TELEDYNE INSTRUMENTS
Hastings Instruments
A Teledyne Technologies Company

APPLICATION NOTE

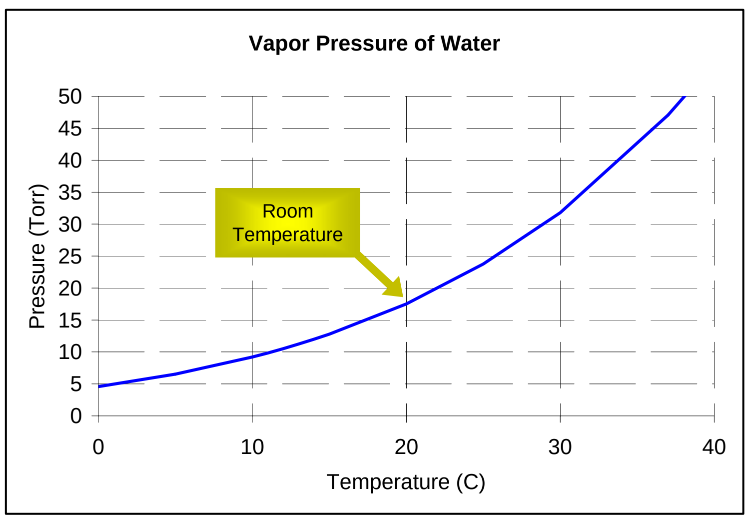
HASTINGS

Effective Vacuum for HVAC and Refrigeration Charging

How can you ensure that water contamination has been removed?

Whether it's in the factory or in the field, a refrigeration system's efficiency and reliability depend on its conditioning before charging. Evacuating an AC or refrigeration system does two things. It removes the air to make room for the refrigerant charge and it reduces moisture to trace levels. Pumping out the air is the easy part. The hard part is getting the water out. 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 lines. The fact is that moisture from the air covers every surface, works its way into the bulk of many materials, and happily remains everywhere unless you actively dehydrate the system. 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 operating system can freeze-up and cause failures in the expansion valve or cap tube. Also, water chemically reacts with the refrigerant to form acids which can corrode and/or form deposits in critical areas of the system. The successful long-term operation of the system depends on your ability to thoroughly condition it before charging.

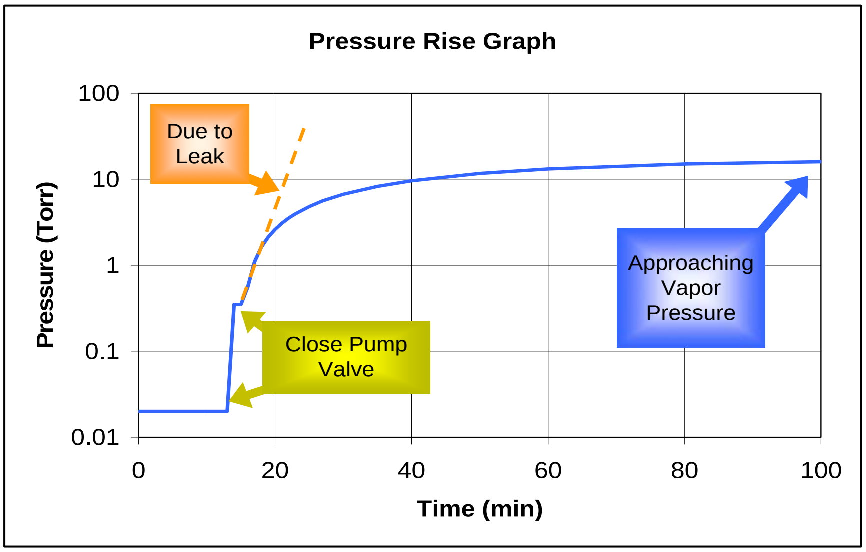
So how do you best remove (and know that you have fully removed) the moisture from a system? Dehydrating a system is usually done with a combination of dry gas purging and vacuum. Knowing how well the job has been done requires a precise vacuum measurement. How does measuring vacuum tell you when the 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're used to thinking of boiling at a temperature, but it's really a combination of temperature and pressure. (That's 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 is our guide to knowing what is going on in a system. On the graph below, you'll notice that at room temperature, the vapor pressure is about 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 dryness is determined by how fast it returns to the 17 Torr vapor pressure. If it races up in a few seconds, there's plenty of water remaining to provide the vapor pressure. If it remains well below the 17 Torr for hours then the system is relatively dry. Since this behavior is an absolute pressure effect and it's at about 1/100th of an atmosphere, a dial vacuum gauge is essentially useless in this application. However, an absolute vacuum gauge with high precision in the 0.01-20 Torr range can be effectively used to ensure proper evacuation has been achieved. The type of vacuum gauge most often used in this application is a thermocouple (TC) gauge.



Method

Drying the interior surfaces, crevices, and materials in an HVAC or 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 of vaporization is usually supplied by the thermal mass of the metal lines and components of the system itself. In other words, as the water evaporates, some parts of the system may get slightly cooler as they supply heat. This is normally such a small effect 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).

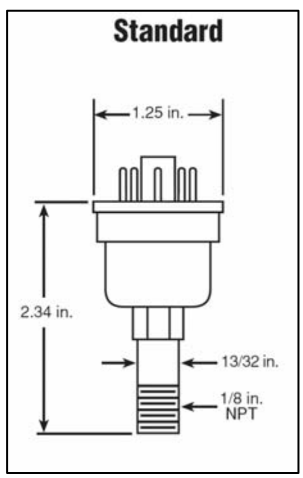
Second, as the water in the system evaporates, it is then removed by the flow of the purging gas and/or the vacuum pump. For complicated or extensive systems this can be significant challenge. A purge gas may not even actively flow through some portions of a complicated system. Likewise, during the evacuation 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. It's more like the pump allows them to fall into a hole…if they happen to fall that way.)

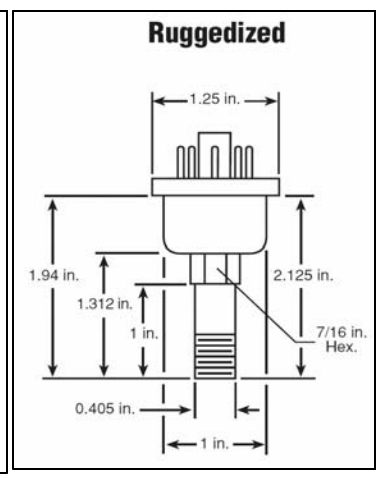


Knowing when the system is dry enough is a tricky business. A vacuum gauge at the pump, even if the pressure reading is very low, does not necessarily indicate that the entire system has been properly dried. The pressure at the pump is always the lowest. But to ensure that the water is out of every part of your system, you need to measure the pressure in the remote regions of the system. Since you can't actually put the gauge where you need it, the best solution is to bring the entire system to the gauge. This can be done by closing the valve that isolates the system and the gauge from the pump. Without the pump the system quickly equilibrates and arrives at a sort of average-pressure-everywhere condition. This event appears as a quick step on a pressure vs. time graph as shown here. Once this condition occurs, the subsequent pressure rise indicates the level of residual moisture and leaks. If the pressure rise is due to moisture, then the graph will plateau at the vapor pressure of water for the system's temperature (be careful 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 set depending on the particular system. Typically this threshold is well below 0.01 Torr (10 microns) per minute.

Instrument Choice

The requirement for measuring absolute pressure precisely in the 0.01 to 20 Torr range is satisfied very well with a thermocouple (TC) vacuum gauge. A TC gauge consists of the measurement tube which is mounted on the vacuum test system and the power supply/readout electronics. There are several versions of TC gauge tubes, each designed to satisfy specific requirements. For general purpose monitoring of HVAC and refrigeration system evacuation in controlled environments (indoor facilities), the Hastings DV-4D thermocouple gauge tube is a cost-effective device with a measurement range of 0.01 to 20 Torr. For installations that may have excessive vibration or mechanical shock, a ruggedized version of the tube is also available as the DV-4R.





The vacuum reading from any of these DV-4 tubes can be accomplished with either a dedicated electronic display or a hand-held battery operated readout. The Hastings Digital VT provides continuous monitoring with an easy to read LED display which also works well in environments where there is vibration (no analog needle movement.) For periodic vacuum checking of one or more tubes, the hand-held HPM-4 is recommended. For convenience, it is powered by a 9V battery and can be connected to any DV-4 tube for an instant reading. To ensure the most accurate measurement, the DB-16D Reference Tube (with NIST Traceable calibration) can be used to validate the electronic calibration.

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

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