Lesson Eight — Specialized Valves

Preface

Plant surveys indicate that the following valves are most frequently found in industrial plants in this order (by quantities used): (1) gate valves; (2) globe valves; and (3) check valves. These are "common" valves in the sense that they are most commonly used. Other valves are considered to be more specialized because of their less frequent use.

Specialized valves include diaphragm valves, relief valves, regulating valves, and blowoff valves. Because many valves are power-operated, the basic operating mechanisms are explained in this lesson.

Construction and Materials

8.01 Before reading about the various valves described in this lesson, you should know that they, like common valves, are furnished in a wide variety of sizes and materials. The materials used are those which provide strength where needed, resistance to corrosion and pressure, and resistance to the effects of temperature.

8.02 Although the construction and operating principles of some of these valves differ from those of the valves covered in Lesson Seven, the basic principles remain the same. That is, specialized valves control fluid flow and regulate it by means of ports and passageways in the valve body, which are opened or closed by some type of closing element.

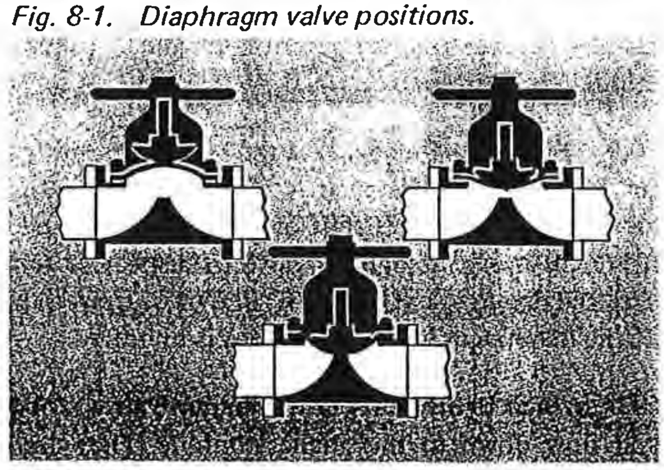
Diaphragm Valves

8.03 The advantages of a DIAPHRAGM valve are best understood after a brief review of the construction of several valves discussed in Lesson Seven. In gate, globe, plug, ball and needle valves, the closing element is in the body of the valve, and designed to let the fluid pass or not pass. The closing element is turned by a valve stem to which it is attached. To prevent the fluid from leaking out along the valve stem, a stuffing box or seal is used. The valve stem goes far enough into the body of the valve to come into contact with the fluid.

8.04 A diaphragm valve uses a flexible disc, or diaphragm, as the closing element. See Fig. 8-1. The diaphragm is a wall, or partition, positioned in the valve body slightly above the opening which the fluid passes through as it goes through the valve. Closure is obtained by pressing the diaphragm tightly against the body, as shown.

8.05 Figure 8-2 is an exploded view of the valve itself. Note that the closing mechanism used to move the diaphragm is completely separated from

Fig. 8-1. Diaphragm valve positions.



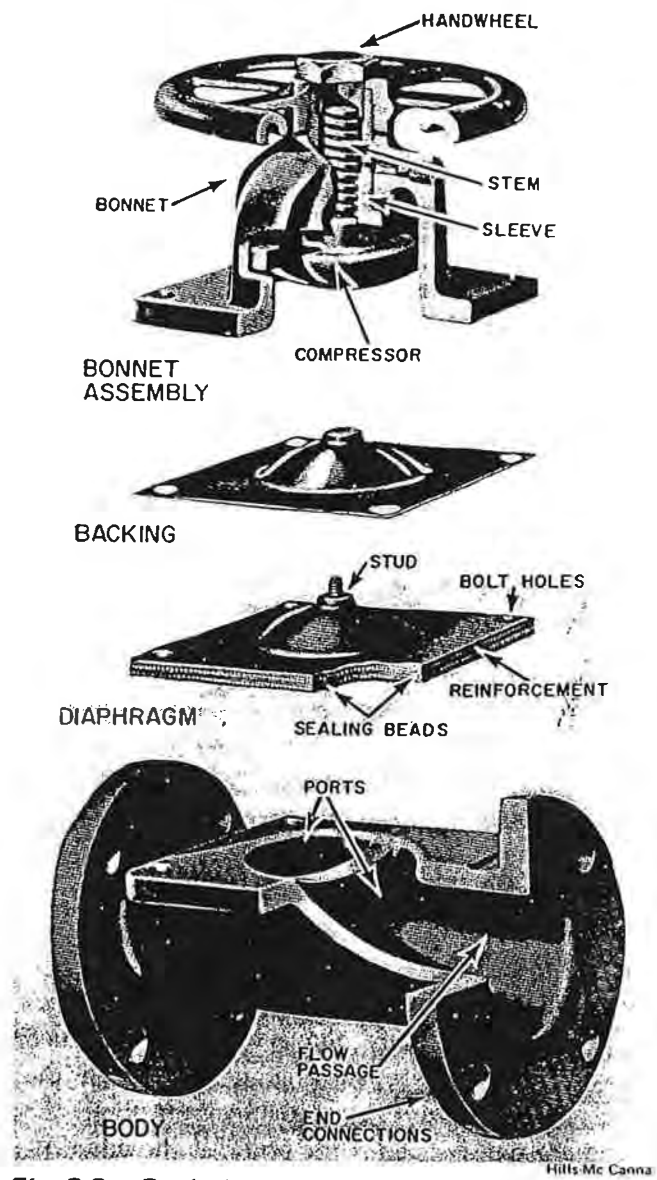


Fig. 8-2. Exploded view of diaphragm valve.

the fluid by the diaphragm. For this reason, this mechanism (the bonnet assembly) does not need conventional valve stem packing material. This is a definite advantage over valves that require such packing, because packing deteriorates and requires periodic replacement.

8.06 Note from Fig. 8-1 that the bonnet assembly and diaphragm are fastened to the valve body with the same bolts. Always shut off and drain the line BEFORE disassembling the valve to inspect or replace the diaphragm. Otherwise, line pressure could lift the diaphragm when the bonnet is unbolted.

8.07 When tightly closed, diaphragm valves stop fluid flow down to the smallest bubble. They are completely droptight, and are well suited to service where tight, accurate closure is important. The tight seal is effective whether the fluid is a gas or a liquid. Because of the flexible construction of the diaphragm, and the means of pressing it firmly against the valve body, a tight seal is obtained even after the valve has served for considerable periods of time with corrosive or scale-forming water. The tight seal is not lost even after the diaphragm has some pitting, corrosion, and tuberculation.

8.08 Diaphragms may be made of any one of a number of materials resistant to the particular fluids being transported. The valve body itself may be made of glass, plastic, or other material fitted with a soft rubber lining. These valves can be used in very severe chemical or abrasive services. Typical examples of abrasive materials are: alumina, sand, cement, fly ash, lime, gravel, and airblown powders. The extremely tight closure feature makes these valves useful in vacuum applications in electronic component manufacturing, pharmaceutical (drug), and chemical processing. The separation of the bonnet assembly from the fluid line means that lubricant or dirt from that source cannot get into the fluid. This makes diaphragm valves excellent for use where the fluid must be kept contaminant-free.

8.09 Diaphragm valves range in size from 1/2 inch to 16 inches, with screwed or flanged ends available in sizes up to 3 inches, and flanged ends only in the 4 inch to 16 inch types. Working pressures range up to 125 psi in the small valves, and to 50 psi in the 14 inch to 16 inch sizes. There are several thousand types of diaphragm and valve body materials available. Valve operation is varied – valve wheel, quick-opening lever, and mechanical power systems. (Power operators are covered later in this lesson.)

Blowoff Valves

8.10 BLOWOFF valves are used most often for steam boiler applications. They have three functions: (1) they permit use of boiler pressure to blow off or blow down a portion of boiler water. This process removes suspended solids and impurities; (2) they provide a way of rapidly lowering the water level in the boiler when necessary; and (3) following boiler cleaning operations (done by adding cleaning acid to the condensate water entering the boiler) the blowoff valve serves to clear the acid solution out of the boiler before it is put back into normal operation. Blowoff valves are located at a low point in the boiler water system.

8.11 There are three types of blowoff valves: (1) SEATLESS, SLIDING PLUNGER; (2) SLIDING DISC, or NONWEDGING GATE; and (3) SEAT-and-DISC, or HARD SEAT. A fourth variety is any combination of two valves in a common body. The seatless, sliding-plunger valve, for example, can be combined with a seat-and-disc valve.

8.12 When boilers operate at pressures of 100 psi or more, boiler codes require that each bottom blowoff pipe have either two slow-opening blowoff valves, or one slow-opening valve and one quick-opening valve. Usually the valves are operated by levers or handwheels. A slow-opening valve requires at least five full (360°) turns of the handwheel to change from full-closed to full-open. Open the slow-opening valve first under normal operating conditions, as it ensures starting the blowoff operation slowly to prevent shock to the system. The quick-opening valve is used for only quick drainage and emergencies.

8.13 The SEATLESS, SLIDING-PLUNGER blowoff valve is shown in Fig. 8-3. As shown, this valve is in the closed position. Input is from the right, output is down through the bottom of the valve. The bottom section of the plunger, positioned BELOW the input portion of the valve, has open ports in it. The valve is opened by turning the handwheel, which raises the plunger until the ports are opposite the valve inlet port. The fluid blown off is discharged down the inside of the plunger. NORMALLY, CLOCKWISE ROTATION of a handwheel CLOSES the valve. The plunger valve is classified as a slow-opening valve.

8.14 Figure 8-4 shows a QUICK-ACTING SLIDING-DISC blowoff valve. This one is lever-operated. The flow is blocked when the solid face of the disc is positioned across the passageway in the body of the valve. The valve is opened by rotating the disc until a hole in it, at one side, is moved into position in place of the solid face. Because a quick-opening valve does not provide a positive shutoff, it should always be used in the line with a slow-opening valve, which does provide a positive shutoff.

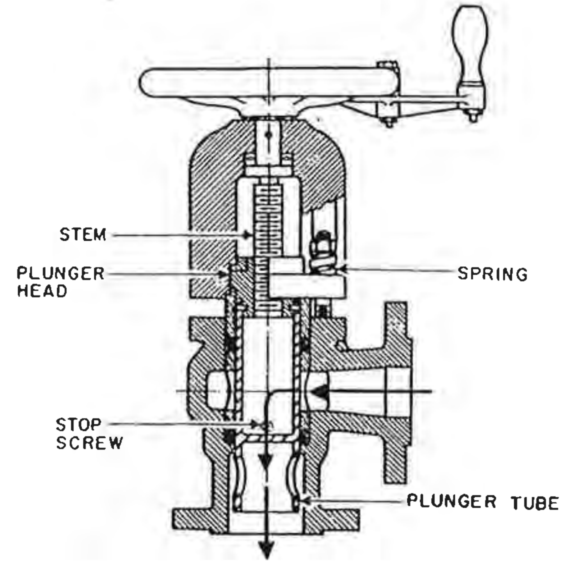
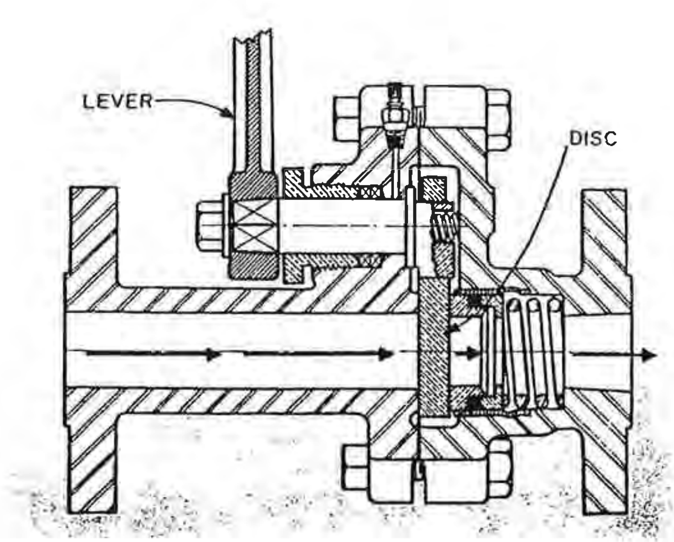


Fig. 8-3. Seatless, sliding-plunger blowoff valve.

8.15 The SEAT-and-DISC blowoff valve is used on higher pressure boilers. Shown in Fig. 8-5, it is the horizontal valve in what is called a unit-tandem valve assembly. The vertical valve in this drawing is a seatless-plunger type. The seat-and-disc valve has a rising, rotating stem. The disc is attached to the bottom of the stem, and is free to rotate. It mates with the valve seat in the body of the valve. Both the disc and body seat have hard-faced seating surfaces.

Fig. 8-4. Sliding-disc blowoff valve.



8.16 In the tandem valve assembly shown in Fig. 8-5, BOTH valves operate on the same input flow. Both are slow-opening valves. In other tandem valve assemblies, you might find one slow-opening and one quick-opening valve. In either case, a tandem unit provides a compact unit which is easy to operate.

8.17 Blowoff valves are usually manually operated by handwheels or levers. Some blowoff valves are made with INTEGRAL SEATS. This means that the seat is a built-in part of the valve body, not a separate part inserted in it. Some valve seats are threaded into the body of the valve, and are sealed either by a gasket or by a seal weld. An integral seat is made by depositing a hard-facing material directly in the body of the valve. A hard material called STELLITE is commonly used.

8.18 When such a seat starts to leak, the seating surface can be recut or reground while the valve remains in place in the pipeline. This eliminates the need for breaking pipe joints, and reduces the frequency of leaks. When the valve is beyond the point of maintenance by recutting or regrinding, the seat must be refaced.

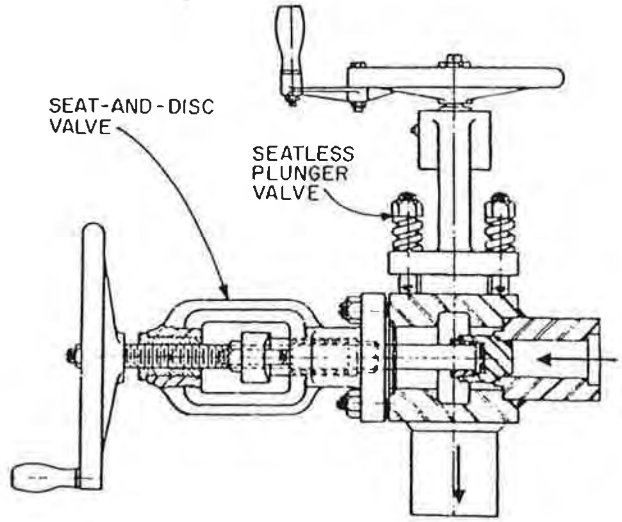


Fig. 8-5. Seat-and-disc blowoff valve, horizontally mounted in unit-tandem valve assembly. (The vertical valve is a seatless-plunger type.)

8-1. The closing element of a diaphragm valve is a __________ disc.

8-2. In a diaphragm valve, the closing element is totally __________ from the fluid.

8-3. Diaphragm valves are well suited to service that requires tight, accurate closure because they are __________.

8-4. Blowoff valves are used most often in ________ __________ applications.

8-5. In boiler water systems, blowoff valves are located at a __________ point.
(high/low)

8-6. A slow-opening valve requires at least ______ complete turns of the handwheel to change from full-open to full-closed.

8-7. Which valve in a system having one slow-opening and one quick-opening valve is opened first?

____

8-8. When an integral valve seat can no longer be recut or reground, it must be __________.

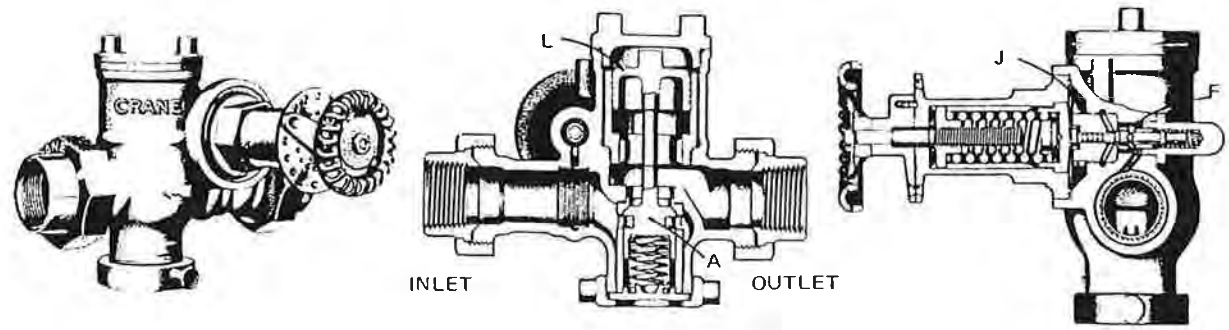


Fig. 8-6. Pressure-regulating valve.

Pressure Regulator Valves

8.19 PRESSURE-REGULATOR valves do just what their name suggests. They regulate pressure in a fluid line, keeping it very close to a preset level. If the demands of a steam or compressed-air line remained steady at all times, no regulator valve would be needed. This ideal condition does not occur, however. Flow demand varies with many factors, such as the number of pieces of equipment in operation, and the change in demand as pumps and equipment warm up. All along the fluid line the demands are continuously changing. Efficient operation requires keeping a constant pressure level.

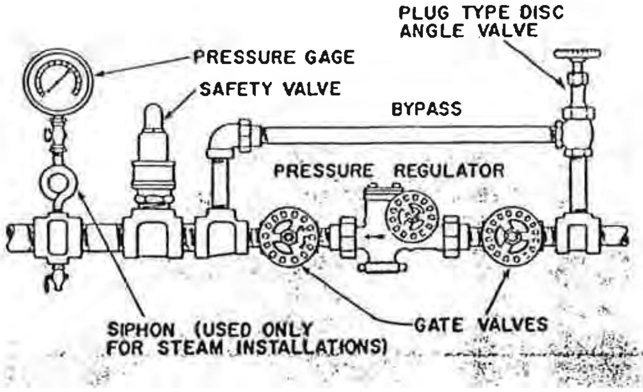
8.20 Pressure-regulating valves are used in both gas and liquid lines. The operating principle is much the same for both types of service. The valve is set to monitor the line, and make needed adjustments on signal from a sensing device.

8.21 Figure 8-6 shows one type of a pressure-regulating valve, and cross section views of such a valve. Although it may seem more complicated than most of the valves, it is actually just a combination of valve types that you have already learned about.

8.22 What you see is really TWO valves that interact with each other. One half is the MAIN VALVE-and-PISTON ASSEMBLY. The other is the AUXILIARY VALVE ASSEMBLY shown at the right. Each of these two assemblies has TWO valve elements that act in opposition to each other. That makes FOUR valve elements in all. ONE of these elements, in the auxiliary valve assembly, is set by the handwheel, and controls the operation of the other three elements as pressure in the fluid line varies. The maintenance man or valve operator sets the controlling valve element in the auxiliary valve assembly. After that, the element set by the handwheel takes over and runs the show. This is the total picture of the regulating process.

8.23 The two pairs of valve elements that are joined together are: the disc valve A and piston L in the main valve assembly; and the diaphragm J and auxiliary valve F in the auxiliary valve assembly. The inlet pressure serves to depress piston L and therefore, open disc valve A. The outlet pressure operates on diaphragm J and thereby on auxiliary valve F, controlling the inlet pressure to piston L. To put it briefly, the OUTLET pressure determines the extent to which the INLET pressure can get at piston L and open the main route through the valve. Use of outlet pressure to control inlet conditions is called FEEDBACK. Through the interacting valves described, both the inlet pressure and the fluid flow through

Fig. 8-7. Installation of pressure-regulating valve.



Crane Co.

the valve are controlled by the pressure from the valve outlet.

8.24 In actual use, pressure-regulator valves are selected to react to a pressure value that is about 50 percent of the maximum flow that could pass through them. Figure 8-7 shows a pressure regulator in a pipeline. Note that there is a gate valve on each side of the pressure-regulating valve. You can also see other valves already described.

Temperature-Regulating Valves

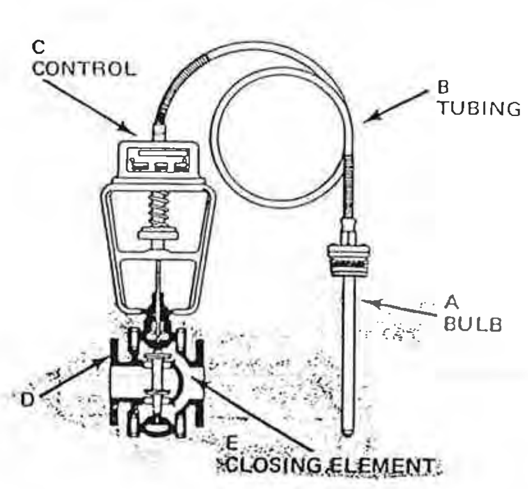
8.25 A TEMPERATURE-REGULATING valve is a close cousin of the pressure-regulating valve. Its purpose is to monitor the temperature in a line or process-solution tank, and to regulate it (raising or lowering the temperature as required). They are also referred to as THERMOSTATIC CONTROL valves.

8.26 Figure 8-8 shows one type of temperature-regulating valve. It consists of a Bulb (A), Tubing (B), a Control mechanism (C), and the Valve Body (D). The control unit C includes a Thermostat, which is an automatic device for regulating temperature. As the temperature drops below the required level (or exceeds it), the thermostat sends a signal. The valve opens or closes accordingly—under control of the spring-loaded closing element (E).

Safety Valves

8.27 SAFETY valves, like RELIEF valves, and the combined form SAFETY RELIEF valves, react

Fig. 8-8. Temperature-regulating valve.



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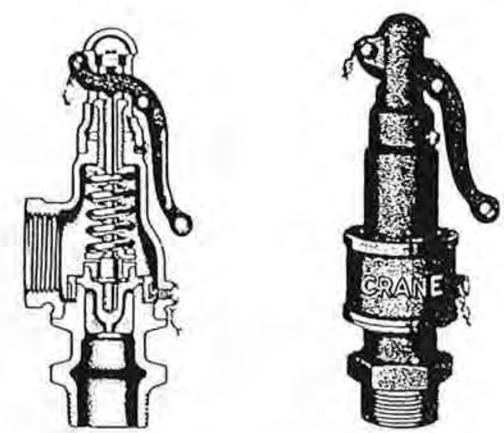


Fig. 8-9. Pop safety valve.

to excessive pressure in a piping system. They provide a rapid means of getting rid of that pressure before a serious accident occurs. The term SAFETY valve usually refers to valves used with gases and steam. RELIEF valves are used with liquids. In both cases the general design is a heavily spring-loaded disc valve that opens in response to excessive pressure.

8.28 In a SAFETY valve, the gas or steam is vented to the air through a large discharge pipe. These valves come in a wide variety of sizes, depending on the overall size of the piping system they are protecting. (The one shown in Fig. 8-7 is a relatively small one.)

8.29 POP safety valves, such as the one shown in Fig. 8-9, are used with gases and steam. These valves function by "popping" wide open at a preset pressure. Pop valves remain open until pressure in the vessel or line has dropped back to a second pressure, slightly lower than line pressure. Then the valves snap shut instantly. Such valves are equipped with a "huddling" chamber, where the steam collects. This chamber is adjustable to permit regulating the valve popping pressure, and the amount of blowdown when it pops.

8.30 Normally, pop valves have drain holes on the discharge side to drain condensate. This is not true where the potential release of poisonous or inflammable gases is involved. Figure 8-10 shows a pair of large safety valves and their individual discharge pipes. From the sizes of these valves, and the rugged springs used to keep them closed under normal conditions, it is evident that they are used in a high-pressure system.

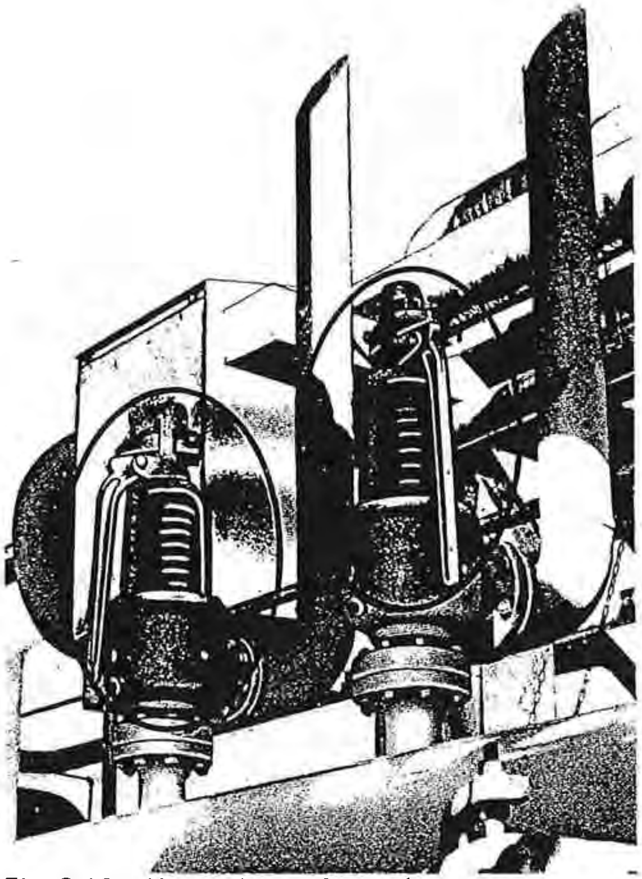


Fig. 8-10. Heavy-duty safety valves.

Relief Valves

8.31 RELIEF valves are used with liquids. Such valves start to open at a preset pressure, but require 20 percent over-pressure to open wide. As the pressure increases, the valve opens farther until it has reached its maximum travel. As the pressure drops, it starts to close and shut off at about the set pressure.

8.32 Figure 8-11 shows how such valves are constructed. Input is from the bottom of the valve. Pressure works against the disc, normally kept seated by the spring above it. The valve opens because the pressure has become great enough to overcome the resistance of the spring.

8.33 For use with hot water tanks and heaters, relief valves responsive to temperature as well as pressure are available. Safety and relief valves are used with saturated steam, air, gas, vapor, and liquids. Safety relief valves are used for all process applications.

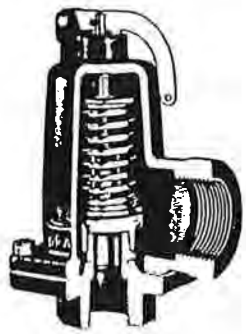


Fig. 8-11. Relief valve.

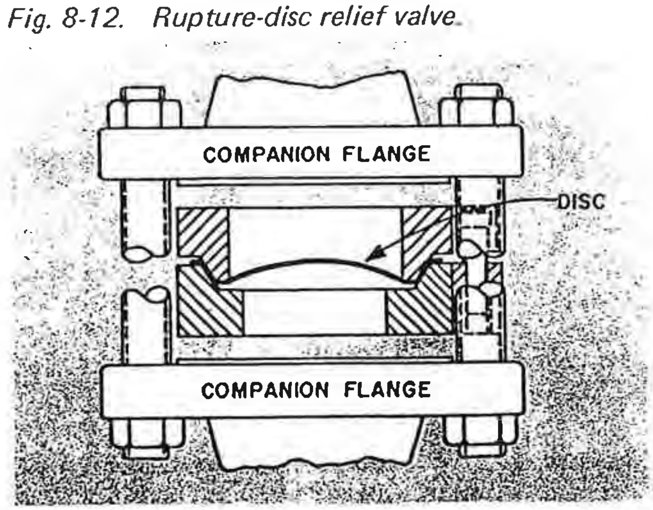
Rupture-Disc Relief Valves

8.34 The RUPTURE-DISC relief valve is another type of relief valve. As shown in Fig. 8-12, this valve is much like a diaphragm valve without a bonnet or control mechanism. Its particular advantage is that it can quickly relieve large volumes of gas or liquid. The disc itself is held in place by flanges. Usually the disc is made of metal and designed to open at a preset pressure. Once open, the valve stays open because the disc has been ruptured. Common disc materials are aluminum, stainless steel, and copper. A gate or plug valve is commonly installed to shut off the line once the valve has opened.

Reducing Valves

8.35 The purpose of PRESSURE-REDUCING valves is to maintain a constant level of reduced pressure in a piping system that is supplied from a higher pressure source. In practice, they are very much like pressure-regulating valves. A pressure-reducing valve reduces pressure by throttling the

Fig. 8-12. Rupture-disc relief valve.



fluid flow. Like the pressure-regulating system, a reducing valve installation includes valves on either side of the reducing valve and a safety valve.

8.36 In high-pressure power plants, steam purity is essential to maintain peak efficiency, and to minimize piping and turbine maintenance. Because impurities in a fluid line can damage the system, power plants use special instrumentation to detect very low amounts of dissolved solids. Such instrumentation requires foolproof pressure reduction in order to do its detective work properly. Figure 8-13 shows a high-pressure reducing valve system, ordinarily installed between the high-pressure steam line and the instrumentation. Steam from the line passes through the high-pressure valve at the left, then into the changeover unit at the right. The pressure in the line can, of course, be shut off by the valve as necessary when the changeover unit is to be inspected for wear or sludge.

Other Valves

8.37 You now have a knowledge of the most common valves found in nearly all types of plant facilities. In addition to those which you have studied, you may work with other valves, although for the most part, they are variations of the valves covered in Lessons Seven and Eight. Examples include BYPASS valves, which are used to carry the flow around or past the point in the system through which the fluid normally passes. A typical application for a bypass is a steam line, where the bypass carries steam to warm up the line before the main valve is opened. The bypass also helps balance the pressure on both sides of a main valve, which makes it easier to open.

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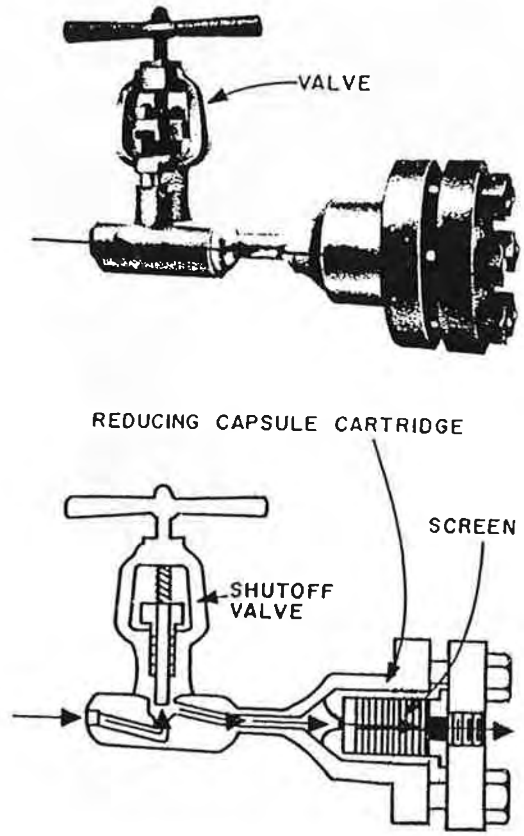

Fig. 8-13. High-pressure reducing valve system.

8.38 A FLOAT valve is one that is controlled by an arm attached to a ball float which rises or falls according to liquid level. A PILOT valve is a small valve used to operate a larger one. A SLURRY valve has a lever-operated knife-edged disc that holds back the solids in a fluid. A THREE-WAY or FOUR-WAY valve has three or four ports. The designation O S & Y valve refers to a type of valve stem and screw and means "Outside Screw and Yoke." All such valves, however, are similar in construction and operation to those you know about now.

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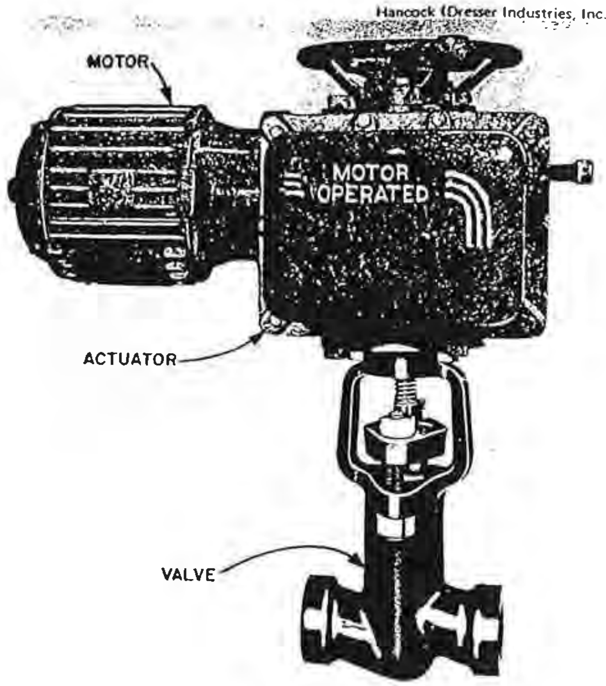


Fig. 8-14. Electrically powered valve actuator.

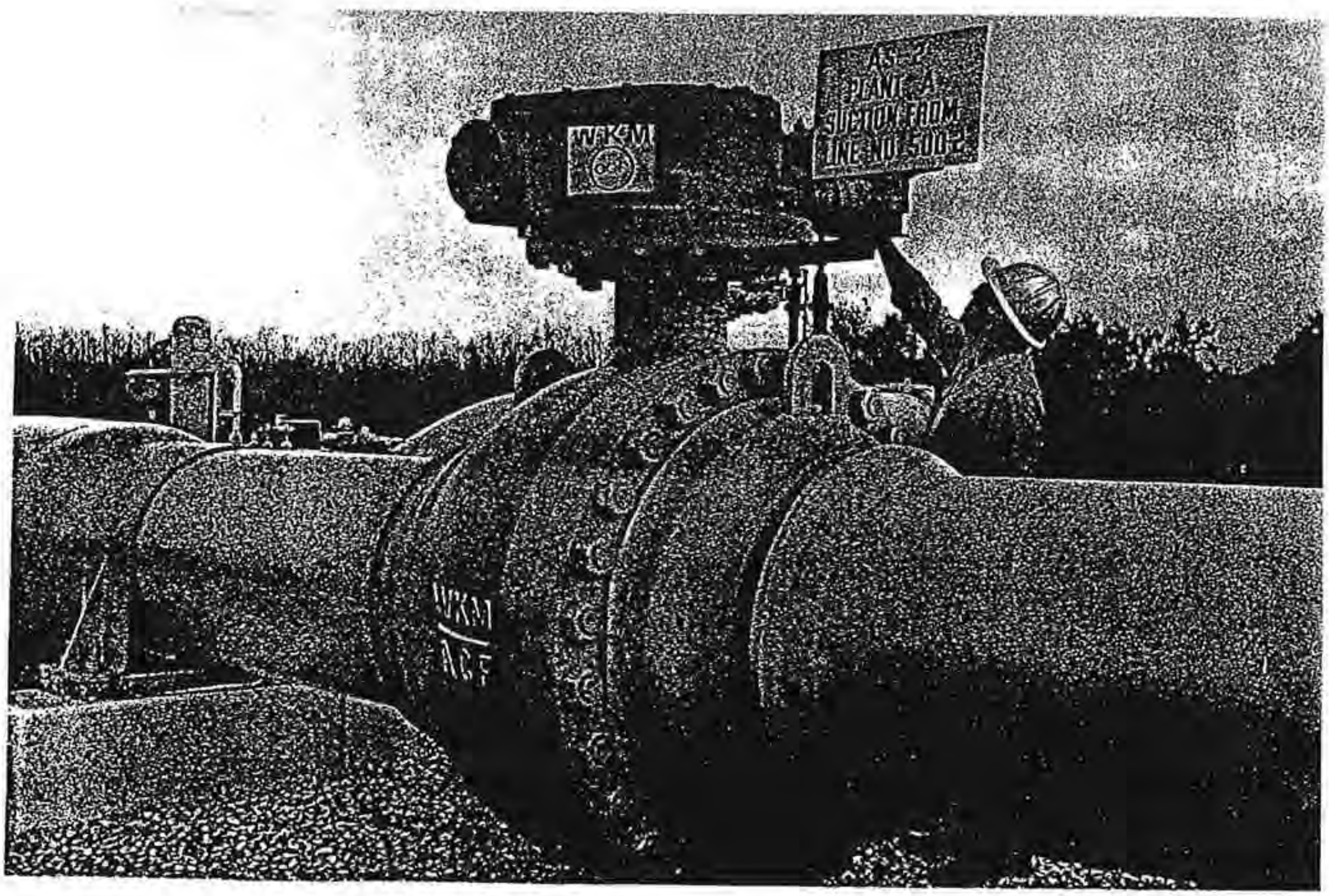
Valve Operators

8.39 In today's automated industries and central control stations many valves are mechanically operated, and powered by electric, air, or gas-powered devices called ACTUATORS or OPERATORS. An electrical device is shown in Fig. 8-14. Reduction gears link the motor to the valve stem. The motor itself must be equipped with electrical limit switches, which shut the motor off when it has turned the valve as far as it can go in a given direction. (If an electric motor is forcibly prevented from turning when current is flowing through its field coils, the coils can burn out rapidly. Usually a protective device is installed to prevent this.)

8.40 The mechanical operator shown in Fig. 8-14 has a handwheel for controlling the valve when the power fails. Figure 8-15 shows a large ball valve in an outdoor pipeline, with an electric operator mounted on top of it.

8.41 Electric motors, plus reducing gearboxes, are used for valve stems that must be rotated. For a lever-operated valve, the mechanical operator must provide a backward and forward motion. Magnetic, hydraulic, and pneumatic operators are used.

Fig. 8-15. Ball valve installation with mechanical actuator.



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Magnetic Operators

8.42 MAGNETIC OPERATORS use SOLENOIDS. A solenoid is a coil of wire in the shape of a doughnut. When a bar of iron is put inside an energized coil, it moves along the coil because of the magnetic field that is created. If the plunger (iron bar) is fitted with a spring, it returns to its starting point when the electrical current is turned off. Solenoids are used as operators for many types of valves.

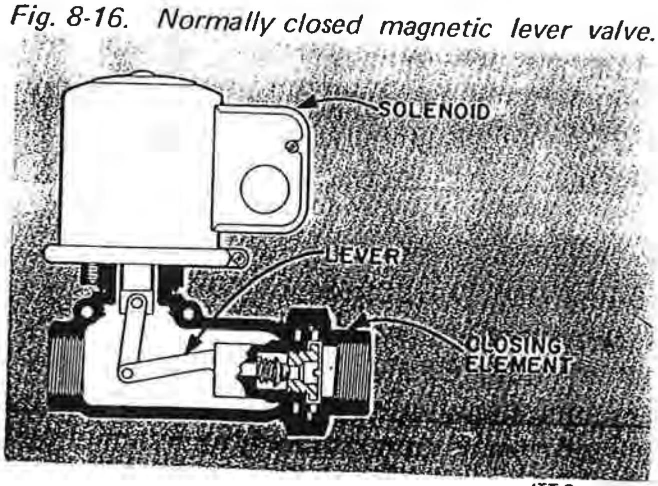
8.43 In a DIRECT-OPERATING valve, the solenoid plunger is used in place of a valve stem and handwheel. The plunger is connected directly to the disc of a globe valve. As the solenoid coil is energized or deenergized, the plunger rises or falls, opening or closing the valve.

8.44 The valve in Fig. 8-16 is lever-operated. The moving power for the lever is a solenoid. This valve is a normally closed valve. The mechanical linkage can, of course, be set to open a normally closed valve or to close a normally open valve.

Pneumatic and Hydraulic Operators

8.45 Figure 8-17 shows a pneumatic ball-valve actuator. (A hydraulic valve operator is much the same in appearance and works in much the same way.) The cylinder assembly is attached to the ball-valve stem close to the pipe. A piston inside the cylinder can move in either direction. The piston rod is linked to the valve stem, opening or closing the valve, depending upon the direction in which the piston is traveling. As a "failsafe" feature, some of these valves are spring-loaded. In case of air or hydraulic pressure failure, the valve operator returns the valve to the safe position.

Fig. 8-16. Normally closed magnetic lever valve.



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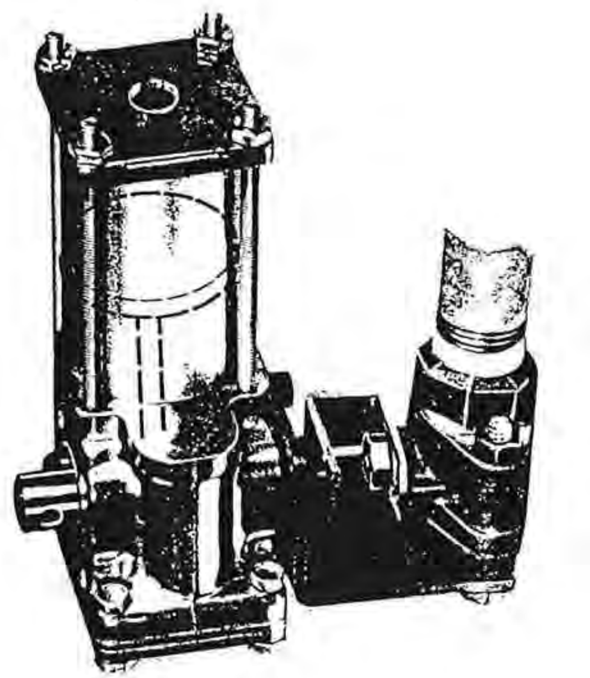

Fig. 8-17. Pneumatic-cylinder actuator for ball valve.

Remote Control

8.46 A man operating a valve at a position some distance from the valve actuator can easily control the actuator, by controlling the valve to which the actuator is attached.

8.47 An example of how such a system works follows: A temperature-controlled valve is submerged in a process solution that must be kept at a certain temperature. If the solution overheats, it is cooled by cold water circulating through coils of tubing in the processing tank. Assuming that a thermostat in the solution detects overheating, an electrical circuit closes, and a solenoid becomes energized. It operates a pneumatic valve that provides compressed air to a distant pneumatic actuator attached to a ball valve in the cold water line. When the valve is opened, cold water flows through the coils in the process solution, and the temperature drops. When it reaches the correct temperature level, the thermostat detects the proper level and deenergizes the solenoid. The distant pneumatic actuator turns the cold water off again.

8.48 Credit for the success of the system belongs in part to the people who designed the system. Credit for having it all work as designed belongs to the informed maintenance craftsmen who keep the system in top condition.

8-9. Name the type of valve used to keep line pressure at a preset level.

____

8-10. Use of outlet pressure to control inlet pressure is called ________ control.

8-11. Pressure regulating valves are set for about ___ percent of the maximum flow that can pass through them.

8-12. Temperature-regulating valves are also referred to as _______ _______ valves.

8-13. The term safety valve usually refers to valves used with ______ and ______.

8-14. The particular advantage of rupture-disc relief valves is that they quickly relieve _______ volumes of fluid.

8-15. A small valve used to operate a larger one is a _______ valve.

8-16. The designation OS + Y means ________ _______ and ______.