

LOW AMBIENT COMPRESSOR OPERATION

Any refrigeration or air-conditioning system utilizing an air-cooled condenser which must operate during spring, fall or winter months must be designed to properly control liquid refrigerant fed to the evaporator under widely varying ambient conditions. Since the flow characteristics of capillary tubes and expansion valves are proportional to the differential pressure across the capillary tube or valve, the problem is most critical under low outdoor ambient conditions when the condensing pressure can fall to very low levels without some means of control.

With a conventional restrictive device, excessively low condensing pressure will reduce the refrigerant flow rate to a point where evaporating pressures can fall to a dangerously low level, and can result in evaporator frosting, compressor short cycling, liquid refrigerant flood-back and other malfunctions; all of which can lead to compressor failure.

In order to maintain satisfactory operation under low ambient conditions, a number of approaches are possible, each of which has both advantages and disadvantages.

Normally some type of outdoor precautions must be taken if compressor operation is anticipated on air-cooled systems in ambient of 10°C or below.

1 Maintaining Constant Air Temperature To Condenser.

An approach that has proven to be highly satisfactory on supermarket installations and other applications where large numbers of compressors are involved is to locate the entire condensing unit inside a machine room. The temperature in the machine room then can be controlled within reasonable limits by means of a thermostat controlling automatic air inlet louvers and exhaust fans. In effect, the condensing unit sees a continuous stable operating environment.

Obviously this involves space and expense, and is used only when sufficient units are involved to provide a continuous source of heat.

2 Reducing Condenser Capacity By Flooding With Liquid Refrigerant

A number of manufacturers offer valves to maintain head pressure by partially flooding the condenser with liquid refrigerant. Various combinations of valves may act to restrict or stop refrigerant flow through the condenser while at the same time bypassing discharge gas directly to the receiver as necessary to maintain a preset condensing pressure. Under normal ambient conditions, the bypass valve is closed and refrigerant flows freely through the condenser.

Under operating conditions, the flooding type control provides good modulation and stable head pressure conditions. However systems of this type do require a considerable quantity of extra refrigerant in order to flood the condenser, possibly requiring an oversize receiver. If insufficient refrigerant is available to flood the condenser, the hot gas bypass valve may feed continuously, and this can create major problems with expansion valve control. If excessive refrigerant is added to the system, it may be impossible to pump the system down and isolate the refrigerant in the receiver and condenser.

Due to the large refrigerant charge in the system a pump-down control is highly advisable for proper compressor protection against liquid refrigerant migration and slugging on start up.

3 Reducing Condenser Capacity by Reducing Condenser Air Flow

Another means of maintaining adequate condensing pressure which has the advantage of not flooding the condenser is provided by limiting the air flow over the condenser surface.

This can be accomplished most simply and economically by cycling the condenser fan from a reverse acting high pressure control, but the resulting rapid fluctuation in head pressure can result in erratic liquid refrigerant control. Where variations in ambient temperature are not too severe, this may provide adequate control, but for larger systems and particularly where air temperatures entering the condenser of -15°C and below may be encountered, better modulation of control is required to prevent potential compressor problems.

Suction-cooled compressors operating with evaporating temperature below -15°C and air-cooled compressors at any evaporator temperature, require constant airflow across the compressor for adequate cooling.

Fan cycling on these applications is not acceptable unless auxiliary cooling of the compressor is provided.

Cylinder and head temperatures are most likely to be extreme at high compression ratios, and the probability is that reduced loads and increased compressor capacity are most likely to result in high compression ratios during low ambient conditions.

Where condensers with multiple fans are used, cycling of individual fans on a staggered basis gives more stable pressure control, but problems still exist if conditions are such that the last fan can cycle on and off.

Better modulation can be obtained by varying the fan motor speed, and this is now possible with available solid state controls and suitable motors.

However even if the condenser fan is completely stopped, the condenser must be protected from the wind to avoid loss of control on cold windy days, and a suitable shroud must be provided.

Another very effective means of reducing air flow over the condenser is by means of power operated shutters actuated by the refrigerant pressure.

Even though extra refrigerant is not required for systems utilizing fan control or shutters, pump-down control is still highly recommended for any unit in which the compressor and suction line are exposed to cold ambient conditions, where the compressor must start and operate under such conditions.

4 Starting At Low Ambient Temperatures

At times, the temperature to which the condenser and receiver may be exposed is so low that there is insufficient pressure available to start the feed of liquid refrigerant to the evaporator on start up. As a result the compressor may pull a deep vacuum on the system within a matter of seconds, and short cycle on the low pressure control. If the low pressure cut-out is set low

enough to prevent short cycling, then the setting may be so low that it no longer provides adequate protection for the compressor, and cannot be used for pump-down control.

It is possible to use a low pressure control with a time delay. This may provide sufficient time to build up head pressure so the unit can then operate normally, but if the same time delay is effective during pump-down, this can allow the compressor to pull an undesirable deep vacuum prior to shutdown.

One proprietary system provides quick receiver pressure by diverting the compressor discharge gas directly to the receiver on start-up, bypassing the condenser until a preset pressure is obtained. This provides excellent start-up pressure under all weather conditions.

Another solution to the start-up problem is the use of a small electric heater band or element on an insulated receiver to maintain a temperature such that the saturated pressure will be adequate to insure refrigerant flow to the evaporator on start-up. The heater can be controlled by a thermostat, while backflow to the condenser can be prevented by a check valve. This type of start-up control, in conjunction with a condensing pressure control, deserves more widespread consideration and usage than it has received.

5 Operating With Low Head Pressure

Some proprietary systems are utilizing expansion valves designed to operate at very low differential pressures in order to take advantage of the increased capacity and reduced power consumption resulting from compressor operation at low condensing pressures.

Since a valve with less restriction will also be less sensitive in its control characteristics, additional system protective features such as suction accumulators and heat exchangers may be necessary to prevent excessively wet refrigerant vapour from reaching the compressor.

A minimum of 8K to 11K superheat at the compressor is essential to ensure proper lubrication.

6 Use Of Crankcase Heaters

Crankcase heaters are strongly recommended on all refrigeration systems where the compressor is exposed to cold ambient temperatures, on all split air-conditioning systems, and on package air-conditioning equipment 5 H.P. and larger. As the refrigerant charge increases, the start-up problems associated with liquid refrigerant become more critical.

The crankcase heater will minimize liquid migration to the crankcase during periods when the compressor is not operating. Another important function of the crankcase heater on outdoor units is to keep the compressor oil warm enough so it remains fluid. On rooftop units exposed to winter winds, the oil may become so viscous without a crankcase heater that the compressor cannot develop oil pressure.

In summary, a number of different approaches for proper cold weather control may be acceptable if properly applied. Such factors as system size, type of application, severity of weather conditions to be expected and unit location must be taken into consideration.

The design goal must be to maintain operating conditions under the most adverse weather conditions which will allow the compressor to operate safely.