Progress Supply Inc. THE INSIDE STORY

Helpful Information for HVAC Contractors from Progress Supply

This is one of a series of technical bulletins from your friends at Progress Supply

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CAPACITY REDUCTION

When one designs an air conditioning or refrigeration system, it is designed for the maximum load that occurs on the hottest days of the year and for the maximum internal load such as lights, people and machinery. **ASHRAE,** the *American Society of Heating, Refrigeration and Air Conditioning Engineers,* provides tables with the maximum design temperature that is not exceeded for either one or three percent of the time for a number of cities in the United States. Using the three percent table means that the temperature for each local is below the design temperature 97% of the time. In addition to the ambient temperature or the space's surrounding temperature, the inside load must also be taken into consideration.

In an air conditioning application the load typically is people, lights and machinery, such as computers. In refrigeration applications the load typically is food. It may be a material that must be stored in a low temperature, possibly to maintain its stability. Like the effects on load that the outside or surrounding temperature has, the product load also is changing. As the product is being cooled, the load is being reduced.

Compressors, with few exceptions, are designed with a **fixed displacement.** This displacement provides a defined CFH (Cubic Feet per Hour) of refrigerant, therefore, a fixed BTU capacity based on the refrigerant being used. Yes, the BTU capacity does change as the differential pressure across the cylinders changes. It is a simple fact of physics that as the ambient air across the air-cooled condenser coil changes, the compressor's head pressure changes. The higher the ambient air, the higher the head pressure.

The next consideration is **suction pressure.** With a fixed displacement compressor, as the liquid control device (TEV or cap tube) reduces the amount of refrigerant into the evaporator, the suction pressure will fall. The compressor removes the refrigerant vapor faster than the liquid control device supplies refrigerant to the evaporator. It is the reduced suction pressure that causes problems with the system.

When the suction pressure falls, it is an indication that the load on the system has been reduced. When this happens, usually the refrigerant system is turned off and stays off until the load rises to a predetermined point. In both air conditioning and refrigeration systems, it is a thermostat that will determine the on and off points for the system.

One of the major problems with the on-off system of control is the temperature change between the on and off points. If the differential between on and off is too narrow, the system will short cycle and this is not good for compressors. In addition, the application must be understood. Can the process tolerate an on/off system? Can it tolerate the differential temperature that a thermostatically-controlled system provides?

Neither you nor I can physically change the compressor's CFH, its designed displacement. Then, what can be done to reduce its capacity to match the load as it is changing?

The compressor will determine what method can be used to have the compressor more closely match the changing load.

COMPRESSOR UNLOADING

Unloading — one of Webster's definitions of unloading is, "to get rid of." Yes, we want to get rid of compressor capacity. In the Copeland lineup of compressors, the following families can be unloaded: **three cylinder 9 and 3D, four cylinder 4R and 4D, six cylinder 6R and 6D, and the eight cylinder 8D.** In addition, the ***screw compressor family and certain scroll compressors can be unloaded.*** Let's look at these families to understand their unloading method.

The 9R series uses a high to low side method of unloading to get rid of unwanted capacity. The unloading models use a head with two compartments. Cylinder one discharges its compressed refrigerant into one compartment, and cylinders two and three discharge their refrigerant into the other compartment. On top of the head over cylinder one is a three-way solenoid valve with piping to the compressor's discharge connection and to the suction side of the compressor's valve plate. When the solenoid valve is de-energized, the refrigerant from cylinder one, along with the refrigerant from cylinders two and three, is discharged to the system through the compressor head discharge connection. When the solenoid is energized, the refrigerant from cylinder one is discharged back to the low side, the suction side of the valve plate. This method is referred to as high to low side unloading. The compressor capacity is reduced by approximately one-third.

The 3D uses an entirely different technique of unloading. It is unique to the 3D. The Discus families of compressors use a disc type of discharge valve. Because of its design, very little re-expansion occurs, resulting in more capacity than the same displacement reed type compressors. The 9R family unloads one cylinder, whereas the 3D unloads all three cylinders, providing for a more balanced crankshaft. The discs of the 3D have a hole in them and a cylinder over each compressor cylinder on top of the valve plate. There is a piston in each of these cylinders that is positioned up and down through the action of an unloading solenoid. When the solenoid is de-energized, the piston in each of the unloading head cylinders is pushed down so that the hole in each disc is closed and the compressor operates at 100% capacity. When the unloader solenoid is energized the pistons in the unloader head move up. This now allows a measured amount of high-pressure discharge refrigerant to go into these cylinders. On the downward stroke of the compressor cylinders, the high pressure in each unloaded cylinder must re-expand, delaying the opening of the suction reed, thus reducing the compressor's capacity. The amount of reduced capacity is a function of the differential pressure across the cylinders.

The 4R, 4D, 6R, 6D, and 8D families use what is referred to as **Suction Stop,** or **Blocked Suction unloading.** This is a very simple method. In the unloader models, the unloader head(s) have a piston mounted in them. The valve plate has a round hole in it where the suction gas comes through out of the compressor's throat to the suction side of the valve plate. A solenoid on top of the unloader head causes the unloader piston to move up or down. When the solenoid is de-energized, the piston is retracted and the suction gas moves through the valve plate hole and into the two cylinders that the valve plate covers. When the solenoid valve is energized, the piston moves down and blocks the hole so that no suction vapor moves through to the two pistons that the valve plate covers.

The four cylinder compressors, 4R and 4D, have only one unloader head, therefore, they can only have a 50% capacity reduction. The 6R and 6D can have one or two cylinders with capacity reduction. Therefore, the capacity reduction can be either one-third or two-thirds, depending on how many unloader solenoids are energized. The 8D can have up to two heads with capacity controls. This will permit 25% or 50% capacity reduction, depending on how many unloaders are energized.

Typically, hermetic compressors do not have capacity reduction. However, there are several hermetic designs that have and do use capacity reduction. One form of capacity reduction is the two-speed compressor. The 100% capacity is at a compressor speed of 3500 RPM. The reduced capacity is at 1750 RPM. This change of speed is done through external contactors that alter the compressor motor from two-pole to four-pole. The two-pole configuration provides the 3500 RPM and the four-pole configuration provides the 1750 RPM speed. The wiring to make this change is somewhat unique and is not in high demand. In addition, the compressor must be allowed to stop before the speed change can take place.

One compressor manufacturer does capacity reduction by causing the compressor's rotation to be reversed. In one direction, the compressor's two cylinders pump refrigerant providing the 100% capacity. When the compressor is reversed, only one cylinder pumps refrigerant, therefore, operating it at a reduced capacity.

This brings us to the **Scroll** and the **Screw compressors.** The mass-produced Scroll compressor is now 15 years old. Because of the demand for this compressor, unloading was not a big factor. The world has changed and the demand for reduced capacity has increased. The Scroll is unique in that the refrigerant from the time it enters the actual compression cycle, is in a slow, continuous compression mode. In the reciprocating compressor, the refrigerant is only in the compression mode when the piston is moving up toward the valve plate and discharge reed.

In the unloading version of the Scroll, the entrance point to the scroll wrap is changed. Currently, in the unloading Scrolls, a solenoid causes the refrigerant to enter at the beginning of the wrap for 100% capacity. When a reduced capacity is required, the solenoid diverts the refrigerant toward the center of the wrap. This reduces the time the refrigerant is in the compression mode, providing a reduced capacity.

What about the **Screw compressor**? Like the Scroll compressor, when the refrigerant enters the screw portion of the compressor, there is continuous compression of the refrigerant. Like the Scroll, there are little to no discharge pulsations in the system. Like the scroll, when the refrigerant enters at the beginning of the screw elements, the compressor provides 100% capacity.

The screw compressor has two means of providing reduced capacity. One method that has been used for a long time is the **slide vane.** The slide vane is moved in either of two directions through hydraulic action. For 100% capacity, the slide vane is at one extreme of the screw elements, permitting the refrigerant to enter at the beginning of the screw elements, providing 100% capacity. As the demand for a reduced capacity occurs, the slide vane is moved toward the other end of the elements. Each movement changes the point that the refrigerant enters the screw elements. Because the refrigerant is being compressed for a shorter period of time, the capacity of the compressor is being reduced. This method of capacity reduction will provide capacity from 30% to 100%.

The second method of Screw compressor capacity reduction is similar to the method described for the scroll compressor. Through solenoids, the entrance point of the refrigerant to the screw elements is changed. This method provides three finite capacities, 100%, 50% and 25%. If one wants to consider zero capacity, off, then four steps.

This article has only considered the 'whys' and the 'hows' of capacity reduction. It has not gone into how these methods fit into systems. From a system perspective, we will continue this train of thought in the next article, so stay tuned for the next episode.

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Cincinnati, Ohio. . .**Progress Supply, Inc.** a leading Southwest Ohio refrigeration, air conditioning and controls wholesale supplier, has added another member to their Johnson Controls "Metasys" support team with the appointment of **Eldon Cline**, who will be headquartered at their Dayton location.

Metasys is a trademark name for Johnson Controls' Automated Building Controls System (ABCS) that helps manage buildings more efficiently by handling virtually all the environmental aspects such as heating, cooling, electricity and humidity. 15,000 Metasys systems are installed in buildings around the world.

Mr. Cline has extensive experience with installation, troubleshooting, and on-site and remote diagnostic service gained by working on Metasys systems throughout the country. He will also provide technical training support for the large Metasys user base in the Dayton area.

Mark Faessler, Progress Supply President, said, "With Kelly Bloomfield in Columbus, Paul Procter in Cincinnati, and now Eldon Cline in Dayton, we feel we have a top-notch team of well-trained and experienced Metasys people." Faessler added, "With our qualified staff on board and now that we are well-stocked with key replacement parts in all three branches, we are ready to meet the needs of our growing customer base."

Progress Supply has been a Johnson Controls wholesale supplier for many years and was named an ABCS wholesaler earlier this past summer as a result of Johnson Controls rearranging its distribution channels for Metasys. The company now has in-store support for all N-2 Metasys products in all three of their locations.

Progress Supply has wholesale stores in Cincinnati, Columbus and Dayton, Ohio, and serves HVAC and Controls customers in over 60 counties in Ohio, West Virginia, Kentucky and Indiana.