Refrigeration and air-conditioning technicians know that the hermetic compressor is the heart of the cooling system. The reason for this is that the compressor pumps refrigerant through the system so that heat can be absorbed by the evaporator and released by the condenser.

To accomplish this, the pumping mechanism, or vapor pump, is driven by a three-phase or single-phase hermetic motor. This article will concern itself with devices involved in starting single-phase hermetic motors.

Current relays

The purpose of a current relay is to either remove the start winding or a starting capacitor in series with the start winding from the circuit at startup. It can either be pushed onto the run and start pins of the compressor terminal or remotely mounted away from the compressor. Current relays are position-sensitive; they must be mounted in an upright position.

The current relay has a low-resistance coil of wire wrapped around the outside of the relay body (see Figure 1). This coil of wire is in series with the run winding of the motor. Internally, normally open relay contacts, wired in series with the start winding, are attached to a vertical armature.

Current in the run winding is at its peak when power is first applied to the compressor. Initially, a solenoid effect acts on the armature to close the relay contacts and engage the start winding. As motor speed increases, the run winding current decreases, causing the contacts to open and drop the start winding out of the circuit. This normally occurs at approximately 75% of full running speed.

A push-on type current relay is used on small fractional-horsepower, hermetic refrigeration compressors. The relay is pushed onto the start and run pins of the compressor hermetic terminal. If the compressor does not use a starting capacitor, then the relay will only have one terminal (see Figure 2).

If a starting capacitor is used, then a relay with two terminals is required (see Figure 3). The neutral wire must be attached to the relay so that it is in series with the relay coil. This is usually the higher of the two terminals on the relay. If a two-terminal relay is used without a start capacitor, then...
a jumper wire must be used in place of the start capacitor to complete the start circuit.

Remote mounted current relays are used on larger fractional-horsepower and small, integral-horsepower hermetic refrigeration compressors. These relays will always be used with a start capacitor (see Figure 4).

Troubleshooting of current relays can be done using an ohmmeter. Push-on relays must be removed from the compressor hermetic terminal to access the start and run terminals of the relay. The resistance of relay coil can be measured by putting the ohmmeter probes on the relay terminals connected to the coil. This reading should be between 0 and 1 ohm.
If the reading is zero (shorted) or greater than 1 ohm, the relay should be replaced with one of the same calibration.

Current relay contacts can be checked by putting the ohmmeter probes on the relay terminals connected to the contacts. When the relay is upright, the resistance reading should be infinite (open). When the relay is flipped upside down, the resistance reading should be zero (shorted). If the relay contacts are not open when the relay is in its upright position or not closed when the relay is flipped upside down, the relay should be replaced.

**Potential relays**

The potential relay is found on large, fractional- or integral-horsepower hermetic refrigeration and air-conditioning compressors. These relays are used to remove a starting capacitor in series with the start winding from the circuit at startup (see Figures 5 and 6).

The relay coil, armature and contacts are assembled in a plastic enclosure (see Figure 7). Connections are made to terminals on the outside of the relay enclosure. The relay coil is wired in parallel with the motor start winding and the relay contacts are normally closed.

The operation of the potential relay is based on the back electromotive force (back EMF) generated across the start winding as the motor speed increases. When the back EMF generated in the start winding reaches the relay “pick-up voltage,” the magnetic field in the relay coil attracts the armature, causing the contacts to open. This takes the start capacitor out of the circuit at around 75% of full running speed. The back EMF at which the contacts close is called the “drop-out voltage” and the relay coil has a designated “continuous coil rating.”

The relay coil is across terminals 2 and 5, while the relay contacts are across terminals 1 and 2. When used with a run capacitor, a 15,000-ohm to 18,000-ohm, 2-W bleed resistor should be attached to the start capacitor to prevent possible arcing when the relay contacts open.

Troubleshooting of a potential relay can be done with an ohmmeter. All electrical connections must be removed from the relay. If the resistance across terminals 2 and 5 is zero, then the relay coil is shorted. If the resistance across terminals 2 and 5 is infinite, then the relay coil is open. If the relay coil is shorted or open, the relay should be replaced.

If the resistance across terminals 1 and 2 is zero then the contacts are closed, but could be welded together. If the resistance across terminals 1 and 2 is infinite, then the contacts are open. If the relay contacts are open or welded together, the relay should be replaced.

A symptom of welded contacts is high current draw at startup, resulting in a tripped motor protector. The replacement relay should have pick-up, drop-out and continuous coil voltages similar to the original relay. Generic relays are generally not recommended, as they are not specifically matched to the voltage characteristics of the motor.

**PTC relays**

The PTC (positive temperature coefficient) relay is commonly used without a starting capacitor, as it is applied to fractional-horsepower, hermetic refrigeration compressors using capillary-tube expansion devices. The advantages to using a PTC relay
are that it is a solid-state device and that it does not open and close based on a specific calibration.

The heart of the PTC relay is a piece of PTC material. The resistance of this material is only 3 or 4 ohms at room temperature but, as it heats up, its resistance quickly climbs to several thousand ohms. This makes the PTC relay a simple, yet effective, switch. The disadvantage of using PTC material is that it takes three to 10 minutes for it to cool down and return to its open condition.

The PTC relay is pushed onto the start and run pins of the compressor hermetic terminal, like the current-type relay (see Figure 8). As the PTC material heats up, the start winding is taken out of the circuit. If a run capacitor is used, the capacitor is wired to the start and run sides of the relay. Initially, current bypasses the run capacitor. As the PTC material heats up, current flows through the run capacitor, which is in series with the start winding.

Troubleshooting of a PTC relay can be done with an ohmmeter. The relay must be removed from the compressor hermetic terminal to check the resistance of the PTC material. The resistance of the PTC material should be from 2 ohms to 5 ohms. If the resistance is less than 2 ohms or greater than 5 ohms, the relay should be replaced.

**Conclusion**

All single-phase hermetic refrigeration compressors require an external starting relay to remove the start winding, start winding and start capacitor or just the start capacitor from the motor circuit. There are several things that lead to the successful application of a starting relay including proper installation, wiring, troubleshooting and replacement of the relay. A systematic review of these items can reduce the time it takes to diagnose a relay problem and get a customer’s system back up and running quickly.

**References**

1. Electricity and Controls for Heating, Ventilating and Air Conditioning, Herman, Stephan L., Sparkman, Bernie L., Split-Phase Motors, pgs.64–71, Starting Relays, pgs.135–142.

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