Functions of Internal Pressure Relief Valves in Hermetic Compressors

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INTRODUCTION

As a result of tremendous growth in the use of non-accessible hermetic compressors and the never ending requirement for the compressors to be small in size and light in weight, a need for an internal pressure relief device was generated.

The cylinder head and its gasket have always been involved in the regulatory agencies testing for strength requirements. The cylinder head must withstand a hydrostatic pressure five (5) times the working pressure, or when using R-502, a pressure of approximately 2000 to 2500 pounds per square inch. The repeated rupture of the cylinder head gasket at pressures lower than the preceding was an acceptable safety relief device.

Because of the consumer need for compactness and lightness, the cylinder head gasket could no longer meet the 2500 psi hydrostatic requirement.

A gasket rupture at lesser pressures was not considered a very serious problem on the accessible hermetic or older belt driven compressors for the removal of several bolts allowed the replacement of the cylinder head gasket. The hermetic, "sealed in a steel shell", compressor presented an entirely different situation because common hand tools would not open or reclose the shell and the cylinder head gasket was not easily replaced. If such a fault occurred, the entire compressor assembly had to be replaced and, therefore, the need for a pressure sensitive relief device.

Whatever device was developed, it must meet certain desirable characteristics and functions.

1. Low cost
2. Small
3. Automatic Reset
4. Very reliable and nuisance free of normal operating pressure conditions.
5. Tamper proof
6. Compatible to compressor environment.

Development testing evolved a small relief valve of two moving parts capable of sensing pressure differential between suction (low side) and discharge (high side) pressure. The valve is placed in the discharge pressure side of the cylinder head adjacent to the gasket which it is to protect. The valve body is made of brass in which a seat is machined where a spring loaded ball rests for closure.

The valve is calibrated to begin opening when it senses a pressure difference between low and high side of 450 to 550 psig. This pressure setting allows maximum loading operation of say 90 psig low side and 400 psig high side with a good margin of safety since the differential in this instance would be 310 psig. You can also envision that if the high side pressure approached the 540 to 640 psig area, the valve would begin to open.

Well, we have protected the cylinder head and its gasket but what happens in the compressor assembly when the valve opens?

As the valve opens, it allows hot, superheated, high pressure refrigerant to flow into the compressor shell volume and:

1. The suction pressure to the compressor immediately rises. Increased suction pressure results in higher motor loading and increased current consumption.
2. The superheated vapor raises the temperature inside the compressor shell warming both the motor and the protector.
3. The compressor speed is reduced slowing its ability to pump into the shell the cool, low pressure low side vapor.

The compressor is now in a posture such that it will:

1. From the increased current consumption and increased protector ambient, cause the protector to open, interrupting the power to the compressor, and the compressor discontinue operation.
2. From the increased pressure condition, stall
the compressor rotor which again will result in a protector opening and subsequent shut down.

Shut down results in a rapid re-closing of the pressure relief valve for the system pressures immediately seek stabilization or zero pressure differential. The compressor, however, will not restart immediately since the protector is open and the power to the compressor motor interrupted.

The shut down then becomes a function of the protector "off time." If an internal protector is used it is obvious that the compressor will remain shut down for at least several minutes since the motor and compressor mass are at elevated temperatures. An external protector would have a lesser "off time" because of its location in the outside air ambient. Non the less, either protector would slow down the cyclic action of the relief valve.

Assuming the high pressure condition was of a temporary nature when the protector resets, the unit will again function since the compressor is not permanently damaged in any way.

If the high pressure condition is of a more permanent nature, such as a condenser fan motor failure, the compressor will continue to cycle safely until the lack of adequate cooling is noticed and the fault repaired.

Since the valve limits the ability of the compressor to pump extremely high discharge pressures, it offers the benefit of less stringent strength requirements for the other components used in the condensing unit such as the condenser, receiver and connecting tubing. Obviously, the lessening of these requirements results in material cost savings.

In summary, the pressure relief valve does offer the benefit of the refrigeration unit experiencing a high pressure side fault without a costly service repair call for replacing the compressor and should result in a less costly unit from the cost of material savings without introducing a nuisance factor during normal operation.