Using proper practices during AC/R system evacuation helps to ensure efficiency and performance.

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A complete evacuation can help prevent system component failure. When a system is not properly evacuated, moisture and contaminants within the system may cause coil leakage, clogged TXVs, and compressor failure. Evacuation is the first line of defense.

Evacuation is critical to the efficiency, longevity, and capacity of all air-conditioning and refrigeration systems. An AC/R system runs at its peak performance when containing only pure refrigerant and oil. The right tools are required to ensure a system is properly evacuated and kept clean, dry and tight. Only with clean oil, full flow and accurate measurement can a complete evacuation be done right.

Importance of evacuation
Since the beginning of mechanical refrigeration dating back to the 1800s, moisture has been the largest detriment to AC/R systems and is still an issue today. The refrigerants used prior to CFCs were ethyl esters, sulfur dioxide and methyl chloride. Not only were they toxic refrigerants, but they were also severely reactant with moisture, causing sludge, a lack of lubrication and often system failures. Modern day CFCs, HCFCs and HFCs react with moisture as well. Moisture, contaminants, and non-condensables in the system are harmful to its performance and health.

There must only be pure refrigerant and oil in a system to ensure total system integrity and maximum system efficiency. Water molecules chemically react with refrigerant and POE oil as they travel past the compressor discharge valve, forming hydrochloric and/or hydrofluoric acid. POE oil decomposes into partial esters, organic acid and alcohol. Sulfuric acid could result from the decomposition of mineral oil with a high sulfur content; hydrochloric acid may form with CFC or HCFC refrigerant breakdown; and hydrofluoric acid can form with HFC refrigerant breakdown. Acids then react with moisture leading to further system problems.

Sludge may form and clog the discharge valves. Acids can break down motor windings by stripping away insulation and attacking the copper wires, which may lead to burnouts. Acids may also create pinhole leaks, as they etch copper particles off of the tubing, leaving the walls thin and porous. These copper particles may reach the crankshaft. This area has one of the highest temperatures within the system. The resulting copper plating may cause the crankshaft to seize, introducing the need for hard-start kits and leading to compressor failure.

Contaminants and moisture are harmful to the system. Only through proper evacuation can a technician prevent issues and maximize efficiency.

Clean oil
How long will it take? Evacuation is a critical procedure that is often one of the longest to complete. However, a complete evacuation can be fast and easy if it is done right.

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Always use the largest-diameter hose and remove restriction for high-speed evacuations.
Clean oil is essential for a pump to pull a deep vacuum and to ensure that the system is clean, dry and tight. Picture yourself with a chainsaw in hand, one with a new, sharp chain. As the machine purrs in your hands, you witness the tool’s power as it slices through the trunk of a thick tree, wood chips flying in every direction. Now picture the chain dulled by use, the chain spinning, leaning limp against the wood, barely leaving a scratch. You can stand there for hours watching that dull chain move against the bark, but it will not help you cut through the wood until you change the chain on the machine. A chain can dull for many reasons, constant use or rust for example, and should be changed as soon as it begins to dull to maintain its quick, slicing ability.

Dirty vacuum pump oil is much like a dull chain on a chainsaw. As the oil becomes saturated with moisture, it needs to be changed to maintain the pump’s ability to pull a deep vacuum.

A vacuum pump can only pull a vacuum as deep as the vapor pressure of the sealing oil. As moisture is removed from the system, the oil becomes saturated and the vapor pressure rises, raising the ultimate vacuum that can be achieved. The saturated oil slows the evacuation process until it becomes so saturated that it prevents the pump from pulling any deeper.

How quickly the oil becomes saturated depends on a number of factors. Relative temperature and humidity of the jobsite, the duration a system is left open, the type of oil used, the size of a system and the amount of contaminants inside a system at any given time all play a critical role here. Depending on any of these factors, the oil may need to be changed once, twice, five, ten or more times during a system evacuation. It is important to note that since contaminant density of a system is greatest during the degassing process at the beginning of an evacuation, so is the rate of the vacuum pump oil contamination. There is no standard for how often the oil should be changed during a job. Oil should be changed early to remove the initial contamination and again each time the rate of evacuation slows.

Without clean oil, you can watch your pump run for hours, but it will not be able to pull a deep vacuum. Once the oil is changed with clean, low vapor pressure oil, the pump will immediately begin to pull down again.
Accurate measurement
The sight glass of a vacuum pump is not a dependable tool to determine when to change the oil. The oil may appear clean through the sight glass window and could lead to the assumption that the pump is still pulling a deep vacuum. The oil may actually be completely saturated with moisture and the evacuation could be stalled. Moisture and contaminants left in the pump settle to the bottom of the sump and all you can see through the sight glass is the cleaner oil on top. Moisture and acids in the pump may also form rust, further affecting the pumps ability to pull a deep vacuum.

A micron gauge is the only tool that will accurately tell you when to change oil. As the vapor pressure of the oil rises and it becomes saturated with moisture, the reading on the micron gauge will begin to slow, indicating that the oil is saturated with moisture and needs to be changed. A micron gauge should be used to confirm that you have reached a vacuum of 500 microns or the micron level specified by the system manufacturer. After reaching the proper micron level, it is important to isolate the gauge and system from the vacuum pump and watch for an acceptable rise. Remaining contamination or leaks may cause a higher-than-acceptable micron rise. This will reveal remaining contamination or leaks that may cause problems.

It is important to note that vacuum cannot be measured with low side or analog gauges because they cannot accurately measure in microns. They are designed to measure pounds of pressure or inches of mercury. Measuring a vacuum with a low side or analog gauge is like trying to measure an inch with the odometer of your car.

Every system is different. Looking at a sight glass will not verify that your oil is clean. Letting your pump run for a set amount of time may not complete a true evacuation. Listening for a pitch change will not assess if a system is properly evacuated. Feeling for cold pipes will not confirm that the system is clean, dry and tight. Without measurement, there is no verifiable result.

Full flow
A pump needs maximum flow to pump at its full capacity. This means removing valve cores and core depressors and using as many 1/2-in. diameter or larger hoses as your system can support to minimize evacuation times. Ensuring that you have full flow during this complicated procedure will make evacuation fast and simple.

A vacuum pump's cfm rating determines the cubic feet of air per minute that a machine can pump. The connecting line from the system to the pump determines how much flow the pump receives. Molecular flow in a vacuum is called “conductance speed.” The conductance speed is equal to the inside diameter of the hose raised to the fourth power. Simply put, when you double the size of the connecting line, you increase the speed by a factor of 16. When small-diameter, pressure-rated hoses with core depressors are used for evacuation and valve cores are not removed, the flow to the pump is reduced to less than 1 cfm, regardless of its published rating. A 1/4-in. hose should never be connected to a system for evacuation.

The connecting line between a vessel and pump must be sufficient to flow the required cfm of the pump. If you are purchasing or have a 6-cfm pump, you will need two 1/2-in. hoses to flow 6 cfm to the pump. A 3-cfm pump requires a minimum of two 3/8-in. hoses to pump 3 cfm. If you use a pressure manifold with 1/4-in. hoses you are cutting the pumps capacity to 1 cfm. Vacuum hoses should be connected directly to the pump and a
pressure manifold should never be connected to a system in an evacuation to achieve the maximum flow. Using multiple pumps will also help speed up evacuation times.

It may seem that using large-diameter hoses is useless when a small access port restriction on the system lies in the path of the flow. This is incorrect. Though the restriction will temporarily slow the flow, once past it, the flow will return to its maximum potential.

The greater the flow, the faster it will go. It is simply science.

Tools and maintenance
Clean oil and unrestricted flow are key to maximizing evacuation speed and completing a proper evacuation. Having only clean oil or full flow is not sufficient. You need both to evacuate quickly and efficiently, yet these are not the only factors that matter.

Vacuum-certified/-rated tools are required for system evacuations. Choosing service tools that will not leak is necessary to prevent system contamination and to pull a deep vacuum. Tools designed for pressure may rely on seals that will contract and leak when placed under a vacuum.

Machines and tools wear down over time. Hoses, O-rings, gaskets and seals can degrade, weaken, and begin to break down causing leaks and extended evacuation times. It is also important to make sure that O-rings, gaskets and seals are lubricated with vacuum pump oil or vacuum grease regularly to keep them from drying out.

Clean, dry and tight
System evacuation is one of the most important procedures in the AC/R industry, as well as one of the lengthiest. It is important to use proper practices to ensure system efficiency and performance. Evacuation is the first line of defense. Done right, it is fast and easy.

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