Normally-open solenoid valves are usually held in the open position by gravity or a spring force. When energized, the power of the solenoid coil, acting on the plunger, pulls the valve pin on the valve port to close it.

Multiaction solenoid valves are available to accommodate many different flow configurations: (1) a common inlet three-way valve directs flow from a common inlet connection to one or the other of two outlet connections, (2) the four-way valve described in the section, Refrigerant Switching Valves. Design compromises usually result in having the ports of these direct-acting valves smaller (or the maximum operating pressure differential lower) than the equivalent normally-closed two-way solenoid valves. As a result, multiaction pilot-operated solenoid valves are used in most cases. Their use warrants careful application analysis, because the pressure differences required to shift and hold the valves may not exist under all operating conditions.

Selection

When solenoid valves are selected, proper consideration should be given to the following:

1. Basic flow configuration, such as two-way normally-closed three-way, etc.
2. Type of fluid to be handled.
3. Temperature and pressure conditions of the entering fluid.
4. Allowable fluid flow pressure drop across the valve that is needed to establish the port size for the required capacity.
5. Capacity in appropriate terms.
6. Maximum operating pressure differential under which the valve will be required: (a) to open, for the normally-closed valve, and (b) to close, for the normally-open valve. Three-way valves and four-way valves require additional information on the operating conditions for which they are required.
7. Safe working pressure. This should not be confused with the pressure difference under which the valve is required to open.
8. Type and size of line connections.
9. Electrical characteristics for the solenoid coil. Voltage and frequency must be specified for alternating current, but only voltage is specified for direct current.
10. Ambient temperature in which the valve will be located.
11. Hazard of location which may make explosion proof coil housings necessary.

Application

Conventional solenoid valves are made to be installed upright in horizontal lines only. Some solenoid valves are made to be installed in vertical lines or in any position; these valves are usually spring loaded.

Solenoid valves must be used with the correct current characteristics for which each one was designed. Momentary overvoltage is not ordinarily harmful, but sustained overvoltage of more than 10 percent may cause solenoid coils to burnout under unfavorable conditions. Undervoltage is harmful to alternating-current operated valves if it causes enough reduction in operating power to prevent valve opening when the coil is energized. This condition may cause burnout of an alternating-current coil, as discussed previously.

Whenever the solenoid valve is energized by a control transformer of limited capacity, the transformer capacity must be sufficient to provide proper voltage during the inrush load. Since the inrush alternating current may be several times the holding current, it is meaningless to check the voltage at the coil leads when only holding current is being supplied. For such applications, the inrush current in amperes, multiplied by the rated coil voltage, gives the necessary volt-ampere capacity which must be provided by the transformer for each solenoid valve simultaneously actuated. The inrush and holding currents of a direct-current solenoid valve are equal.

Where electrical supply lines for solenoid valves are protected by fuses, they should be sized according to the holding current and should preferably be of the slow blowing type.

When direct-current solenoid valves are installed, a capacitor or other device is wired across the coil leads to absorb or destroy the counter-voltage surge generated by the coil when the circuit is broken, in order to protect the coil insulation and the controlling switch. This is not considered necessary with low voltage direct-current coils.

Whenever it is necessary to reassemble the solenoid valve after installation, the magnetic coil sleeves (if required) must be replaced in their correct respective positions, to operate the valve properly. Leaving the coil sleeves out of an alternating-current valve may result in coil burnout.

In order to avoid valve failure due to low voltage, the solenoid valve coil should not be energized by the same contacts, or at the same instant that a heavy motor load is connected to the electrical supply line. The solenoid coil can be energized immediately before or after the heavy motor load is connected to the line.

Solenoid valves are used for the following applications:

a. *Refrigerant liquid*. In order to prevent flow of refrigerant liquid to the evaporator, a solenoid valve is installed in the liquid line just ahead of the expansion valve. The intended purpose may be: (1) to prevent flow of refrigerant liquid to the evaporator when the compressor is idle, (2) to provide individual temperature control in each room of a multiple system, or (3) to control the number of evaporator sections used as the load varies on a central air conditioning installation.

b. *Refrigerant suction gas*. In commercial type multiple systems, especially those having evaporators which contain a large amount of refrigerant, it is common practice to provide solenoid valves in the suction line from each unit or room, as well as in the liquid line, in order to isolate each evaporator completely. Otherwise, there would be migration of refrigerant gas from one evaporator to another, through the suction line, during the *off* cycle. This would result in uneven performance and possible floodback when the compressor starts again.

In applications (a) and (b), the solenoid valves are operated by two-wire or three-wire thermostats. The compressor may be operated by a low-pressure switch or directly by the thermostats. The compressor may or may not be operated on a pump-down cycle, which can be a continuous pump-down cycle or a pump-down and lock-out cycle.

c. *Refrigerant discharge gas*. In many of the hot-gas defrost applications, a solenoid valve, installed in a line which is connected to the discharge line between the compressor and the condenser, feeds the evaporator with hot gas which provides heat for the defrosting operation. The solenoid valve remains closed at all times except during the defrosting operation. A solenoid valve installed in a bypass around one or more compressor cylinders will provide compressor capacity control. Such a valve may be used to bypass the entire compressor output and thus reduce the compressor starting load where required.

d. *Water and other liquids*. Solenoid valves are frequently used to control the flow of water and many other liquids. Actually, water is generally considered to be one of the more harmful liquids because it tends to deposit solids on the internal solenoid valve surfaces and causes corrosion. For this reason, solenoid valves for water service should be of the type that can easily be dismantled and cleaned.

e. *Air*. Many air systems rely on the use of solenoid valves to operate controls or actuators. Since rapid cycling is often required, solenoid valves for air service should be selected with due consideration for endurance.

f. *Steam*. The application of solenoid valves in industrial steam systems is quite varied. Because of the continuous high steam temperatures involved, special high temperature solenoid coils are usually required. Careful consideration should be given to the ambient temperatures in which the valves are located.

Pilot Solenoid Valve Application

Pilot solenoid valves are used quite extensively in industry. A few applications pertaining to refrigerating systems are given here as examples.

Two-way, normally-closed, direct-acting pilot solenoid valves are used with: (1) a large, piston type, spring-loaded expansion valve to provide refrigerant liquid shut-off service, as shown in Fig. 10, (2) an evaporator pressure regulator to provide either shut-off service, or a pressure pilot selector, (3) a large, piston type, spring-loaded regulator to provide refrigerant gas shut-off service, and (4) four-way refrigerant switching valves on heat pump systems to accomplish cooling, heating, and defrosting.

Three-way, direct-acting, pilot solenoid valves are used to operate: (1) a cylinder unloading mechanism for compressor capacity reduction and (2) three-way and four-way reversing valves on heat pump systems to accomplish cooling, heating, and defrosting.

REFRIGERANT REVERSING VALVES

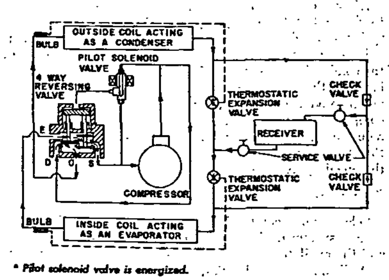
Refrigerant reversing valves are three-way or four-way two-position valves which are usually operated by pilot solenoid valves and are designed for reversing or changing the direction of refrigerant flow through certain parts of a refrigeration system. They are used on refrigerating and year-round air conditioning (heat pump) systems to control cooling, heating, and defrosting operations. Reversal from cooling to heating is the principal application, but temporary reversal may be used to defrost the heat exchangers.

Operation

Valves are usually operated by either a two-way or three-way pilot solenoid valve which may be an integral part of the reversing valve or a separate valve connected to the reversing valve by tubes.

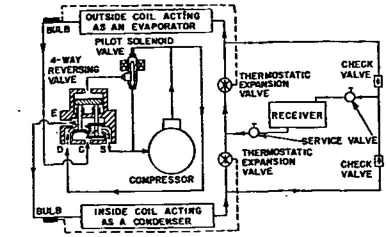
In general, the reversing valves currently available can be divided into the *poppet valve* group and the *slide valve* group. Although there are design modifications to be found within each of these groups, it is hoped that the following explanation will be sufficient to acquaint the reader with the general principles of operation.

The reversing valve connections to the refrigeration system may be made so as to cause the system to *fail-safe* on either the heating (defrosting) or the cooling cycle, in the event that the solenoid valve coil fails. This is done by making the proper choice in connecting the two line connections on the reversing valve to the inside and outside heat exchange coils.



* Pilot solenoid valve is energized.

Fig. 22 .... Four-Way Poppet Type Reversing Valve Used in Cooling Cycle of Refrigeration System*



* Pilot solenoid valve is de-energized.

Fig 23 .... Four-Way Poppet Type Reversing Valve Used in Heating (Defrosting) Cycle of a Refrigeration System*

A *four-way poppet reversing valve* is shown in the cooling cycle in Fig. 22 and in the heating cycle in Fig. 23. In Fig. 22 the three-way pilot solenoid valve is energized and the chamber above the reversing valve piston is connected to the compressor suction pressure, causing the piston to rise. In this position, the hot gas from the compressor follows the path D-C, and the cold gas from the evaporator follows path E-S.

In Fig. 23 the pilot solenoid valve is de-energized and the chamber above the piston is connected to the compressor discharge pressure, moving the piston downward. In this position, the hot gas from the compressor follows path D-E, and the cold gas from the evaporator follows path C-S.

After the reversing valve has shifted, the pressure differential across the piston is reduced by equalization to a low value, which is equal to the pressure drop through the valve, caused by the refrigerant flow. The valve is then held in position by the pressure drop across the closed valve poppets. If, for any reason, the reversing valve changes position during the shut-down period, it will return to the position last selected by the pilot solenoid valve when compressor operation is resumed.

A *four-way slide reversing valve* is shown in the cooling cycle in Fig. 24 and in the heating (or defrosting) cycle in Fig. 25. During the cooling cycle, the refrigerant flows through the system as indicated by the arrows in Fig. 24. Chamber C and chamber D are at equal pressures.

In order to reverse to the heating cycle as shown in Fig. 25 the pilot solenoid valve is energized, opening pilot port A and closing pilot port B, thereby bleeding chamber C to the suction line. The bleed hole in piston G, or the leakage around piston G, permits equalization of the pressures on both sides of the piston. The rate of gas flow out of chamber C through the pilot valve is greater than the rate of flow into chamber C through the bleed hole in, or leakage around, piston H. A pressure difference is created which develops enough force on the piston to cause the valve to reverse. When piston H reaches the end of its stroke, the valve pin F attached to it enters a port in the end cap of the reversing valve and seals off leakage of gas through the pilot solenoid valve. Thus pilot port A may remain open and gas will not be bypassed to the suction line through the pilot solenoid valve.

In order to reverse to the cooling cycle, the pilot solenoid valve is de-energized, closing pilot port A and opening pilot