or off-cycle pressurization unit/ tool (8 psig maximum).

  Notes:

  - *R-113 units are difficult to pressurize; nitrogen can be used (see "Leak Testing with Nitrogen and Trace Gas," p. 14" for instructions).*
  - *The EPA does allow performing leak test with nitrogen in conjunction with a trace gas (see "Leak Testing with Nitrogen and Trace Gas," p. 14").*
- If the unit does not have a permanently-mounted off-cycle pressurization system, a portable system can be used.

Important: *When using a portable system, be sure that the person operating the portable system is experienced in its use.*

- In the case of large leaks[1], the refrigerant may need to be removed before repairs can be made; refer to Unit contains little or no refrigerant.
- Upon finding leaks, make necessary repairs.

  Note: *It is not always necessary to remove the entire refrigerant charge to repair small leaks; e.g., if a flare joint is leaking, it may be possible to stop the leak by tightening the joint.*
- Recheck for leaks—leaks that were repaired as well as those that may have been initially missed—until no additional leaks are found.
- After verifying that all leaks have been repaired, put the system back into operation, and verify that it is operating properly.

Unit contains little or no refrigerant

Important: *Document all actions as performed, including venting of test charge.*

- If the system has a purge unit, ensure that the purge is isolated from the rest of the system.
- Check for leaks; if no leaks are detected, recover refrigerant to required levels in accordance with current EPA regulations (see "Definitions from the Clean Air Act (in the United States)," p. 5) for the specific refrigerant. Refer to Table 2, p. 14 for applicable evacuation levels. Using a mixture of dry nitrogen and a trace gas, increase pressure gradually and in accordance with leak testing standards for that particular equipment and for the specific refrigerant used in the equipment.

  Notes:

  - *A standard practice in leak testing is to build pressure in increment levels and leak test at each level, to uncover possible hidden leaks.*
  - For more information on quantities of refrigerant used in the dry nitrogen/trace gas mixture, refer to "General Information," p. 14.
- Leak test, repair leaks, and perform a standing vacuum test (see "Standing Vacuum," p. 17).
- After verifying that all leaks have been repaired, vent the trace gas, evacuate the system, and recharge with the refrigerant per manufacturer's instruction.

Note: *The mixture of trace gas and dry nitrogen does not have to be recovered. They are classified as "trace gas" specifically used for leak testing and can be vented to the atmosphere (see "Standing Vacuum," p. 17).*

- Put the system back into operation and verify that it is operating properly.

Medium- and High-Pressure Equipment—Standard Procedures

⚠WARNING

Refrigerant under High Pressure!

Failure to follow instructions below could result in an explosion which could result in death or serious injury or equipment damage.

System contains refrigerant under high pressure. Recover refrigerant to relieve pressure before opening the system. See unit nameplate for refrigerant type. Do not use non-approved refrigerants, refrigerant substitutes, or refrigerant additives.

[1] In the United States, guidelines for "large leaks" are provided under: 58 FR 28660 Protection of Stratospheric Ozone; Refrigerant Recycling (U.S. Environmental Protection Agency, 1993). <http://www.epa.gov/ozone/fedregstr/58fr28660.html>

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⚠WARNING

Explosion Hazard and Deadly Gases!

Failure to follow all proper safe refrigerant handling practices could result in death or serious injury.

Never solder, braze or weld on refrigerant lines or any unit components that are above atmospheric pressure or where refrigerant may be present. Always remove refrigerant by following the guidelines established by the EPA Federal Clean Air Act or other state or local codes as appropriate. After refrigerant removal, use dry nitrogen to bring system back to atmospheric pressure before opening system for repairs. Mixtures of refrigerants and air under pressure may become combustible in the presence of an ignition source leading to an explosion. Excessive heat from soldering, brazing or welding with refrigerant vapors present can form highly toxic gases and extremely corrosive acids.

- If the unit still contains refrigerant with adequate pressure for leak testing, shut down the unit, and start to check for leaks starting at the top of the unit and working downward.
- If the leaks cannot be found, recover the refrigerant charge from the equipment. The vacuum level reached during recovery is left to the discretion of the technician[1], as trying to reach recommended levels may introduce non-condensables into the system or to the recovered refrigerant; refer to "Definitions from the Clean Air Act (in the United States)," p. 5.
- After all refrigerant has been recovered or if the unit was totally out of refrigerant from the start, perform a leak test using dry nitrogen and a trace gas.

  Note: *For more information on quantities of refrigerant used in the dry nitrogen/trace gas mixture, refer to "General Information," p. 14.*

Important: *Before increasing the pressure, verify the setting of the safety relief valve.*

- Increase pressure in accordance with leak testing standards for that particular equipment (typically found in the *Installation, Operation, and Maintenance* manual for that equipment) and for the specific refrigerant used in the equipment (refer to Table 2, p. 14). Systematically leak check all possible places from which refrigerant could escape (i.e., O-rings, gaskets, flanges, welds, threaded and solder joints, etc.).

  Note: *Do not restrict leak checking to only portions of the system that are soldered or brazed.*

- If no leaks are found, an increase in test pressure is required; increase pressure in accordance with leak testing standards for that particular equipment and for the specific refrigerant used in the equipment (see Table 2, p. 14).
- Upon finding leaks, remove pressure, and make necessary repairs.
- Recheck for leaks—leaks that were repaired as well as those that may have been initially missed—until no additional leaks are found.
- After verifying that all leaks have been repaired, vent the trace gas, evacuate the system, and recharge with the refrigerant per manufacturer's instruction.

Note: *The mixture of trace gas and dry nitrogen does not have to be recovered. They are classified as "trace gas" specifically used for leak testing and can be vented to the atmosphere (see "General Information," p. 14).*

- Put the system back into operation and verify that it is operating properly.

Very High-Pressure Equipment—Standard Procedures

Note: *These refrigerants are used for special applications; reference the equipment-specific Installation, Operation, and Maintenance manual for leak testing pressures.*

⚠WARNING

Refrigerant under High Pressure!

Failure to follow instructions below could result in an explosion which could result in death or serious injury or equipment damage.

System contains refrigerant under high pressure. Recover refrigerant to relieve pressure before opening the system. See unit nameplate for refrigerant type. Do not use non-approved refrigerants, refrigerant substitutes, or refrigerant additives.

- Recover refrigerant to required levels in accordance with EPA regulations for the specific refrigerant; see Table 2, p. 14 for applicable evacuation levels.
- After all refrigerant has been recovered, perform a leak test using dry nitrogen and a trace gas. Increase pressure in the system in accordance with leak testing standards typically found in the *Installation, Operation, and Maintenance* manual for that particular equipment and the specific refrigerant used in the equipment.

  Note: *For more information on quantities of refrigerant used in the dry nitrogen/trace gas mixture, refer to "General Information," p. 14.*

- Upon finding leaks, remove pressure, and make necessary repairs.

[1] In the United States, guidelines for the level of vacuum reached during refrigerant recovery are provided under: 58 FR 28660 Protection of Stratospheric Ozone; Refrigerant Recycling (U.S. Environmental Protection Agency, 1993). <http://www.epa.gov/ozone/fedregstr/58fr28660.html>

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- Recheck for leaks—leaks that were repaired as well as those that may have been initially missed—until no additional leaks are found.
- After verifying that all leaks have been repaired, vent the trace gas, evacuate the system, and recharge with the refrigerant per manufacturer's instruction.

  Note: *The mixture of trace gas and dry nitrogen does not have to be recovered. They are classified as "trace gas" specifically used for leak testing and can be vented to the atmosphere (see* "General Information," p. 14*).*
- Put the system back into operation and verify that it is operating properly.

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Appendix

Refrigerants by Pressure

Important: *The examples of refrigerants listed in Table 1 do NOT represent a comprehensive listing of all refrigerants. Refrigerants used in the field change over time and it is imperative that field technicians thoroughly research the refrigerant(s) used on the particular job prior to beginning work on the equipment.*

⚠WARNING

Hazardous Pressures!

Failure to follow recommendations could result in death or serious injury. If recommended leak test pressures are exceeded, the compressor could rupture or explode, which could result in death or serious injury. Follow instructions below and refer to Table 1 for recommended test pressures.

- **Ensure that low side compressor sump pressure NEVER exceeds the leak test pressures found in referenced table.**
- **Test high side pressure ONLY IF the compressor and the low side of the system can be totally isolated from exposure to the high side pressure.**
- **When testing the high side, ALWAYS monitor the low side pressure and limit the low side pressure to the values listed in referenced table.**
- **NEVER test either the low side or high side of the compressor above the low side pressure listed in referenced table.**

Table 1. Maximum recommended test pressures (psig)

Refrigerant Type	Pressure Range	Low Side Pressure	High Side Pressure	
			Water-Cooled	Air-Cooled
R-11	Low	8	8	N/A
R-113	Low	8	8	N/A
R-123	Low	8	8	N/A
R-1233zd	Low	8	8	N/A
R-514A	Low	8	8	N/A
R-12	Medium	80	125	170
R-114	Medium	15	35	50
R-134a	Medium	85	135	185
R-500	Medium	100	150	200
R-513A	Medium	85	135	185

Table 1. Maximum recommended test pressures (psig) (continued)

Refrigerant Type	Pressure Range	Low Side Pressure	High Side Pressure	
			Water-Cooled	Air-Cooled
R-22	High	140	200	280
R-401A	High	100	150	210
R-401B	High	110	160	220
R-401C	High	*Reference the equipment* Installation, Operation, and Maintenance *manual for leak testing pressures.*		
R-402A	High	185	265	350
R-402B	High	170	245	320
R-404A	High	175	250	335
R-407A	High	175	250	335
R-407B	High	185	270	350
R-407C	High	165	240	315
R-502	High	155	225	300
R-410A	High	235	340	445
R-410B	High	*These refrigerants are used for special applications; reference the equipment-specific* Installation, Operation, and Maintenance *manual for leak testing pressures.*		
R-13	Very High			
R-23	Very High			
R-503	Very High			

Note: If system employs pressure relief devices on either the low side or high side, the test pressure should not exceed 90% of the relief device pressure setting.

Applicable Evacuation Levels

Important: *When servicing or disposing of equipment, certified technicians must evacuate the refrigerant with an approved recovery unit. Applicable evacuation levels specified in the follwing table must be met.*

Table 2. Applicable evacuation levels[(a)]

Type of Appliance	Recovery Units Manufactured Date	
	Before 15 Nov 1993 Grandfathered Unit	After 15 Nov 1993 ARI / UL Unit
R-22, R-402A, R-402B, R-407A, R-407B, R-407C appliance, or isolated component of such appliance, normally containing less than 200 pounds of refrigerant.	0	0
R-22, R-402A, R-402B, R-407A, R-407B, R-407C appliance, or isolated component of such appliance, normally containing 200 pounds or more of refrigerant.	4	10
Very high pressure appliance: R-410A, R-410B, R-13, R-23, R-503	0	0
Other high-pressure appliance, or isolated component of such appliance, normally containing less than 200 pounds of refrigerant: R-12, R-114, R-134a, R-401A, R-401B, R-401C, R-500, R-502	4	10
Other high-pressure appliance, or isolated component of such appliance, normally containing more than 200 pounds of refrigerant: R-12, R-114, R-134a, R-401A, R-401B, R-401C, R-500, R-502, R-513A	4	15
Low-pressure appliance: R-11, R-113, R-123, R-1233zd, R-514A	25	25 mm Hg absolute

(a) Inches of Hg vacuum relative to standard atmospheric pressure of 29.9 inches of Hg, except where noted.

Leak Testing with Nitrogen and Trace Gas

General Information

Trace gas

A trace gas is a small quantity of a gas, usually HCFC-22, used in leak testing. Nitrogen and trace gas are used in the system to help detect leaks under pressure while limiting the amount of refrigerant that could escape the system.

Note: *Use Dalton's law of partial pressures to calculate the amount of trace gas required; Dalton's law of partial pressures states that the total pressure equals sum of all the partial pressures.*

Calculating trace gas (example with 15% trace gas[1])

If the required system test pressure is 165 psig, what is the pressure the system must be raised to with trace gas before adding nitrogen to bring the system pressure up to the final test pressure?

Test Gas = 15% Trace Gas + 85% Nitrogen

Note: *Use absolute pressure for the calculation.*

Test Pressure + 14.7 psia = Test Pressure psia

Test Pressure =165 +14.7 psia = 179.7 psia (round to 180 psia)

15% Trace Gas Pressure (psia) = 180 psia * 15% = 27 psia

Test Pressure (psig) = 27 psia - 14.7 psia = 12.3 psig

Based on this example, first break the vacuum or pressurize the system to 12.3 psig (27 psia) with R-22, and then pressurize the system to 165 psig (180 psia) with nitrogen to obtain the required pressure and trace gas for leak testing.

Nitrogen

Nitrogen has the following qualities:

1. Inert, very dry, and non-flammable.
2. If properly evacuated after the leak test is preformed,nitrogen does not go into solution with refrigeration oil to create noncondensible pressure problems.

⚠WARNING

Explosion Hazards!

Failure to properly regulate pressure could result in a violent explosion, which could result in death, serious injury, or equipment or property-only-damage.

When using dry nitrogen cylinders for pressurizing units for leak testing, always provide a pressure regulator on the cylinder to prevent excessively high unit pressures. Never pressurize unit above the maximum recommended unit test pressure as specified in applcable unit literature.

Never pressurize unit above the maximum recommended unit test pressure as specified in applicable unit literature.

The nitrogen regulating valve must be equipped with two pressure gauges:

1. One gauge to measure cylinder pressure.
2. One gauge to measure cylinder discharge or downstream pressure.

Using Nitrogen and Trace Gas to Leak Test a System

⚠WARNING

Explosion Hazards!

Failure to follow these instructions could result in death or serious injury or equipment or property-only damage.

Use only dry nitrogen with a pressure regulator for ressurizing unit. Do not use acetylene, oxygen or compressed air or mixtures containing them for pressure testing. Do not use mixtures of a hydrogen containing refrigerant and air above atmospheric pressure for pressure testing as they may become flammable and could result in an explosion. Refrigerant, when used as a trace gas should only be mixed with dry nitrogen for pressurizing units.

⚠WARNING

Explosion Hazards!

Failure to properly regulate pressure could result in a violent explosion, which could result in death, serious injury, or equipment or property-only-damage.

When using dry nitrogen cylinders for pressurizing units for leak testing, always provide a pressure regulator on the cylinder to prevent excessively high unit pressures. Never pressurize unit above the maximum recommended unit test pressure as specified in applcable unit literature.

⚠WARNING

Do Not Attempt To Repair Nitrogen Regulator!

Nitrogen regulators must only be repaired by manufacturer or qualified technician. Do not attempt to repair nitrogen regulators! Failure to follow these instructions could result in regulator failure which could cause an explosion and result in death or serious injury.

⚠WARNING

Transport Nitrogen Cylinder Safely!

Failure to follow these instructions could result in an explosion which could result in death or serious injury.

When moving or transporting a nitrogen cylinder, always have the shipping cap in place and properly secure the cylinder.

[1] The ideal quantity of trace gas is the lowest possible quantity that can be detected by the available electronic leak detector(s); this mixture will vary based on the type of refrigerant used as a trace gas, as well as on the sensitivity of the electronic leak detector(s). Refer to the unit *Installation, Operation, and Maintenance* manual, and to the leak detection equipment manual, for specific information.

⚠WARNING

Hazards Pressures!

Failure to follow instructions could result in death or serious injury. If recommended leak test pressures are exceeded, the compressor could rupture or explode, which could result in death or serious injury. Follow instructions below and refer to Table 1 for recommended test pressures.

- **Ensure that low side compressor sump pressure NEVER exceeds the leak test pressures found in referenced table.**
- **Test high side pressure ONLY IF the compressor and the low side of the system can be totally isolated from exposure to the high side pressure.**
- **When testing the high side, ALWAYS monitor the low side pressure and limit the low side pressure to the values listed in referenced table.**
- **NEVER test either the low side or high side of the compressor above the low side pressure listed in referenced table.**

This section reviews basic safety practices when performing a leak test using nitrogen and trace gas. Refer to "Nitrogen and Trace Gas Leak Testing Steps," p. 17for more information.

- Remove existing refrigerant from the unit in accordance with current EPA regulations (see Table 2, p. 14).
- Add trace gas to the system.

  Note: *For more information on quantities of refrigerant used in the dry nitrogen/trace gas mixture, refer to "General Information," p. 14.*

- Always connect a properly functioning two-stage nitrogen regulator on the nitrogen cylinder.

  Note: *When the system is shut down, the pressures on the high and low sides of the system equalize.*

Figure 3. Two-stage nitrogen regulator

- A common misconception is to think that a static (not running) compressor can withstand normal running discharge pressures during a pressure test. Compressors have both high- and low-pressure design features. Because the low side of the compressor can't be guaranteed to be isolated from the high side during pressure testing, the low-side pressure should be limited to the pressure listed in Table 1, p. 13 when leak-testing the system, unless a higher pressure is explicitly specified.

  Note: *With the exception of braze joint leaks at the suction, discharge, or oil equalizer lines, any hermetic compressor that has a leak on the body or shell of the compressor (i.e., weld joints or non-replaceable electrical terminals) must be replaced rather than repaired.*

- An HVAC gauge manifold may be used to help control the introduction of nitrogen pressure in the system.

  Note: *Besides the nitrogen regulator's second stage gauge, at least one other gauge is required to read system pressure while pressurizing. If possible, connect both the low- and high-side manifold gauges to verify the pressure to avoid over-pressurizing.*

- Close the nitrogen cylinder hand-valve and disconnect the hose from the nitrogen regulator to prevent any possibility of high pressure nitrogen arbitrarily leaking into the system.
  - Use a quality, properly functioning electronic leak detector to begin leak testing. Periodically re-test or calibrate the electronic leak detector during the leak testing process to confirm that it is operating properly and leaks are not missed.
  - To pinpoint and/or provide visual validation of a leak, use soap bubbles specifically manufactured for HVAC leak testing.
  - Perform leak test at different pressure stages and repair large leaks[1] before progressing to final leak test pressure.
- Vent the trace gas and repair all leaks.

Note: *The mixture of trace gas and dry nitrogen does not have to be recovered. They are classified as "trace gas" specifically used for leak testing and can be vented to the atmosphere (see "General Information," p. 14).*

- Validate repairs are complete by again performing leak test procedures described earlier in this section.

If the specific system *Installation, Operation, and Maintenance* manual is not available, refer to Table 1, p. 13 or contact the Trane Technical Support team for safe leak testing pressures.

[1] In the United States, guidelines for "large leaks" are provided under: 58 FR 28660 Protection of Stratospheric Ozone; Refrigerant Recycling (U.S. Environmental Protection Agency, 1993). <http://www.epa.gov/ozone/fedregstr/58fr28660.html>

Nitrogen and Trace Gas Leak Testing Steps

⚠WARNING

Prevent Contact Between Oxidizing Gases and Oil or Grease!

Do not permit oil or grease to come in contact with cylinders or their valves, especially cylinders containing oxidizing gases. Contact between pressurized oxidizers and oil or grease could cause an explosion and result in death or serious injury.

⚠WARNING

Cylinder Under Pressure!

Failure to follow these instructions could result in death or serious injury.

When opening a cylinder valve, open the valve slowly. Point the valve opening away from yourself and other persons. Never use a wrench or hammer to open or close a hand wheel-type cylinder valve. If the valve is frozen and cannot be operated by hand, return the cylinder to the gas vendor.

⚠WARNING

Do Not Alter Cylinders, Regulators, or Pressure Relief Devices!

Failure to follow these instructions could result an explosion which could result in death or serious injury.

Never tamper with or attempt to repair or alter cylinders, regulators, or any pressure relief devices. Return cylinders to the gas vendor for all repairs. Have regulators checked and cleaned periodically by trained service personnel.

NOTICE

Equipment Damage!

Failure to follow instructions could result in equipment damage. Before attaching the regulator to the cylinder:

Check the regulator to assure that it is the proper regulator for the gas in the cylinder. If the connections do not fit together readily, the wrong regulator is being used. Attempting to fit improper connections together could result in permanent damage the threads.

Clean the threads and mating surfaces of the regulator and hose connections. Wipe the outlet with a clean, dry, lint-free cloth. Particulates on these surfaces could clog the regulator filter (where present) or cause regulator malfunction.

Crack nitrogen service valve open to blow out any dirt or debris in the service valve connection.

1. Before using the gas, read all label information and the data sheets associated with the use of that particular gas.
2. Before opening the cylinder valve, attach the regulator securely, with the secondary valve closed and with the regulator flow backed off (counterclockwise).
3. Always use a cylinder wrench or other tightly-fitting wrench to tighten the regulator nut and tube connections. When working with tubing or tube fittings, where turning a wrench could put torque on weaker system parts, use a second wrench in a suitable location to counter the torque.
4. Teflon® tape should not be used on cylinder connections or tube fitting connections, all which have metal-to-metal-face seals or gasketed seals. Teflon tape should only be used on tapered pipe threads on the outlet side of the regulator where the seal is made at the threads.
5. After the desired nitrogen pressure has been added to the system, disconnect the hose between the regulator and the system. This will eliminate any possible way of nitrogen leaking in and over pressuring the system.
6. Before a regulator is removed from a cylinder, close the cylinder valve and release all pressure from the regulator.
7. Never completely empty a rented gas cylinder; discontinue use of the cylinder when it has at least 25 psi remaining. Mark the cylinder so that others know that it is nearly empty (e.g., write "MT" on a piece of tape and stick it on the cylinder in such a way that the tape will not come off unless intentionally removed). Verify that the valve is closed and secure the cylinder valve protective cap and outlet cap or plug, if used.
8. Use pressure relief devices (e.g., pressure relief valves and rupture discs where appropriate to protect against the over pressurizing of any element of the compressed gas system that cannot safely withstand full cylinder pressure). Refer to Table 1, p. 13 for correct system pressure.
9. Assure that all valves, tubing, hoses, and tube fittings used are designed for the application. If in doubt, contact the regulator manufacturer or the distributor who provides repair service on the regulator.
10. Where there is any chance for equipment malfunction, inspect the condition of the equipment at appropriate intervals.

Standing Vacuum

Standing Vacuum Test Process Steps

This technique for leak checking is valuable in determining whether a leak has been properly repaired or for determining whether there is a small leak in a piece of low-pressure equipment.

Note: *Refer to the most recent edition of ASHRAE 3-1990 for a complete description of the Standing Vacuum test process.*

Important: *Document leak repair process as performed.*

1. Recover refrigerant.
2. Pull to a deep vacuum.

Important:

- *POE oil can absorb moisture. If exposed to moisture, and/or if unable to pull a deep vacuum due to slow expelling moisture, we recommend that the POE oil be removed and replaced.*
- *Dehydration/evacuation can vary by equipment. Standard practice for unitary equipment is to evacuate the system to 500 microns (0.5 mm Hg) or less, and standard practice for CenTraVac™ chillers is to evacuate the system to between 500 microns (0.5 mm Hg) and 1,000 microns (1 mm Hg). Always refer to the Installation, Operation, and Maintenance manual for the equipment for specific instructions.*

3. Valve off system.
4. Let stand for 12 hours.

Important: *Instruments that measure small changes in vacuum must be very accurate and appropriate for the job. Manometers, electronic vacuum instruments, or wet bulb indicators such as the Vac-U-Ator™ (http://www.vacuator.com) are made especially for large tonnage HVAC equipment.*

5. After 12 hours, the vacuum level should not be more than 2.5 mm Hg (2,500 microns Hg), per ASHRAE 3-1990.

Important: *Acceptable vacuum level for a standing vacuum test can vary by equipment. For unitary equipment, the maximum allowable rise over a 15-minute period is 200 microns (0.2 mm Hg). For CenTraVac chillers, the maximum allowable rise over a 12-hour period is 500 microns (0.5 mm Hg). Always refer to the* Installation, Operation, and Maintenance *manual for the equipment for specific instructions.*

Standing Hold

Standing Hold Test

⚠WARNING

Explosion Hazards!

Failure to follow these instructions could result in death or serious injury or equipment or property-only damage.

Use only dry nitrogen with a pressure regulator for ressurizing unit. Do not use acetylene, oxygen or compressed air or mixtures containing them for pressure testing. Do not use mixtures of a hydrogen containing refrigerant and air above atmospheric pressure for pressure testing as they may become flammable and could result in an explosion. Refrigerant, when used as a trace gas should only be mixed with dry nitrogen for pressurizing units.

⚠WARNING

Explosion Hazards!

Failure to properly regulate pressure could result in a violent explosion, which could result in death, serious injury, or equipment or property-only-damage.

When using dry nitrogen cylinders for pressurizing units for leak testing, always provide a pressure regulator on the cylinder to prevent excessively high unit pressures. Never pressurize unit above the maximum recommended unit test pressure as specified in applcable unit literature.

The standing hold test consists of pressurizing the system with a high pressure, dry nitrogen gas and recording the pressure variation. For this test, an increase in pressure—in accordance with leak testing standards for that particular equipment and for the specific refrigerant used in the equipment—is applied to the system for a predetermined period of time.

A disadvantage of this leak detection method is that it can only be used when the system can be shut down for a period of time (usually overnight or longer.) This can be very time consuming because some low-level leaks could require a holding period of 48 hours or more.

This is not a recommended method for large vessels or tonnage units because a small leak on a large vessel will not change the pressure enough to register on the gauge readings. Also, even though nitrogen is an inert gas when mixed with a trace gas, there could be changes in pressures due to variations in temperature.

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