Lesson Nine — Strainers, Filters, and Traps

Preface

Filters, strainers, and traps are piping system components designed to help protect the system from the harmful or undesirable effects of both solid and fluid impurities. Because of the considerable variety of materials carried by piping systems, there is an equal range of choices in protective devices.

This lesson describes the basic designs of filters and strainers, which remove solid particles from fluid lines. Traps are described because of their importance and use in piping systems. They are used to remove unwanted condensate and air from steam lines. (It has been estimated that over 75 percent of all plant facilities in the United States make use of steam in some application.) The major maintenance considerations of these protective components are also explained.

General Applications

9.01 Although you may think of filters, strainers, and traps in terms of specific systems, the basic principles apply in many systems. The examples used in this lesson include applications found in almost every plant: hot and cold water lines; steam lines; lubricating lines; and pneumatic (air) and hydraulic lines.

9.02 Two such systems are those that carry hot and chilled water for heating and air conditioning, and lines that carry fluids for various process applications. Any kind of contaminant in these lines is potential trouble that must be removed. Pipes can become clogged, thereby causing greatly increased friction and lower line pressure. Solid particles score pipe and tubing walls, making thin spots that can break open under pressure and cause leakage. They may also damage fittings, valves, seals, and pump components.

9.03 Solid particles in a high-pressure line can damage a valve in two ways: (1) by clogging the valve so it cannot close tightly, and (2) by wearing away the closely machined valve parts. In a piping system, where pressures must be closely controlled, the valves cannot function properly when solid particles are present.

Strainers

9.04 A STRAINER is a device made of wire mesh screens, which remove solid particles from a fluid. Strainers are used in pipe lines carrying water, air, gas, oil, steam, and nearly any other

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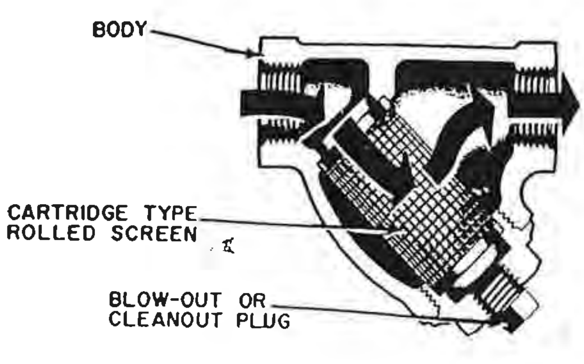

Fig. 9-1. Cross-section view of a typical strainer.

fluid carried by pipes. As a rule, strainers are installed ahead of valves, pumps, regulators, and traps to protect them against the damaging effects of contaminants.

9.05 A common design uses two screens, cylindrical in shape, one inside the other, and separated by a small space. The inner cylinder is a coarse-mesh screen; the outer one is a fine-mesh screen. The fluid passes first through the coarse screen, which catches the larger particles. Then it passes through the fine-mesh screen, which blocks smaller particles. Then the fluid passes back into the line. Figure 9-1 shows the construction of a strainer. Particles in the fluid are caught in two ways. Either they do not make it through the screen, or they do not make the sharp turn that the fluid must take as it leaves the unit. The bottom of the unit serves as a sump or pot where the solids collect.

9.06 Note the blowout or cleanout plug at the bottom. The unit can be cleaned out easily, at intervals, by two different procedures: (1) the cleanout plug can be removed, and the pressure in the line can be used to blow the fixture clean; or (2) the large retaining nut at the bottom of the fitting can be removed, permitting the cartridge to slide out for cleaning or replacement. It is important, of course, that the valve system in the line permit shutting off the line first.

9.07 It has been estimated that at least 50 percent of the solid impurities in fluids in closed circulating systems are FERROUS, meaning that they contain iron. When the fluid is water, iron pipes are almost certain to be in the line somewhere between the reservoir and the plant. Old systems acquire scale. New systems may contain metal chips, mill scale, or weld splatter.

9.08 Mill scale is the thin layer of iron oxide formed during the manufacture of pipes. As rust develops inside the pipe, small flakes of scale break off. They are also broken loose by mechanical shocks, or by the expansion or contraction of the pipe. Strainers get rid of such particles.

9.09 Figure 9-2 shows a picture of a high-temperature hot-water line (HTHW) in a plant, and a diagram of the same installation. (The symbols in the diagram that look like bow ties represent valves.) Water first goes through the strainer and then the trap in this installation.

9.10 The fine-mesh screens in strainers catch a considerable amount of the solid matter in the fluid. The MAGNETIC FERROUS TRAP in Fig. 9-2 catches iron particles that have passed through the strainer. This trap consists simply of a ring of magnets with spaces between them. Magnets attract iron. Since half the particles in the water are ferrous, they stick to the magnets.

Fig. 9-2. Magnetic ferrous trap installation.

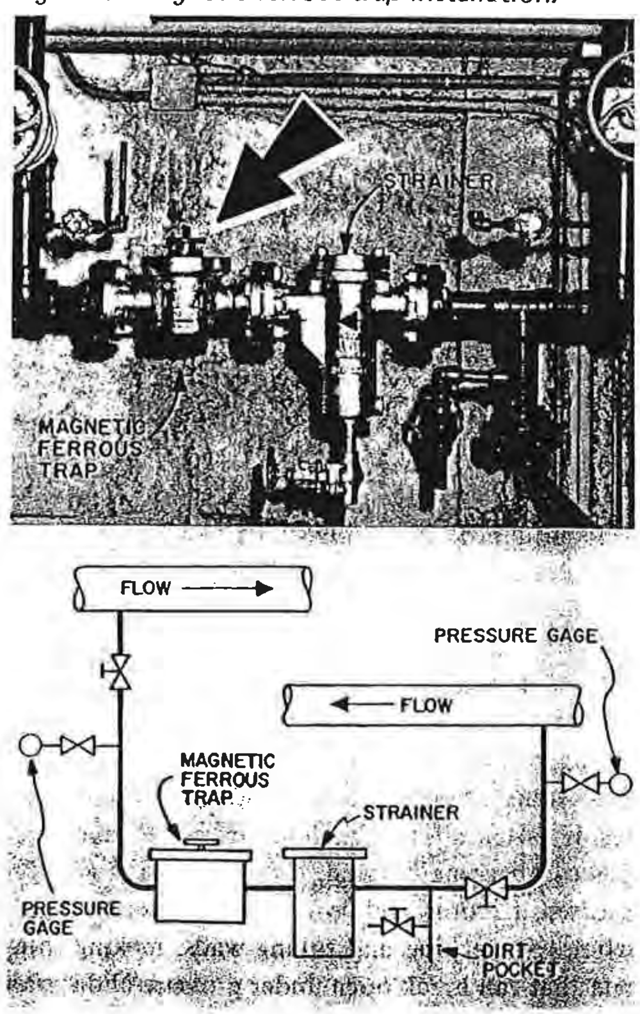

Fig. 9-3. Magnet assembly in magnetic trap.

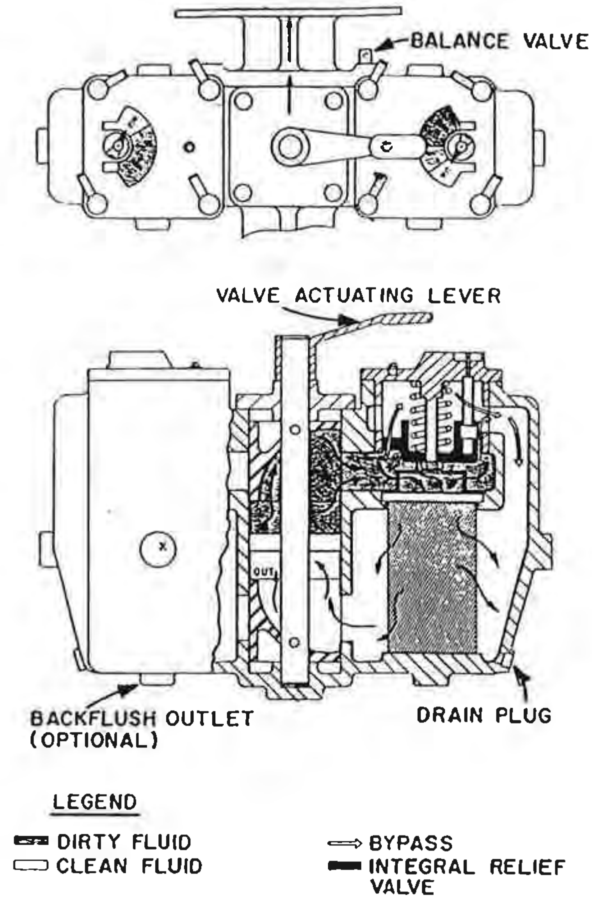

Fig. 9-4. Cross-section of a duplex filter.

9.11 Figure 9-3 shows what the magnet assembly looks like. Remove it from the trap housing at intervals for cleaning. Wipe the magnets clean with a cloth. Because of the combined operation of the strainer and the trap, both nonmagnetic and magnetic particles in the water are removed. This is, of course, an actual installation. It has been reported that these devices eliminated pump and seal failures caused by solids in the water.

Filters

9.12 Strictly speaking, the term FILTER is limited to devices that remove solid contaminants *only* from a fluid (liquid or gas). This is done by passing the fluid through some kind of porous barrier. Filter cartridges have replaceable elements made of nylon cloth, paper, wire cloth, or fine-mesh nylon cloth between layers of coarse wire. These materials strain out unwanted particles, which collect on the entry side of the filter element. When saturated, the element is replaced.

9.13 Most filters have two common features: (1) they cause the fluid to make sharp changes in direction as it passes through; and (2) they contain some kind of barrier that will not let larger particles pass. The change of direction is important. The larger particles are too heavy to change direction quickly. Many of them drop straight down into the bottom of the filter. Others are caught at the barrier.

9.14 Figure 9-4 shows a filter designed for either a suction or a pressure line. This is a DUPLEX FILTER, which has two identical filters side by side. One of them is always in use. When the filter element needs cleaning, the other side of the duplex unit is switched into service. Dirty fluid comes into the midsection and passes down through the filter element, which could be a fine-gage nylon cloth, a wire cloth, or finely perforated stainless steel.

9.15 From the filter element the fluid passes out of the unit and back into the line. This unit has a "telltale" indicator, which shows when the filter element becomes excessively clogged and requires cleaning. If nothing is done at this time, incoming fluid simply bypasses the filter element entirely and there is no filtering action. Such a bypass feature in a fluid line is important. If there were no

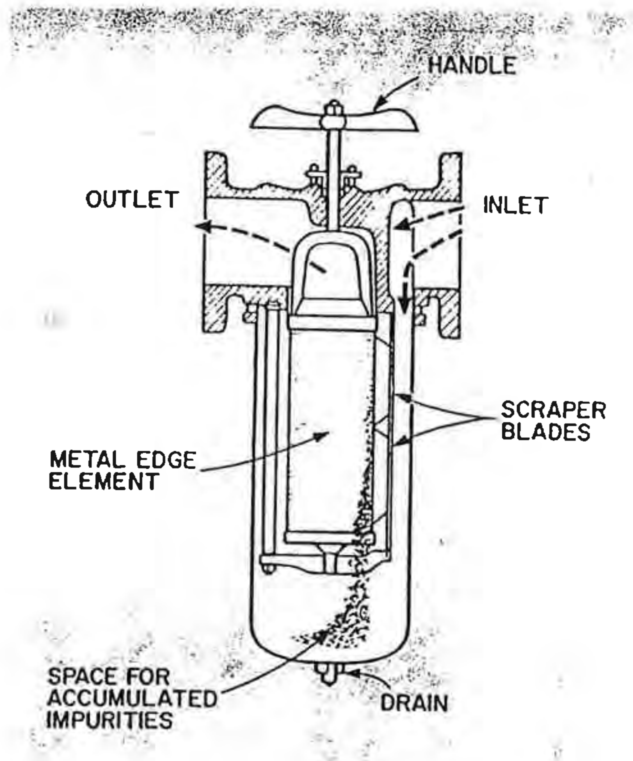

Fig. 9-5. Cross-section of edge-type filter.

bypass, and the filter became too clogged to pass fluid, the pump in the line would be damaged as it reacted to the unmovable fluid in the line.

9.16 Figure 9-5 shows a cross section of an EDGE-TYPE FILTER. This is called a FULL FLOW filter, meaning that all the oil in the system passes through it. The filter consists of a stack of discs with holes in their centers, like flat doughnuts, with little separation between them. Entering this filter, the oil passes down the outside of the stack. Before leaving the filter, the oil comes out of the center of the stack, having passed between the discs. Impurities in the oil are left behind on the outer surface of the stack. A cleaner blade in the filter moves around this outer surface, wiping off the impurities collected there. It is operated manually by means of the handle at the top of the filter housing. Impurities drop down into the sump portion of the filter. A plug at the bottom of the sump permits removal of sludge.

9.17 Figure 9-6 shows a CARTRIDGE-TYPE FILTER, much like the type used in automobiles.

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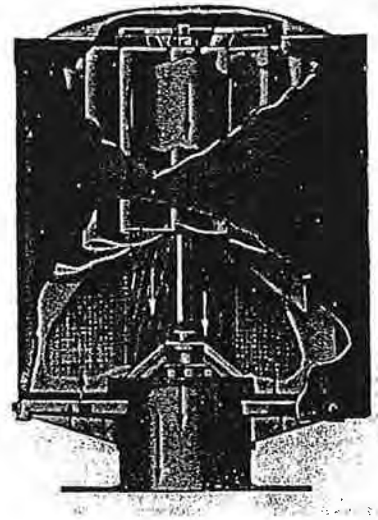
Fig. 9-6. Cross-section of cartridge-type filter.

Fig. 9-7. Compressor air-intake filter.



Dollinger Corporation

Here the oil passes down into the filter, then through the walls of the cartridge element, which has small holes in it, and up and out. When this element becomes completely coated with sludge, it is replaced.

9.18 In pneumatic lines, where clean air is a must, filtering of the air starts BEFORE it reaches the compressor. A compressor intake filter is shown in Fig. 9-7. Air flows up inside the outer portion of this unit, passes through various screens and around baffles, and exits down the center of the unit into the compressor intake pipe.

9-1. Valves cannot function properly when ________ particles are present.

9-2. A strainer is a device made up of ______ ______ screens.

9-3. Strainers are usually installed __________ *(ahead of/after)* pumps and valves.

9-4. At least ____ percent of the solid impurities in a fluid line are ferrous.

9-5. The term filter refers to a device designed to remove ________ contaminants only.

9-6. Filter cartridges usually have __________ elements.

9-7. A duplex filter has ______ filter elements.

9-8. In pneumatic lines, filtering starts ______ the air reaches the compressor.

Steam

9.19 Before going into steam traps, consider the nature of steam and its behavior. Basically, it is a matter of temperatures and pressure. Water boils at 100°C (212°F). This is true at sea level, where the atmospheric pressure or pressure of the air, is 14.7 pounds per square inch (psi). If heated to 212°F the particles of water become active enough to form steam, which overcomes the atmospheric pressure and rises into the air.

9.20 At the top of Pike's Peak (altitude 14,110 feet) where the atmospheric pressure is lower than it is at sea level, boiling occurs at a lower temperature. In fact, water will boil away without becoming hot enough to hard boil an egg. So at lower atmospheric pressure the water can vaporize into steam at a lower temperature.

9.21 On the other hand, if the pressure on the water is increased, the temperature necessary to produce boiling must be higher, because there is more pressure to overcome. At a pressure of 100 psi, water boils at 170°C (338°F); at 200 psi it boils at 198°C (388°F). These temperatures are significant because the pressures in steam boilers are higher than atmospheric pressure (14.7 psi). Therefore, the boiling temperature must be higher than 100°C (212°F).

9.22 If water in a system is kept under to 160°C (320°F), the water will not boil (at 100 psi, water boils at 170°C or 338°F). If, for some unusual reason, the pressure drops down to 14.7 psi (atmospheric pressure), the water boils rapidly and turns into steam.

9.23 Suppose that steam is circulating in a line at 104°C (220°F) at atmospheric pressure. Then, far along the line, the temperature drops to 99°C (210°F). What happens? The steam condenses back into water that is close to the boiling point. These are unlikely cases but they are useful in relating the importance of pressure and temperature in a steam line.

9.24 As water comes to a boil at 100°C (212°F), steam forms. Small particles of water are carried up with the steam, which is called wet saturated steam, or simply wet steam. The moisture is what makes the steam visible. If still more heat is applied, all of the water will be turned into dry saturated steam. The steam is invisible. If it is heated still more, it becomes superheated steam, or dry steam.

9.25 If a line is carrying dry saturated steam (100 psi and temperature 170°C or 338°F or below) and there is a drop in pressure somewhere at a distance from the boiler, the saturated steam will change into superheated steam.

9.26 It is evident that steam at high pressure and temperature is tricky. Hoses and pipes in the system must be selected to take these changes in stride. Remember these changes. If, for example, a sudden opening of a drain valve at the end of a steam line causes a sudden drop in pressure, superheated steam can "flash" into being. The piping system must be able to take it. The maintenance craftsman, in turn, must be on guard against it.

9.27 Remember that steam and hot water under pressure in piping systems are dangerous.

9.28 TRAPS are used to remove water (condensate) from steam lines. Condensate is undesirable because: (1) water produces rust, and (2) water plus steam leads to water hammer. In addition to getting water out of the steam line, it is important to get the air out of it.

9.29 Traps are devices that open and close in response to conditions in the piping system. They empty condensate and air into an outlet pipe, but hold steam in the system. The condensate is either used in some other heating application or returned to the boiler.

9.30 The operation of a trap depends on what is called the DIFFERENTIAL PRESSURE. The differential pressure is the difference, in psi, between the inlet and outlet pressures. A trap will not operate well or at all at a higher differential pressure than it was designed for.

9.31 The capacity of a trap isn't determined by its nominal size (expressed in inches and fractions of inches), but by the size of the discharge orifice, or opening. For example, a 1-inch trap can handle condensate in quantities ranging from 3000 to 10,000 pounds per hour, depending on its orifice size.

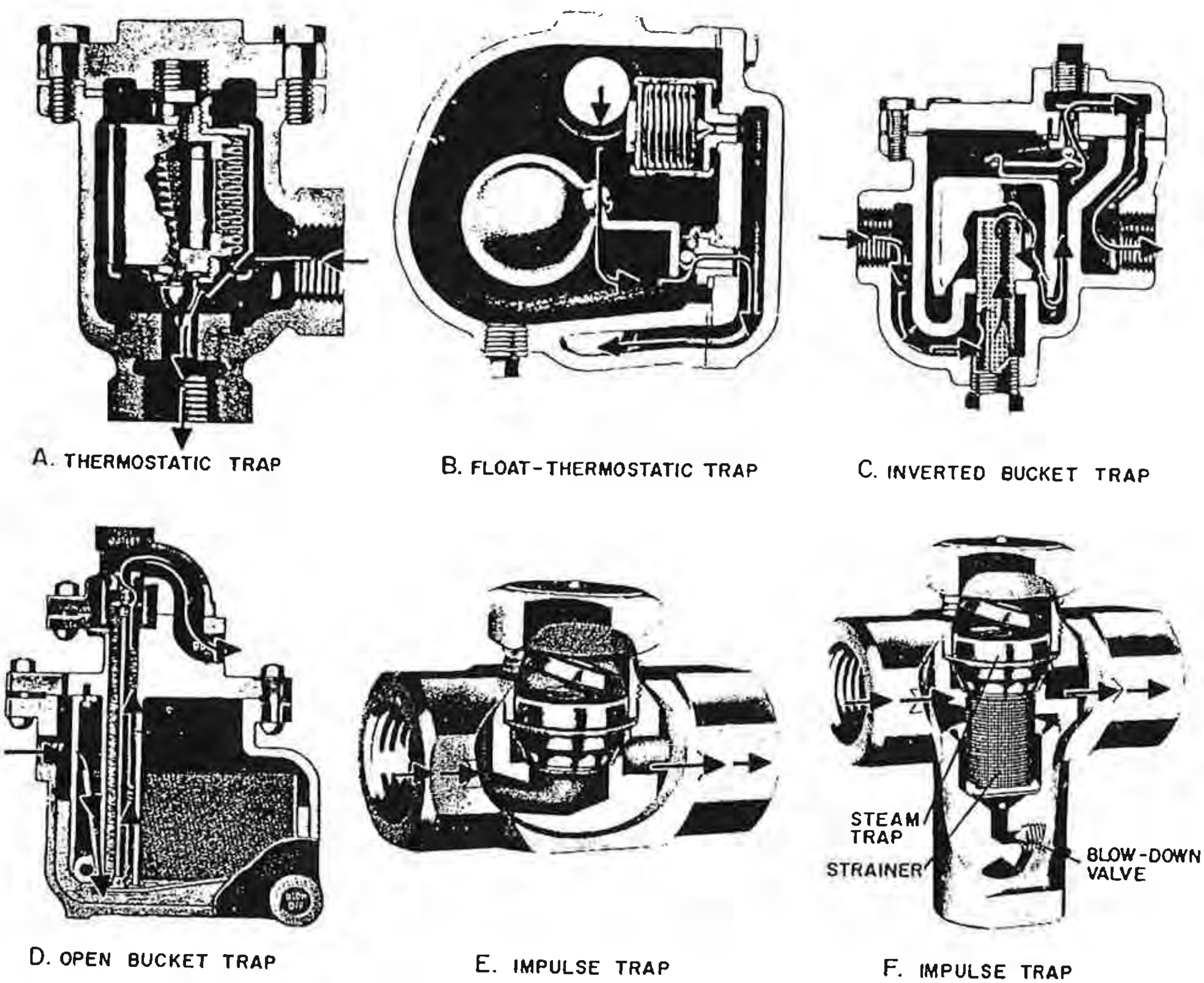


Fig. 9-8. Common steam traps.

9.32 Two general types of traps are THERMOSTATIC and MECHANICAL. Anything described as thermostatic is responsive to temperature. See Fig. 9-8(A). When temperature and pressure are normal, the thermostatic element expands downward to close the opening of the outlet pipe. When either the temperature or the pressure drops, the thermostatic element contracts, opening the way to the outlet pipe, through which condensate and air escape. The trap is designed to operate at a definite temperature drop – a certain number of degrees drop below the saturated temperature for the existing steam pressure.

9.33 MECHANICAL STEAM TRAPS include these types: FLOAT-and-THERMOSTATIC; FLOAT; INVERTED BUCKET; and UPRIGHT BUCKET. The float-and-thermostatic trap is shown in Fig. 9-8(B). Condensate water in a steam trap raises the float and opens the outlet port so that the water flows out of the trap.

9.34 This is a mechanical trap, although it does have a thermostatic element at the top, as shown. The thermostatic bypass remains open when air or condensate is in the trap at a temperature below the thermostatic element's closing temperature permitting air to leave the system. When the air has gone and hot steam enters the trap, the element closes again, keeping the steam in the system.

9.35 Traps are often used for handling condensate from fan coils, unit heaters, unit ventilators, and ventilating coils. How this is done is shown in Fig. 9-9. Note that under the unit heater the pipe is capped and a sediment pocket or sump is formed. In addition, a strainer is installed in the line between the unit heater and the trap.

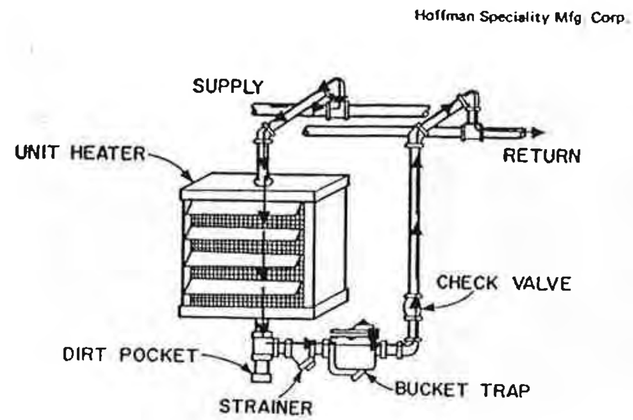


Fig. 9-9. Inverted-bucket trap installation.

9.36 A float trap is designed for applications where there is no problem of air in the system. It handles condensate only. It looks like the trap shown in Fig. 9-8(B), but without the thermostatic element.

9.37 An inverted bucket trap is shown in Fig. 9-8(C). Instead of a float, as in the designs just described, this trap has an inverted (upside down) bucket mechanically linked to the outlet port. The bucket is supplied with a small vent hole. During operation, a small portion of condensate remains around the bottom of the bucket and forms a seal. Live steam and condensate entering the trap raises the bucket, closing the valve. Steam leaking through the vent allows the bucket to drop, opening the valve and permitting condensate to leave the trap.

9.38 This trap is used where the condensate is led to a return line, as illustrated in Fig. 9-9. Note carefully the elements in this drawing. The check valve in the vertical pipe leading from the trap to the return line permits flow in one direction only. In this case, the condensate can only move upward to the return.

9.39 An UPRIGHT or OPEN BUCKET trap shown in Fig. 9-8(D) is used for applications where there are slight or small variations of load or pressure. Condensate enters the trap on the inlet side, and fills the space surrounding the bucket. It finally rises so high that it overflows into the bucket, sinking it. The discharge port opens and steam pressure then forces the condensate out of the trap and the operating cycle is repeated.

9.40 An IMPULSE TRAP (Fig. 9-8E) is a very simple device that usually has only one moving part—a disc. Hot condensate and steam form pressure in the trap, thereby closing the valve. As soon as the steam cools back into condensate, the trap opens to discharge the water. As additional hot condensate and steam increase the temperature, the cycle is repeated. Figure 9-8(F) shows an impulse trap equipped with an integral or built-in strainer and a blowdown connection.

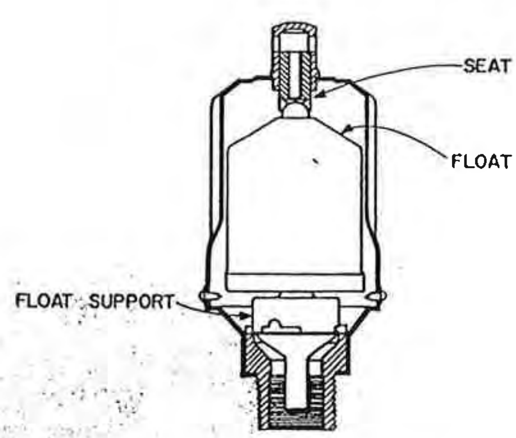
Vent Valves

9.41 In heating systems having radiators, steam cannot enter the radiators if they are filled with air. Therefore, each radiator has a VENT VALVE to let air out of the line. The valve closes with the entry of steam or hot water. Its purpose is to keep the steam in the system.

9.42 The vent opens when air is to be vented, and shuts against steam and hot water. It opens again when steam temperature has dropped sufficiently, or when water has drained away to permit the air-venting process to resume. The vent valve shown in Fig. 9-10 has a float which rests on a float support when the valve is open and air is escaping from the line. As steam or hot water enters the valve, the float rises to close the valve at the top.

9.43 A VACUUM VENT VALVE does the same job, but it also has a vacuum check valve in the top, which prevents the return of air into the system. See Fig. 9-11. Although called valves, vent valves could just as well be called traps. They do not control flow of the fluid in the system but see to it that unwanted elements (water and air in the cases mentioned) are bled from the system.

Fig. 9-10. Vent valve.



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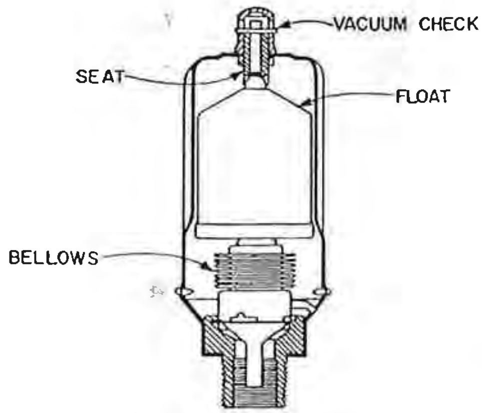


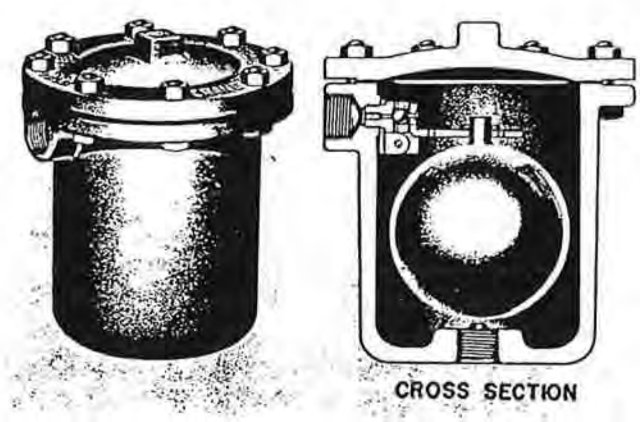
Fig. 9-11. Vacuum vent valve.

9.44 Air-vent or water-drain valves of the ball float type are used to remove air from water piping, oil piping, and pressure vessels, or to remove water or oil from compressed-air systems. They are not used on steam lines. Steam lines require steam traps.

9.45 Figure 9-12 shows an air-vent water-drain valve. This valve does double duty. When used to remove air from water- or oil-carrying systems, the valve is installed at the highest point in the system, where air collects. This type installation is shown in Fig. 9-13. Normally the valve is filled with water or oil. As air collects, it forces the liquid out. Then the float drops, the outlet valve opens, and the air escapes. The valve is mounted in an upright position.

9.46 When used to drain water or oil from air systems the valve must be installed at the lowest point of the system, where fluid (liquid) collects. See Fig. 9-14. The operation is the reverse of that for venting air. In this case the water or oil that gathers in the valve finally pushes the float upward, opening the outlet, through which the water or oil then leaves the system.

Fig. 9-12. Air-vent water-drain valve.



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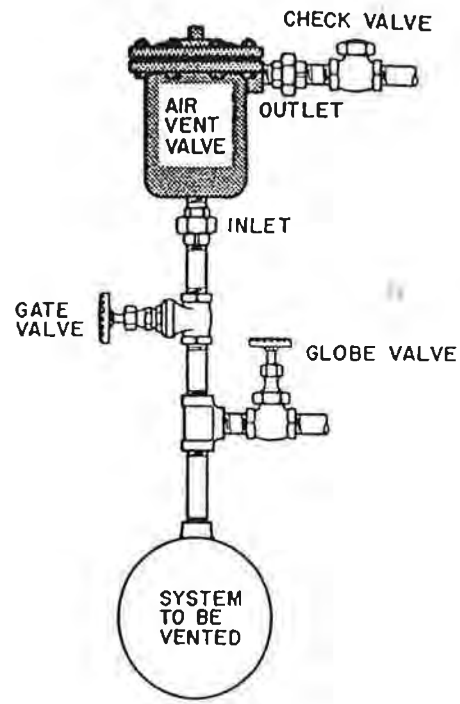
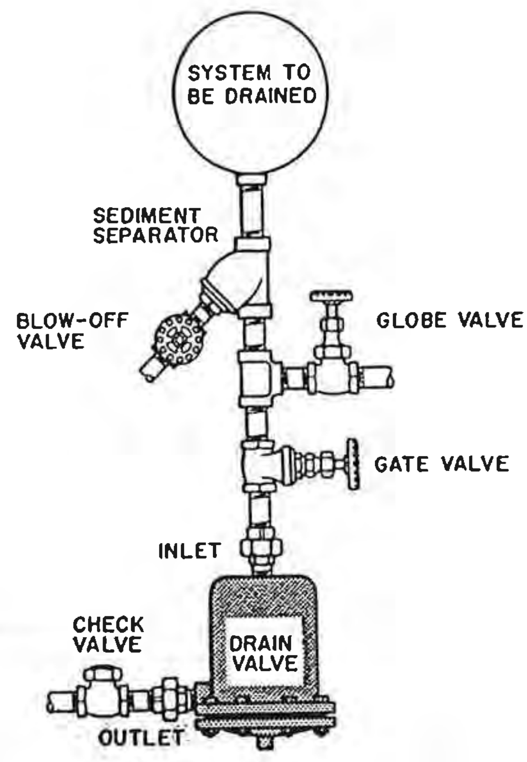


Fig. 9-13. Air-vent valve installation.

Fig. 9-14. Water-drain valve installation.



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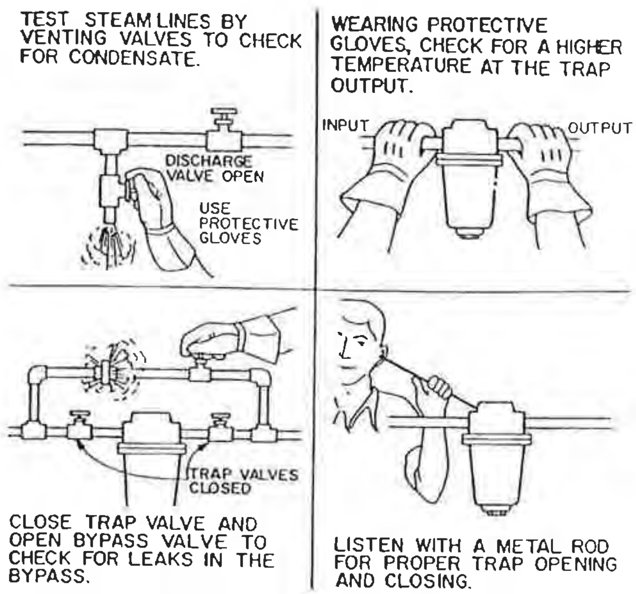


Fig. 9-15. Trap maintenance problems.

Trap Maintenance

9.47 Traps operate under constantly varying fluid pressure and temperature conditions. They accumulate sludge that prevents tight closing. The moving parts of floats, buckets, and valves wear. Because the moving parts are in a steam-water mixture, or a mixture of compressed air and water, they are difficult to lubricate.

9.48 Trap maintenance includes periodic cleaning; removing sludge that interferes with valve action; adjusting mechanical linkage between floats or buckets and valves; and reseating the valves when necessary. If this is not done, the trap will not operate properly.

9.49 Figure 9-15 shows a number of tests that maintenance men perform to ensure proper operation. A trap-discharge line permits venting the output of the trap into the open. In a steam line, the output should be only steam if the trap has properly blocked the passage of water. Temperature checks of the piping on each side of the trap indicate if the trap is operating as it should be. The steam at output should show a higher temperature than the steam at input, which contains condensate, which is cooler than pure steam.

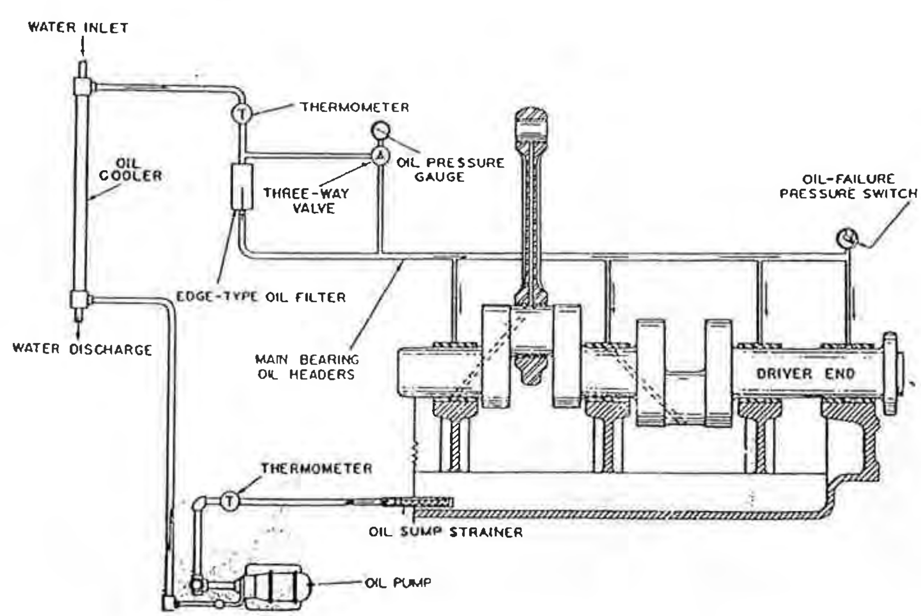
9.50 A simple test – just listening to the trap action, will tell how the trap float or bucket is opening and closing. If the trap has a bypass line around it, leaky valves will show up when the main line to the trap is cut off, forcing all the fluid through the bypass.

Typical Piping System

9.51 An important fluid system found in many plants is used to lubricate heavy machinery. The system circulates oil under pressure. Figure 9-16 shows a system used to lubricate a cylinder-type air compressor.

9.52 The oil circulating in the lubrication system must do these jobs: (1) form and maintain a strong film between wearing surfaces – bearings, cylin-

Fig. 9-16. Air compressor lubrication system.



ders, pistons, piston rods, to minimize friction and wear; (2) protect against corrosion; and (3) carry away frictional heat generated in the bearings. The oil must circulate at the right pressure, and it must be kept clean. The oil should not be allowed to overheat to the point at which it wiil thin out and lose its good lubricating properties.

9.53 Trace the system shown in Fig. 9-16 starting with the oil pump at the bottom of the drawing. First, the oil passes through an OIL COOLER or HEAT EXCHANGER. This is a pair of tubes, one inside the other, but not connected together. The inner tube carries cooling water. The hot oil flows through the outer tube, losing some of its heat to the inner one. (Heat passes from a warmer body to a cooler one.) After passing through the oil cooler, the water has been warmed up by the heat obtained from the tube carrying the oil. The oil emerges cooler, having given up some of its heat to the water. Some heat has been exchanged. Technically, a device of this kind is called a HEAT EXCHANGER; it is a common component in fluid systems.

9.54 The cooled oil next passes a thermometer that provides a continuous reading of oil temperature. Note that there is a second thermometer in the line between the compressor crankcase and the oil pump. This gives the temperature of the oil as it comes *out* of the compressor. The oil then goes through an EDGE-TYPE FILTER, through a three-way valve to an oil pressure gauge, and then into the compressor. Completing the loop, the oil passes down through the compressor to the crankcase. From there it enters the return line to the oil pump. An oil sump strainer is located at the outlet port of the crankcase. the OIL-FAILURE PRESSURE SWITCH is designed to cut off the unit driving the compressor if the pressure in the lubricant system drops below a predetermined level.

9.55 Each of the components you have studied in this lesson has a definite place in a piping system. For example, the system you have just traced is a typical one, and the systems you will be working with in most industrial installations will have the same characteristics.

. ... _____ psi

9-10. At an altitude of 10,000 feet, water boils at a ________ *(higher/lower)* temperature than at sea level.

9-11. Pressure in steam boilers is ________ *(higher/lower)* than atmospheric pressure.

9-12. For your personal safety, consider steam and hot water under pressure in a piping system to be potentially ________.

9-13. Steam traps are used to remove ________ from steam lines.

9-14. The operation of steam traps depends on ________ ________.

9-15. The two basic types of steam traps are ________ and ________.

9-16. Vacuum vent valves prevent the return of _____ into a system.