Sequence Valves

The symbol for a sequence valve closely resembles the symbol for a relief valve, with one important exception: its downstream port does not go to the tank but directly to a second actuator. The purpose of this valve is to permit one actuator to move before a second one does; this is accomplished by feeding one of the lines to the second actuator through a sequence valve and setting sufficient tension on the sequence valve spring to ensure that the first cylinder operates first. Frequently, this process involves trial and error as one determines the maximum potential load on the first cylinder (Fig. 24). Since the valve is in an actuator line, a bypass check must be used for return motion, and it must be drained externally.

Counterbalance Valves

These valves are generally used on vertical cylinders where gravity tries to help the load pull the rod out of the cylinder. These valves hold back any load that tends to "over-haul" the cylinder and permit close control of the cylinder motion, without jerking. Again, the symbol closely resembles the symbol for a relief valve, but this valve is always in a cylinder line and requires a bypass check for return flow (Fig. 25).

Pressure-Reducing Valves

These valves are used to reduce pressure in a branch circuit while ensuring that high pressure is available elsewhere. From the graphical symbol you can see that the valve is nor-
nally open to begin with. Its pilot line is attached internally to the downstream port because it is trying to control downstream pressure. Upstream pressure may vary widely, but the valve will respond. The valve remains open until the downstream line reaches the desired pressure level (Fig. 26).

**Directional Valves**

These valves are the “traffic cops” of hydraulic systems, sending fluid to the proper location at the proper time. We will simplify the subject for this discussion by covering only the so-called “bang-bang”-type valves which have discrete operating positions, including the most common two- and three-position spool-type valves and the logic-type valves that serve the same purpose.

Understanding spool-type valves is easy if you know how they are named. In the most complicated case, the following information will be needed:

- Number of positions of spool
- Number of ways fluid can flow
- How operated
- Type of center on spool
- How spool centered

In general, spool-type valves are available as either two- or three-position. The two-position is used only when you do not wish to stop the cylinder in midstroke; the three-position is used when you do. To find the number of ways fluid can flow, count the large pipes hooked to the valve, but omit drain lines; generally, you will find P for pressure, T for tank, A & B for cylinder lines. With four connections, this valve would be a four-way. Methods of operation include manual, solenoid and pilot-operated, solenoid-controlled. Hydraulic valves can also be air-operated. In the early days of hydraulics, all valves were manually operated, which often brought the operator dangerously close to the work. Solenoid-operated valves safely distanced the operator from the work to manage the electrical controls that, in turn, operated the so-

lenoids. Pilot operation was devised because increasingly larger valves caused huge current draws on the large solenoid operators. Pilot operation involves using a small directional valve to operate a larger valve, with the pilot generally mounted on top of the main valve (Fig. 27).

Directional valve spools are usually designed for either P to A/B to T, or P to B/A to T flow patterns in the two end positions. The centers of three-position spools are cut in different ways, depending on what the designer wants to happen during the interval when the valve is in center (rest) position. Figure 28 is a partial list of some of the centers which

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**Fig. 26** Pressure reducing valve.

**Fig. 27** Solenoid controlled pilot operating valve (Courtesy of Vickers, Inc.).

**Fig. 28** Various center conditions for four-way valves (Courtesy of Vickers, Inc.).
can be obtained from most manufacturers; many others, not shown, are also available. Figure 28 also offers some of the reasons for using a particular center. Two-position spool valves generally use the same spool as three-position valves, but the center position is not used because the spool never stops in that position.

If a solenoid is present on both ends of a directional valve, it is tempting to think of it as a three-position valve. Sometimes, however, this is not true, as with detented valves (Fig. 29). In the normal design, "bang-bang"-type valves receive a constant electrical signal that keeps a solenoid energized for the duration of an operation. Sometimes, however, with equipment using sequenced operation, it is necessary to send a signal to a solenoid, then discontinue it immediately, but keep the valve in the position dictated by the signal. This calls for a "detented" valve and requires some sort of mechanical device inside the valve that will hold the spool where last positioned. When the signal is removed, the spool will "stay put" without centering springs, but flow forces and vibration will soon cause it to shift at the wrong time. It is important to know that the only way to distinguish a detented from a standard three-position valve is the manufacturer's model number; a particular letter or number will indicate "detented."

Two-position valves are easy to identify, having a solenoid visible only on one side. A spring on the other side is hidden behind a plate.

**Check Valves**

Check valves are also classified as directional valves, because their usual function is to permit flow in a single direction. At times, however, a certain minimum pressure must be available in a circuit as pilot pressure for shifting the main section of a directional valve; check valves lend themselves readily to this purpose. By changing the light spring to one matching the required pressure (usually 65 psi) and reversing the check in a tank line (Fig. 30), the required pressure can be maintained. This becomes especially important when the main directional-valve spool is tandem or open-centered. With that type of center, all pressure is lost when the main valve passes center, and nothing is available for shifting unless the reversed check (or similar device) is present in the tank line.

![Check Valve Diagram](image)

**Fig. 30—Pilot pressure check valve**
(Courtesy of Vickers, Inc.).

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Third installment in a series based on Section 10 of the *Lubrication Engineers Manual*. The next installment will appear in the June 1998 issue of *Lubrication Engineering*.