BRISTOL COMPRESSORS™

Crankcase Heaters

Application Bulletin 135

Application Bulletin

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Subject: Crankcase Heaters

1.0 **PURPOSE**

Guidance for customers in the following:

- Importance of sound and vibration (lab and field) testing prior to production release
- First year of operation and low ground temperature concerns
- Applying dual compressors
- Lubrication return and refrigerant migration
- Refrigerant metering devices
- Safety pressure controls
- Start assist components
- Time delays
- Filter/drier requirements (direct expansion systems only)
- Reverse refrigerant migration
- Microprocessor control
- Hot water heating

1.0 **Purpose**

To inform the customer of the following:

- Importance of a crankcase heater and the need for system evaluation to assure necessity and proper sizing of the heater for each application
- Compressor charge limitation
- Systems exceeding the compressor charge limitation
- High and low ambient liquid refrigerant migration and methods to correct
- Important factors and test procedures to determine need and/or sizing of a crankcase heater

2.0 **Crankcase Heater Importance and Sizing**

A crankcase heater, correctly sized and energized for the minimum required length of time, will minimize the condensing of refrigerant in the compressor and increase the longevity of the compressor bearings and other critical components. When a system has been off – new system start-up or out-of-service condition which de-energizes the crankcase heater for at least 18 to 24 hours, the system is thermally *soaked out*. This means all system components, including the condensed refrigerant, are at a stable temperature and pressure and vary only as the ambient changes. When this occurs, refrigerant has *migrated* to the compressor sump and saturated the volume in the cylinders, cylinder head, shock loop, and discharge muffler with a mixture of refrigerant and oil. If the compressor is started in this condition, *liquid slugging* will occur. To prevent this abusive slugging, a *temperature difference (ΔT)* must be maintained between the sump of the compressor and the coolest point in the system. For the best safety margin, the compressor sump must be maintained at least 20°F warmer than the coolest section of the system, only if this section(s) can *hold* the system charge. If the *"coolest section"* does not have the volume to hold the system charge, the sump needs to be 20°F above the warmest section of the system. Please note that certain applications may require a 30°F ΔT, and system tests are needed to assure adequate ΔT under the worst case conditions expected. At ambients of 20°F and lower, refrigerant will migrate out of the compressor when a 5°F ΔT is maintained.

> *NOTE:* Some users have a misconception that a properly sized crankcase heater will protect the compressor under all circumstances. If the system loses compressor suction superheat

to a point that the heat output of the crankcase heater cannot maintain the sump ΔT, refrigerant can migrate to the compressor sump. Optimum crankcase heater operation requires the following compressor superheats to be maintained (refer to Application Bulletin 121) – suction = 5°F minimum, sump over saturated suction = 30°F, discharge = 50°F minimum.

The crankcase heater size (in watts) depends on the following factors:

- Differential temperature (between compressor sump and system) which is necessary to move/keep liquid refrigerant out of the compressor
- Total system charge and potential overcharge
- Time the heater is energized before compressor starts up
- Maximum system ambient (indoor section and outdoor section)
- Sun load on condenser (louvered, covered or exposed coil)
- Type of system: split, package, air conditioning, heat pump, chiller, close coupled, long line sets, etc.
- CFM of air across compressor
- Type/location of heater – in well or wrap around

Since the above factors are dependent on system design, it is critical to evaluate the heater in each application.

3.0 Charge Limitation

The "compressor charge limitation" is published on the individual specification summary sheet for each compressor. If the total system charge is *below* this amount, and the compressor superheats are maintained within our Application Bulletin 121, most applications will not need a crankcase heater. However, there could be circumstances (defrost mode on heat pumps, hot water heating cycle that switches into the cooling or heating cycle on the fly, harvest cycle on ice machines, etc.) where "at or below" charge limit levels could reduce the compressor life unless proper refrigerant control and system controls/protection are utilized.

4.0 Systems Exceeding the Compressor Charge Limitation

These systems *require* a crankcase heater and may require a pump down scheme or accumulator to prevent flooded starts (refer to individual product bulletins for required testing and to Application Bulletin 101 on accumulators/refrigerant control. These precautions are necessary since refrigerant can collect in the suction line or evaporator during the off-cycle, returning to the compressor as a solid liquid column, with extreme velocity, on start-up. The velocity and the weight of the liquid slug(s) may be of sufficient magnitude to override any anti-slug protection devices designed within the compressor.

5.0 Refrigerant Migration

Defined as the movement of refrigerant from one system component to another due to the temperature/pressure difference (ΔP) between those components.

5.1 High Ambients

If crankcase heater wattage is inadequate, high ambient temperatures (greater than or equal to 80°F) coupled with high solar load on the system condenser coil (no louvers) can cause refrigerant to migrate out of the condenser, in *reverse*, back into the discharge line through the compressor valves to the lowest temperature area of the system. During this *reverse migration*, refrigerant can liquefy in the cylinders of the compressor which can result in a start-up slug. To minimize this effect, the crankcase heater needs to maintain the sump at least 20°F above the highest temperature in the system.

Other wide differential temperature circumstances to consider are:

- Building under construction, i.e., no cooling (evaporator warmer than condenser). Also see *Ground Source Heat Pumps* (Application Bulletin 134).
- A split system evaporator is normally in a cooler location, while a rooftop package system evaporator is in a much hotter location and could be even hotter than the condenser on initial start-up and after extended shut-down periods. This condition can allow refrigerant to fill the vital parts of the compressor, resulting in a start-up slug even if the system charge is within the published limitation.

5.2 Low Ambients

At low ambients (less than or equal to 60°F) and low condenser solar load, refrigerant can migrate from the evaporator through the compressor to the condenser. Again, refrigerant will tend to liquefy in the cylinders of the compressor. The crankcase heater needs only to maintain the sump at least 5°F above the lowest temperature in the system to minimize the effect. The lower ambient will allow refrigerant to flow out of the compressor at a faster rate than at the higher ambient.

6.0 The Following is a Recommended Test Procedure to Confirm if a Crankcase Heater is needed and/or Properly Sized

Heaters are normally sized to move refrigerant out of the compressor in 12 to 24 hours. This time allotment is suggested in order to allow the effects of sun exposure (approximately 720 BTU's of heat per square foot of exposed coil - no louvers - to the system) to be minimal at some time during the compressor off period. Large compressors will be equipped with sight glasses which can be used to see when enough refrigerant has moved out of the sump to create a safe level. The best assurance is to never let the compressor sump be the location of the lowest temperature component in the system.

- Install compressor or system in a controlled environment room, capable of controlling the condensing unit and evaporator at the highest and lowest (worst case) ambient they will be subjected to in the field within a 24-hour period. (Package systems should be tested with the evaporator and condenser sections at the expected worst case temperature.)
- Compressor weight to be monitored with scales and equipped with sight tube and/or sight glass mounted on compressor at normal oil level.
- Double-sided sight glasses should be installed in suction and discharge line of system to confirm if liquid is returning to compressor at any time.
- Connect the condenser and evaporator to the compressor (or equivalent containers equal to the volume in the system).
- Use flexible lines to connect compressor to system or container (not needed when using sight tube or sight glass mounted on compressor).
- Evacuate the system.
- Record weight of the compressor.
- Charge the system to its normal refrigerant charge level.
- After the environment temperature is set, allow system to soak-out for 24 hours.
- Record the weight of compressor after 24 hours.
- Energize the crankcase heater.
- Record weight of compressor at least every hour.
- Crankcase heaters are normally sized to remove all liquid refrigerant from compressor in 24 hours or less. Testing for 12 hours of total test time at the night time temperatures, or for the number of hours the system will be at lower temperatures, will be a determining factor in sizing the heater.
- If refrigerant remains in the compressor sump after the recommended removal time, the wattage of the crankcase heater will need to be increased or system modifications made to improve the removal rate.

7.0 Test Compressor Availability

Compressors with a sight glass or sight tube are available and recommended for test. They will allow visual monitoring of the amount of refrigerant being moved out of the compressor throughout the test.

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