TELEDYNE HASTINGS INSTRUMENTS
Everywhereyoulook™

Effective Vacuum for HVAC and Refrigeration Charging

How Can You Ensure that Water Contamination Has Been Removed?

Whether in a factory or in the field, a refrigeration or HVAC system's efficiency and reliability depend on conditioning before charging. Conditioning these systems accomplishes two critical requirements: removing air to make room for the refrigerant charge and reducing moisture in the system to trace levels.

While pumping out the air is easily done, removing water is difficult. We're not just talking about liquid water; the challenge is to strip away the thin layer of moisture that's clinging to the inside surfaces: the compressor, condenser, valves and tubing lines.

The fact is, moisture from the air covers every surface, works its way into the bulk of many materials and resiliently remains, unless the system is actively dehydrated. Of course, if you don't remove the moisture before charging, the refrigerant will remove it later - and that's a bad thing. Why? Moisture in the refrigerant of an HVAC/refrigeration system can freeze and cause failures in the expansion valve or cap tube. Additionally, water chemically reacts with the refrigerant to form acids which can corrode and/or leave deposits in critical areas. The successful long-term operation of the system depends on your ability to thoroughly condition it before charging.

So how do you best remove (and know that you have fully removed) the moisture from an HVAC/refrigeration system? Evacuating a system is typically accomplished through a combination of dry gas purging and vacuum. Knowing how well the system has been evacuated requires a precise vacuum measurement. How does measuring vacuum tell you when the system is dry? The measurement approach takes advantage of our understanding of water, specifically its vapor pressure. Vapor pressure is the pressure where a liquid boils. We are used to thinking of boiling at a temperature, but it's really a combination of temperature and pressure. (Which is why water boils at a lower temperature at high altitude, hence causing cooking recipes to be adjusted.) The vapor pressure of water at various temperatures provides a means of knowing, with certainty, the moisture state of the system.

In Figure 1, you'll notice that at room temperature, the vapor pressure is approximately 17 Torr (mmHg) absolute. So for example, if a system at room temperature is pumped to less than 1 Torr absolute pressure and then isolated, its state of dehydration is determined by how fast it returns to the 17 Torr vapor pressure. If it races up in a few seconds, an excess of moisture remains and is providing vapor pressure. If it remains well below 17 Torr vapor pressure for hours, the system can be considered relatively dry. Since this behavior is an absolute pressure effect and it is approximately $1/100^{th}$ of an atmosphere, a dial vacuum gauge is essentially useless for this application.

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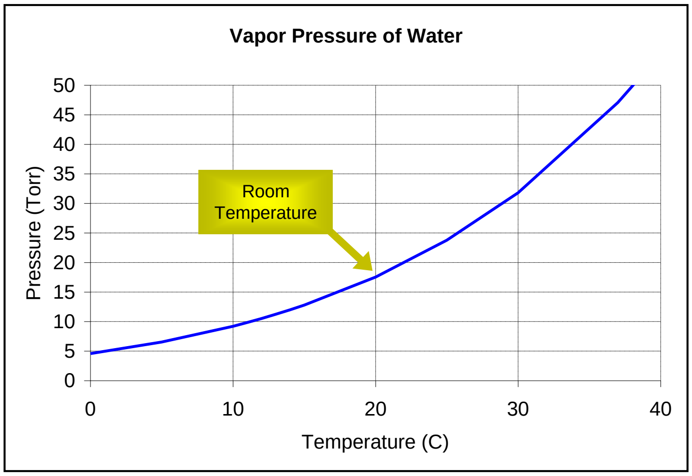
However, an absolute vacuum gauge with high precision in the 0.01-20 Torr range can effectively be used to ensure proper evacuation has been achieved. The type of vacuum gauge most often used in this application is a thermocouple (TC) gauge.

Figure 1 Pressure at Temperature Graph



Method

Drying the interior surfaces, crevices and materials in an HVAC/refrigeration system involves two actions: evaporation and removal.

First, to quickly evaporate the moisture, the system's pressure must be less than water's vapor pressure and there must be a source of heat to provide the energy for the water to change state from liquid to gas. The heat for vaporization is usually supplied by the thermal mass of the metal tubing lines and components of the system itself.

In other words, as the water evaporates, portions of the system may get slightly cooler as they supply heat. This is normally such a small amount that it is unnoticeable; however, if there is a pocket of liquid water when the system is first evacuated, it may actually freeze in the system. Unless enough heat is supplied to the ice, it will remain in the system for some time, slowly subliming (transforming directly from solid to gas).

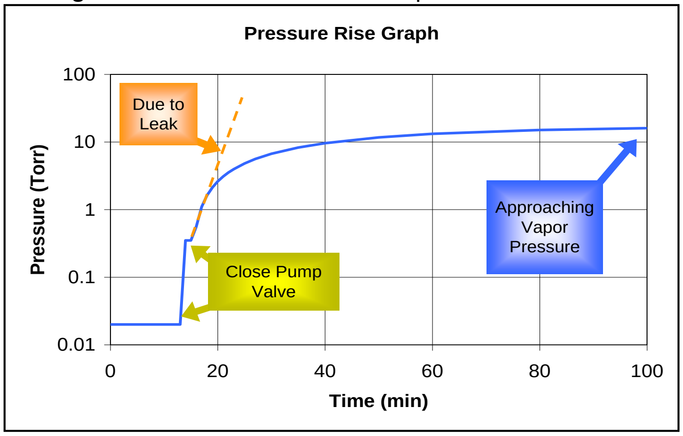
Second, as the water in the system evaporates, it is then removed by the flow of the purging gas and/or the vacuum pump. For complicated/extensive systems this can be a significant challenge considering that the purge gas may not actively flow through some portions of system. Similarly, during the evacuation procedure the moisture in remote regions of the system has to "find its way" to the pump. (Keep in mind that at very low pressures, the gases and vapors are not "pulled" to the pump. A more accurate analogy is that the pump allows them to "fall into a hole"; if they should so happen to fall in that direction.)

Knowing when the system is sufficiently dry requires consideration of multiple factors. A vacuum gauge located at the pump, even if the pressure reading is very low, does not necessarily indicate that the entire system has been properly dried, because pressure at the pump is always lowest. To ensure that the water has been removed from every portion of the system, the pressure must be measured in remote regions. Because it is often difficult or impossible to install the gauge in these areas, the best solution is to essentially "bring the entire system to the gauge". This can be accomplished by closing the valve that isolates the system and the gauge from the pump. Without the pump, the system quickly equilibrates and arrives at what can be considered a condition of average-pressure in all locations. This event appears as a quick step on a Pressure Vs. Time graph as shown in Figure 2.

Once this condition occurs, the subsequent pressure rise indicates the level of residual moisture and leaks. If the pressure rise is due to moisture, the graph will plateau at the vapor pressure of water for the system's temperature (do not forget to consider that there may be cold spots in the system that will "pump" the water vapor to maintain the pressure at the correspondingly lower value).

If there is a leak in the system, it will be revealed as a continual pressure rise above vapor pressure of water. An acceptable pressure rise rate is dependent on the type of system. Typically, this threshold is well below 0.01 Torr (10 microns) per minute.

Figure 2 Pressure Vs. Time Graph



Instrument Choice

The ability to measure absolute pressure precisely in the 0.01 to 20 Torr range is ideally accomplished by use of a thermocouple (TC) vacuum gauge. A TC vacuum gauge consists of the measurement vacuum tube mounted on the system to be tested, along with power supply/readout electronics. There are several different types of TC vacuum gauge tubes, each designed to satisfy specific requirements. For general purpose monitoring of HVAC/refrigeration system evacuation in controlled environments (indoor facilities), the Teledyne Hastings DV-4D (Figure 3) TC vacuum gauge tube is a cost-effective device with a measurement range of 0.01 to 20 Torr. For installations that have excessive vibration or mechanical shock, a ruggedized version of the tube is also available as the DV-4R.

Figure 3 DV-4D Vacuum Tube

The vacuum reading from any DV-4 tubes can be shown using either a dedicated electronic display or a hand-held battery-operated readout (Figure 4). Both Teledyne Hastings DVT and DCVT displays provide continuous monitoring with easy to read LED displays and work well in environments where vibration is present (vibration causes analog needle movement on non-LED displays). For periodic vacuum checking of one or more tubes, the hand-held HPM 4/5/6 is recommended. Powered by a 9V battery, the HPM 4/5/6 is portable and is easily connected to any DV-4 tube for an instantaneous reading. To ensure the most accurate measurement, the DB-16D Reference Tube (with NIST Traceable calibration) can be used to validate the electronic calibration.

Figure 4 Teledyne Hastings Vacuum Product Offerings

For Information on all Teledyne Hastings Vacuum Measurement and Mass Flow Instruments, visit our website:

www.teledyne-hi.com or contact us at +1-757-723-6531