Refrigerant Leak Prevention: Best Practices – Tech Tip

Introduction

Refrigerant charging and leak prevention are critical for several reasons:

1. Refrigerant leaks contribute substantially to climate change. The beneficial effects of electrification can be eroded if the refrigerant leaks.
2. Refrigerant leaks can harm system energy efficiency, further contributing to climate change and increasing the cost of electricity to the building.
3. Refrigerant leaks can cause poor comfort, including inadequate heating in winter and inadequate cooling in summer, resulting in substantial health risks and also in potential code violations for indoor temperature control.

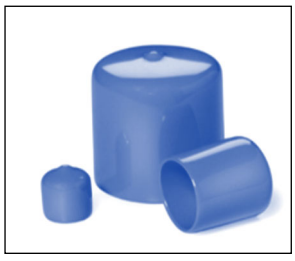
This document gives best practices for preventing refrigerant leaks while installing heat pumps. These best practices can be superseded by specific program requirements for programs you may be participating in.

Refrigerant leaks contribute to climate change.

General

- Use digital pressure and vacuum gauges for pressure and vacuum measurement. Digital gauges more clearly show whether goals (below) have been met.
- Minimize refrigerant pipe lengths (locate outdoor unit as close as possible to indoor units) to minimize refrigerant quantity.
- Use continuous line sets unless the length of refrigerant piping is longer than standard line sets.
- Avoid putting lines in wall cavities. If you must, and there are joints, use brazed joints and install access panels
- Protect line sets from damage during transportation and storage before installation. Keep line sets capped until ready for use to prevent contamination or moisture from entering the system.
- Allow for pipe expansion, and properly support and protect line sets both inside and outside the structure.

Digital gauge



Temporary caps to prevent humidity and dirt entering tubing

- Measure refrigerant piping (line sets), the total length of one pipe only (not the total length of both pipes), from the connection at the outdoor unit to the connection at all indoor units. Calculate the refrigerant charge to add using manufacturer requirements. Write down these values (line lengths and refrigerant charge) for use in the charging report.
- All technicians working with refrigerant charging and connecting refrigerant piping should:
  - Participate in a kickoff meeting to ensure that they understand the importance of these best practices and, just as important, the urgent reasons for them.
  - Have reviewed and certified in writing that they have received and read this Refrigerant Charging and Leak Prevention Best Practices document.
  - Be certified to EPA 608 and have copies of their certification on-site.

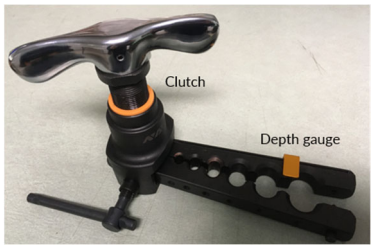
Flare Joints

- Cut tubing, leaving a few inches of slack in case a flare is defective and must be re-made.
- Use a good quality tubing cutter, work gradually to avoid deforming the tubing, and inspect to make sure that the cut is square.
- Deburr to remove the thin lip of copper inside the tubing, but be careful not to gouge or thin the tubing wall.

Cutting tube

Deburring tube

- Some line sets come shipped from the factory pre-flared. Inspect carefully for damage in transport. If damaged, cut tubing and make new flares.
- Use good quality flaring tools that have the following features:
  - A gauge or stop that ensures the tubing is positioned at the correct depth
  - An "eccentric" cone that rolls around the interior of the tubing, forming it into shape
  - A clutch that disengages the cone when the flare is complete
  - Use battery-powered flaring tools to anneal the copper and make it less brittle.
  - Check the size and roundness of the flare using a flare sizing gauge.



Gauge tool with clutch

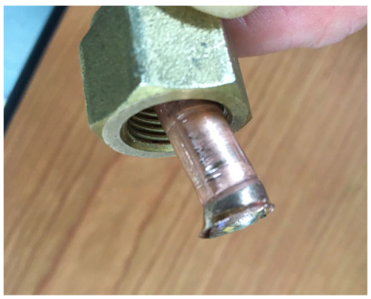
Flare sizing gauge

- Prior to assembly, inspect the flare to ensure that it is symmetrical and that contact surfaces are clean, shiny, and free of scratches.
- Apply a thin coat of refrigeration oil or an approved assembly lubricant to the contact surface to improve the seal and to the back of the flare nut to keep it from binding.
- Align the cones and hand-tighten the flare nut.
- Tighten the flare nut to the manufacturer-recommended torque using a torque wrench. If the assembly is too loose, the surfaces will not form a good seal; if it is too tight, the flare will crack or split. Torque specs are found in manufacturers' instructions and range from around 13 ft-lbs for ¼" tubing to around 56 ft-lbs for ⅝" tubing. Use a torque wrench with a digital gauge.

Torque wrench set

Torque wrench application

- Only use flare nuts supplied with the equipment. Manufacturers' torque specs are for OEM flare nuts, which tend to be longer (with more threads) and of better quality than aftermarket ones.
- If subsequent testing reveals a leak at any flare connection, do not attempt to tighten it further; cut out the defective flare and make a new flare.

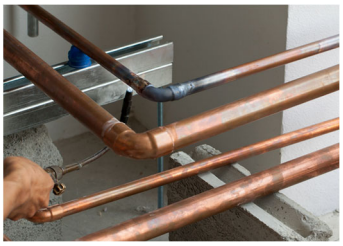


Crushed (over-torqued) flare

Brazed Joints

- Use brazed joints in locations recommended by the heat pump manufacturer and in difficult-to-access locations like joints located in walls or high off the ground.
- Flow nitrogen through the tubing while brazing to prevent formation of copper oxide scale, and for safety around open flames.

Pressure Testing



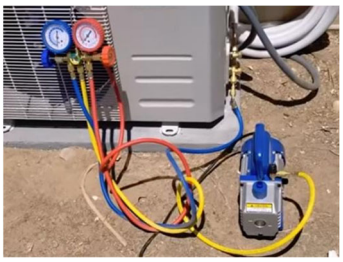
Brazed joints

- Inspect lines sets for damage such as kinking.
- Fill the system with nitrogen for a standing pressure test. Once the system is pressurized, isolated, and allowed to stabilize, it must hold steady for a specified period. Pressurization should be done gradually so that catastrophic leaks are caught with minimal waste. The target pressure, specified by the manufacturer, is typically 500 psig – 550 psig.
- Test for a minimum of one hour.
- Use a digital pressure gauge with a resolution of maximum 0.1 psi. Do not use analog pressure gauges. A drop in pressure indicates a leak, which should be located and repaired.

Soap bubble test

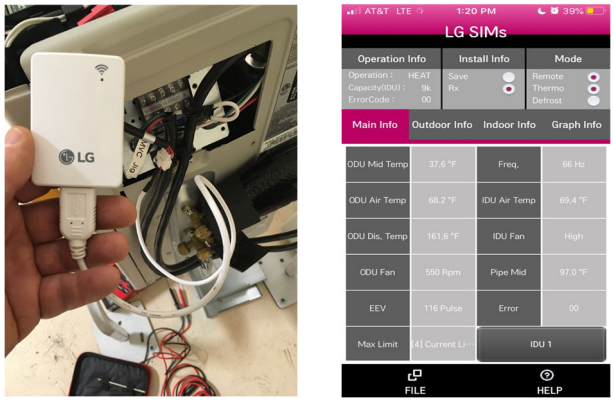
- Measure the outdoor air temperature in the shade at the beginning and end of the test. Correct for the air temperature by 1 psi for each degree Fahrenheit change in temperature. Note that if the outdoor air temperature increases, an increase in pressure could still indicate a leak. For example, if outdoor air temperature increases by 6 degrees, we would expect an increase in pressure of 6 psi. A smaller increase, for example an increase by only 3 psi, indicates a likely leak. If any deviation from expected pressures is found, a leak should be suspected, investigated, and repaired.
- If a leak is suspected due to the pressure changing, apply an approved leak-testing solution (not household dish detergent) to all flares and other site-made connections. Check each fitting for bubble formation. Use a flashlight and inspection mirror when necessary to inspect areas that are hidden.

Drawing a Vacuum and the Vacuum Test



Vacuum pump

- After the successful system pressure test, evacuate the system.
- Use a correctly sized vacuum pump. If a vacuum pump is oversized, it can draw a vacuum too quickly and create ice from humidity in the system. If a vacuum pump is undersized, it will not draw a vacuum quickly enough. The purposes of evacuation are to remove air and moisture from the system and as a secondary leak check.
- Use a digital vacuum gauge. Do not use an analog vacuum gauge.



Bluetooth-enabled vacuum gauge and app results

- Once the system is pulled down into a deep vacuum of maximum 200 microns, isolate the system from the vacuum pump and observe changes in vacuum pressure. If the system remains below a decay target of 500 microns after 10 minutes or more of isolation, the system passes. If the system fails, it may be because air is entering through a leak or because excess moisture remains in the system. If the initial deep vacuum or decay target vacuum specified by the manufacturer is less than 200 and 500 microns respectively, use the manufactured-required vacuums. This best practice does not require a triple vacuum. If the heat pump manufacturer requires a triple vacuum, use the triple vacuum procedure, and use this procedure for the final of the three vacuums.
- Use a Bluetooth-enabled vacuum gauge paired with a mobile app to provide a time-stamped record of the vacuum test result.

Charging the System and Final Leak Checks

Refrigerant leak detector

- Charge the system with refrigerant. Use a digital scale to accurately measure the required refrigerant into the system.
- Once the system has been charged with refrigerant, make a final leak check all external connections, valves and ports. Use both an approved bubble solution and an electronic leak detector.
- Write the total liquid line lengths and final total charge in permanent marker on the outdoor unit and inside the covers of indoor units.

- To minimize risk of tampering or refrigerant theft, install locking caps on charging ports.
- Do not use refrigerant gauges or hoses to charge systems for which the manufacturer does not require a superheat/subcool test. They are not required for most installations of variable speed heat pumps. Using gauges will cause unnecessary release of refrigerant that is trapped in the gauge hoses.

Refrigerant tank on a digital scale

Locking caps

Charging Report and Other Documentation

- Provide a refrigerant charging report, including:
  - name and address of the project
  - heat pump number (if more than one system)
  - line lengths
  - pounds/ounces of added refrigerant charge
  - manufacturer instructions
  - these instructions signed by all technicians who perform pipe connections and/or refrigerant charging
  - photographs of bubble testing
  - photographs of electronic leak tests
  - time-stamped reports of vacuum decay tests generated by mobile apps
- Provide a sheet to the owner that allows the facility manager to track leak occurrences by heat pump.

Additional considerations

In considering ways to minimize the impact of refrigerant leaks on global warming, it should be noted that the choice of system can substantially reduce the risk of leaks:

1. As opposed to split system heat pumps, which are the focus of these best practices, entirely packaged systems that are factory-charged with refrigerant likely have lower leak rates. These include interior-wall–mounted packaged room heat pumps, packaged terminal heat pumps, single-package water-to-air ground source heat pumps, packaged rooftop heat pumps, single-package water-to-air heat pumps, etc.

2. One alternative is to select heat pumps that use alternative low-global-warming refrigerants, such as refrigerant 32.

3. If split system heat pumps are chosen, residential-size split system heat pumps use far less refrigerant per ton of heating/cooling than do large commercial VRF heat pumps. See Tech Tip, Choosing Air Source Heat Pumps for Multifamily Buildings.

Heat pump outdoor units

References

1. HPD-NYSERDA Electrification Pilot, Space Heating Heat Pump Technical Requirements. See HPD Pilot Web Page.
2. Preventing Refrigerant Leaks in Heat Pump Systems, Jon Harrod and Ian M. Shapiro, ASHRAE Journal, January 2021.