

Low-Pressure Chiller Leak Detection and Monitoring

Low-pressure chillers are typically centrifugal chiller type refrigeration systems operating under a vacuum in the evaporator section of the system. The condenser and compressor sections could be at a slightly negative pressure or up to 15 psig positive pressure. By the nature of their being under a vacuum, any leaks in the low-pressure portions of the system will draw in atmospheric air and moisture. A purge unit is typically used to remove air and other non-condensables from the refrigeration system. Moisture is typically removed by a filter dryer.

Referring to a pressure-temperature chart for R123, a common refrigerant used in low-pressure systems, for a common ambient temperature in a chiller room of 70 degrees a corresponding pressure of minus 6.6 inches of vacuum is indicated. When the chiller is off, the entire chiller is at this temperature and pressure; which means that, if there is a leak anywhere on the machine, air is entering the chiller. When the chiller is operating, a common temperature in the evaporator would be 38 degrees with a corresponding pressure of -18.7 inches of vacuum. The condenser of this system would have a temperature of approximately 96 degrees which would have a corresponding pressure of +4.6 psig. When the chiller is operating, and if leaks are in the evaporator or low-pressure sections, air would be introduced into the system; however, if the leaks are in the condenser or compressor sections refrigerant would leak out of the system due to the positive pressure in these sections.

The purge unit is a small, independent, adjunct refrigeration system that separates the non-condensables from the refrigerant and recondenses and collects any refrigerant in the exhaust vent stream. The remaining non-condensables (mostly air) are then vented. The collected refrigerant is typically returned to the chiller.

When air or non-condensables are present, the purge system demonstrates their presence by running the "pump out" compressor. The amount of time the pump out compressor runs is a measure of the presence of a leak, how bad it is, and whether it is getting worse over time. A chiller with no leaks would have no pump out time. A chiller with a very small leak might have 5 minutes of pump out time in a 24-hour period. A chiller with a very large leak might have 20 minutes of pump out time in a 24-hour period or it might pump out constantly.

Typically, the purge units have an activated carbon or molecular sieve secondary adsorption canister to significantly reduce the refrigerant emissions. Without the secondary adsorption canister less than one to as much as many pounds of refrigerant may be vented with each pound of air purged from the system. The secondary adsorption canister should reduce emissions to less than 0.01 pounds (and often much less) of refrigerant per pound of air.

Accumulation of non-condensable gases such as air in the system will cause an increase in condensing pressure in the chiller and result in the loss of operating efficiency. In some installations this increase in condenser pressure and loss of efficiency can be used to trigger the purge unit.

In other installations the purge unit is on whenever the chiller is running or is always on even if the chiller is not running. In these cases the purge unit pump out will cycle based on the temperatures and pressures within the purge unit which indicate if non-condensables are being purged from the refrigeration system. With no leaks, although the purge system is on, the pump out will rarely operate to remove non-condensables.

An additional mode of operation for the purge unit is an adaptive mode which uses the history of the refrigeration system and purge unit to initiate purge unit operation. Which will then operate until it senses no additional non-condensables.

Excessive or increased purge run time and abnormally high condenser pressures could be a sign that there is a leak in the refrigeration system. On a well maintained refrigeration system without leaks the purge unit will record little or no purge time for months on end.

While conventional leak inspections methods using electronic 'sniffers', soap bubbles, or oil residue; leak monitoring; and leak testing may not be effective on the low-pressure portions of the system, a parametric monitoring program that includes monitoring purge frequency, purge time, ultrasonic leak detectors, and system temperatures and pressures will alert the operator to leaks. Some types of secondary exhaust adsorption canisters may require replacement based on purge run time, others will be automatically regenerated. However, these systems should be monitored and regularly repaired or replaced to assure that the purge unit exhaust is not venting refrigerants.

The conventional leak inspections and monitoring should still be conducted on the portions of the system that are above atmospheric pressure such as the condenser and compressor.

Effective monitoring of a low-pressure chiller may be a hybrid of conventional concentration monitors on the high-pressure portions of the system and parametric monitoring of the purge unit on the low-pressure portion of the system.

When a leak is indicated in the low pressure portion of the chiller the system may require pressurization to look for the leak if it cannot be identified through ultrasonic testing. System pressurization can be accomplished by recovering the refrigerant and pressurizing the system with an inert gas such as nitrogen or by heating the chilled water in the evaporator, raising the unit pressure into a positive pressure (refer to a pressure temperature chart). Raising the temperature of the chilled water in the

evaporator to somewhat above 82 degrees would usually put it into a positive pressure. A temperature of 100 degrees would yield a pressure of 6.1 psig which is usually sufficient to leak check reliably with an electronic halogen leak detector. After the leaks have been repaired another pressurized leak check may be required. If the refrigerant charge was removed, the system needs to be evacuated to remove all non-condensables and moisture that entered during the repair process. While the system is evacuated a standing vacuum test should be conducted by holding the vacuum for 12 hours at 500 microns and noting any change in pressure. Changes in pressure during the standing vacuum test indicate leaks if all moisture has been removed. Moisture in the system can lead to a misrepresentative standing vacuum test and should be removed before charging the system.

If the purge unit indicates non-condensables with the chiller off or shortly after start-up but not after sustained chiller operation the leak is likely on the high-pressure portion of the system. Conversely, if the purge system indicates non-condensables after sustained operation of the chiller, but not with the chiller off or upon start-up, the leak is likely in the low-pressure portion.

In addition to the inspections and maintenance of the main refrigeration system, the purge system, being itself a refrigeration system, should be regularly inspected and maintained.

Additional information on system leak inspections, leak tests, and monitoring for low-pressure refrigeration systems can be found in ANSI/ASHRAE Standard 147-2002.