Selection & Service
Electric Stepper Valves

by David W. Jones

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Selecting an electric stepper valve for a refrigeration application, whether it is an ESV (Electric Stepper Expansion Valve) or an ESR (Electric Stepper Regulator), is much the same as selecting a standard valve. The laws of thermodynamics are not changed by the electric motor in the valve or the electronics controlling the valve. One still needs to know the system refrigerant, evaporator load, liquid temperature, desired capacity and pressure drop across the valve regardless if the valve is a conventional valve or a stepper valve.

While stepper valves are a relatively new technology for the refrigeration industry they have actually been around a number of years in various other industries. There is nothing complicated or mysterious about the valves. The stepper motor that drives the valve is like any other electric motor and should be thought of as such. It works, acts, and behaves like an electric motor, only it operates with a square wave instead of a sine wave like a standard AC motor. The average service technician is very familiar working with AC and DC electric motors so a stepper motor should not present any real difficulties once he is familiar with the correct service techniques.

As far as the refrigeration system is concerned there is no difference between a stepper valve and a conventional valve. The stepper expansion valve works the same way as a thermo expansion valve, controlling the evaporator superheat by regulating the amount of refrigerant in the evaporator coil. A stepper regulator works the same way as a conventional regulator does by opening and closing to control the evaporator pressure which in turn controls the evaporator temperature.

Stepper Motor Types

There are two types of motors used on these valves - unipolar and bipolar. The names refer to the direction of the current flow through the motor windings.

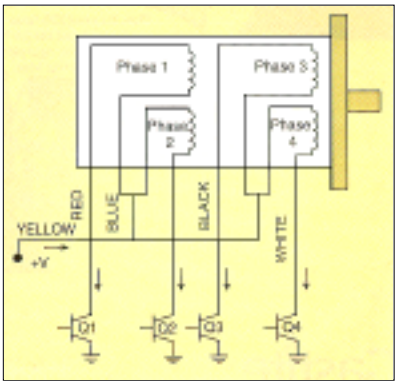

Figure 1. A unipolar motor/driver circuit diagram.

A simple unipolar motor with a simple drive circuit is shown in ***Figure 1***. As the transistors are turned on in pairs the current will flow from the positive terminal of the power supply through the motor winding, through the transistor to ground. As can be seen from the diagram the current can only flow through the motor windings in one direction. Since the current only flows in one direction, this means that the magnetic field, caused by the current flow, creates only one magnetic pole, hence the name unipolar.

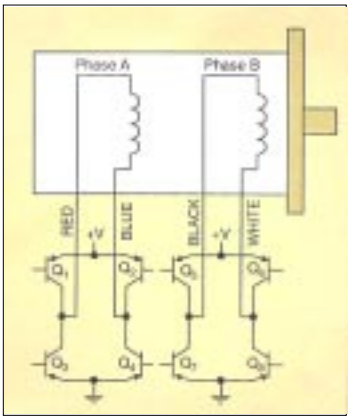

Figure 2. A bipolar motor/driver circuit diagram.

A bipolar motor with a simple control bridge circuit is shown in ***Figure 2***. By turning two transistors on at a time in each bridge circuit the direction of the current in each winding can be reversed depending on which transistors are turned on. Since the current can be reversed in each winding this means that each winding can create two magnetic fields, hence the name bipolar.

Stepper Valve Selection

When you select an electric stepper valve, there are two parameters you must take into account that aren't a concern when you're choosing a conventional valve. One of the two parameters is the type of motor the stepper valve has in it, either bipolar r unipolar. These are the two main types used in refrigeration valves at this time. The other parameter is the motor voltage. If either of these two parameters do not match the valve controller then the valve will not perform correctly.

The easiest way to identify which type of stepper valve is in the system is to count the number of terminals on the valve. A unipolar stepper motor valve will have five terminals and a bipolar stepper valve will have only four leads. At this time, the Alco ESV is the only valve that is using a unipolar motor. Both Alco and Sporlan 's electric stepper suction regulators use bipolar motors, but the current rating is very different between the two.

It is very important to know the type of motor the valve has and that the appropriate controller setting is selected.. For a stepper to work correctly in the system, the electronic controller must be setup for the type of valve motor it will control. A unipolar valve will run with a bipolar driver circuit and a bipolar valve will run with a unipolar driver circuit but in both cases the valve will run backwards to what the controller tells it to.

The voltage of the stepper valve and the controller must also match for the system to operate correctly. The correct voltage to the stepper motor valve is just as critical as it is for any electric motor. Too high or too low a voltage will cause problems with valve operation. The stepper valve will operate with the incorrect voltage under certain circumstances for short periods of time, but at some point it will fail completely.

If a 24 VDC stepper valve is operated with an electronic controller set for 12 VDC there will be a large reduction in valve performance. The torque of the motor is greatly reduced at lower voltages. With a loss of torque, the valve

will fail to operate at high pressures. The valve may not be able to move when necessary or if it does move it may skip steps due to the loss of torque. Either of these conditions will cause the controller to lose track of where the valve is, which will cause over all system problems.

If a 12 VDC stepper happens to be installed with a 24 VDC controller, several problems could arise. The current draw of the valve motor will be increased by about four times because of the difference in motor resistance. This increase in motor current can cause the components on the controller board to fail if they are not rated for this large of current. If the board components do not fail the life of the motor windings will be shortened due to the excessive current.

Competitive Replacement

Replacing one manufacturer's stepper valve with another manufacturer's is not as simple as replacing conventional valves but it need not be a complicated affair either. The service mechanic should be aware that in most cases the existing case controller could be used for both a Sporlan valve and an Alco valve. When converting from one manufacturer's valve to another there may be required changes that need to be made to the case controller. A hand held terminal may have to be used to change the valve parameters in the case controller software as well.

When replacing a Sporlan stepper regulator with an Alco stepper (or vice versa) the same wiring harness can be used since both valves are bipolar. The wire colors are the same except the Alco Blue wire is the same as the Sporlan Green wire. The other leads in the wiring harness can be connected color for color without any change in valve performance. The changes to the case controller will still have to be made for the valve to operate properly.

There is one exception to the above procedure and that is if an Alco stepper suction regulator replaces a Sporlan stepper suction regulator with a CPC controller. Due to the difference in current draw between the two valves the existing controller has to be changed out. Before doing this procedure, contact CPC and Alco Controls for the correct parts and procedure for doing this.

Replacing the Sporlan stepper expansion valve with an Alco stepper expansion requires the wiring harness to be changed out. This is because the Alco stepper expansion valve is a unipolar valve that requires a wiring harness that has five wires, while the Sporlan expansion valve is bipolar requiring only four wires. Once the wiring harness is changed out changes still have to be made to the controller to accept the new valve.

Troubleshooting

One problem that service technicians have with stepper valves is determining when they have a bad valve or a bad controller. The following are techniques that the serviceman can use to troubleshoot stepper valves with a Digital Multi Meter (DMM). These techniques were developed in Alco Controls' lab and in field tests using Alco stepper valves.

To determine the valve motor type and voltage, you can use the number of leads and the resistance of the windings.

Remember by counting the leads you can determine the type of motor. If the motor is a bipolar motor it will have four leads while a unipolar motor will have at least five leads. The voltage of the motor can be determined by measuring the resistance of the motor windings and then refer to the manufacturer's motor specs. A rule of thumb is a higher voltage motor will have much higher resistance.

If the valve motor type is correct and is matched to the controller then the following steps can be used to determine if the problem is with the valve or with the controller. Before starting the check out procedure, it is recommended that the DMM is set to the AC voltage setting even though the voltage rating for the stepper valve is DC. The DC setting will work with a unipolar valve but it will read zero when testing a bipolar valve so the recommendation is to use the AC setting on the meter to avoid any confusion.

The motor type must be known before using the following techniques. The voltage measurements for a unipolar motor are taken different than with a bipolar motor. The determination of motor type, as discussed above, is as simple as just counting the motor leads or terminals. A unipolar motor has at least five leads while a bipolar motor has four leads.

The following steps are used if the valve in question has a unipolar motor in it.

1. When measuring between the colored leads White and Black or Red and Blue a nominal voltage (rated motor voltage) should be read on the DMM.
2. Any measurements taken between the common lead (Yellow) and any other lead will give a voltage reading of ½ nominal voltage.
3. Any other lead combinations will not give a meaningful voltage reading.
4. If the DC setting is used with the DMM, the above readings will be the same, but the positive lead of the meter must be connected to the Yellow lead. On a stepper motor this lead is the positive voltage lead when the motor is running.

When troubleshooting a bipolar valve the following steps should be followed.

1. When measuring between the White and Black leads or the Blue (Green) and Red leads, the nominal motor voltage should be read with the DMM.
2. Other lead combinations will give half of the nominal voltage.

With the above voltage readings the serviceman should be able to determine is there is a controller failure or a valve failure. If the voltage to the motor is with the manufacturer's recommendation, then the valve can be assumed to be bad. If the motor voltage is outside of the manufacturer's recommendation, there is either a controller problem or a power supply problem.

Attention to detail and following the few simple steps enumerated here will ensure the satisfactory installation and, if necessary, replacement of these state-of-the-art valves.

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