

***Mechanical
Room
Update***

**Considerations In
The Application Of
Centrifugal
Chillers Using
Open Drive Motors**



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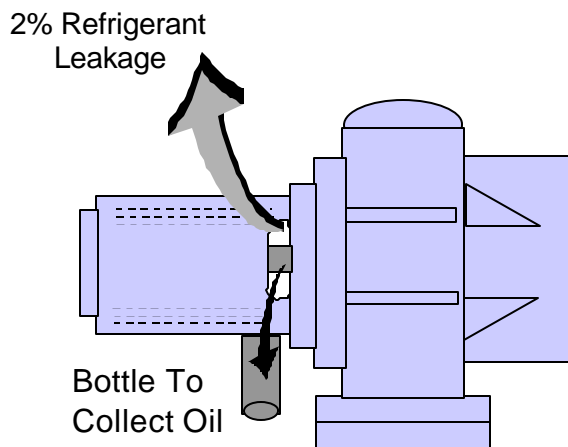
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Considerations In The Application Of Centrifugal Chillers Using Open Drive Motors

Approximately 30% to 35% of the centrifugal water cooled chillers sold in the U.S. market utilize open drive motors, the remaining percentage are semi hermetic (sealed motors that are serviceable). The largest manufacturer of open drive motor centrifugals (York International) states that “the life of the motor is between 8-15 years with the average life being ten years, with increasing risk of motor burnout thereafter”. This quote is qualified by the condition that the motor has careful maintenance. Open motors not only require careful maintenance, but also proper installation. The following three items should be considered and applied:

- Refrigerant and oil leakage
- Failure modes
- Proper ventilation

Refrigerant and oil leakage is a factor on open drive centrifugal chillers. As the drive shaft from the compressor drive unit is connected to the open motor outside of the compressor housing a “rear seal” must be used to ensure minimum leakage of oil and refrigerant through this seal. Open drive seals are designed to minimize leaks in two modes during operation of the chiller when the compressor shaft is rotating and



during a shutdown period when the shaft is stationary. As seals are designed to accommodate both conditions, along with normal contact wear on the seal, both oil and refrigerant will leak through the seal. Refrigerant loss increases as the seals dry, during long shut down periods. The industry average loss of refrigerant entrapped in the oil leaking through the rear seal is 2% of the full chiller refrigerant charge annually. Oil leakage varies and is measured by collection in measured containers connected to shaft seal drains.

ASHRAE Guideline 3, Reducing Emission of Fully Halogenated Chlorofluorocarbon Refrigerants In Refrigeration and Air-conditioning

Equipment and Applications provides some understanding and recommendation for real seal leaks in the following statement:

“Shaft seals are required on open-style compressors and they can be a source of refrigerant leakage. There are several factors that contribute to the degradation of performance and ultimate failure of seals. Seals should be designed recognizing that in operation the refrigerant and oil to which they will be exposed may contain contaminants. Shaft-seal designs that do not rely on the commonly used carbon faces are available. Double-faced seals and single-carbon seals with improved features to keep the carbon in a wet state have been found to be effective and are recommended.

The design and installation of the shaft-seal assembly should minimize external oil loss and prevent direct refrigerant loss. Lack of lubrication during shutdown periods can cause mating faces of the seal to dry out and adhere together. On large systems, a separate oil pump to lubricate the seal prior to starting the compressor is recommended.

Open reciprocating compressors typically have carbon-face seals that require positive pressure in order to function properly. Since these are not two-way seals, leakage may occur during evacuation. To prevent leakage, temporary sealing measures such as shaftcaps or clay-like weather stripping around the protrusion of the shaft should be used.

The motor-compressor alignment is critical in limiting refrigerant leakage and is affected by the style of the coupling and the speed and horsepower of the motor. Refrigeration machinery requires stringent alignment to accommodate thermal growth over the load and temperature ranges.

Shutdown and startup procedures should assure that oil is present to wet the seal faces. It may be necessary to run the oil pump and rotate the shaft periodically during long shutdown periods. If this is not possible, the seals should be inspected and lubricated before starting the system.”

Failure modes in open drive chillers typically occur as a result of misalignment, improper electrical protection and over heating. As noted in ASHRAE Guideline 3, motor compressor alignment is critical. Thermal growth during operation along with shipment loads can cause motor bearing failure along with increased rear seal leakage. Proper alignment documentation at the manufacturer’s factory should be requested along with a “hot” or “after run-in” realignment in the final installation. This critical alignment procedure should be included as part of the start up operation and as part of any service contract that is included.

Protection at the power supply is also critical in motor protection. Ground fault protection options for motor starters should be used on all installations to ensure full protection. Almost all motor failures that resulted from electrical overloads could have been prevented with the proper ground fault protection. Temperature in a mechanical room can also shorten motor life and lead to failure. To quote from one chiller manufacturer’s service manual (York) “Open motors are rated at 104° F (40°C). For higher than 104°F ambient, the motor insulation life is approximately halved for each 18°F (10°C) increment at full load.”

Proper Ventilation can reject this heat during chiller operation and also ensure any vented refrigerant (2% of charge) is removed from the mechanical room. Open motor heat rejection is determined by the following formula:

$$\text{CFM} = (\text{Full Load Motor kW}) \text{ Motor Efficiency} \times 3413$$

To properly use this formula in a specification, the following is the statement that should be used in the chiller specification:

Should the mechanical contractor choose to provide a chiller with an open motor instead of the specified semi-hermetic motor, the contractor shall either:

Supply additional ventilation to maintain a maximum mechanical room temperature of 104 F (40 C).

Additional ventilation requirements shall be calculated as follows:

$$\text{Cfm} = \frac{(\text{Full load motor kW}) (0.05) (3413)}{(104 - 95) (1.08)}$$

$$\text{Cfm} = (\text{FLkW motor}) (17.6)$$

or, if the mechanical room is air conditioned, the mechanical contractor shall install additional cooling equipment to dissipate the motor heat as per the following formula:

$$\text{Btuh} = (\text{FLkW motor}) (0.05) (3413)$$

$$\text{Btuh} = (\text{FLkW motor}) (171)$$

and, alternately

$$\text{Tons} = \frac{\text{Btuh}}{12,000}$$

In either case, the additional piping, valves, air-handling equipment, insulation, wiring, switch-gear changes, ductwork, and coordination with other trades shall be the responsibility of the mechanical contractor. Shop drawings reflecting any changes to the design shall be included in the submittal, and incorporated into the final as-built drawings for the project.

Also, if an open motor is provided, a mechanical room thermostat shall be installed and set at 104 F (40 C). If this temperature is exceeded, the chillers shall shut down and an alarm signal shall be generated to the central Energy Management System (EMS) display module prompting the service

personnel to diagnose and repair the cause of the over temperature condition. The mechanical contractor shall be responsible for all changes to the design, including coordination with temperature control, electrical, and other trades.

In addition, the electrical power consumption of any auxiliary ventilation and/or mechanical cooling required to maintain the mechanical room conditions stated above shall be considered in the determination of conformance to the scheduled chiller energy efficiency requirement.

Rejection of this mechanical room heat requires additional power and should be considered as part of the total required power of the chiller during selection. If you consider that chiller performance is a heat balance of energy in vs. energy out (cooling), accounting for the open motor heat rejection must be part of this balance.

Unlike hermetic, refrigerant cooled motors that have a reliability design life of 25 years, open drive motors require careful consideration during installation. With proper consideration open drive drip proof motor life can be extended to the full 10 to 15 years life period..

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