EVACUATION OF REFRIGERANT PIPING SYSTEMS

Proper evacuation after initial installation or after service where the system has been opened to atmosphere is critical to proper operation of an air conditioning system. Evacuation is a twostep process of degassing and dehydration. Degassing removes non-condensables which cause increased head pressures and increased operating cost. Where high temperatures are frequent, non-condensables combined with moisture will also cause oil failure, decreased capacity, and increased compressor wear and potential failure. Losses associated with improper evacuation can be very high.

Moisture is the second issue. Moisture breaks down POE oil in HFC systems, (R410a) causing premature failure of the oil. Because POE breaks down into its fundamental components, it can clog the metering device and contaminate the piping. This could result in the need for a complete system replacement. Moisture, refrigerant, and mineral oils form acids that will cause system failure due to copper plating and damage to compressor windings.

A vacuum gauge is used to determine the level of atmosphere (degassing and dehydration) in the system. Quick and deep evacuation of an air conditioner or refrigeration system simply comes down to correct practices including proper installation and assembly, keeping out the moisture during fabrication, and of course the right tools, hoses, and gauges to measure the level of degassing and dehydration. When moisture (liquid) enters a system, or condenses, the only way it can be removed is in a vapor. When it comes to system evacuation, only small amounts of moisture are practical to remove this way. It is not practical to remove large amounts of water with a vacuum pump, as boiling water produces large amounts of water vapor. One pound of water (about 1 pint) produces about 867 ft^3 of water vapor at 70ºF. Keep it clean, dry, and tight.

- Tubing must be kept clean and dry through the entire installation. Moisture, dirt, and other contaminates can compromise system operation and significantly increase the time required for evacuation.

- Valve cores should be removed with a vacuum rated core tool to allow nitrogen to be purged through the system and to allow the system to be valved off whenever possible during tubing installation.

- A tubing bender should be used to minimize the number of fittings and reduce internal restrictions. Fittings require tube cutting, cleaning, deburring, assembly, brazing, nitrogen purging, and leak testing. **The best thing to do is eliminate fittings all together**. A good bender will pay for itself in short order.

- Cut piping should be reamed or deburred. Internal restrictions can cause erosion of the piping, decreased suction gas velocity and poor oil return. Even a few fittings that are not assembled properly can compromise the quality of the installation.

- Nitrogen should be purged through the piping during the installation (fit-up) and during brazing to avoid the introduction of contaminates and moisture into the piping and to avoid the formation of copper oxides during brazing. Use a calibrated flow meter to avoid using excess nitrogen. Sweeping the system with nitrogen during installation will significantly decrease evacuation times.

- For non VRF/VRV systems, install a filter dryer to remove trace moisture after evacuation. Small amounts of moisture can be trapped under compressor oil or in the case of POE, bonded to the oil itself. A dryer equipped with a moisture indicator installed right before the metering device will efficiently remove trace moisture and help quickly identify potential moisture problems. Installing the dryer inside near the evaporator will better protect the metering device, assure visually that 100% liquid is present, and prevent the dryer from failing prematurely.

PURGING

After the lines and the various components have been installed, it is necessary to make sure that there is flow through the entire system by purging with a dry gas such as dry nitrogen from the liquid line to the suction side of the system. Purging will not only carry out small drops of water (if present) but it will also expel some of the system moisture.

PRESSURE TEST WITH A DRY GAS

A standing pressure test is used to check for leaks by using a dry gas again like dry nitrogen. We never hope to find leaks while in a vacuum. (Although it does happen.) When air leaks in, moisture comes along for the ride which can take hours to remove if the amount is excessive. A temperature compensated pressure test will make the process fast and efficient. Performing this test will again remove some additional moisture that will not have to be removed during the evacuation process. When releasing this high-pressure gas, do not relieve the pressure all the way to atmospheric. Take it down to about 1 psig, so air cannot get back into the system.

TEST YOUR VACUUM PUMP (BLANK OFF TESTING)

Attach the micron gauge directly to the vacuum pump via the 1/4" connection and verify that the pump is capable of achieving a vacuum level of 100 microns or less. A good quality pump will easily achieve levels below 50 microns. Pump blank offs are notorious for leaking, so do not depend on one for isolating the vacuum pump. Use core tools to isolate the pump and the hoses thus minimizing any chance of gas permeation through the hoses. Remember even the best vacuum rated hoses will leak and that is why isolation is a necessity. If your pump cannot achieve 100 microns or less, change the oil with a high quality, low vapor pressure oil. Many times, several oil changes are required to remove significant amounts of moisture from a wet pump. Compared to system breakdown, oil is cheap; change it often. If the pump will still not achieve a deep vacuum, it may be time for replacement or service.

NOTES ON GAS THE BALLAST (IF EQUIPPED)

Water can only be removed from a system in vapor form. If the atmosphere that you are removing from the refrigeration system is moisture laden, as that moisture enters the pump it is in vapor form, it is in a state of equilibrium with the air in the system. This state of equilibrium is what is meant by the term ballast. (something that gives stability)

The ballast, when it is open introduces free air into the pump during the discharge stroke to keep this moisture in equilibrium. If the gas ballast is closed, the pressure created in the discharge stroke will condense the water vapor and drop the moisture out into the oil. Having the ballast open during the initial pull down of a wet system will help to prevent condensation within the pump. (keep it open until you are at 15,000-10,000 microns,)

Moisture is what kills the vacuum pump oil. When oil is wet, the vapor pressure increases to a point where a deep vacuum cannot be created. (wet oil is white oil) If the oil is wet, it is cheaper and faster to change the oil than to let the gas ballast work it out. That moisture will also damage your pump if left in so always change the oil if you are working on a wet system. The reason you should always change the oil is; it is hard to see how cloudy it is through a small unlit sight glass.

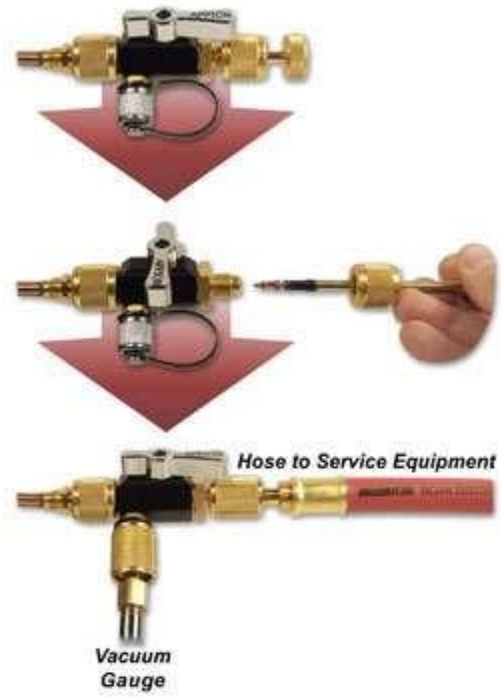
An open gas ballast prevents the pump from reaching its ultimate vacuum levels and should be closed after you reach 15,000-10,000 microns. The gas ballast is used only during the roughing period and is only needed when there is moisture in the system.

One of the most important things you can do is to always nitrogen sweep or purge a system before performing an evacuation. This means push the nitrogen through the system, one side to the next WITHOUT significantly raising the system pressure. This will push out the moisture vapors without dropping them out into the system in liquid form.

If you purge during assembly, and sweep the system with nitrogen prior to evacuation, you will likely not need to use the gas ballast at all. The gas ballast is only effective in removing small amounts of moisture, so a very wet system will require frequent oil changes if you want to make fast work of getting the job done.

EVACUATION

A/C & Refrigeration systems are designed to operate with only oil and refrigerant flowing through them. When a typical system is installed and/or serviced, air and moisture enter the system. Oxygen, nitrogen and moisture (all make up our air or atmosphere) are detrimental to system operation. Removal of the air and other non-condensables is called **degassing** and removal of the moisture **dehydration**. Removal of both is typically referred to as **evacuation**. Assuming the valve cores are removed, connect large diameter vacuum rated hoses to the back of the core tools (do not use side ports of the core tool for evacuation) at both the high and low side of the system so that both sides can be pulled down simultaneously. While at first it may seem counter intuitive to use large diameter hoses the value rapidly becomes apparent after starting the evacuation. 1/2" hoses will



decrease the time required for evacuation by a factor of **16 times** over the typical 1/4" hoses used by most of the industry. Larger hoses reduce friction and therefore increase conductance speed. The conductance speed of 1/4" hose is so small it should never be used for evacuation. If you can, avoid 1/4" hoses for evacuation as they are too time consuming and costly to be effective. Connect the hoses directly to the vacuum pump with a brass flare tee or with a vacuum rated manifold. Do not use manifolds that are not equipped with O-ring seals, as packing often holds under pressure but leaks in a vacuum. Keep connections to a minimum and points of access to the maximum. In other words, connect to as many places as you can on the system but eliminate unneeded hoses or fittings. If only two points of access are available, connect directly to the vacuum pump eliminating the need for a manifold. Install a high quality digital vacuum gauge with a copper line or brass connector directly to the core installed on the **suction line**. This will allow the evacuation rig (hoses and fittings) to be completely isolated from the system during the "standing pressure tests" where the quality of the vacuum will be measured.

Start with fresh and dry vacuum pump oil. Vacuum pump oil is extremely hygroscopic (moisture absorbing) so starting fresh will make things go a lot faster. If your pump is equipped with a gas ballast, open the ballast until a level of ***10,000*** microns is reached. Within narrow limits, the purpose of the vacuum ballast is to prevent water vapor from condensing in the pump during the discharge stroke of action. Generally, it is better and faster to change the oil rather than to wait for the gas ballast to remove excess moisture from the oil during pump operation. Moisture destroys vacuum pump oil by increasing its vapor pressure so much that a high level of vacuum cannot be created. The pump cannot develop a higher vacuum then the vapor pressure of its sealant. If in doubt change it out!

1ST STANDING TEST

Pull a vacuum until a level of 1000 microns is reached, (if using large diameter hoses and core tools, evacuation of the piping will not take a long time). Isolate the vacuum with the core tools allowing the pump to continue to run and **record the leak rate** (after about a 5-minute stabilization period) indicated by the vacuum gauge if equipped. Leak rate is simply derived from a vacuum decrease (increase in pressure) over a unit of time, typically displayed in microns per second. A rise in the pressure after a short stabilization period indicates there is still moisture in the system or the presence of a small system leak.

2^{ND} STANDING TEST

Open the core tools and allow the system to continue the evacuation process until the vacuum level is 500 microns or less. Then, repeat the "standing test" to determine if there is a **decrease in leak rate** after the stabilization of the vacuum. If there is no leak, the 2nd leak rate in the system should be considerably less than the first indicating progress in the job of dehydration.

TELLING THE DIFFERENCE BETWEEN MOISTURE AND A SYSTEM LEAK

If the leak rate has not decreased, two things may be happening:

1. The system is still contaminated with moisture. (Possibly trapped under the compressor oil.)

2. The system has a small leak that was not detected by the initial high pressure test. (Some leaks are more apparent under vacuum than pressure.)

A high quality, high resolution digital vacuum gauge can indicate a leak much faster than a pressure gauge due to the sensitivity of the instrument. While the micron gauge is quite capable, testing for a leak in a vacuum is not an acceptable practice over a standing pressure test, as moisture is drawn into the system during the evacuation process. If you find you have a leak under vacuum, break the vacuum with dry nitrogen and try to find it under a pressure.

DO NOT open the system to atmosphere under a vacuum! Doing so undermines all your time and effort to this point.

If the system has a **leak,** the vacuum gauge will continue to rise until atmospheric pressure has been reached. However, if the system is vacuum tight but still contains moisture the rise will level off when the vapor pressure equalizes in the system typically between 20,000 and 25,000 microns between 72ºF and 80º F. At that point, the vacuum reading will become stable. (Note: a system that continues to level off at 3500-4500 microns may have turned system moisture to ice. Should this occur, the system temperature may have to be raised by an external heat source to get the moisture out of the system.)

If the system indicates **moisture**, a multiple evacuation with a **nitrogen sweep** will significantly reduce the amount of moisture in the system. To perform this procedure, reduce the system pressure to between 1000 and 2500 microns. Isolate the vacuum pump with the core tools and disconnect the vacuum hose from the low side of the system. Break the system vacuum with nitrogen introduced at the side port of the core tool. Break the vacuum with nitrogen to the equivalent to atmospheric pressure (760,000 microns) then purge nitrogen through the system at 1-3 psig, from the high to the low side letting it vent out the open port of the core tool. **Do not pressurize the system** as this will not remove moisture. There is no need to pressurize the system unless you are performing a leak check. Increasing the system pressure will cause the water to drop out of the nitrogen similar to that of compressed air in an air compressor. Nitrogen does not absorb water, but entrains it and helps it move along out of the system, allowing the liquid water to warm, evaporate, and increase the water vapor pressure without introducing additional moisture into the system. If the system is drying out, you will notice that deeper levels of vacuum are quickly achieved indicating progress in the job of dehydration. If desired or required, repeat this process until the moisture is removed. Typically, no more than a triple evacuation with sweep is required. If marked progress is not achieved during this process, repeat the nitrogen purge to remove liquid moisture that may exist. If a **leak** is indicated, it must be repaired before the evacuation can be completed.

After the second leak rate test, check the condition of the vacuum pump oil. Oil that is milky contains moisture and will not allow a finishing vacuum to be achieved due to the increase of vapor pressure and loss of sealing caused by the moisture in the oil. If the oil is wet, change it with clean dry oil. If in doubt change it out!

FINISH VACUUM

After the second standing test, allow the vacuum pump to run until the system is preferably below 200 microns (With a good pump 50-100 microns is easily achievable). Isolate the vacuum rig with the core tools and allow the system to stand for 15 to 30 minutes. If the micron level does not rise above 500 microns the evacuation is complete. If the pressure rises above 500 microns, open the core tools again and allow the evacuation to continue. Experience and/or a high-resolution digital micron gauge will allow for shorter times of evaluation.

After the evacuation is complete, follow the manufactures recommended procedure for charging the system.

If you are working on a **non** VRF/VRV new installation, keep the pump isolated and open (crack) the liquid line service letting a small amount of refrigerant into the system, bringing the system slowly into a positive pressure. (Note: When the vacuum gauge indicates "high pressure" you are above 20,000 microns but still in negative pressure.) As most gauges can handle up to 500 psig, you need not be concerned with damaging the micron gauge by over pressurization. Once the liquid line is completely open, repeat the process for the suction service valve. Reinstall the valve cores and remove the vacuum gauge and core tools. (Note: Refrigerant may make the vacuum sensor act erratic after removal until the refrigerant vapor is out of the sensor. The sensor is calibrated for air and a refrigerant atmosphere will affect the readings.)

After the cores have been installed and core tools removed, purge your manifold hoses and install gauges to finish commissioning the system.

If servicing an existing installation, break the vacuum with the required system refrigerant prior to removing the core tools, and continue the commissioning procedure as required by the manufacturer.