CHAPTER 9

PUMPS, VALVES, AND PIPING

As a Fireman, you must have a general knowledge of the basic operating principles of various types of pumps and supporting components, such as the different types of valves and piping used aboard ships.

Aboard ship, pumps, valves, and piping are used for a number of essential services. They supply water to the boilers, draw condensate from the condensers, supply seawater to the firemain, circulate cooling water for coolers and condensers, pump out bilges, transfer fuel oil, supply seawater to the distilling plants, and are used for many other purposes. The operation of the ship's propulsion plant and of almost all the auxiliary machinery depends on the proper operation of pumps. Although most plants have two pumps, a main pump and a standby pump, pump failure may cause failure of an entire power plant.

With the knowledge gained in this chapter, you should be able to describe pumps, valves, and piping systems in terms of their construction, function, and operation. The information in this chapter, as it is throughout the book, is of a broad and general nature. You should refer to the appropriate manufacturer's technical manuals and/or ship's plans, information books, and plant or valve manuals for specific problems with individual equipment. By studying this material, you should be able to relate to the specific equipment found on your ship.

PUMPS

Pumps are vitally important to the operation of your ship. If they fail, the power plant they serve also fails. In an emergency, pump failures can prove disastrous. Maintaining pumps in an efficient working order is a very important task of the engineering department. As a Fireman, you must have a general knowledge of the basic operating principles of the various types of pumps used by the Navy.

It is not practical or necessary to mention all of the various locations where pumps are found aboard ship. You will learn their location and operation as you perform your duties. The pumps with which you are primarily concerned are used for such purposes as

- providing fuel oil to the prime mover,
- circulating lubricating (lube) oil to the bearings and gears of the MRG,
- supplying seawater for the coolers in engineering spaces,
- pumping out the bilges, and
- transferring fuel oil to various storage and service tanks.

CLASSIFICATION OF PUMPS

Pumps aboard ship outnumber all other auxiliary machinery units. They include such types as centrifugal, rotary, and jet pumps. In the following section we discuss these different pumps and their application to the engineering plant.

Centrifugal Pumps

Aboard gas turbine ships, centrifugal pumps of various sizes are driven by electric motors to move different types of liquid. The fire pump and seawater service pump are two examples of this type of pump.

A basic centrifugal pump has an impeller keyed to a drive shaft, which is rotated by an electric motor. The drive shaft is fitted inside a casing, which has a suction inlet and a discharge

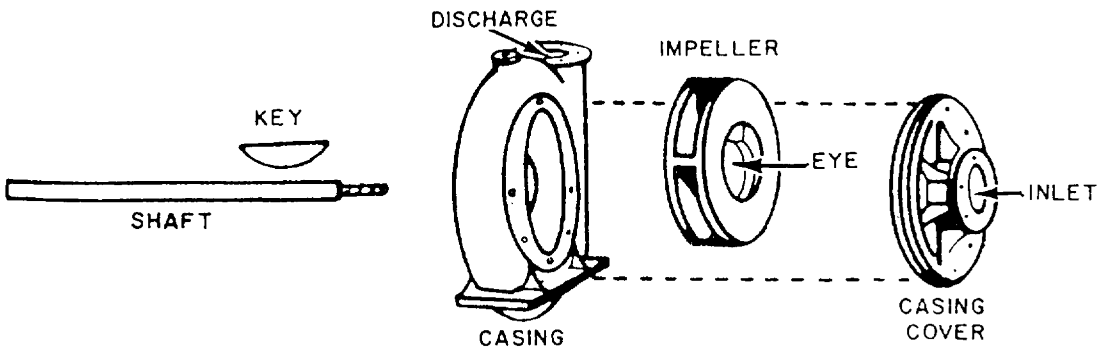


Figure 9-1.—Centrifugal pump.

outlet. Figure 9-1 shows the arrangement of components in a centrifugal pump.

CENTRIFUGAL PUMP CLASSIFICATION.— Centrifugal pumps may be classified in several ways. For example, they may be either single-stage or multistage. A single-stage pump has only one impeller; a multistage pump has two or more impellers housed together in one casing. In a multistage pump, each impeller usually acts separately, discharging to the suction of the next-stage impeller. Centrifugal pumps are also classified as horizontal or vertical, depending on the position of the pump shaft.

Impellers used in centrifugal pumps may be classified as single-suction or double-suction, depending on the way in which liquid enters the eye of the impeller. Figure 9-2 shows single-suction and double-suction arrangements of centrifugal pump impellers. The single-suction impeller (view A) allows liquid to enter the eye from one side only; the double-suction impeller (view B) allows liquid to enter the eye from both sides. The double-suction arrangement has the advantage of balancing the end thrust in one direction with the end thrust in the other direction.

Impellers are also classified as CLOSED or OPEN. A closed impeller has side walls that extend from the eye to the outer edge of the vane tips; an open impeller does not have side walls. Most centrifugal pumps used in the Navy have closed impellers.

CONSTRUCTION.— As a rule, the casing for the liquid end of a pump with a single-suction impeller is made with an end plate that can be removed for inspection and repair of the pump. A pump with a double-suction impeller is generally made so one-half of the casing may be lifted without disturbing the pump.

Since an impeller rotates at high speed, it must be carefully machined to minimize friction. An impeller must be balanced to avoid vibration. A close radial clearance must be maintained between

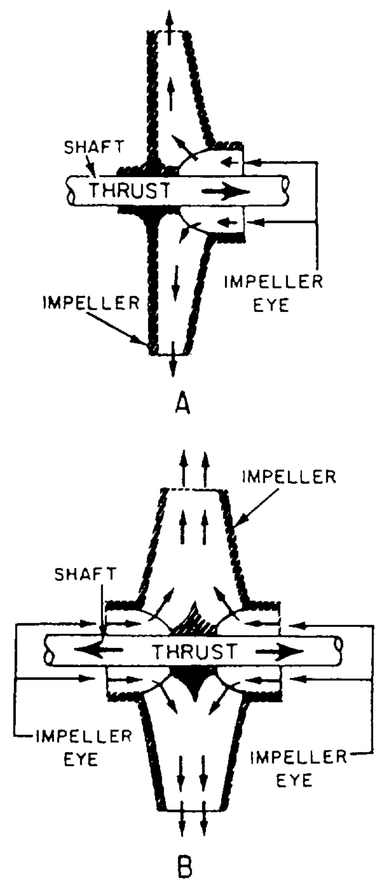


Figure 9-2.—Centrifugal pump impellers. A. Single-suction. B. Double-suction.

the outer hub of the impeller and that part of the pump casing in which the hub rotates. The purpose of this is to minimize leakage from the discharge side of the pump casing to the suction side.

Because of the high rotational speed of the impeller and the necessarily close clearance, the rubbing surfaces of both the impeller hub and the casing at that point are subject to stress, causing rapid wear. To eliminate the need for replacing an entire impeller and pump casing solely because of wear in this location, most centrifugal pumps are designed with replaceable casing wearing rings.

In most centrifugal pumps, the shaft is fitted with a replaceable sleeve. The advantage of using a sleeve is that it can be replaced more economically than the entire shaft.

Mechanical seals and stuffing boxes are used to seal between the shaft and the casing. Most pumps are now furnished with mechanical seals; mechanical seals do not result in better pump operation; but, they do provide a better environment, keep bilges dry, and preserve the liquid being pumped.

Seal piping (liquid seal) is installed to cool the mechanical seal. Most pumps in saltwater service with total head of 30 psi or more are also fitted with cyclone separators. These separators use centrifugal force to prevent abrasive material (such as sand in the seawater) from passing between the sealing surfaces of the mechanical seal. There is an opening at each end of the separator. The opening at the top is for "clean" water, which is directed though tubing to the mechanical seals in the pump. The high-velocity "dirty" water is directed through the bottom of the separator, back to the inlet piping for the pump.

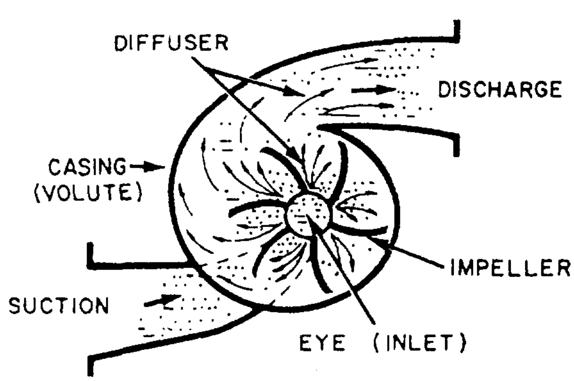


Figure 9-3.—Centrifugal pump flow.

Bearings support the weight of the impeller and shaft and maintain the position of the impeller—both radially and axially. Some bearings are grease-lubricated with grease cups to allow for periodic relubrication.

The power end of the centrifugal pump you are to work with has an electric motor that is maintained by your ship's Electrician's Mate.

OPERATION.— Liquid enters the rotating impeller on the suction side of the casing and enters the eye of the impeller (fig. 9-3). Liquid is thrown out through the opening around the edge of the impeller and against the side of the casing by centrifugal force. This is where the pump got its name. When liquid is thrown out to the edge of the casing, a region of low pressure (below atmospheric) is created around the center of the impeller; more liquid moves into the eye to replace the liquid that was thrown out. Liquid moves into the center of the impeller with a high velocity (speed). Therefore, liquid in the center of the impeller has a low pressure, but it is moving at a high velocity.

Liquid moving between the blades of the impeller spreads out, which causes the liquid to slow down. (Its velocity decreases.) At the same time, as the liquid moves closer to the edge of the casing, the pressure of the liquid increases. This change (from low pressure and high velocity at the center to high pressure and low velocity at the edge) is caused by the shape of the opening between the impeller blades. This space has the shape of a diffuser, a device that causes the velocity-pressure relationship of any fluid that moves through it to change.

A centrifugal pump is considered to be a nonpositive-displacement pump because the volume of liquid discharged from the pump changes whenever the pressure head changes. The pressure head is the combined effect of liquid weight, fluid friction, and obstruction to flow. In a centrifugal pump, the force of the discharge pressure of the pump must be able to overcome the force of the pressure head; otherwise, the pump could not deliver any liquid to a piping system. The pressure head and the discharge pressure of a centrifugal pump oppose each other. When the pressure head increases, the discharge pressure of the pump must also increase. Since no energy can be lost, when the discharge pressure of the pump increases, the velocity of flow must decrease. On the other hand, when the pressure head decreases, the volume of liquid discharged from the pump increases. As a general rule, a

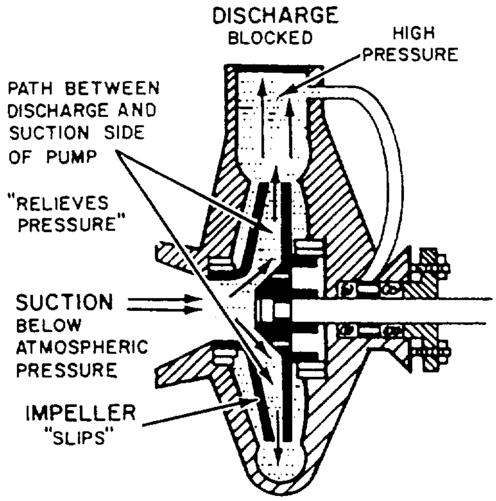


Figure 9-4.—Nonpositive-displacement pump.

centrifugal pump is usually located below the liquid being pumped. (**NOTE:** This discussion assumes a constant impeller speed.)

Figure 9-4 shows that when the pump discharge is blocked, nothing happens because the impeller is hollow. A tremendous buildup in pressure cannot occur because the passages in the impeller (between the discharge and suction side of the pump) act like a built-in relief valve. When the discharge pressure and pressure head are equal (as in this case), the impeller is allowed to rotate (slips) through the liquid in the casing.

NOTE: Centrifugal pumps used for intermittent service may have to run for long periods of time against a blocked discharge. Friction between the impeller and the liquid raises the temperature of the liquid in the casing and causes the pump to overheat. To prevent this, a small line is connected between the discharge and the suction piping of the pump.

When a centrifugal pump is started, the vent line must be opened to release entrained air. The open passage through the impeller of a centrifugal pump also causes another problem. It's possible for liquid to flow backwards (reverse flow) through the pump. A reverse flow, from the discharge back to the suction, can happen when the pressure head overcomes the discharge pressure of the pump. A reverse flow can also occur when the pump isn't running and another pump is delivering liquid to the same piping system. To prevent a reverse flow of liquid through a centrifugal pump, a check valve is usually installed in the discharge line.

NOTE: Instead of two separate valves, some installations use a globe stop-check valve.

With a check valve in the discharge line, whenever the pressure above the disk rises above the pressure below it, the check valve shuts. This prevents liquid from flowing backwards through the pump.

MAINTENANCE.— You must observe the operation and safety precautions pertaining to pumps by following the EOP subsystem of the EOSS—if your ship has EOSS. If not, use the *Naval Ships' Technical Manual (NSTM)* and/or the instructions posted on or near each individual pump. You must follow the manufacturer's technical manual or MRCs for PMS-related work for all maintenance work. The MRCs list in detail what you have to do for each individual maintenance requirement.

Mechanical Seals.— Mechanical seals are rapidly replacing conventional packing as the means of controlling leakage on centrifugal pumps. Pumps fitted with mechanical seals eliminate the problem of excessive stuffing box leakage, which can result in pump and motor bearing failures and motor winding failures.

Where mechanical shaft seals are used, the design ensures that positive liquid pressure is supplied to the seal faces under all conditions of operation and that there is adequate circulation of the liquid at the seal faces to minimize the deposit of foreign matter on the seal parts.

One type of mechanical seal is shown in figure 9-5. Spring pressure keeps the rotating seal face

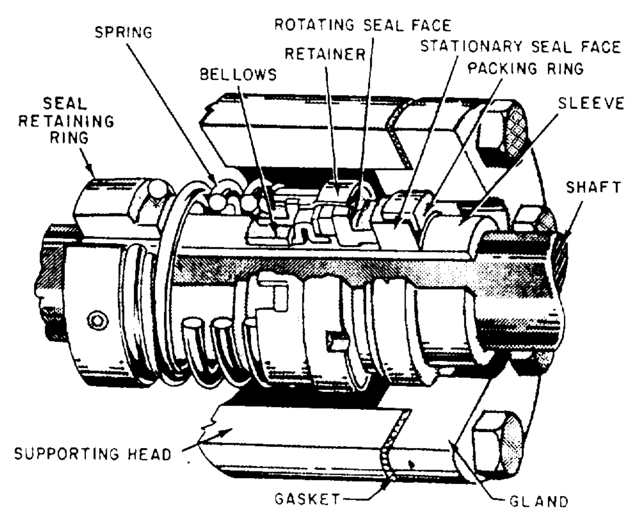


Figure 9-5.—Type-1 mechanical seal.

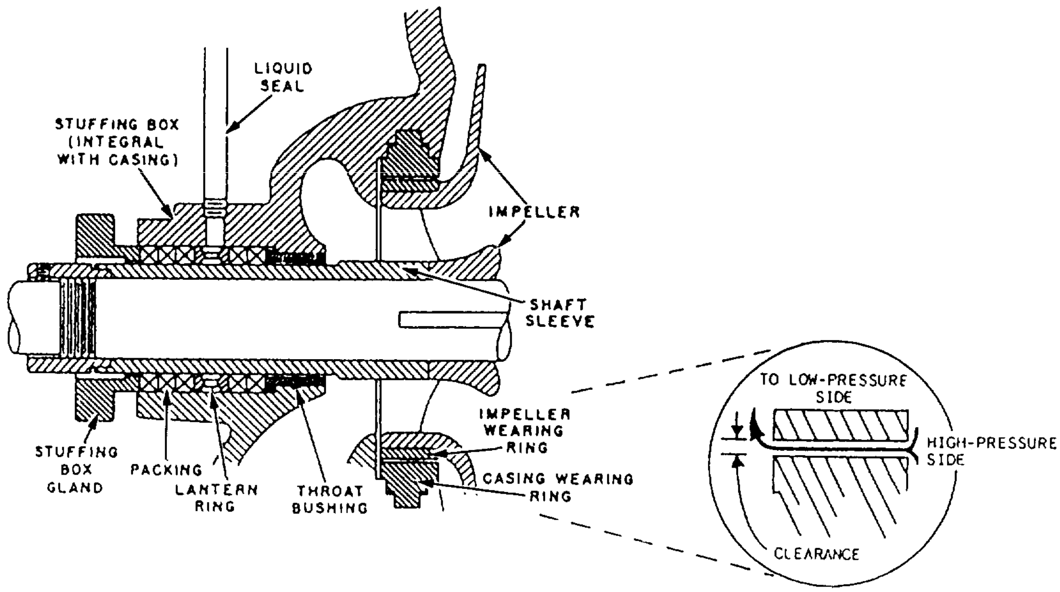


Figure 9-6.—Stuffing box on a centrifugal pump.

snug against the stationary seal face. The rotating seal and all of the assembly below it are affixed to the pump shaft. The stationary seal face is held stationary by the seal gland and packing ring. A static seal is formed between the two seal faces and the sleeve. System pressure within the pump assists the spring in keeping the rotating seal face tight against the stationary seal face. The type of material used for the seal face depends on the service of the pump. When a seal wears out, it is simply replaced.

You should observe the following precautions when performing maintenance on mechanical seals:

- Do not touch new seals on the sealing face because body acid and grease can cause the seal face to prematurely pit and fail.

- Replace mechanical seals when the seal is removed for any reason or when the leakage rate cannot be tolerated.

- Position mechanical shaft seals on the shaft by stub or step sleeves. Shaft sleeves are chamfered (beveled) on outboard ends to provide ease of mechanical seal mounting.

- Do not position mechanical shaft seals by using setscrews.

Fire pumps and all seawater pumps installed in surface ships are being provided with mechanical shaft seals with cyclone separators. The glands are designed to incorporate two or more rings of packing if the mechanical shaft seal fails.

A water flinger is fitted on the shaft outboard of the stuffing box glands to prevent leakage from the stuffing box following along the shaft and entering the bearing housings. They must fit tightly on the shaft. If the flingers are fitted on the shaft sleeves instead of on the shaft, ensure that no water leaks under the sleeves.

Stuffing Box Packing.— Although most centrifugal pumps on gas turbine ships have mechanical seals, you should be familiar with stuffing box packing.

The packing in centrifugal pump stuffing boxes (fig. 9-6) is renewed following the PMS. When replacing packing, be sure to use packing of the specified material and the correct size. Stagger the joints in the packing rings so they fall at different points around the shaft. Pack the stuffing box loosely and set up lightly on the gland, allowing a liberal leakage. With the pump in operation, tighten the glands and gradually compress the packing. It is important to do this gradually and evenly to avoid excessive friction. Uneven tightening could cause overheating and possible scoring of the shaft or the shaft sleeve.

On some centrifugal pumps, a lantern ring is inserted between the rings of the packing. When repacking stuffing boxes on such pumps, be sure to replace the packing beyond the lantern ring.

The packing should not block off the liquid seal line connection to the lantern ring after the gland has been tightened.

Figure 9-6 shows how the packing is arranged. Notice how the lantern ring lines up with the liquid seal connection when the gland is tightened.

Renewing Shaft Sleeves.— In some pumps the shaft sleeve is pressed onto the shaft tightly by a hydraulic press. In this case, the old sleeve must be machined off with a lathe before a new one can be installed. On others, the shaft sleeve may have a snug slip-on fit, butted up against a shoulder on the shaft and held securely in place with a nut. On smaller pumps, new sleeves can be installed by removing the water end casing, impeller, and old shaft sleeves. New sleeves are carried as repair parts; they can also be made in the machine shop. On a large pump, the sleeve is usually pressed on; the old sleeve must be machined off before a new one can be pressed on. You must disassemble the pump and take the sleeve to a machine shop, a repair shop, or a naval shipyard to have this done.

To prevent water leakage between the shaft and the sleeve, some sleeves are packed, others have an O-ring between the shaft and the abutting shoulder. For detailed information, consult the appropriate manufacturer's technical manual or applicable blueprint.

Renewing Wearing Rings.— The clearance between the impeller and the casing wearing ring (fig. 9-7) must be maintained as directed by the manufacturer. When clearances exceed the specified amount, the casing wearing ring must be replaced. On most ships, this job can be done by the ship's force, but it requires the complete disassembly of the pump. All necessary information on disassembly of the unit, dimensions of the wearing rings, and reassembly of the pump is specified by PMS or can be found in the manufacturer's technical manual. Failure to replace the casing wearing ring when the allowable clearance is exceeded results in a decrease of pump capacity and efficiency. If a pump has to be disassembled because of some internal trouble, the wearing ring should be checked for clearance. Measure the outside diameter of the impeller hub with an outside micrometer and the inside diameter of the casing wearing ring with an inside micrometer; the difference between the two diameters is the actual wearing ring diametric clearance. By checking the actual wearing ring clearance with the maximum allowable clearance, you can decide whether to renew the ring before reassembling the pump. The applicable MRCs area readily available source of information on proper clearances.

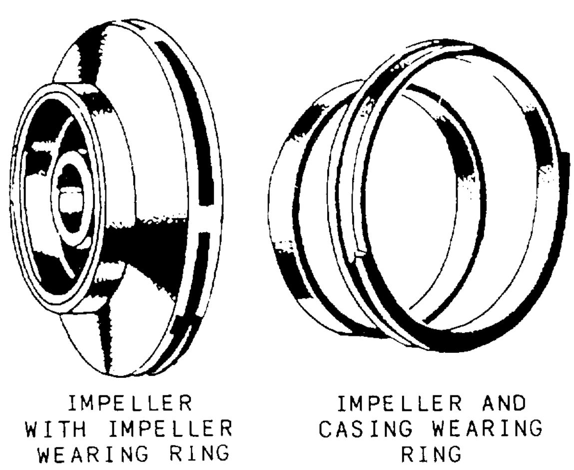


Figure 9-7.—Impeller, impeller wearing ring, and casing wearing ring for a centrifugal pump.

Wearing rings for most small pumps are carried aboard ship as part of the ship's repair parts allowance. These may need only a slight amount of machining before they can be installed. For some pumps, spare rotors are carried aboard ship. The new rotor can be installed and the old rotor sent to a repair activity for overhaul. Overhauling a rotor includes renewing the wearing rings, bearings, and shaft sleeve.

Operating Troubles.— You will be responsible for the maintenance of centrifugal pumps. The following table is a description of some of the problems you will have to deal with together with the probable causes:

TROUBLE	CAUSE
Does not deliver any liquid	Insufficient priming
	Insufficient speed of the pump
	Excessive discharge pressure (such as a partially closed valve or some other obstruction in the discharge line)
	Excessive suction lift
	Clogged impeller passages
	Wrong direction of rotation
	Clogged suction screen (if used)
	Ruptured suction line
	Loss of suction pressure

TROUBLE	CAUSE
Insufficient capacity	Air leakage into the suction line
	Insufficient speed of the pump
	Excessive suction lift
	Clogged impeller passages
	Excessive discharge pressure
	Mechanical defects (such as worn wearing rings, impellers, stuffing box packing, or sleeves)
Does not develop enough discharge pressure	Insufficient speed of the pump
	Air or gas in the liquid being pumped
	Mechanical defects (such as worn wearing rings, impellers, leaking mechanical seals, and sleeves)
Works for a while and then fails to deliver liquid	Air leakage into the suction line
	Air leakage in the stuffing boxes
	Clogged water seal passages
	Insufficient liquid on the suction side
	Excessive heat in the liquid being pumped
Takes too much power and the motor overheats	Operation of the pump at excess capacity and insufficient discharge pressure
	Misalignment
	Bent shaft
	Excessively tight stuffing box packing
	Worn wearing rings
	Other mechanical defects
Vibration	Misalignment
	Bent shaft
	Clogged, eroded, or otherwise unbalanced impeller
	Lack of rigidity in the foundation

Insufficient suction pressure may also cause vibration, as well as noisy operation and fluctuating discharge pressure.

Rotary Pumps

Another type of pump you find aboard ship is the rotary pump. A number of types are included in this classification, among which are the gear pump, the screw pump, and the moving vane pump. Unlike the centrifugal pump, which we have discussed, the rotary pump is a positive-displacement pump. This means that for each revolution of the pump, a fixed volume of fluid is moved regardless of the resistance against which the pump is pushing. As you can see, any blockage in the system could quickly cause damage to the pump or a rupture of the system. You, as a pump operator, must always be sure that the system is properly aligned so a complete flow path exists for fluid flow. Also, because of their positive displacement feature, rotary pumps require a relief valve to protect the pump and piping system. The relief valve lifts at a preset pressure and returns the system liquid either to the suction side of the pump or back to the supply tank or sump.

Rotary pumps are also different from centrifugal pumps in that they are essentially self-priming. As we saw in our discussion of centrifugal pumps, the pump is located below the liquid being pumped; gravity creates a static pressure head which keeps the pump primed. A rotary pump operates within limits with the pump located above the source of supply.

A good example of the principle that makes rotary pumps self-priming is the simple drinking straw. As you suck on the straw, you lower the air pressure inside the straw. Atmospheric pressure on the surface of the liquid surrounding the straw is therefore greater and forces the liquid up the straw. The same conditions basically exist for the gear and screw pump to prime itself.

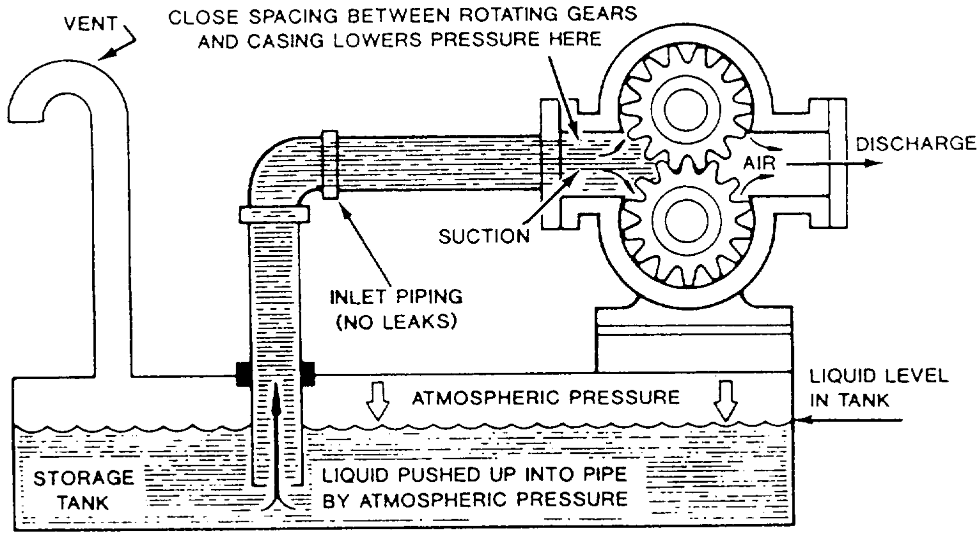


Figure 9-8.—Gear pump located above the tank.

Figure 9-8 shows a gear pump located above the tank. The tank must be vented to allow air into the tank to provide atmospheric pressure on the surface of the liquid. To lower the pressure on the suction side of the pump, the clearances between the pump parts must be close enough to pump air. When the pump starts, the air is pumped through the discharge side of the pump and creates the low-pressure area on the suction side, which allows the atmospheric pressure to force the liquid up the pipe to the pump. To operate properly, the piping leading to the pump must have no leaks or it will draw in air and can lose its prime.

Rotary pumps are useful for pumping oil and other heavy viscous liquids. In the engine room, rotary pumps are used for handling lube oil and fuel oil and are suitable for handling liquids over a wide range of viscosities.

Rotary pumps are designed with very small clearances between rotating parts and stationary parts to minimize leakage (slippage) from the discharge side back to the suction side. Rotary pumps are designed to operate at relatively slow speeds to maintain these clearances; operation at higher speeds causes erosion and excessive wear, which result in increased clearances with a subsequent decrease in pumping capacity.

Classification of rotary pumps is generally based on the types of rotating element. In the following paragraphs, the main features of some common types of rotary pumps are described.

GEAR PUMPS.— The simple gear pump (fig. 9-9) has two spur gears that mesh together and revolve in opposite directions. One is the driving gear, and the other is the driven gear. Clearances between the gear teeth (outside diameter of the gear) and the casing and between the end face and the casing are only a few thousandths of an inch. As the gears turn, the gears unmesh and liquid flows into the pockets that are vacated by the meshing gear teeth. This creates the suction that draws the liquid into the pump. The liquid is then carried along in the pockets formed by the gear teeth and the casing. On the discharge side, the liquid is displaced by the meshing of the gears and forced out through the discharge side of the pump.

One example of the use of a gear pump is in the LM2500 engine fuel pump. However, gear pumps are not used extensively on gas turbine ships.

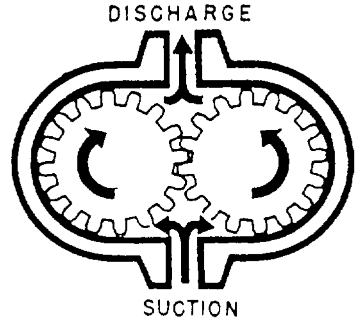


Figure 9-9.—Simple gear pump.

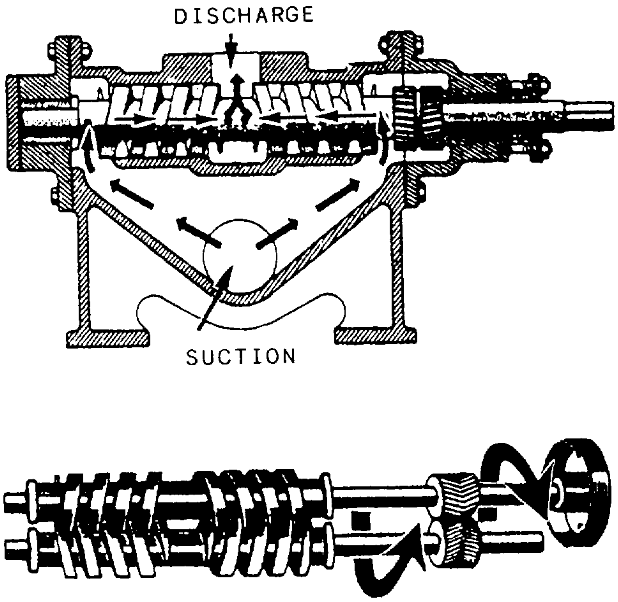


Figure 9-10.—Double-screw, low-pitch pump.

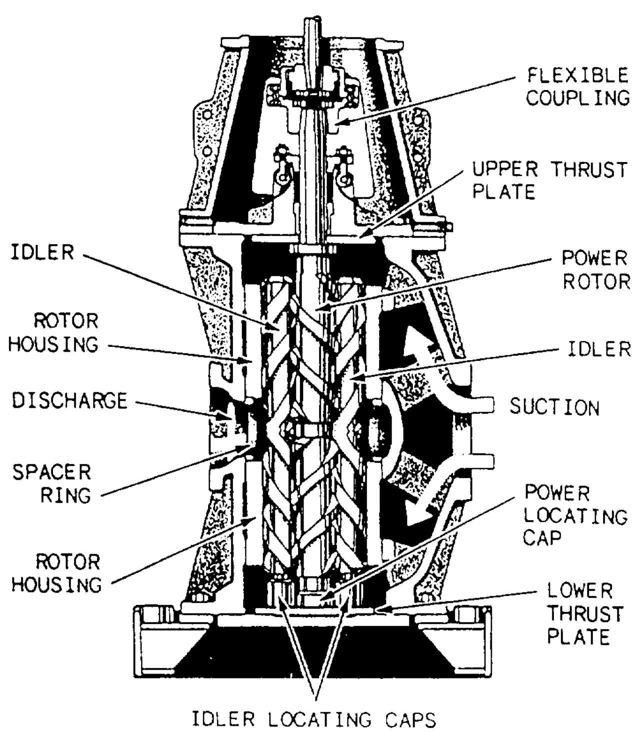


Figure 9-11.—Triple-screw, high-pitch pump.

SCREW PUMPS.— Several different types of screw pumps exist. The differences between the various types are the number of intermeshing screws and the pitch of the screws. Figure 9-10 shows a double-screw, low-pitch pump; and figure 9-11 shows a triple-screw, high-pitch pump. Screw pumps are used aboard ship to pump fuel and lube oil and to supply pressure to the hydraulic system. In the double-screw pump, one rotor is driven by the drive shaft and the other by a set of timing gears. In the triple-screw pump, a central rotor meshes with two idler rotors.

In the screw pump, liquid is trapped and forced through the pump by the action of rotating screws. As the rotor turns, the liquid flows in between the threads at the outer end of each pair of screws. The threads carry the liquid along within the housing to the center of the pump where it is discharged.

Most screw pumps are now equipped with mechanical seals. If the mechanical seal fails, the stuffing box has the capability of accepting two rings of conventional packing for emergency use.

SLIDING VANE PUMPS.— The sliding-vane pump (fig. 9-12) has a cylindrically bored housing with a suction inlet on one side and a discharge outlet on the other side. A rotor (smaller in diameter than the cylinder) is driven about an axis that is so placed above the center line of the cylinder as to provide minimum clearance between the rotor and cylinder at the top and maximum clearance at the bottom.

The rotor carries vanes (which move in and out as the rotor rotates) to maintain sealed spaces between the rotor and the cylinder wall. The vanes trap liquid on the suction side and carry it to the discharge side, where contraction of the space expels liquid through the discharge line. The vanes slide on slots in the rotor. Vane pumps are used for lube oil service and transfer, tank stripping, bilge, aircraft fueling and defueling and, in general, for handling lighter viscous liquids.

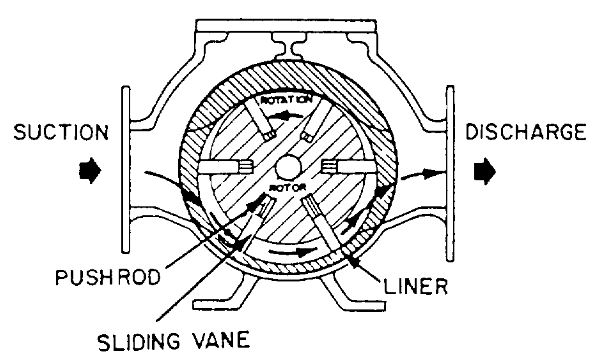


Figure 9-12.—Sliding vane pump.

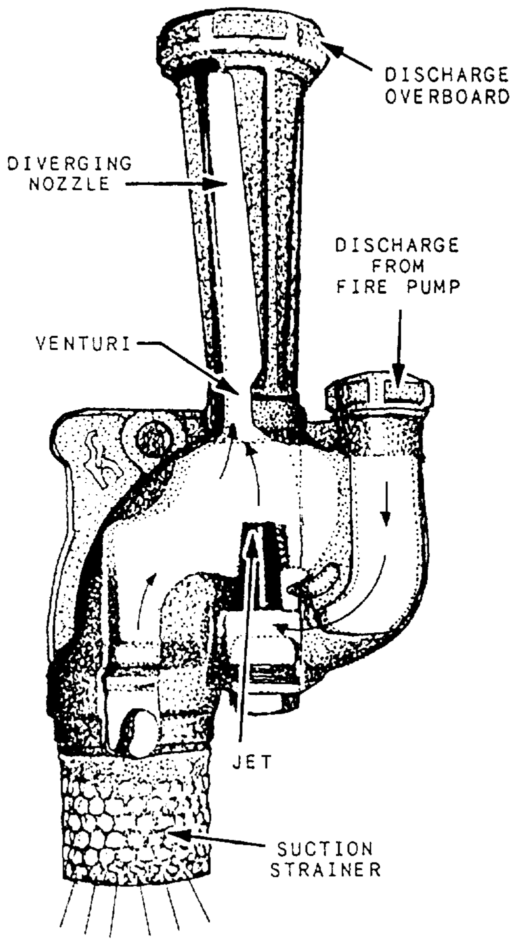


Figure 9-13.—Eductor.

Jet Pumps

The pumps discussed so far in this chapter have had a variety of moving parts. One type of pump you find in the engine room is the jet pump, usually called an eductor. Figure 9-13 shows an eductor, which has no moving parts. These pumps are used for pumping large quantities of water overboard in such applications as pumping bilges and dewatering compartments. As an engineer, you will think of eductors as part of the main and secondary drainage system; you will also become familiar with them as part of the ship's damage control equipment.

Eductors use a high-velocity jet of seawater to lower the pressure in the chamber around the converging nozzle. Seawater is supplied to the converging nozzle at a relatively low velocity and exits the nozzle at a high velocity. As the seawater leaves the nozzle and passes through the chamber,

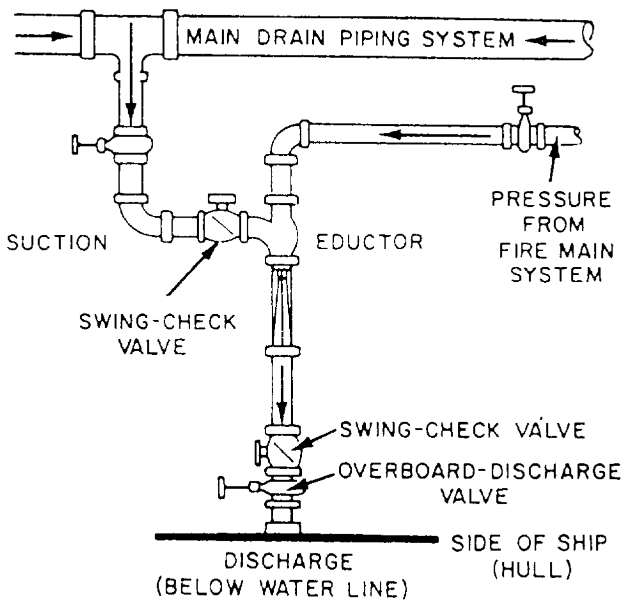


Figure 9-14.—Typical eductor system.

air becomes entrained in the jet stream and is pumped out of the chamber. Pressure in the chamber decreases, allowing atmospheric pressure to push the surrounding water into the chamber and mix with the jet stream. The diverging nozzle allows the velocity of the fluid to decrease and the pressure to increase; the discharge pressure is then established.

Figure 9-14 is an example of a typical shipboard eductor system. Note that the eductor discharge piping is below the water line. The swing-check valve above the overboard-discharge valve prevents water from backing up into the system if the system pressure drops below the outside water pressure. To prevent engineering spaces from flooding, you must follow the step-by-step procedures that are posted next to eductor stations.

ALIGNMENT OF SHAFT AND COUPLING

When you install or assemble pumps driven by electric motors, make sure the unit is aligned properly. If the shaft is misaligned, you must realign the unit to prevent shaft breakage and damage to bearings, pump casing wearing rings, and throat bushings. Always check the shaft alignment with all the piping in place.

Some driving units are connected to the pump by a FLEXIBLE COUPLING. A flexible coupling

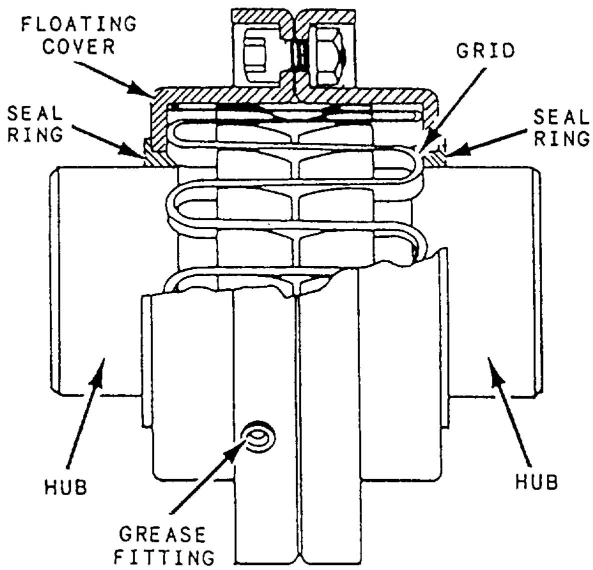


Figure 9-15.—Grid-type flexible coupling.

(fig. 9-15) is intended to take care of only a slight misalignment. Misalignment should never exceed the amount specified by the pump manufacturer. If the misalignment is excessive, the coupling parts are subjected to severe punishment, necessitating frequent replacement of pins, bushings, and bearings. It is absolutely necessary to have the rotating shafts of the driver and driven units in proper alignment. Figure 9-16 shows coupling alignment.

You should check the shaft alignment when the pump is opened for repair or maintenance, or if a noticeable vibration occurs. You must realign the unit if the shafts are out of line or inclined at an angle to each other. Whenever practicable, check the alignment with all piping in place and with the adjacent tanks and piping filled.

When the driving unit is connected to the pump by a FLANGE COUPLING, the shafting may require frequent realignment, which may be indicated by high temperatures, noises, and worn bearings or bushings.

Wedges, or shims, are sometimes placed under the bases of both the driven and driving units (fig. 9-16, view A) for ease in alignment when the machinery is installed. When the wedges or other packing have been adjusted so the outside diameters and faces of the coupling flanges run true as they are manually revolved, the chocks are fastened, the units are securely bolted to the foundation, and the coupling flanges are bolted together.

The faces of the coupling flanges should be checked at 90-degree intervals. This method is shown in figure 9-16, view B. Find the distances between the faces at point a, point b (on the

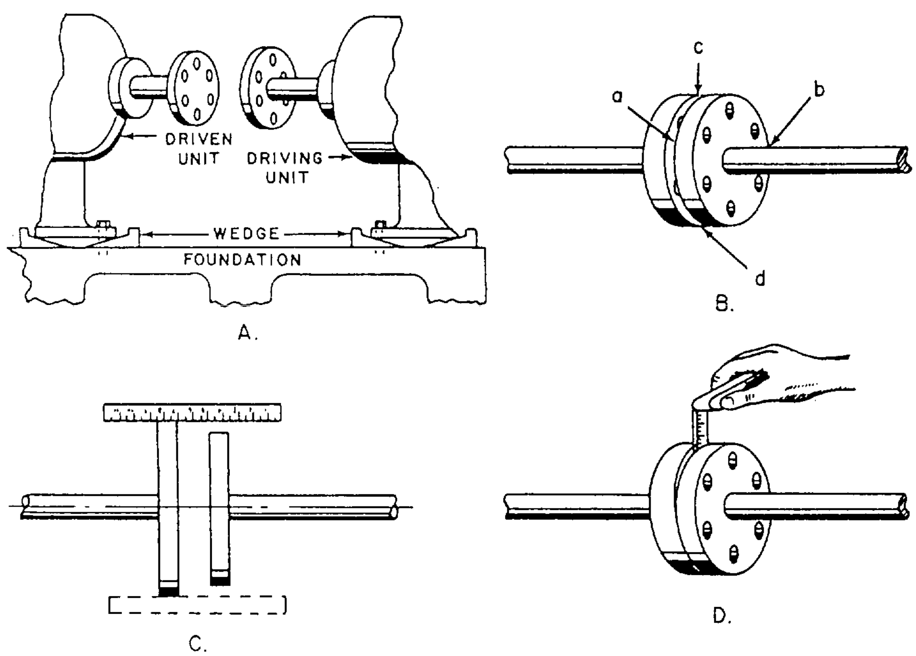


Figure 9-16.—Coupling alignment.

opposite side), point c, and point d (opposite point c). This action will show whether the coupling faces are parallel to each other. If they are not parallel to each other, adjust the driving unit or the pump with shims until the couplings check true. While measuring the distances, you must keep the outside diameters of the coupling flanges in line. To do this, place the scale across the two flanges, as shown in figure 9-16, view C. If the flanges do not line up, raise or lower one of the units with shims, or shift them sideways.

The procedure for using a thickness gauge to check alignments is similar to that for a scale. When the outside diameters of the coupling flanges are not the same, use a scale on the surface of the larger flange, and then use a thickness gauge between the surface of the smaller flange and the edge of the scale. When the space is narrow, check the distance between the coupling flanges with a thickness gauge, as shown in figure 9-16, view D. Check wider spaces with a piece of square key stock and a thickness gauge.

CONSTANT-PRESSURE PUMP GOVERNORS

A governor is a feedback device that is used to provide automatic control of speed, pressure, or temperature. A constant-pressure pump

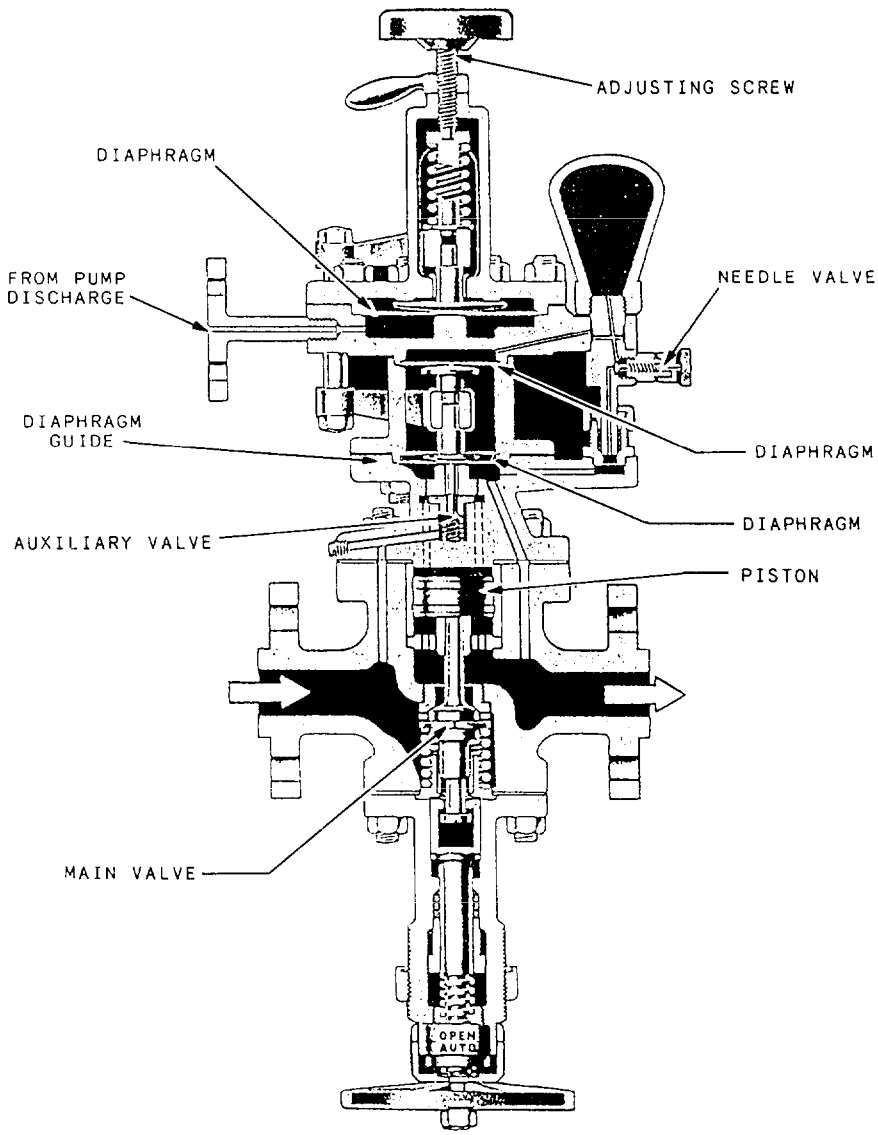


Figure 9-17.—Constant-pressure pump governor.

governor maintains a constant discharge pressure, regardless of pump capacity or output. Most constant-pressure pump governors used in the Navy control steam-driven pumps, both rotary and centrifugal types.

The constant-pressure pump governor (sometimes referred to as pressure-regulating) consists essentially of an automatic throttling valve installed in the steam supply line to the pump's driving unit. A pipeline connects the governor to the pump's discharge line. Variations in discharge pressure, or in pressure differential, actuate the governor, causing it to regulate the pump speed by varying the flow of steam to the driving unit.

A constant-pressure pump governor for a lubricating oil service pump is shown in figure 9-17. The governors used on fuel oil service pumps and on main feed pumps are of the same type. The size of the upper diaphragm and the amount of spring tension vary on governors used for different services. You will find detailed information concerning the operation and adjustment of governors in chapter 503 of the *NSTM*.

VALVES

A valve is any device used to control fluids in a closed system. In this section we will discuss valve construction and the most common types of valves you will use in the day-to-day operation and maintenance of the various shipboard engineering systems. Valves are typed or classified according to their use in a system.

VALVE CONSTRUCTION

Valves are usually made of bronze, brass, cast or malleable iron, or steel. Steel valves are either cast or forged and are made of either plain steel or alloy steel. Alloy steel valves are used in high-pressure, high-temperature systems; the disks and seats (internal sealing surfaces) of these valves are usually surfaced with a chromium-cobalt alloy known as Stellite. Stellite is extremely hard.

Brass and bronze valves are never used in systems where temperatures exceed 550°F. Steel valves are used for all services above 550°F and in lower temperature systems where internal or external conditions of high pressure, vibration, or shock would be too severe for valves made of brass or bronze. Bronze valves are used almost exclusively in systems that carry salt water. The seats and disks of these valves are usually made of Monel, a metal that has excellent corrosion- and erosion-resistant qualities.

Most submarine seawater valves are made of an alloy of 70 percent copper to 30 percent nickel (70/30).

VALVE TYPES

Although many different types of valves are used to control the flow of fluids, the basic valve types can be divided into two general groups: stop valves and check valves.

Besides the basic types of valves, many special valves, which cannot really be classified as either stop valves or check valves, are found in the engineering spaces. Many of these valves serve to control the pressure of fluids and are known as pressure-control valves. Other valves are identified by names that indicate their general function, such as thermostatic recirculating valves. The following sections deal first with the basic types of stop valves and check valves, then with some of the more complicated special valves.

Stop Valves

Stop valves are used to shut off or, in some cases, partially shut off the flow of fluid. Stop valves are controlled by the movement of the valve stem. Stop valves can be divided into four general categories: globe, gate, butterfly, and ball valves. Plug valves and needle valves may also be considered stop valves.

GLOBE VALVES.— Globe valves are probably the most common valves in existence. The globe valve derives its name from the globular shape of the valve body. However, positive identification of a globe valve must be made internally because other valve types may have globular appearing bodies. Globe valve inlet and outlet openings are arranged in several ways to suit varying

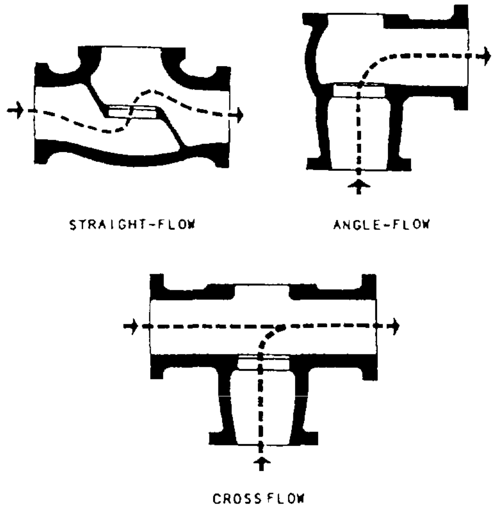


Figure 9-18.—Types of globe valve bodies.

requirements of flow. Figure 9-18 shows the common types of globe valve bodies: straight-flow, angle-flow, and cross flow. Globe valves are used extensively throughout the engineering plant and other parts of the ship in a variety of systems.

GATE VALVES.— Gate valves are used when a straight-line flow of fluid and minimum restriction is desired. Gate valves are so named because the part that either stops or allows flow through the valve acts somewhat like the opening or closing of a gate and is called, appropriately, the gate. The gate is usually wedge shaped. When the valve is wide open, the gate is fully drawn up into the valve, leaving an opening for flow through the valve the same size as the pipe in which the valve is installed. Therefore, there is little pressure drop or flow restriction through the valve. Gate valves are not suitable for throttling purposes since the control of flow would be difficult due to valve design and since the flow of fluid slapping against a partially open gate can cause extensive damage to the valve. Except as specifically authorized, gate valves should not be used for throttling.

Gate valves are classified as either RISING-STEM or NONRISING-STEM valves. On the nonrising-stem gate valve shown in figure 9-19, the stem is threaded on the lower end into the gate. As the handwheel on the stem is rotated, the gate travels up or down the stem on the threads, while the stem remains vertically stationary. This type of valve almost always has a pointer-type indicator

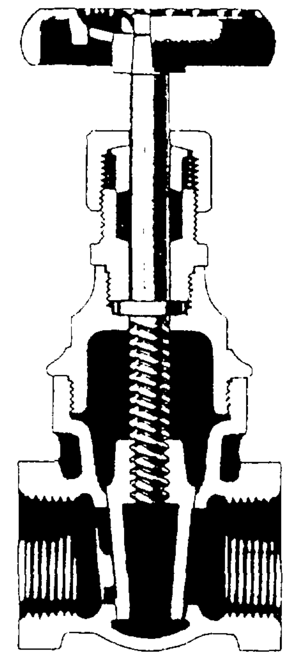


Figure 9-19.—Cutaway view of a gate valve (nonrising-stem type).

threaded onto the upper end of the stem to indicate valve position.

The rising-stem gate valve, shown in figure 9-20, has the stem attached to the gate; the gate and stem rise and lower together as the valve is operated.

Gate valves used in steam systems have flexible gates. The reason for using a flexible gate is to prevent binding of the gate within the valve when the valve is in the closed position. When steam lines are heated, they will expand, causing some distortion of valve bodies. If a solid gate fits snugly between the seat of a valve in a cold steam system, when the system is heated and pipes elongate, the seats will compress against the gate, wedging the gate between them and clamping the valve shut. This problem is overcome by use of a flexible gate (two circular plates attached to each other with a flexible hub in the middle). This design allows the gate to flex as the valve seat compresses it, thereby preventing clamping.

BUTTERFLY VALVES.— The butterfly valve, one type of which is shown in figure 9-21, may be used in a variety of systems aboard ship. These valves can be used effectively in freshwater, saltwater, JP-5, F-76 (naval distillate), lube oil, and chill water systems aboard ship. The butterfly valve is light in weight, relatively small, relatively

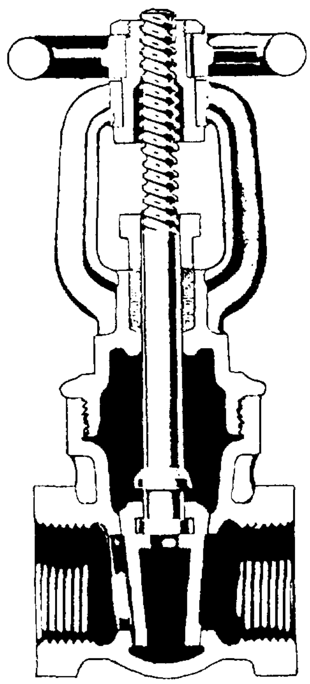


Figure 9-20.—Cutaway view of a gate valve (rising-stem type).

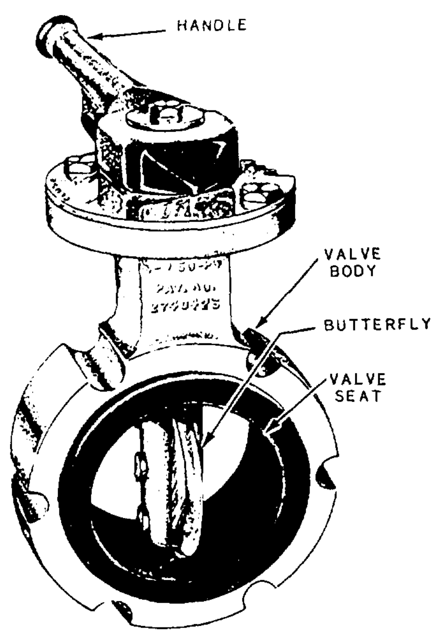


Figure 9-21.—Butterfly valve.

quick-acting, provides positive shut-off, and can be used for throttling.

The butterfly valve has a body, a resilient seat, a butterfly disk, a stem, packing, a notched positioning plate, and a handle. The resilient seat is under compression when it is mounted in the valve body, thus making a seal around the periphery of the disk and both upper and lower points where the stem passes through the seat. Packing is provided to form a positive seal around the stem for added protection in case the seal formed by the seat should become damaged.

To close or open a butterfly valve, turn the handle only one quarter turn to rotate the disk 90°. Some larger butterfly valves may have a handwheel that operates through a gearing arrangement to operate the valve. This method is used especially where space limitation prevents use of a long handle.

Butterfly valves are relatively easy to maintain. The resilient seat is held in place by mechanical means, and neither bonding nor cementing is necessary, Because the seat is replaceable, the valve seat does not require lapping, grinding, or machine work.

BALL VALVES.— Ball valves, as the name implies, are stop valves that use a ball to stop or start the flow of fluid. The ball (fig. 9-22) performs the same function as the disk in the globe valve. When the valve handle is operated to open the valve, the ball rotates to a point where the hole through the ball is in line with the valve body inlet and outlet. When the valve is shut, which requires only a 90-degree rotation of the handwheel for most valves, the ball is rotated so

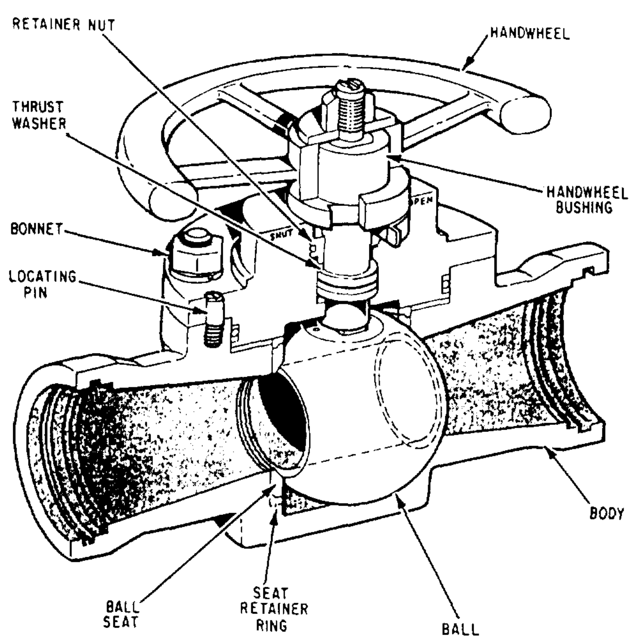


Figure 9-22.—Typical seawater ball valve.

the hole is perpendicular to the flow openings of the valve body, and flow is stopped.

Most ball valves are of the quick-acting type (requiring only a 90-degree turn to operate the valve either completely open or closed), but many are planetary gear operated. This type of gearing allows the use of a relatively small handwheel and operating force to operate a fairly large valve. The gearing does, however, increase the operating time for the valve. Some ball valves contain a swing check located within the ball to give the valve a check valve feature. Ball valves are normally found in the following systems aboard ship: seawater, sanitary, trim and drain, air, hydraulic, and oil transfer.

Check Valves

Check valves are used to allow fluid flow in a system in only one direction. They are operated by the flow of fluid in the piping. A check valve may be the swing type, lift type, or ball type.

As we have seen, most valves can be classified as being either stop valves or check valves. Some valves, however, function either as stop valves or as check valves—depending on the position of the valve stem. These valves are known as STOP-CHECK VALVES.

A stop-check valve is shown in cross section in figure 9-23. This type of valve looks very much like a lift-check valve. However, the valve stem is long enough so when it is screwed all the way down it holds the disk firmly against the seat, thus preventing any flow of fluid. In this position, the valve acts as a stop valve. When the stem is raised, the disk can be opened by pressure on the inlet side. In this position, the valve acts as a check valve, allowing the flow of fluid in only one direction. The maximum lift of the disk is controlled by the position of the valve stem. Therefore, the position of the valve stem limits the amount of fluid passing through the valve even when the valve is operating as a check valve.

Stop-check valves are widely used throughout the engineering plant. Stop-check valves are used in many drain lines and on the discharge side of many pumps.

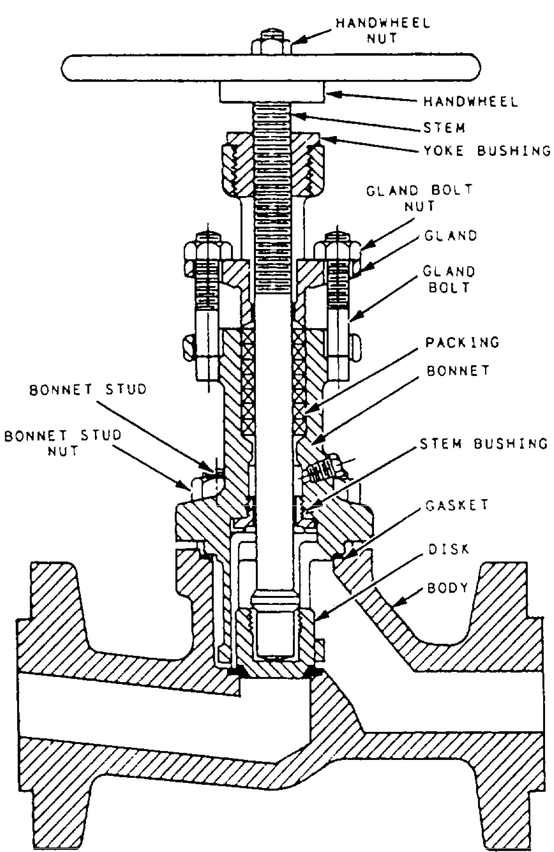


Figure 9-23.—Stop-check valve.

Special-Purpose Valves

There are many types of automatic pressure control valves. Some of them merely provide an escape for pressures exceeding the normal pressure; some provide only for the reduction of pressure; and some provide for the regulation of pressure.

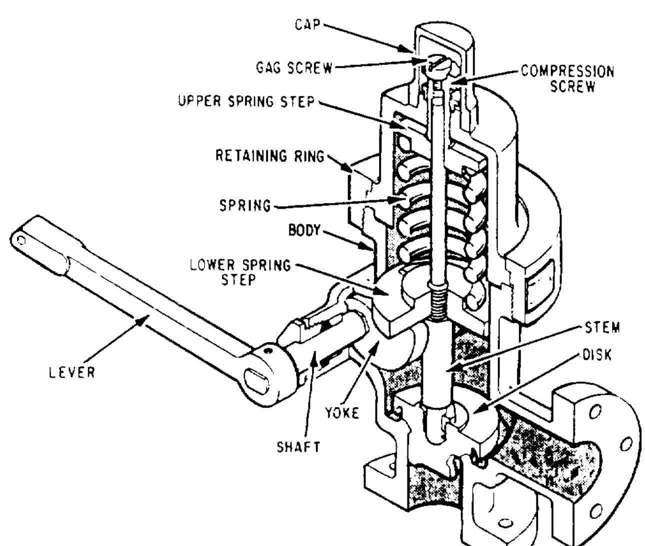


Figure 9-24.—Typical relief valve.

RELIEF VALVES.— Relief valves are automatic valves used on system lines and equipment to prevent overpressurization. Most relief valves simply lift (open) at a preset pressure and reset (shut) when the pressure drops only slightly below the lifting pressure. Figure 9-24 shows a relief valve of this type. System pressure simply acts under the valve disk at the inlet of the valve. When system pressure exceeds the force exerted by the valve spring, the valve disk lifts off its seat, allowing some of the system fluid to escape through the valve outlet until system pressure is reduced to just below the relief set point of the valve. The spring then reseats the valve. An operating lever is provided to allow manual cycling of the relief valve or to gag it open for certain tests. Virtually all relief valves are provided with some type of device to allow manual cycling.

Other types of relief valves are the high-pressure air safety relief valve and the bleed air surge relief valve. Both of these types of valves are designed to open completely at a specified lift pressure and to remain open until a specific reset pressure is reached—at which time they shut. Many different designs of these valves are used, but the same result is achieved.

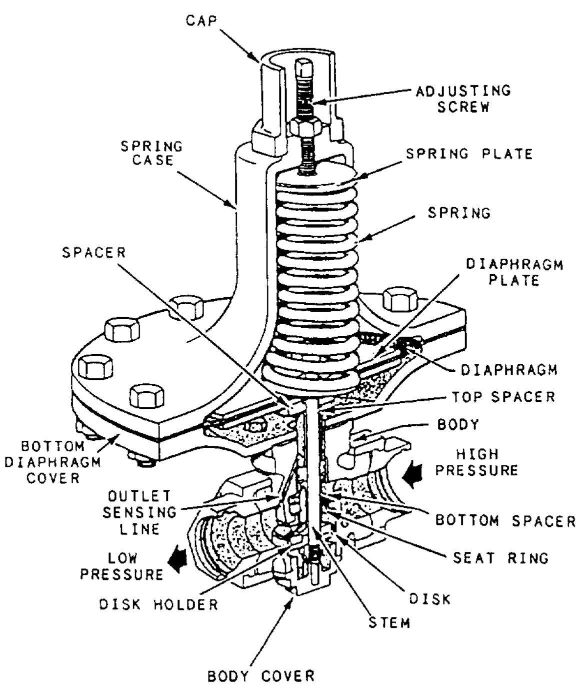


Figure 9-25.—Pressure-reducing (spring-loaded) valve.

SPRING-LOADED REDUCING VALVES.— Spring-loaded reducing valves, one type of which is shown in figure 9-25, are used in a wide variety of applications. Low-pressure air reducers and others are of this type. The valve simply uses spring pressure against a diaphragm to open the valve. On the bottom of the diaphragm, the outlet pressure (the pressure in the reduced pressure system) of the valve forces the disk upward to shut the valve. When the outlet pressure drops below the set point of the valve, the spring pressure overcomes the outlet pressure and forces the valve stem downward, opening the valve. As the outlet pressure increases, approaching the desired value, the pressure under the diaphragm begins to overcome spring pressure, forcing the valve stem upwards, shutting the valve. You can adjust the downstream pressure by removing the valve cap and turning the adjusting screw, which varies the spring pressure against the diaphragm. This particular spring-loaded valve will fail in the open position if a diaphragm rupture occurs.

REMOTE-OPERATING VALVES.— Remote-operating gear is installed to provide a means of operating certain valves from distant stations. Remote-operating gear may be mechanical, hydraulic, pneumatic, or electric.

Some remote-operating gear for valves is used in the normal operation of valves. For example, the main drain system manual valves are opened and closed by a reach rod or a series of reach rods and gears. Reach rods may be used to operate engine-room valves in instances where the valves are difficult to reach from the operating stations.

Other remote-operating gear is installed as emergency equipment. Some of the main drain and almost all of the secondary drain system valves are equipped with remote-operating gears. You can operate these valves locally, or in an emergency, you can operate them from remote stations. Remote-operating gear also includes a valve position indicator to show whether the valve is open or closed.

PRESSURE-REDUCING VALVES.— Pressure-reducing valves are automatic valves that provide a steady pressure into a system that is at a lower pressure than the supply system. Reducing valves of one type or another are found, for example, in firemain, seawater, and other systems. A reducing valve can normally be set for any desired downstream pressure within the design limits of the valve. Once the valve is set, the reduced pressure will be maintained regardless of changes in the supply pressure (as long as the supply pressure is at least as high as the reduced pressure desired) and regardless of the amount of reduced pressure fluid that is used.

Various designs of pressure-reducing valves are in use. Two of the types most commonly found on gas turbine ships are the spring-loaded reducing valve (already discussed) and the air-pilot operated diaphragm reducing valve.

Air-pilot operated diaphragm control valves are used extensively on naval ships. The valves and pilots are available in several designs to meet different requirements. They may be used to reduce pressure, to increase pressure, as unloading valves, or to provide continuous regulation of pressure. Valves and pilots of very similar design can also be used for other services, such as liquid-level control and temperature control.

The air-operated control pilot may be either direct acting or reverse acting. A direct-acting, air-operated control pilot is shown in figure 9-26. In this type of pilot, the controlled pressure—that is, the pressure from the discharge side of the diaphragm control valve—acts on top of a diaphragm in the control pilot. This pressure is balanced by the pressure exerted by the pilot adjusting spring. If the controlled pressure increases and overcomes the pressure exerted by the pilot adjusting spring, the pilot valve stem is forced downward. This action causes the pilot valve to open, thereby increasing the amount of operating air pressure going from the pilot to the diaphragm control valve. A reverse-acting pilot has a lever that reverses the pilot action. In a reverse-acting pilot, therefore, an increase in controlled pressure produces a decrease in operating air pressure.

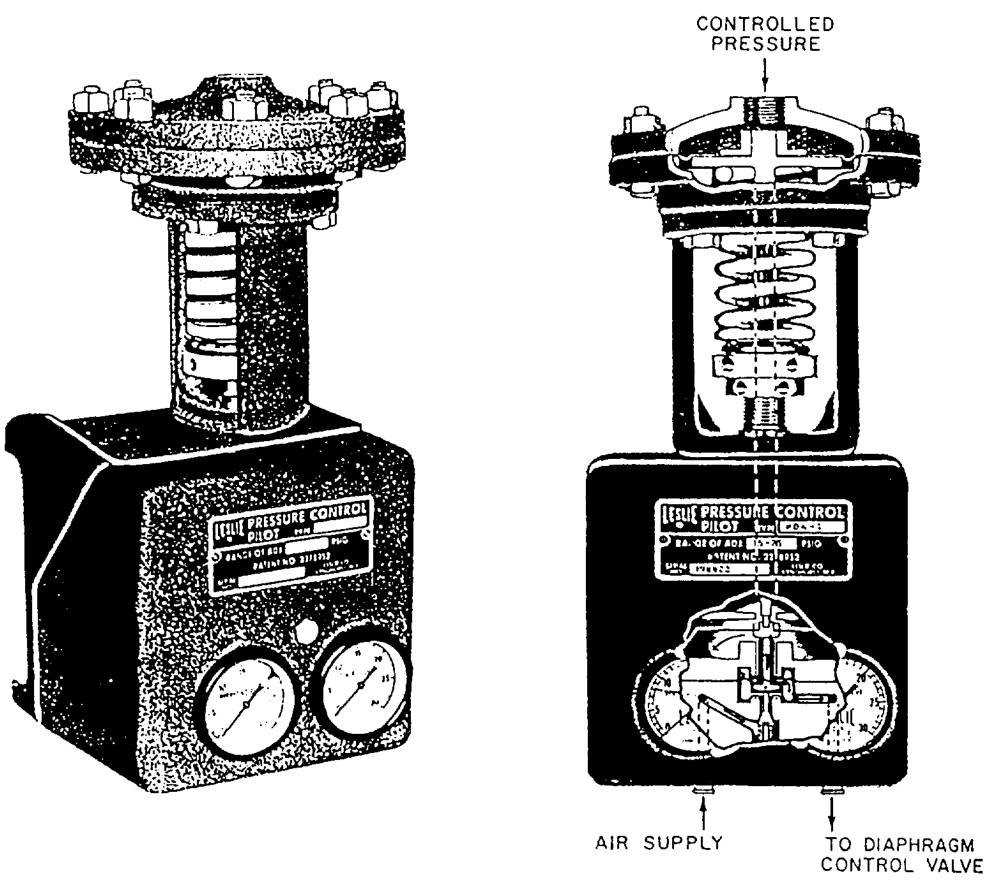


Figure 9-26.—Air-operated control pilot.

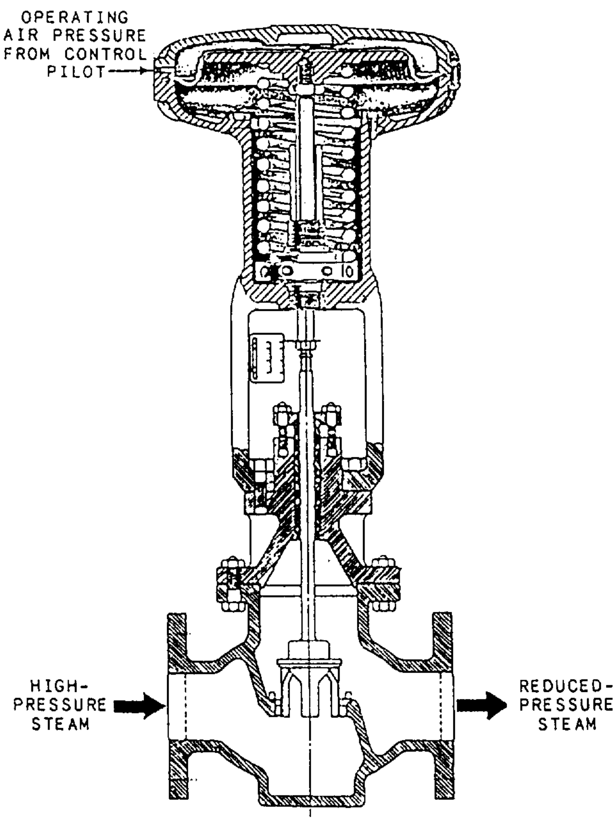


Figure 9-27.—Diaphragm control valve, downward-seating type.

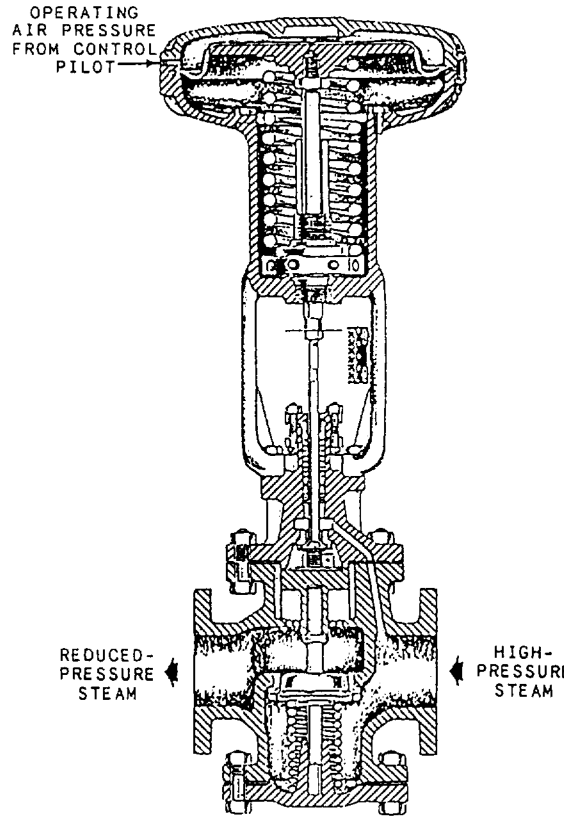


Figure 9-28.—Diaphragm control valve, upward-seating type.

In the diaphragm control valve, operating air from the pilot acts on the valve diaphragm. The superstructure, which contains the diaphragm, is direct acting in some valves and reverse acting in others. If the superstructure is direct-acting, the operating air pressure from the control pilot is applied to the TOP of the valve diaphragm. If the superstructure is reverse-acting, the operating air pressure from the pilot is applied to the UNDERSIDE of the valve diaphragm.

Figure 9-27 shows a very simple type of direct-acting diaphragm control valve with operating air pressure from the control pilot applied to the top of the valve diaphragm. Since the valve in the figure is a downward-seating valve, any increase in operating air pressure pushes the valve stem downward toward the closed position.

Now look at figure 9-28. This is also a direct-acting valve with operating air pressure from the control pilot applied to the top of the valve diaphragm. Note that the valve shown in figure 9-28 is more complicated than the one shown in figure 9-27 because of the added springs under the seat. The valve shown in figure 9-28 is an upward-seating valve rather than a downward-seating valve. Therefore, any increase in operating air pressure from the control pilot tends to OPEN this valve rather than to close it.

As you have seen, the air-operated control pilot may be either direct acting or reverse acting. The superstructure of the diaphragm control valve may be either direct acting or reverse acting. And, the diaphragm control valve may be either upward seating or downward seating. These three factors, as well as the purpose of the installation, determine how the diaphragm control valve and its air-operated control pilot are installed in relation to each other.

To see how these factors are related, let's consider an installation in which a diaphragm control valve and its air-operated control pilot are used to supply controlled steam pressure.

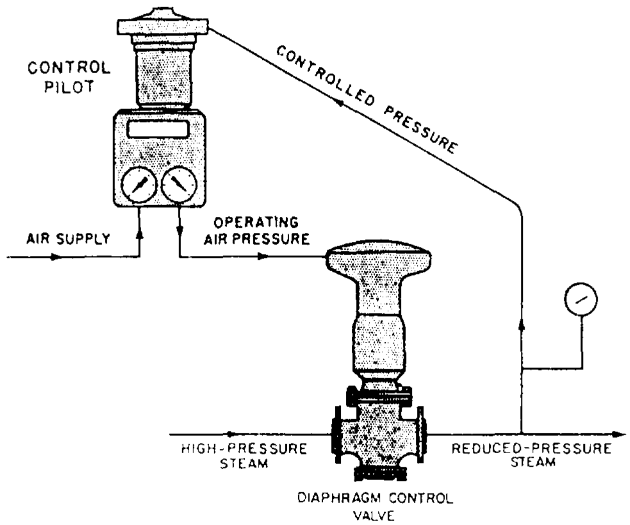


Figure 9-29.—Arrangement of control pilot and diaphragm control valve for supplying reduced-steam pressure.

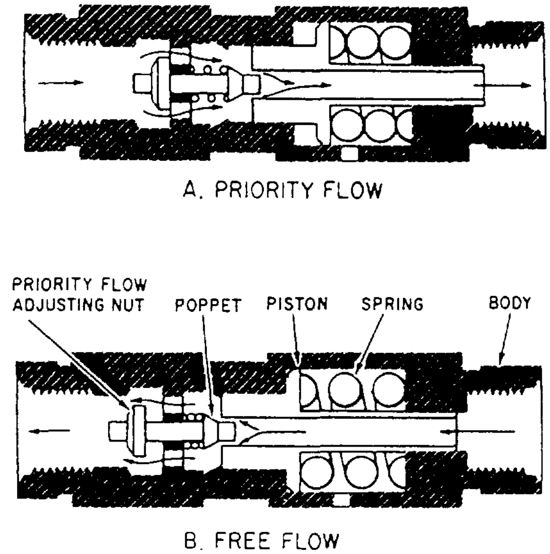


Figure 9-30.—Priority valve.

Figure 9-29 shows one arrangement that you might use. Assume that the service requirements indicate the need for a direct-acting, upward-seating diaphragm control valve. Can you figure out which kind of a control pilot—direct acting or reverse acting—should be used in this installation?

Try it first with a direct-acting control pilot, As the controlled pressure (discharge pressure from the diaphragm control valve) increases, increased pressure is applied to the diaphragm of the direct-acting control pilot. The valve stem is pushed downward and the valve in the control pilot is opened. This increases the operating air pressure from the control pilot to the top of the diaphragm control valve. The increased operating air pressure acting on the diaphragm of the valve pushes the stem downward, and since this is an upward-seating valve, this action OPENS the diaphragm control valve still wider. Obviously, this won't work for this application. An INCREASE in controlled pressure must result in a DECREASE in operating air pressure. Therefore, we made a mistake in choosing the direct-acting control pilot, For this particular pressure-reducing application, you should choose a REVERSE-ACTING control pilot.

It is not likely that you will be required to decide which type of control pilot and diaphragm control valve is needed in any particular installation. But you must know how and why they are selected so you do not make mistakes in repairing or replacing these units.

PRIORITY VALVES.— In systems with two or more circuits, it is sometimes necessary to have some means of supplying all available fluid to one particular circuit in case of a pressure drop in the system. A priority valve is often incorporated in the system to ensure a supply of fluid to the critical/vital circuit. The components of the system are arranged so the fluid to operate each circuit, except the one critical/vital circuit, must flow through the priority valve. A priority valve may also be used within a subsystem containing two or more actuating units to ensure a supply of fluid to one of the actuating units. In this case, the priority valve is incorporated in the subsystem in such a location that the fluid to each actuating unit, except the critical/vital unit, must flow through the valve.

Figure 9-30 shows one type of priority valve. View A of figure 9-30 shows the valve in the priority-flow position; that is, the fluid must flow through the valve in the direction shown by the arrows to get to the noncritical/vital circuits or actuating units. With no fluid pressure in the valve, spring tension forces the piston against the stop and the poppet seats against the hole in the center of the piston. As fluid pressure increases, the spring compresses and the piston moves to the right. The poppet follows the piston, sealing the hole in the center of the piston until the preset pressure is reached. (The preset pressure depends upon the requirements of the system and is set by the manufacturer.) Assume that the critical/vital circuit or actuating unit requires 1500 psi.

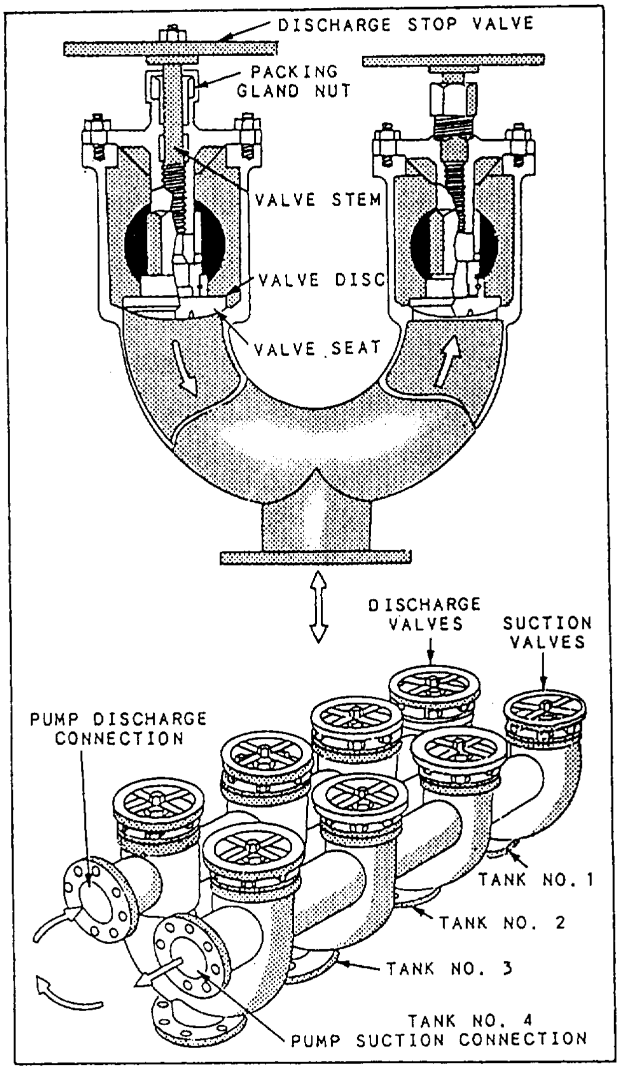


Figure 9-31.—Valve manifold showing cutaway view of the valves and typical combination of suction and discharge valves.

When the pressure in the valve reaches 1500 psi, the poppet reaches the end of its travel. As the pressure increases, the piston continues to move to the right, which unseats the poppet and allows flow through the valve, as shown in view A of figure 9-30. If the pressure drops below 1500 psi, the compressed spring forces the piston to the left, the poppet seats, and flow through the valve stops.

Figure 9-30, view B, shows the priority valve in the free-flow position. The flow of fluid moves the poppet to the left, the poppet spring compresses, and the poppet unseats. This allows free flow of fluid through the valve.

VALVE MANIFOLDS

Sometimes suction must be taken from one of many sources and discharged to another unit or units of either the same or another group. A valve manifold is used for this type of operation. An example of such a manifold (fig. 9-31) is the fuel oil filling and transfer system where provision must be made for the transfer of oil from any tank to any other tank, to the service system, or to another ship. If, for example, the purpose is to transfer oil from tank No. 1 to tank No. 4, the discharge valve for tank No. 4 and the suction valve from tank No. 1 are opened, and all other valves are closed. Fuel oil can now flow from tank No. 1, through the suction line, through the pump, through the discharge valve, and into tank No. 4. The manifold suction valves are often of the stop-check type to prevent draining of pumps when they are stopped.

VALVE HANDWHEEL IDENTIFICATION AND COLOR CODING

Valves are identified by markings inscribed on the rims of the handwheels, by a circular label plate secured by the handwheel nut, or by label plates attached to the ship's structure or to the adjacent piping.

Piping system valve handwheels and operating levers are marked for training and casualty control purposes with a standardized color code. Color code identification is in conformance with the color scheme of table 9-1. Implementation of

Table 9-1.—Valve Handwheel Color Code

FLUID	VALVE HANDWHEEL & OPERATING LEVER
STEAM	WHITE
POTABLE-WATER	DARK BLUE
NITROGEN	LIGHT GRAY
HP AIR	DARK GRAY
LP AIR	TAN
OXYGEN	LIGHT GREEN
SALT WATER	DARK GREEN
JP-5	PURPLE
FUEL OIL	YELLOW
LUBE OIL	STRIPED YELLOW/BLACK
FIRE PLUGS	RED
FOAM DISCHARGE	STRIPED RED/GREEN
GASOLINE	YELLOW
FEEDWATER	LIGHT BLUE
HYDRAULIC	ORANGE
HYDROGEN	CHARTREUSE
HELIUM	BUFF
HELIUM/OXYGEN	STRIPED BUFF/GREEN
SEWAGE	GOLD

this color scheme provides uniformity among all naval surface ships and shore-based training facilities.

MAINTENANCE

Preventive maintenance is the best way to extend the life of valves and fittings. Always refer to the applicable portion of the *Standard Navy Valve Technical Manual,* NAVSEA 0948-LP-012-5000, if possible. When making repairs on more sophisticated valve types, use the available manufacturer's technical manuals. As soon as you observe a leak, determine the cause, and then apply the proper corrective maintenance. Maintenance may be as simple as tightening a packing nut or gland. A leaking flange joint may need only to have the bolts tightened or to have a new gasket or O-ring inserted. Dirt and scale, if allowed to collect, will cause leakage. Loose hangers permit sections of a line to sag, and the weight of the pipe and the fluid in these sagging sections may strain joints to the point of leakage.

Whenever you are going to install a valve, be sure you know the function the valve is going to perform—that is, whether it must start flow, stop flow, regulate flow, regulate pressure, or prevent backflow. Inspect the valve body for the information that is stamped upon it by the manufacturer: type of system (oil, water, gas), operating pressure, direction of flow, and other information.

You should also know the operating characteristics of the valve, the metal from which it is made, and the type of end connection with which it is fitted. Operating characteristics and the material are factors that affect the length and kind of service that a valve will give; end connections indicate whether or not a particular valve is suited to the installation.

When you install valves, ensure they are readily accessible and allow enough headroom for full operation. Install valves with stems pointing upward if possible. A stem position between straight up and horizontal is acceptable, but avoid the inverted position (stem pointing downward). If the valve is installed with the stem pointing downward, sediment will collect in the bonnet and score the stem. Also, in a line that is subject to freezing temperatures, liquid that is trapped in the valve bonnet may freeze and rupture it.

Since you can install a globe valve with pressure either above the disk or below the disk (depending on which method will be best for the operation, protection, maintenance, and repair of the machinery served by the system), you should use caution. The question of what would happen if the disk became detached from the stem is a major consideration in determining whether pressure should be above the disk or below it. If you are required to install a globe valve, be SURE to check the blueprints for the system to see which way the valve must be installed. Very serious casualties can result if a valve is installed with pressure above the disk when it should be below the disk, or below the disk when it should be above.

Valves that have been in constant service for a long time will eventually require gland tightening, repacking, or a complete overhaul of all parts. If you know that a valve is not doing the job for which it was intended, dismantle the valve and inspect all parts. You must repair or replace all defective parts.

The repair of globe valves (other than routine renewal of packing) is limited to refinishing the seat and/or disk surface. When doing this work, you should observe the following precautions:

- When refinishing the valve seat, do not remove more material than is necessary. You can finish valves that do not have replaceable valve seats only a limited number of times.

- Before doing any repair to the seat and disk of a globe valve, check the valve disk to make certain it is secured rigidly to and is square on the valve stem. Also, check to be sure that the stem is straight. If the stem is not straight, the valve disk cannot seat properly,

- Carefully inspect the valve seat and valve disk for evidence of wear, for cuts on the seating area, and for improper fit of the disk to the seat. Even if the disk and seat appear to be in good condition, you should perform a spot-in check to find out whether they actually are in good condition.

Figure 9-32 shows a standard checkoff diagram for performing a routine inspection and minor maintenance of a valve.

Spotting-In Valves

The method used to visually determine whether the seat and the disk of a valve make good contact with each other is called spotting-in. To

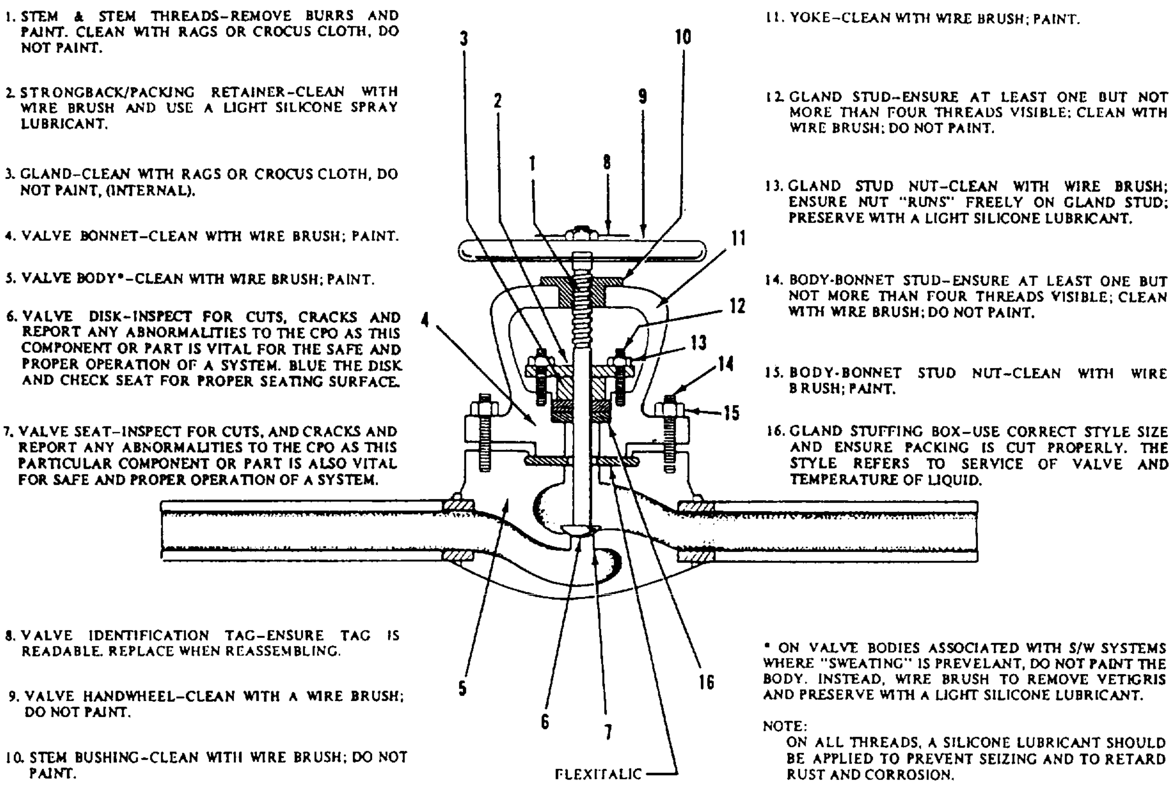


Figure 9-32.—Valve maintenance checkoff diagram.

spot-in a valve seat, you first apply a thin coating of prussian blue (commonly called Blue Dykem) evenly over the entire machined face surface of the disk. Insert the disk into the valve and rotate it one-quarter turn, using a light downward pressure. The prussian blue will adhere to the valve seat at those points where the disk makes contact. Figure 9-33 shows the appearance of a correct seat when it is spotted-in; it also shows the appearance of various kinds of imperfect seats.

After you have noted the condition of the seat surface, wipe all the prussian blue off the disk face surface. Apply a thin, even coat of prussian blue to the contact face of the seat, place the disk on the valve seat again, and rotate the disk one-quarter turn. Examine the resulting blue ring on the valve disk. The ring should be unbroken and of uniform width. If the blue ring is broken in any way, the disk is not making proper contact with the seat.

Grinding-In Valves

The manual process used to remove small irregularities by grinding together the contact surfaces of the seat and disk is called grinding-in. Grinding-in should not be confused with refacing processes in which lathes, valve reseating machines, or power grinders are used to recondition the seating surfaces.

To grind-in a valve, first apply a light coating of grinding compound to the face of the disk. Then insert the disk into the valve and rotate the disk back and forth about one-quarter turn; shift

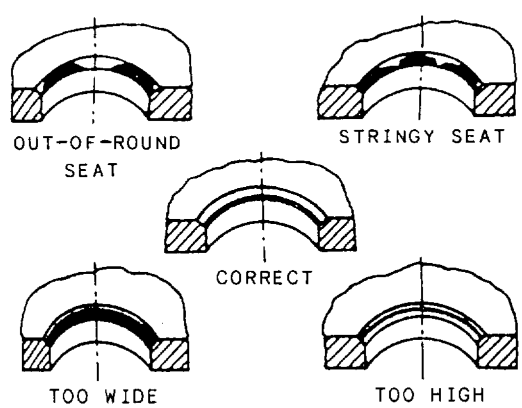


Figure 9-33.—Examples of spotted-in valve seats.

the disk-seat relationship from time to time so the disk will be moved gradually, in increments, through several rotations. During the grinding process, the grinding compound will gradually be displaced from between the seat and disk surfaces; therefore, you must stop every minute or so to replenish the compound. When you do this, wipe both the seat and the disk clean before applying the new compound to the disk face.

When you are satisfied that the irregularities have been removed, spot-in the disk to the seat in the manner previously described.

Grinding-in is also used to follow up all machining work on valve seats or disks. When the valve seat and disk are first spotted-in after they have been machined, the seat contact will be very narrow and will be located close to the bore. Grinding-in, using finer and finer compounds as the work progresses, causes the seat contact to become broader. The contact area should be a perfect ring covering about one-third of the seating surface.

Be careful to avoid overgrinding a valve seat or disk. Overgrinding will produce a groove in the seating surface of the disk; it will also round off the straight, angular surface of the disk. Machining is the only process by which overgrinding can be corrected.

Lapping Valves

When a valve seat contains irregularities that are slightly larger than can be satisfactorily removed by grinding-in, the irregularities can be removed by lapping. A cast-iron tool (lap) of exactly the same size and shape as the valve disk is used to true the valve seat surface. The following are some precautions you should follow when lapping valves:

- Do not bear heavily on the handle of the lap.
- Do not bear sideways on the handle of the lap.
- Change the relationship between the lap and the valve seat occasionally so that the lap will gradually and slowly rotate around the entire seat circle.
- Keep a check on the working surface of the lap. If a groove develops, have the lap refaced.
- Always use clean compound for lapping.
- Replace the compound frequently.
- Spread the compound evenly and lightly.
- Do not lap more than is necessary to produce a smooth even seat.
- Always use a fine grinding compound to finish the lapping job.
- Upon completion of the lapping job, spot-in and grind-in the disk to the seat.

You should use only approved abrasive compounds for reconditioning valve seats and disks. Compounds for lapping valve disks and seats are supplied in various grades. Use a coarse grade compound when you find extensive corrosion or deep cuts and scratches on the disks and seats. Use a medium grade compound as a follow-up to the coarse grade; you may also use it to start the reconditioning process on valves that are not too severely damaged. Use a fine grade compound when the reconditioning process nears completion. Use a microscopic-fine grade for finish lapping and for all grinding-in.

Refacing Valves

Badly scored valve seats must be refaced in a lathe, with a power grinder, or with a valve reseating machine. However, the lathe, rather than the reseating machine, should be used for refacing all valve disks and all hard-surfaced valve seats. Work that must be done on a lathe or with a power grinder should be turned over to shop personnel.

Repacking Valves

If the stem and packing of a valve are in good condition, you can normally stop packing gland leaks by tightening up on the packing. You must be careful, however, to avoid excessive thread engagement of the packing gland studs (if used) and to avoid tightening old, hardened packing, which will cause the valve to seize. Subsequent operation of such a valve may score or bend the stem.

Coils, rings, and corrugated ribbon are the common forms of packing used in valves. The form of packing to be used in repacking a particular valve will depend on the valve size, application, and type. Packing materials will be discussed in more detail later in this chapter.

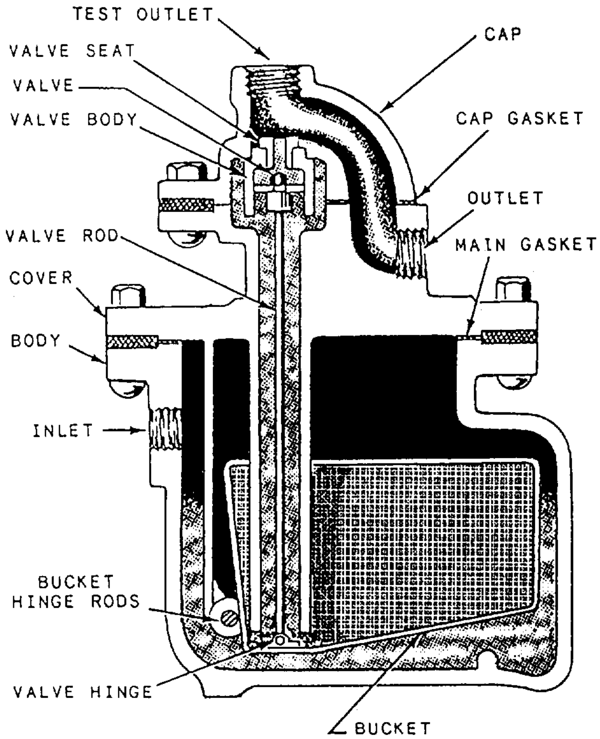


Figure 9-34.—Bucket-type steam trap.

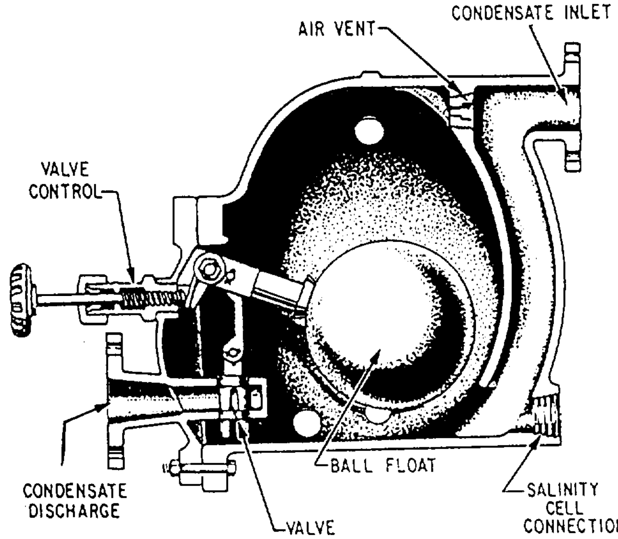


Figure 9-35.—Ball-float steam trap.

STEAM TRAPS

Steam traps are installed in steam lines to drain condensate from the lines without allowing the escape of steam. There are many different designs of steam traps; some are suitable for high-pressure use and others for low-pressure use.

TYPES OF STEAM TRAPS

Some types of steam traps that are used in the Navy are the mechanical steam traps, bimetallic steam traps, and orifice-type steam traps.

Mechanical Steam Traps

Mechanical steam traps in common use include bucket-type traps and ball-float traps.

The operation of the bucket-type steam trap, shown in figure 9-34, is controlled by the condensate level in the trap body. The bucket valve is connected to the bucket in such a way that the valve closes as the bucket rises. As condensate continues to flow into the trap body, the valve remains closed until the bucket is full. When the bucket is full, it sinks and thus opens the valve. The valve remains open until enough condensate has blown out to allow the bucket to float, thus closing the valve.

Figure 9-35 shows a ball-float steam trap. This trap works much in the same way as the bucket trap. Condensate and steam enter the body of the trap, and the condensate collects at the bottom. As the condensate level rises, the ball float rises until it is raised enough to open the outlet valve of the trap. When the outlet valve opens, the condensate flows out of the trap into the drain system, and the float level drops, shutting off the valve until the condensate level rises again.

Bimetallic Steam Traps

Bimetallic steam traps of the type shown in figure 9-36 are used in many ships to drain

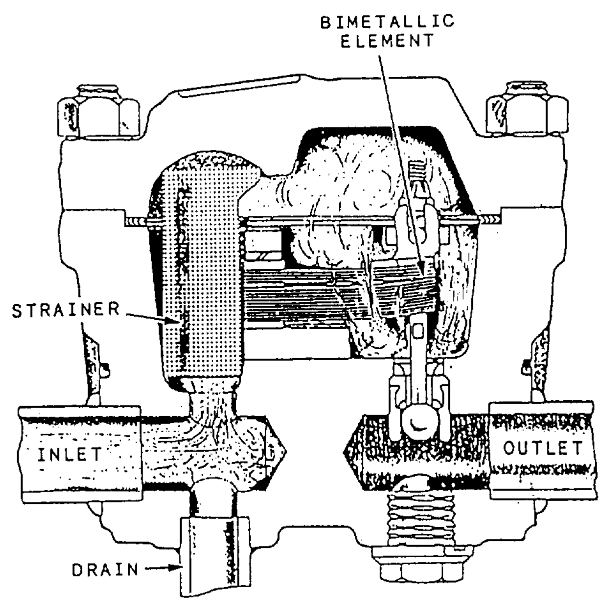


Figure 9-36.—Bimetallic steam trap.

condensate from main steam lines, auxiliary steam lines, and other steam components. The main working parts of this steam trap are a segmented bimetallic element and a ball-type check valve.

The bimetallic element has several bimetallic strips fastened together in a segmented fashion, as shown in figure 9-36. One end of the bimetallic element is fastened rigidly to a part of the valve body; the other end, which is free to move, is fastened to the top of the stem of the ball-type check valve.

Line pressure acting on the check valve keeps the valve open. When steam enters the trap body, the bimetallic element expands unequally because of the different response to the temperature of the two metals; the bimetallic element deflects upward at its free end, thus moving the valve stem upward and closing the valve. As the steam cools and condenses, the bimetallic element moves downward, toward the horizontal position, thus opening the valve and allowing some condensate to flow out through the valve. As the flow of condensate begins, an unbalance of line pressure across the valve is created; since the line pressure is greater on the upper side of the ball of the check valve, the valve now opens wide and allows a full capacity flow of condensate.

Orifice Steam Traps

Aboard ship, continuous-flow steam traps of the orifice type are used in systems or services in which condensate forms at a fairly steady rate. Figure 9-37 shows one orifice-type steam trap.

Several variations of the orifice-type steam trap exist, but all have one thing in common—they have no moving parts. One or more restricted passageways or orifices allow condensate to trickle through but do not allow steam to flow through. Besides orifices, some orifice-type steam traps have baffles.

MAINTENANCE

A strainer is installed just ahead of each steam trap. The strainer must be kept clean and in good condition to keep scale and other foreign matter from getting into the trap. Scale and sediment can clog the working parts of a steam trap and seriously interfere with the working of the trap.

Steam traps that are not operating properly can cause problems in systems and machinery. One way to check on the operation of a steam trap is to listen to it. If the trap is leaking, you will probably be able to hear it blowing through. Another way to check the operation of steam traps is to check the pressure in the drain system. A leaking steam trap causes an unusual increase in pressure in the drain system. When observing this condition, you can locate the defective trap by cutting out (isolating from the system) traps, one at a time, until the pressure in the drain system returns to normal.

You should disassemble, clean, and inspect defective steam traps. After determining the cause of the trouble, repair or replace parts as required. In some steam traps, you can replace the main working parts as a unit; in others, you may have to grind in a seating surface, replace a disk, or perform other repairs. You should reseat defective trap discharge valves. Always install new gaskets when reassembling steam traps.

FILTERS AND STRAINERS

Fluids are kept clean in a system principally by devices such as filters and strainers. Magnetic

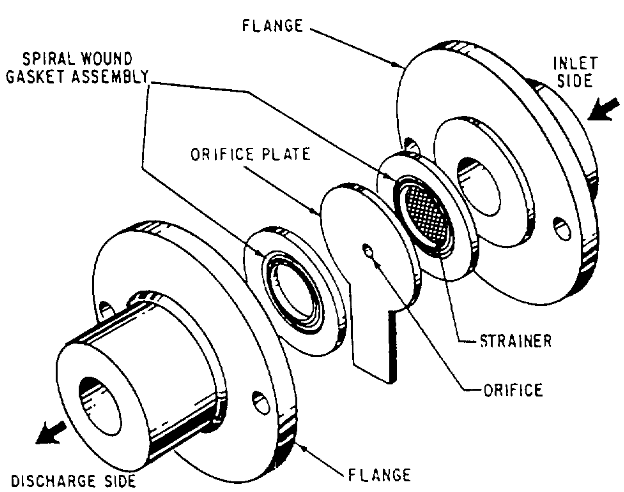


Figure 9-37.—Constant-flow drain orifice.

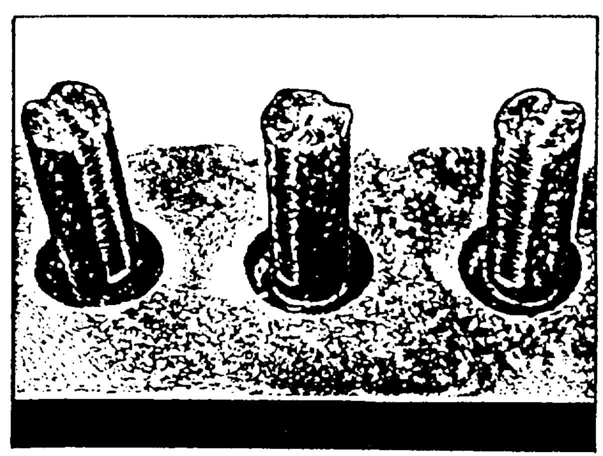


Figure 9-38.—Magnetic plugs.

plugs (fig. 9-38) also are used in some strainers to trap iron and steel particles carried by fluid. Studies have indicated that even particles as small as 1 to 5 microns have a degrading effect, causing failures and hastening deterioration in many cases.

There will always be controversy over the exact definitions of filters and strainers. In the past, many such devices were named filters but technically classed as strainers. To minimize the controversy, the National Fluid Power Association gives us these definitions:

FILTER - A device whose primary function is the retention, by some porous medium, of insoluble contaminants from a fluid.

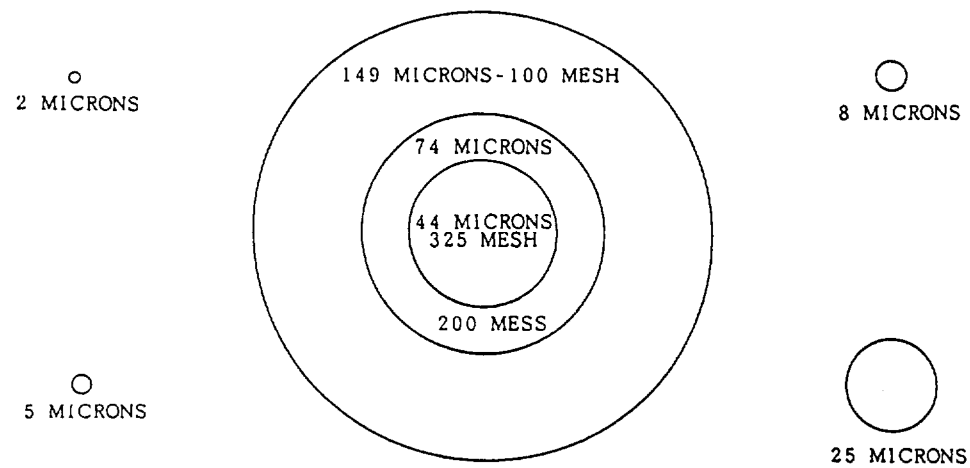
STRAINER - A coarse filter.

To put it simply, whether the device is a filter or a strainer, its function is to trap contaminants from fluid flowing through it. The term *porous medium* simply refers to a screen or filtering material that allows fluid flow through it but stops various other materials.

MESH AND MICRON RATINGS

Filters, which may be made of many materials other than wire screen, are rated by MICRON size. A micron is 1-millionth of a meter or 39-millionths of an inch. For comparison, a grain of salt is about 70 microns across. The smallest particle visible to the naked eye is about 40 microns. Figure 9-39 shows the relationship of

RELATIVE SIZE OF MICRONIC PARTICLES
MAGNIFICATION 500 TIMES



RELATIVE SIZES

LOWER LIMIT OF VISIBILITY (NAKED EYE)	40 MICRONS
WHITE BLOOD CELLS	25 MICRONS
RED BLOOD CELLS	8 MICRONS
BACTERIA (COCCI)	2 MICRONS

LINEAR EQUIVALENTS

1 INCH	25.4 MILLIMETERS	25,400 MICRONS
1 MILLIMETER	0.0394 INCHES	1,000 MICRONS
1 MICRON	25,400 OF AN INCH	0.001 MILLIMETERS
1 MICRON	3.94×10^{-5}	0.000039 INCHES

SCREEN SIZES

MESHES PER LINEAR INCH	U.S. SIEVE NO.	OPENING IN INCHES	OPENING IN MICRONS
52.38	50	0.0117	297.0
72.45	70	0.0083	210.0
101.01	100	0.0059	149.0
142.86	140	0.0041	105.0
200.00	200	0.0029	74.0
270.26	270	0.0021	53.0
323.00	325	0.0017	44.0
		0.00039	10.0
		0.000019	0.5

Figure 9-39.—Relationship of micron sizes.

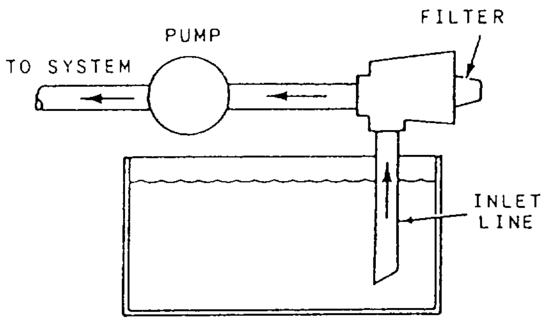


Figure 9-40.—Inlet line filter.

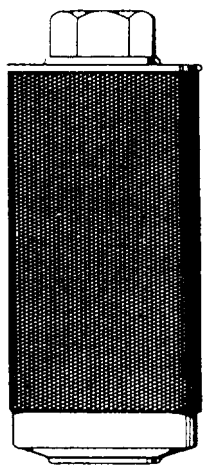


Figure 9-41.—Inlet strainer.

the various micron sizes with mesh and standard sieve sizes.

A simple screen or a wire strainer is rated for filtering fineness by a MESH number or its near equivalent, STANDARD SIEVE number. The higher the mesh or sieve number, the finer the screen.

When a filter is specified as so many microns, it usually refers to the filter's NOMINAL rating. A filter nominally rated at 10 microns, for example, would trap most particles 10 microns in size or larger. The filter's ABSOLUTE rating, however, would be a somewhat higher size, perhaps 25 microns. The absolute rating is the size of the largest opening or pore in the filter. Absolute rating is an important factor only when it is mandatory that no particles above a given size be allowed to circulate in the system.

FILTER/STRAINER LOCATION

There are three general areas in a system for locating a filter: the inlet line, the pressure line, or a return line. Both filters and strainers are available for inlet lines. Filters are normally used in other lines.

Inlet Filters and Strainers

Figure 9-40 shows the location of an inlet line filter. An inlet line filter is usually a relatively coarse mesh filter. A fine mesh filter (unless it is very large) creates more pressure drop than can be tolerated in an inlet line.

Figure 9-41 shows a typical strainer of the type installed on pump inlet lines inside a reservoir. It is relatively coarse as filters go, being constructed of fine mesh wire. A 100-mesh strainer protects the pump from particles about 150 microns in size.

Pressure Line Filters

A number of filters are designed for installation right in the pressure line (fig. 9-42) and can trap much smaller particles than inlet line

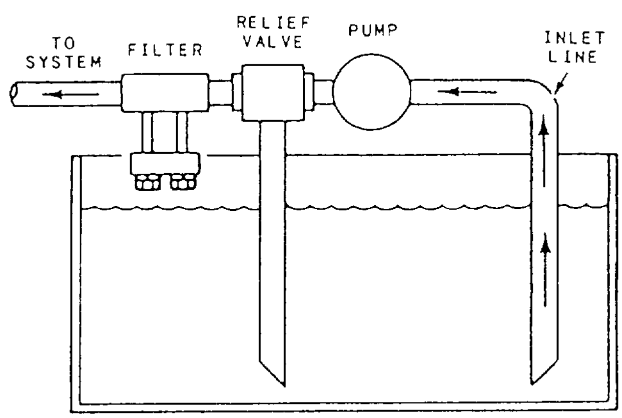


Figure 9-42.—Pressure line filter.

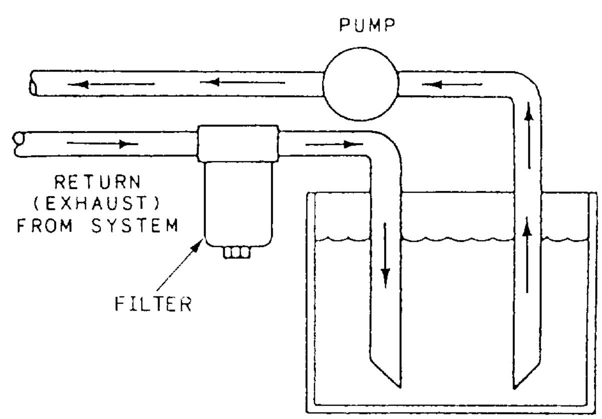


Figure 9-43.—Return line filter.

filters. Such a filter might be used where system components, such as valves, are less dirt-tolerant than the pump. The filter thus would trap this fine contamination from the fluid as it leaves the pump. Pressure line filters must be able to withstand the operating pressure of the system.

Return Line Filters

Return line filters (fig. 9-43) also can trap very small particles before the fluid returns to the reservoir/tank. They are particularly useful in systems that do not have large reservoirs/tanks to allow contaminants to settle out of the fluid. A return line filter is nearly a must in a system with a high-performance pump, which has very close clearances and usually cannot be sufficiently protected by an inlet line filter.

FILTER/STRAINER MATERIALS

The materials used in filters and strainers are classified as mechanical, absorbent, or adsorbent. Most strainer material is of the mechanical type, which operates by trapping particles between closely woven metal screens and/or disks, and metal baskets. The mechanical type of material is used mostly where the particles removed from the medium are of a relatively coarse nature.

Absorbent filters are used for most minute-particle filtration in fluid systems. They are made of a wide range of porous materials, including paper, wood pulp, cotton, yarn, and cellulose. Paper filters are usually resin-impregnated for strength.

Adsorbent (or active) filters, such as charcoal and fuller's earth, are used mostly in gaseous or vapors systems. This type of filter material should not be used in hydraulic systems since they remove essential additives from the hydraulic fluid.

CONSTRUCTION OF FILTER ELEMENTS

Filter elements are constructed in various ways. The three most common filter element construction types are the surface type (most common), the depth type, and the edge type.

Surface-type filter elements (fig. 9-44) are made of closely woven fabric or treated paper with pores to allow fluid to flow through. Very accurate control of the pore size is a feature of the surface-type elements.

A depth-type filter element (fig. 9-45) is composed of layers of a fabric or fibers, which provide many tortuous paths for the fluid to flow through. The pores or passages vary in size, and the degree of filtration depends on the flow rate. Increases in flow rate tend to dislodge trapped particles. This filter is limited to low-flow, low pressure-drop conditions.

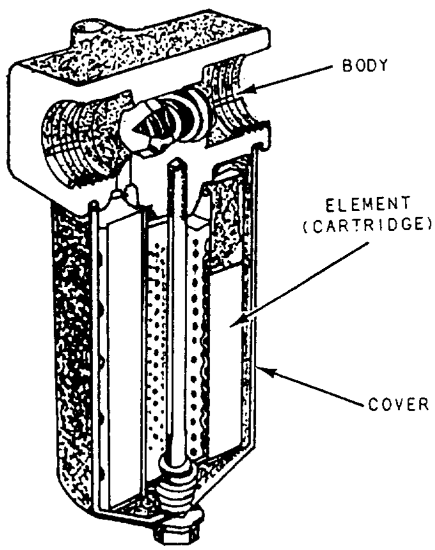


Figure 9-44.—Filter assembly using a surface-type element.

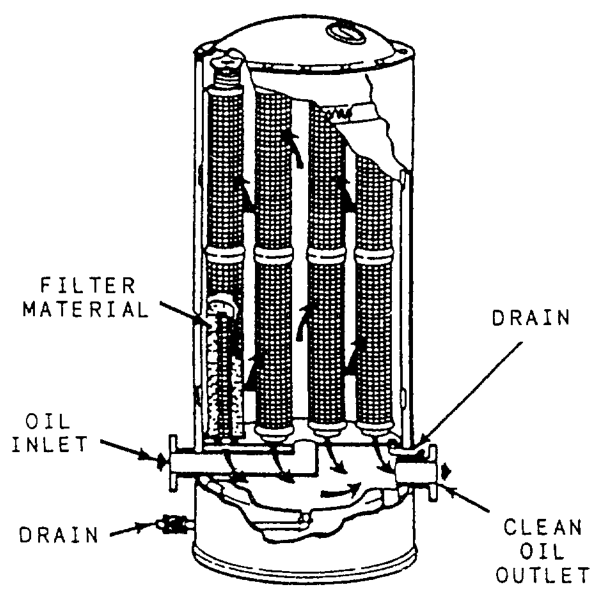


Figure 9-45.—Depth-type filter element.

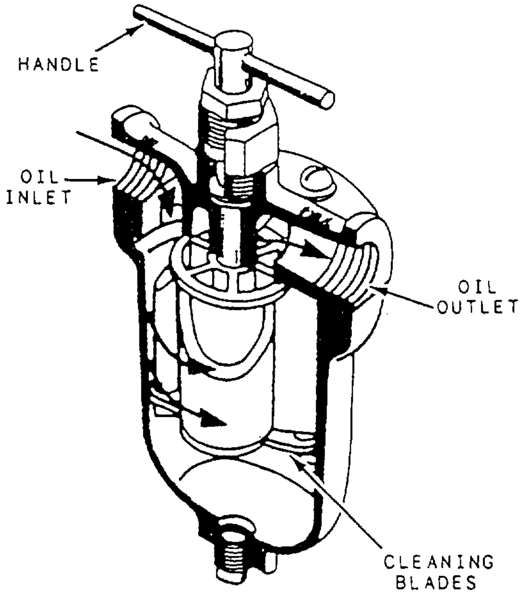


Figure 9-46.—Edge-type filter element.

An edge-type filter element (fig. 9-46) separates particles rom fluids passing between finely spaced plates. The filter shown features stationary cleaner blades that scrape out the collected contaminants when the handle is twisted to turn the element.

TYPES OF FILTERS

In this section we will discuss the various filters (simplex, duplex, full flow, proportional flow, and indicator) that you will most frequently find installed in equipment.

Simplex Filter

The simplex filter has one or more cylindrically shaped fine mesh screens or perforated metal sheets. The size of the opening in the screens or the perforated metal sheets determines the size of particles filtered out of the fluid. The design of this type of filter is such that total flow must pass through a simplex filter.

Duplex Filters

Duplex filters are similar to simplex filters except in the number of elements and in provision for switching the flow through either element. A duplex filter may consist of a number of single element filters arranged in parallel operation, or it may consist of two or more filters arranged within a single housing. The full flow can be diverted, by operation of valves, through any single element. The duplex design is most commonly used in fuel or hydraulic systems because the ability to shift to an off-line filter when the elements are cleaned or changed is desirable without the system being secured.

Full-Flow Filters

The term *full-flow* applied to a filter means that all the flow into the filter inlet port passes through the filtering element. In most full-flow filters, however, there is a bypass valve preset to open at a given pressure drop and divert flow past the filter element. This prevents a dirty element from restricting flow excessively. Figure 9-47 shows a full-flow filter. Flow, as shown, is out-to-in; that is, from around the element, through it to its center. The bypass opens when total flow can no longer pass through the contaminated element without raising the system pressure. The element is replaceable after removing a single bolt.

Proportional-Flow Filters

A proportional-flow filter (fig. 9-48) may use the venturi effect to filter a portion of the fluid flow. The fluid can flow in either direction. As it passes through the filter body, a venturi throat causes an increase in velocity and a decrease in

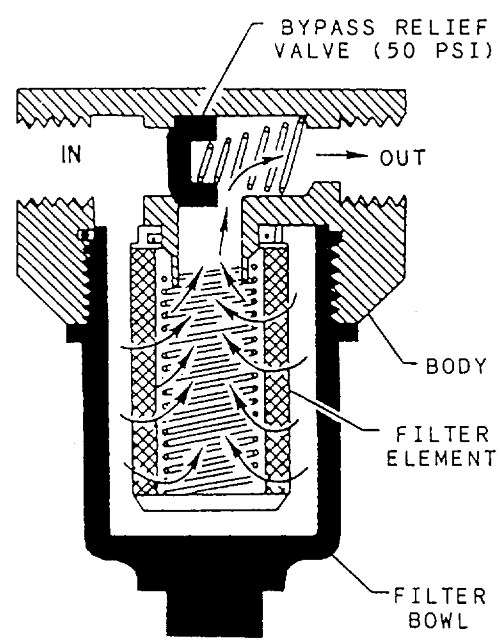


Figure 9-47.—Full-flow filter.

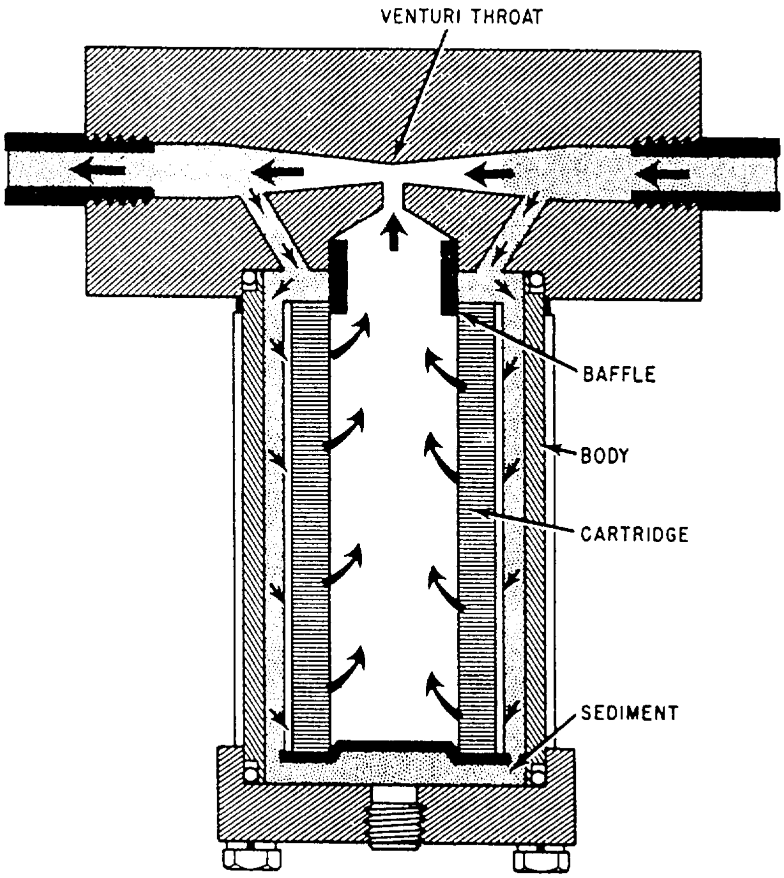


Figure 9-48.—Proportional-flow filter,

pressure. The pressure difference forces some of the fluid through the element to rejoin the main stream at the venturi. The amount of fluid filtered is proportional to the flow velocity. Hence, the name proportional-flow filter.

Indicating Filters

Indicating filters are designed to signal the operator when the element needs cleaning. There are various types of indicators, such as color-coded, flag, pop-up, and swing arm. Figure 9-49 shows a color-coded indicating filter. The element is designed so it begins to move as the pressure increases due to dirt accumulation, One end is linked to an indicator that shows the operator just how clean or dirty the element is. Another feature of this type of filter is the ease and speed with which the element can be removed and replaced. Most filters of this kind are designed for inlet line installation.

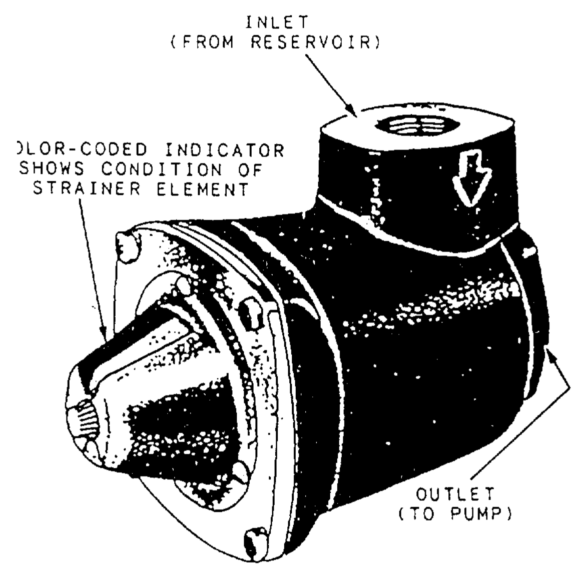


Figure 9-49.—Color-coded indicating filter.

Filter/Separator

The filter/separator is a two-stage unit consisting of a coalescer stage and a separator stage within a single housing. Each stage is made up of replaceable elements, the number of which is determined by such considerations as the capacity of the elements in gallons per minute (gpm) and the elements dirt retaining properties. Coalescer elements filter solids from the fluid and cause small particles of undissolved water to combine (coalesce) into larger drops of water that, because of their weight, will settle in the filter/separator sump. Separator elements are provided to remove any remaining free water that has not coalesced. Water that accumulates in the filter/separator sump is removed through a drain line, either automatically or manually.

In-Line or Cone Filter

In-line or cone filters have conical-shaped fine mesh screen or perforated metal sheet that is inserted into the system pipe and secured by a set of flanges. Its system application determines whether it is considered a filter or strainer. It is most commonly used in seawater systems, where it is considered a strainer. This type of filter is prohibited in fuel systems.

MAINTENANCE

Proper operation of filters, strainers, and filter separators is essential for satisfactory gas turbine and diesel engine performance. Besides clogging the systems with foreign matter, continued operation with unfiltered fluids results in accelerated pump wear and system degradation. Routine maintenance of filters, strainers, and filter/separators is adequately covered in *NSTM*, Chapter 541, "Petroleum Fuel Stowage, Use, and Testing," paragraphs 541-8.51 through 541-8.59.

PIPING

The control and application of fluid power would be impossible without a suitable means of conveying the fluid from the power source to the point of application. Fluid lines used for this purpose are called piping. They must be designed and installed with the same care applicable to other components of the system. To obtain this desired result, attention must be given to the various types, materials, and sizes of lines available for the fluid power system. The different types of lines and their application to fluid power systems are described in the first part of this section. The last part of this section is devoted to the various connectors applicable to the different types of fluid lines.

IDENTIFICATION OF PIPING

The three most common lines used in fluid power systems are pipe, tubing, and flexible hose. They are sometimes referred to as rigid (pipe), semirigid (tubing), and flexible piping. In commercial usage, there is no clear distinction between piping and tubing, since the correct designation for each product is established by the manufacturer. If the manufacturer calls its product pipe, it is pipe; if the manufacturer calls it tubing, it is tubing.

In the Navy, however, a distinction is made between pipe and tubing. The distinction is based on the method used to determine the size of the product. There are three important dimensions of any tubular product—outside diameter (OD), inside diameter (ID), and wall thickness. The product is called tubing if its size is identified by actual measured outside diameter and by actual wall thickness. The product is called pipe if its size is identified by a nominal dimension and wall thickness.

PIPING MATERIALS

The pipe and tubing used in fluid systems today are commonly made from steel, copper, brass, aluminum, and stainless steel. The hose assemblies are constructed of rubber or Teflon. Each of these materials has its own distinct advantages or disadvantages, depending upon its application.

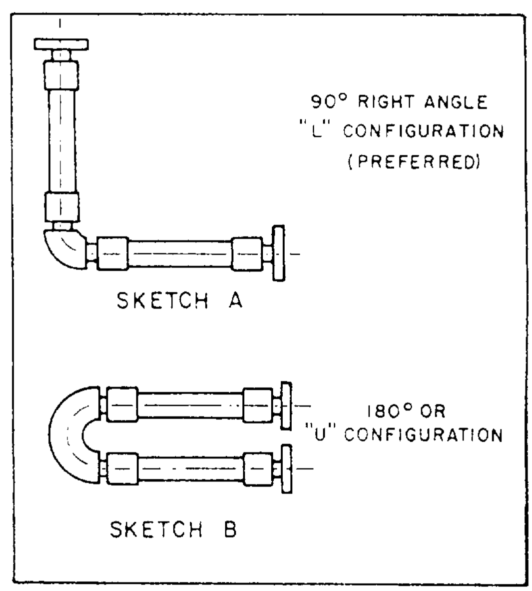


Figure 9-50.—Types of flexible hose installations and fittings.

Steel piping and tubing are relatively inexpensive, have a high tensile strength, are suitable for bending and flanging, and are very adaptable to high pressures and temperatures. Its chief disadvantage is a comparatively low resistance to corrosion.

Copper and brass piping and tubing have a high resistance to corrosion and are easily drawn or bent. Pipe or tubing made from these materials is unsuitable for systems with high temperatures, stress, or vibration because they have a tendency to harden and break.

Aluminum has many characteristics and qualities required for fluid systems. It has a high resistance to corrosion, is lightweight, is easily drawn or bent, and (when combined with certain alloys) will withstand high pressures and temperatures.

Stainless steel piping or tubing is relatively lightweight and is used in a system that will be exposed to abrasion, high pressure, and intense heat. Its main disadvantage is high cost.

FLEXIBLE HOSE ASSEMBLIES

The flexible hose assembly is a specific type of flexible device that uses reinforced rubber hose and metal end fittings. It is used to absorb motions between resiliently mounted machinery and fixed or resiliently mounted piping systems. The motions to be considered may be of either relatively large size due to high-impact shock or of smaller size due to the vibratory forces of rotating machinery. The configuration selected must contain enough hose to accommodate shock and vibratory motions without stressing the hose assembly or machinery to an unacceptable degree.

Approved Flexible Hose Configurations

The arrangements (or configurations) determined to give the best noise attenuation characteristics and to accommodate the motions of resiliently mounted equipment are shown in figures 9-50 and 9-51. The 90° "L" configuration

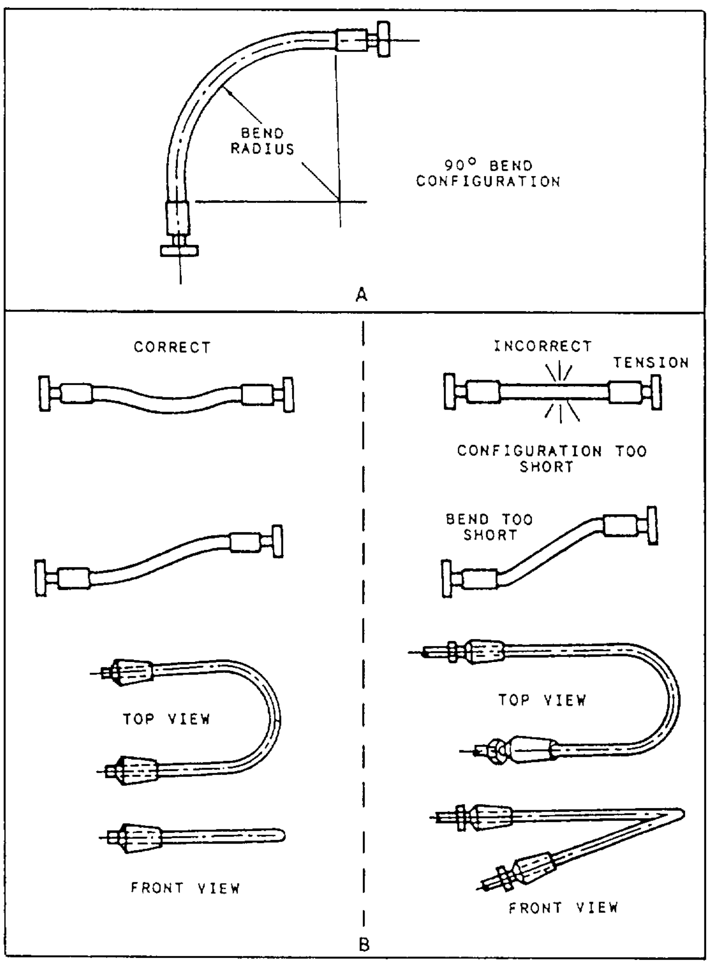


Figure 9-51.—Other approved single hose length configurations.

(dogleg) is the preferred configuration; however, where space and piping arrangement prohibit the use of the "L" configuration, a 180° or "U" configuration may be used. The 90° "L" and 180° "U" configurations are shown as sketches A and B of figure 9-50.

A configuration that uses a single length of hose bent to about 90° is approved where the hose does not bend below its specified minimum bending radius when the equipment moves to the maximum limits allowed by its mounts (view A of fig. 9-51). The straight single hose configuration and the 180° single hose bend (view B of fig. 9-51) are also approved for use where the hose size is less than 1 inch ID.

Flexible connections that use rubber hose are not used in systems where the maximum continuous operating temperature is in excess of 200°F.

Hose Identification

Hose is identified by the manufacturer's part number and the size or dash number. The dash number is the nominal hose inside diameter in sixteenths of an inch. Hose built to military specification (MILSPEC) requirements have the number of the specification and, where applicable, the class of hose, the quarter and year of manufacture, and the manufacturer's trademark. This information is molded or otherwise permanently repeated periodically on the hose cover (sometimes referred to as the "lay line marking"). Other information permanently marked on the hose cover is the manufacturer's code and the date of manufacture. For interpretations of commercial lay line markings, refer to the appropriate manufacturer's catalog or manual.

Fitting Identification

Use special care in identifying hose fittings because their designation is more complex than hose. A fitting suitable for connecting to a given hose size can end in more than one size and type of connection to the piping. A fitting, therefore, must be identified by the manufacturer's part number, the size of the end connection that joins the piping system, and the dash size to show the size hose to which it makes up. For interpretation of manufacturer markings, consult the appropriate manufacturer's manual. Fittings meeting military specification requirements have the specification number, class of fitting (where applicable), type, size, and manufacturer's trademark.

A cross index between the manufacturers' designations and military specifications and information to correctly identify approved hoses and fittings can be found in *Piping Devices, Flexible Hose Assemblies*, volume 1, NAVSEA S6430-AE-TED-010.

Inspection of Hose and Fittings Prior To Make-Up

The basic inspection methods for hose and fittings are listed as follows:

1. Ensure that the hose and couplings are the correct ones for the intended use and that the age of the rubber hose does not exceed a shelf life of 4 years. Teflon and metal hose have no limiting shelf life.
2. Inspect for signs that the hose has been twisted. Use the hose lay line for a guide to determine whether or not any twist is present. <u>If twisted, reject.</u>
3. Inspect for signs that the hose has been kinked or bent beyond its minimum bend radius. <u>If suspect, reject.</u>
4. Inspect for signs of loose inner liner. If found, cut the hose to see if this condition exists throughout the entire length. <u>If suspect, reject.</u>
5. Visually check the inner liner and outer rubber cover of the hose for breaks, hairline cuts, or severe abrasions. <u>If any suspect areas are found, reject.</u>
6. Inspect the fittings for defects, such as cracked nipples and damaged threads. <u>If suspect, or if defects are found, reject.</u>

Procedures for making up hoses and fittings can also be found in the *NSTM*, chapter 505, or the appropriate manufacturer's catalog or manual, and are not covered here due to the many types available.

Visual Inspection

After assembling the hose and fittings, visually inspect the entire configuration to ensure the following:

1. The hose inner liner and outer cover is intact and contains no cuts or harmful abrasions.
2. The hose has not been twisted (check the lay line).

3. The circumferential chalk line on the hose next to the coupling has been drawn before the hydrostatic test.

4. The internal spring (if installed) is evenly spaced and flat against the inner liner. Ensure a gap exists between one of the end fittings and the end of the spring.

Hydrostatic Test

Upon completion of visual inspection, hydrostatically shop test the hose assembly with fresh water. For each style and size of hose, test the pressure to ensure that it is twice the maximum allowable pressure shown in chapter 505 of the *NSTM*. When you test pressure, hold for not more than 5 minutes nor less than 60 seconds. When test pressure is reached, visually inspect the hose assembly for the following defects:

1. Leaks or signs of weakness

2. Twisting of the hose (this indicates that some twist existed before pressure was applied)

3. Slippage of the hose out of the coupling (a circumferential chalk line can help determine this)

If any of these defects occur, reject the assembly.

CAUTION

Do not confuse hose elongation under pressure with coupling slippage. If the chalk line returns to near its original position, no slippage has occurred and the assembly is satisfactory. If there is any doubt, perform a second test. If doubt persists after the second test, reject the assembly.

Air Test

Hose assemblies intended for gas or air service must also be tested with air or nitrogen at 100 psi and the assembly immersed in water. Random bubbles may appear over the hose and in the fitting area when the assembly is first pressurized. Do not construe this as a defect. However, if the bubbles persist in forming at a steady rate at any particular point on the hose, reject the assembly.

Installation of Flexible Hose Assemblies

After completion of tests, proceed as follows:

1. Install as soon as possible.

2. Do not leave the hose assembly around on decks or on docks where they can be subjected to any form of abuse.

3. Make up hose assemblies as late as possible during the availability schedule to minimize the chances of damage while the ship is being overhauled.

4. Install plastic dust caps, plugs, or tape ends to protect threaded areas until the hose assembly is installed.

When installing flexible base connections, observe the following requirements:

1. Ensure each leg of hose is free of twist between end fittings.

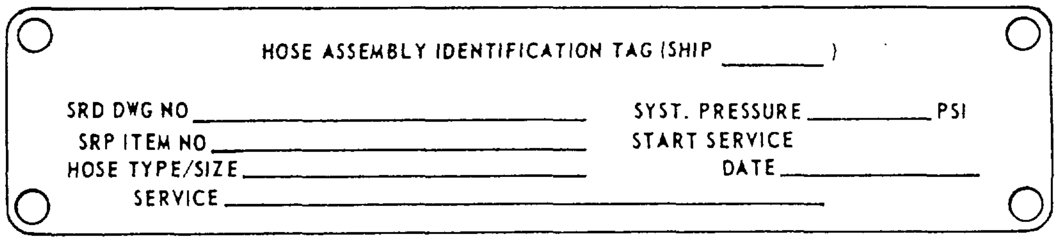
2. Ensure the fixed piping near the flexible configuration is properly supported so that it does not vibrate from the resiliently mounted equipment.

3. Ensure the configurations are clear of all surrounding structures and remain so when resiliently mounted equipment moves through its maximum excursion under shock.

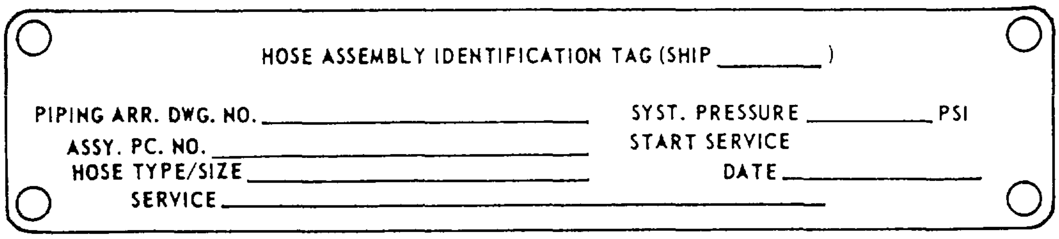
4. Locate flexible connections as close as possible to the sound-mounted unit.

5. Support the free elbow of the configuration with an approved pipe hanger so as not to sag or otherwise unduly stress or distort the configuration.

6. Do not appreciably change the alignment of the hose configuration between the unpressurized and pressurized conditions. If you do, you could cause misalignment or improper support at the fixed end.



A
ID TAG WHEN SELECTED RECORD DRAWING IS AVAILABLE



B
ID TAG WHEN SELECTED RECORD DRAWING DOES NOT EXIST

Figure 9-52.-Hose assembly identification tags.

7. Obtain metal hose assembly identification tags (fig. 9-52) from your local SIMA and secure them onto one of the legs of the hose configuration. The tag is made of a non-corroding material. Do not remove or alter the tag once it is attached.
8. Leave the configuration in a condition where one end can hang down unsupported during installation or dismantling of piping. Otherwise, you can damage the hose wire reinforcement.

Periodic Inspection By Ship's Force

No less than once a quarter, preferably about once a month, visually inspect all flexible piping connections to determine whether any signs of weakness or unusual conditions exist. Inspect the hose in other systems semiannually. To assist you when performing this inspection, you should compile a checkoff list of hose assemblies and locations for your assigned spaces or equipment. This list will consist of all flexible devices installed (and their locations) together with a list of inspections to be performed on each flexible device. When you perform the listed inspections, note the following:

1. Evidence of leakage at fitting ends.
2. Discoloration of fittings (possible indication wire reinforcement is rusting).
3. Slippage of hose out of fitting.
4. Twisting of hose or other distortion or unusual appearance.
5. Cracking of outer rubber cover.
6. Rubber cover rubbed thin by abrasion or chafing.
7. High pulsations, fluid hammer, or whipping caused by pressure pulsations.
8. Large vibrations due to improper supports at the fixed end.
9. Large area of hose covered with paint. (The intent of this requirement is to eliminate having the flexible hose connections deliberately painted. The hose does not have to be replaced if a few paint drops inadvertently fall onto it. Do not attempt to clean off dried paint from the hose.)
10. Check hangers to ensure they have not broken off, become distorted, or been otherwise damaged.
11. Soft spots or bulges on hose body (indicates weakening of bond between outer rubber cover and wire braid or deterioration of the reinforcing wire).
12. If results of visual inspection indicates weakening of hose or fittings, or makes hose configuration suspect, replace the hose immediately, if at all possible. Keep under surveillance while under pressure until it is replaced.

13. If necessary to remove a flexible hose configuration from the system, examine the interior of the hose for cracks or other signs of deterioration of the inner liner. Do not damage the liner by trying to dislodge sea growth. Do not remove the end fittings from any section of hose that is to be installed.
14. Presence of identification tag.

Storage

The following guidelines are recommended for proper storage of hose and fittings:

- Hose—Hose should be stored in a dark, dry atmosphere away from electrical equipment; temperature should not exceed 125°"F. Storage in straight lengths is preferred, but if hose is to be coiled, take care to ensure the diameter of the bend is not less than 3 feet. To prevent damage during storage, wrap the hose with burlap or other suitable material.

- Reusable end fittings—Protect all threads with tape or other suitable material, and wrap the entire fitting in a protective covering to prevent nicking or other damage.

Shelf Life

The following are shelf life requirements for hose and reusable end fittings:

- Hose—Do not install reinforced rubber hose that is over 4 years old from the date of manufacture. This time is measured from the quarter and year of manufacture but does not include the quarter year of manufacture. Consider the shelf life of hose ended upon installation aboard ship. To ensure against its accidental use, dispose of any hose not installed that has exceeded the above shelf life.

- Reusable end fittings—There is no shelf life for end fittings. They should be replaced on an individual basis when examination makes them suspect.

Servicing

No servicing or maintenance is required since hose or fittings must be replaced at the slightest suspicion of potential failure. If a fitting is removed from a section of hose, that hose section must not be reused, regardless of its service life.

Service Life of Rubber Hose

All rubber hose has a periodic replacement time. All flexible rubber hose connections will be replaced every 5 years (± 6 months) in critical systems and every 12 years in noncritical systems. Wire braided Teflon hose has no specified shelf or service life. Its replacement is based on inspection of the hose for excessive wear or damage.

FITTINGS

Some type of connector must be provided to attach the pipe, tube, or hose to the other components of the system and to connect sections of the line to each other. There are many different types of connectors (commonly called fittings) provided for this purpose. Some of the most common types of fittings are covered in the following paragraphs.

Threaded Joints

The threaded joints are the simplest type of pipe fittings. Threaded fittings are not widely used aboard modern ships except in low-pressure water piping systems. The pipe ends connected to the union are threaded, silver-brazed, or welded into the tail pieces (union halves); then the two ends are joined by setting up (engaging and tightening up on) the union ring. The male and female connecting ends of the tail pieces are carefully ground to make a tight metal-to-metal fit with each other. Welding or silver-brazing the ends to the tail pieces prevents contact of the carried fluid or gas with the union threading.

Bolted Flange Joints

Bolted flange joints (fig. 9-53) are suitable for all pressures now in use. The flanges are attached

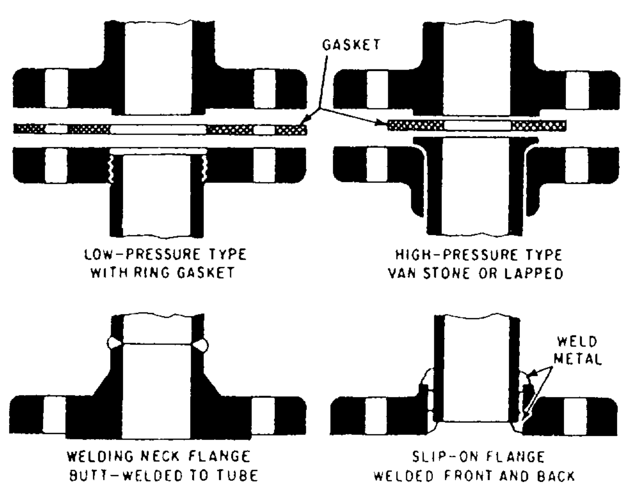


Figure 9-53.—Four types of bolted flange piping joints.

to the piping by welding, brazing, screw threads (for some low-pressure piping), or rolling and bending into recesses. Those shown in figure 9-53 are the most common types of flange joints used. Flange joints are manufactured for all standard fitting shapes, such as the tee, cross, elbow, and return bend. The Van Stone and the welded-neck flange joints are used extensively where piping is subjected to high pressures and heavy expansion strains. The design of the Van Stone flange makes it easier to line up the fastening holes in the two parts of the flange.

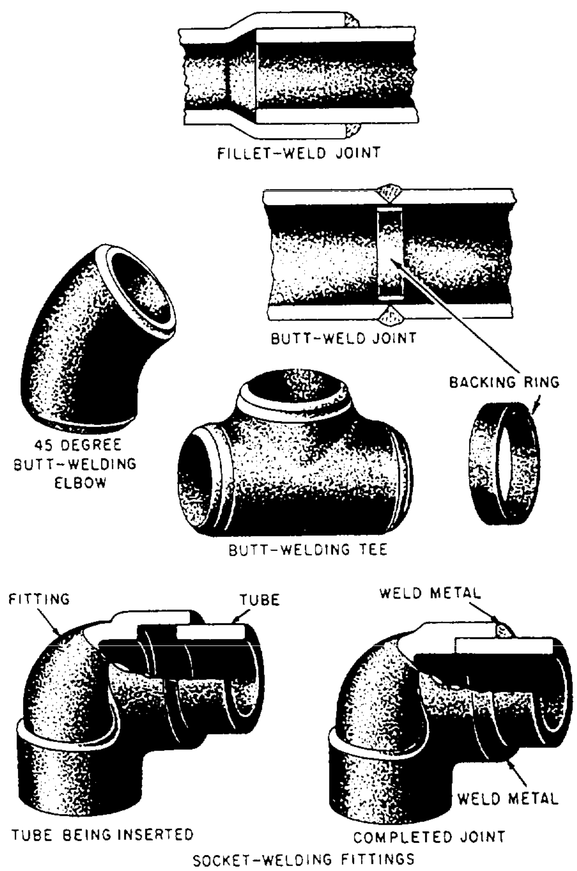


Figure 9-54.—Various types of welded joints.

Welded Joints

The majority of joints found in subassemblies of piping systems are welded joints, especially in high-pressure piping. The welding is done according to standard specifications, which define the material and techniques. Three general classes of welded joints are fillet-weld, butt-weld, and socket-weld (fig. 9-54).

Silver-Brazed Joints

Silver-brazed joints (fig. 9-55) are commonly used for joining nonferrous piping when the pressure and temperature in the lines make their use practicable—temperatures must not exceed 425°F; for cold lines, pressure must not exceed 3000 psi. The alloy is melted by heating the joint with an oxyacetylene torch. This causes the molten metal to fill the few thousandths of an inch annular space between the pipe and the fitting.

Unions

The union fittings are provided in piping systems to allow the piping to be taken down for

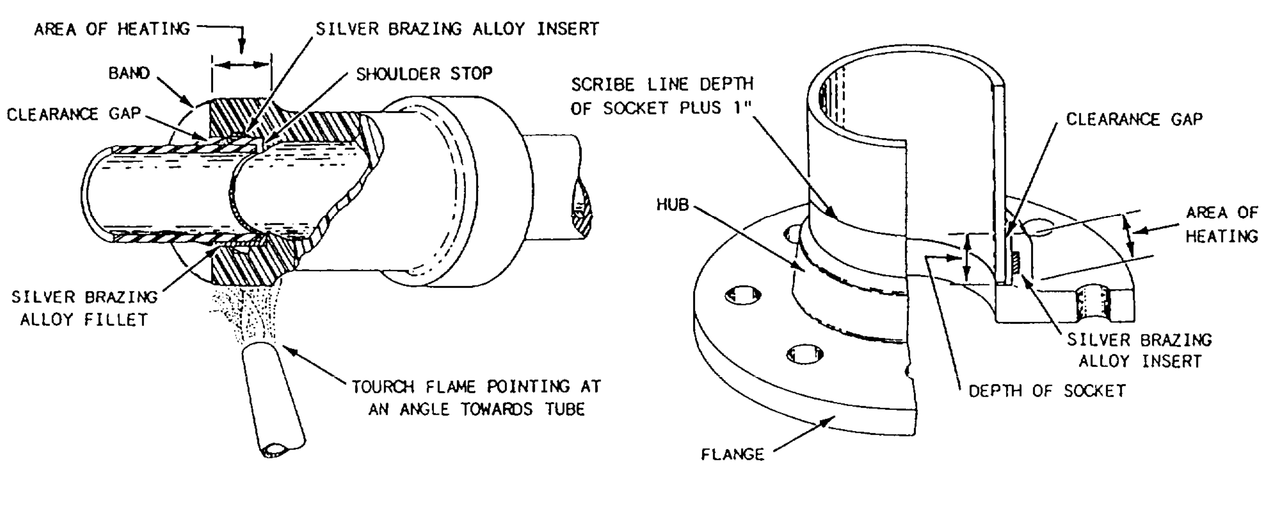


Figure 9-55.—Silver-brazed joints.

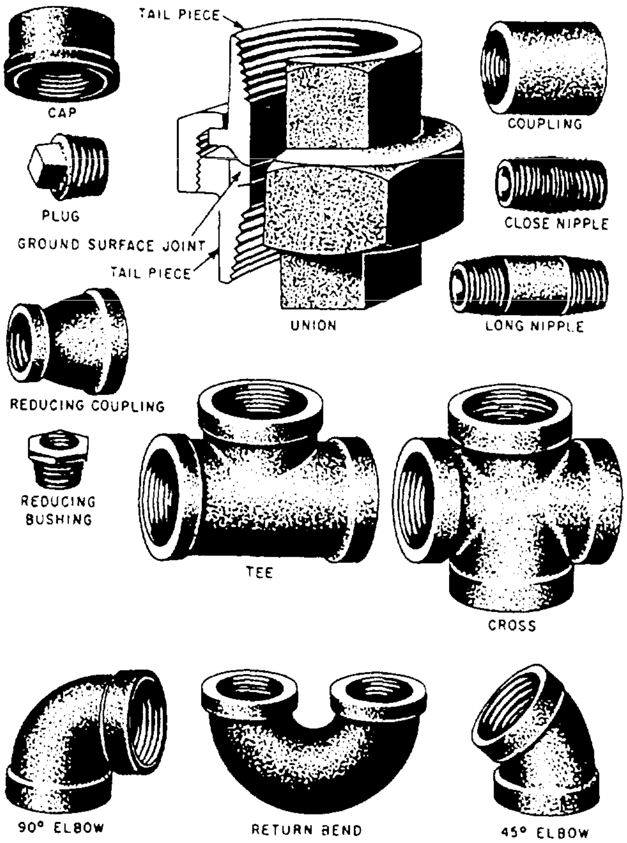


Figure 9-56.—Unions/threaded pipe connectors.

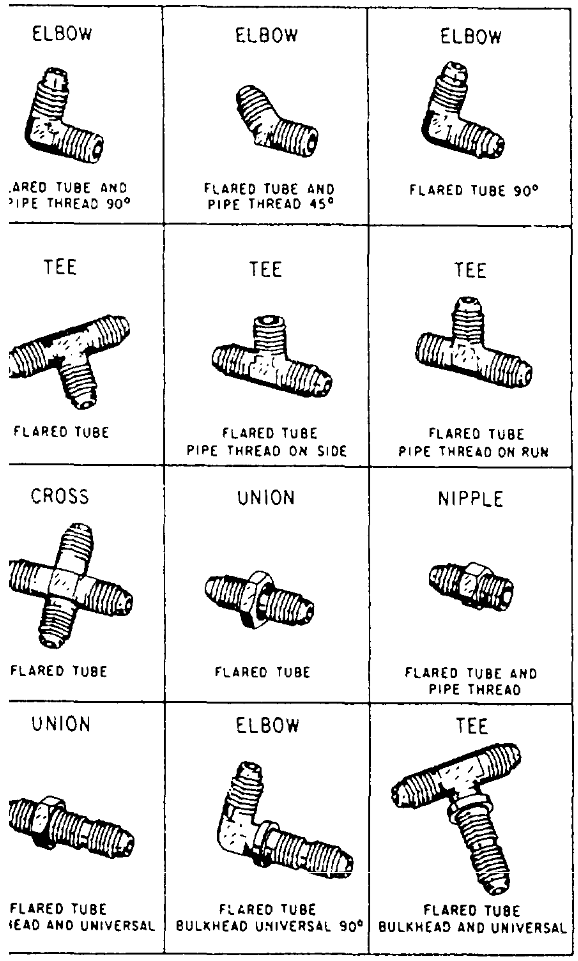


Figure 9-57.-Flared-tube fittings.

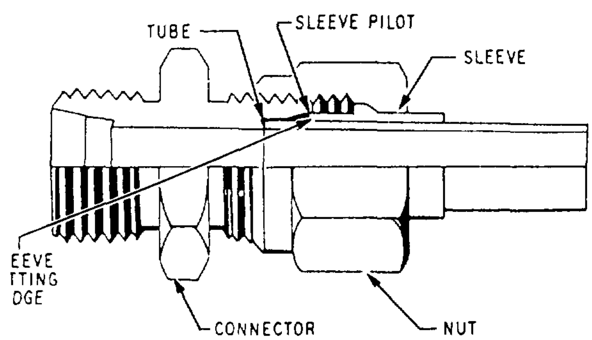


Figure 9-58.-Double-male flareless fitting.

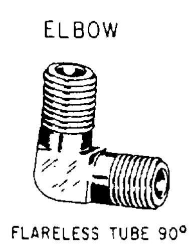


Figure 9-59.—Typical flareless fitting.

repairs and alterations. Unions are available in many different materials and designs to withstand a wide range of pressures and temperatures. Figure 9-56 shows some commonly used types of unions/threaded pipe connectors. The union is most commonly used for joining piping up to 2 inches in size.

Flared Fittings

Flared fittings are commonly used in tubing lines. These fittings provide safe, strong, dependable connections without the necessity of threading, welding, or soldering the tubing. Flared fittings are made of steel, aluminum alloy, or bronze. Do not mix materials when using these fittings. For example, for steel tubing use only steel fittings and for copper or brass tubing use only bronze fittings, Figure 9-57 shows the most common types of flared fittings.

Flareless Fittings

Flareless fittings (figs. 9-58 and 9-59) are suitable for use in hydraulic service and air service systems at a maximum operating pressure of 3000 psi and a maximum operating temperature of 250°F. Flareless fittings are installed to conserve space and to reduce weight, installation time, and system cleaning time. Do not use flareless fittings if you do not have enough space to properly tighten the nuts or if you have to remove the equipment or piping for access to the fittings. An exception to this rule is a gauge board. It is designed so it may be removed as a unit for repairs or alterations. Do not use flareless fittings where you cannot easily deflect the piping to permit assembly and disassembly.

Before assembly, ensure the tubing end is square, concentric, and free of burrs. For an effective fitting, be sure the cutting edge of the sleeve or ferrule bites into the periphery of the tube; you can do this by presetting the ferrule.

FLANGE SAFETY SHIELDS

A fuel fire in the MER or an AMR can be caused by a leak at a fuel oil or lube oil pipe flange connection. Even the smallest leak can spray fine droplets of oil on nearby hot surfaces. To reduce this possibility, FLANGE SAFETY SHIELDS are provided around piping flanges of inflammable liquid systems, especially in areas where the fire hazard is apparent. The spray shields are usually made of aluminized glass cloth and are simply wrapped and wired around the flange.

PIPE HANGERS

Pipe hangers and supports are designed and located to support the combined weight of the piping, fluid, and insulation. They absorb the movements imposed by thermal expansion of the pipe and the motion of the ship. The pipe hangers and supports prevent excessive vibration of the piping and resilient mounts or other materials. They are used in the hanger arrangement to break all metal-to-metal contact to lessen unwanted sound transmissions.

One type of pipe hanger you need to become familiar with is the variable spring hanger. This is used to support the ship's bleed air piping. It provides support by directly compressing a spring or springs. The loads carried by the hangers are equalized by adjustment of the hangers when they are hot. These hangers have load scales attached to them with a traveling arm or pointer that moves in a slot alongside the scale. This shows the degree of pipe movement from cold to hot. The cold and hot positions are marked on the load scale. You should check the hangers when they are hot to ensure that the pointers line up with the hot position on the load scales. You can adjust hangers that are out of position by loosening the jam nut on the hanger rod and turning the adjusting bolt of the hanger.

INSPECTIONS AND MAINTENANCE

Reasonable care must be given to the various piping assemblies as well as to the units connected to the piping systems. Unless the piping system is in good condition, the connected units of machinery cannot operate efficiently and safely. You should be familiar with all the recommended maintenance procedures and observe the safety precautions when working on piping systems.

The most important factor in maintaining piping systems in satisfactory condition is keeping joints, valves, and fittings tight. To ensure this condition, you need to make frequent tests and inspections.

Piping should be tested at the frequency and test pressure specified following the PMS and the applicable equipment technical manual. Test pressure must be maintained long enough to show any leaks or other defects in the system.

Instruction manuals should be available and followed for the inspection and maintenance of piping systems and associated equipment; however, if the manufacturer's instruction manual is not available, you should refer to the *NSTM*, chapter 505, for details of piping inspection and maintenance.

PIPING SYSTEM IDENTIFICATION MARKING

All piping should be marked to show the name of the service, destination (where possible), and direction of flow (fig. 9-60).

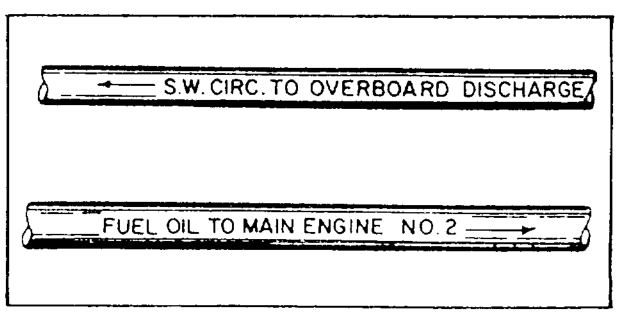


Figure 9-60.—Pipe markings.

The name of the service and destination should be painted on by stencil or hand lettering, or by application of previously printed, stenciled, or lettered adhesive-backed tape. Lettering will be 1 inch high for a 2-inch or larger OD bare pipe or insulation. For smaller sizes, lettering size may be reduced or label plates attached by wire or other suitable means.

Direction of flow will be indicated by an arrow 3 inches long pointing away from the lettering. For reversible flow, arrows are to be shown on each end of the lettering.

Black is used for lettering and arrows. However, on dark-colored pipe (including oxygen piping), white is used.

Markings will be applied to piping in conspicuous locations, preferably near the control valves and at suitable intervals so every line will have at least one identification marking in each compartment through which it passes. Piping in cabins and officers' wardrooms will not normally be marked.

PACKING AND GASKET MATERIAL

Packing and gasket materials are required to seal joints in steam, water, gas, air, oil, and other lines and to seal connections that slide or rotate under normal operating conditions. There are many types and forms of packing and gasket materials available commercially.

PACKING AND GASKET SELECTION

To simplify the selection of packing and gasket materials commonly used in naval service, the Naval Sea Systems Command has prepared a packing and gasket chart, Mechanical Standard Drawing B-153. It shows the symbol numbers and the recommended applications for all types and kinds of packing and gasket materials.

The symbol number used to identify each type of packing and gasket has a four-digit number. The first digit shows the class of service with respect to fixed and moving joints; the numeral 1 shows a moving joint (moving rods, shafts, valve stems), and the numeral 2 shows a fixed joint (flanges, bonnets). The second digit shows the material of which the packing or gasket is primarily composed—asbestos, vegetable fibre, rubber, metal, and so forth. The third and fourth digits show the different styles or forms of the packing or gasket made from the material.

Practically all shipboard packing and gasket problems can be solved by selection of the correct material from the listings on the packing and gasket chart. The following examples show the kind of information that you can get from the packing and gasket chart.

Suppose you are required to repack and install a valve in a 150-psi seawater service system. Under the subhead Symbols and Specifications for Equipments, Piping and Independent Systems, you find that symbol 1103 indicates a suitable material for repacking the valve. Notice that the first digit is the numeral 1, indicating that the material is for use in a moving joint. Under the List of Materials, you find the packing is asbestos rod, braided.

For installing the valve, you need proper gaskets. By use of the same subhead, you find that symbols 2150, 2151 type II, 2152, and 2290 type II are all suitable for installing the valve. Notice that the first digit is the numeral 2, which indicates that it is designed for fixed joints. Again, by referring to the List of Materials, you can determine the composition of the gasket.

Besides the Naval Ship Systems Command drawing, most ships have a packing and gasket chart made up specifically for each ship. The shipboard chart shows the symbol numbers and the sizes of packing and gaskets required in the ship's piping system, machinery, and hull fittings.

PACKING OF MOVING JOINTS

Valves are components used to control the transfer of liquids and gases through fluid piping systems. Most valves have moving joints between the valve stem and the bonnet. When fluid is on one or both sides of a moving joint, the joint may leak. Sealing the joint prevents this leakage. Sealing a moving joint presents a problem because the seal must be tight enough to prevent leakage, yet loose enough to let the valve stem turn without binding. Packing is the most common method of sealing a moving joint.

Packing is a sealing method that uses bulk material (packing) that is reshaped by compression

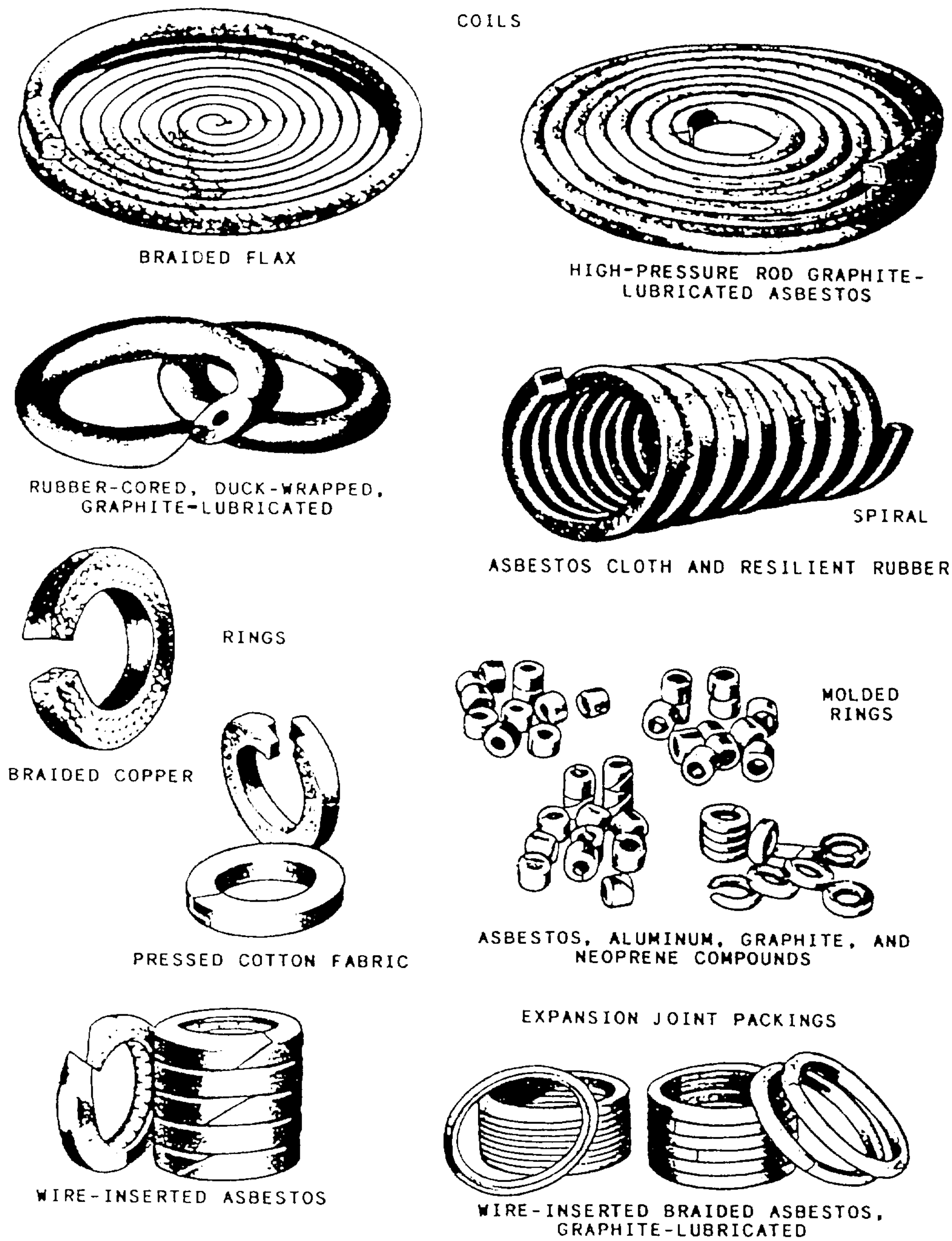


Figure 9-61.—Types of packing.

to effectively seal a moving joint. Figure 9-61 shows several types of packing in common use today.

Packing is inserted in STUFFING BOXES that have annular chambers located around valve stems and rotating shafts. The packing material is compressed to the necessary extent and held in place by gland nuts or other devices.

A corrugated ribbon packing has been developed for universal use on valves. This packing comes in four widths (1 inch, 3/4 inch, 1/2 inch, and 1/4 inch) and is easily cut to length, rolled on the valve stem, and pushed into the stuffing box to form a solid, endless packing ring when compressed (fig. 9-62). Corrugated ribbon packing is suitable for use in systems of high temperatures (up to 1200°F

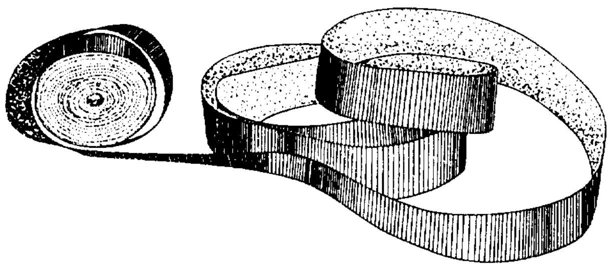


Figure 9-62.—Corrugated ribbon packing.

and 2000 psi). It is easily removed since it does not harden.

PACKING OF FIXED JOINTS

Figure 9-63 shows gasket material used for fixed joints. At one time, fixed joints could be satisfactorily sealed with gaskets of compressed asbestos sheet packing (view A of fig. 9-63). Today the 15 percent rubber content of the packing makes it unsatisfactory for modern, high-temperature, high-pressure equipment. Two types of gaskets (metallic or semimetallic) are in use in present day high-temperature and high-pressure installations. Gaskets of corrugated copper or of asbestos and copper are sometimes used on low- and medium-pressure lines.

Serrated-face metal gaskets (view B of fig. 9-63) made of steel, Monel, or soft iron have raised serrations to make a better seal at the piping flange joints. These gaskets have resiliency. Line pressure forces the serrated faces tighter against the adjoining flange. The gaskets shown are of two variations.

Spiral-wound, metallic-asbestos gaskets (view C of fig. 9-63) are made of interlocked strands of preformed corrugated metal and asbestos strips, spirally wound together (normally called the FILLER), and a solid metal outer or centering

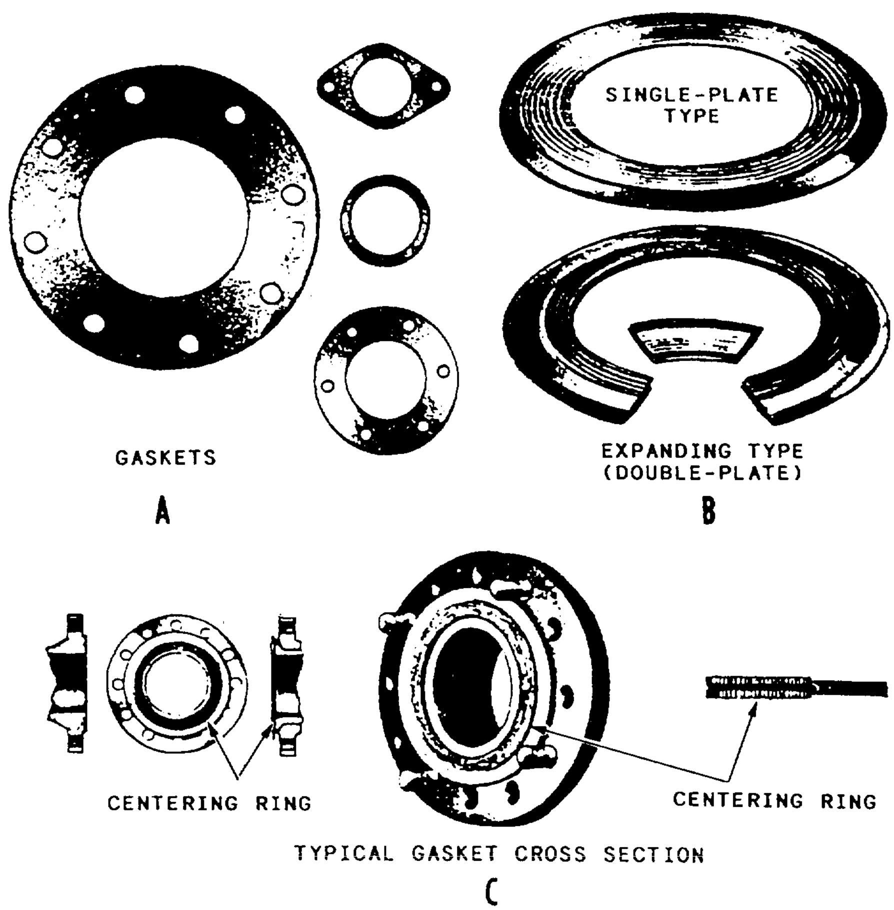


Figure 9-63.—Fixed-joint gaskets. A. Sheet asbestos gaskets. B. Serrated-face metal gaskets. C. Spiral-wound, metallic-asbestos gaskets.

ring (normally called the RETAINING RING). The centering ring is used as a reinforcement to prevent blowouts. The filler piece is replaceable. When renewing a gasket, you should remove this piece from the retaining metal ring and replace it with a new filler. Do not discard the solid metal retaining outer or centering ring unless it is damaged. You can compress the gaskets to the thickness of the outer or centering ring.

When renewing a gasket in a flange joint, you must exercise special precautions when breaking the joint, particularly in steam and hot water lines, or in saltwater lines that have a possibility of direct connection with the sea. Be sure to observe the following precautions:

1. No pressure is on the line.
2. The line pressure valves, including the bypass valves, are firmly secured, wired closed, and tagged.
3. The line is completely drained.
4. At least two flange-securing bolts and nuts diametrically opposite remain in place until the others are removed, then slackened to allow breaking of the joint, and removed after the line is clear.
5. Precautions are taken to prevent explosions or fire when breaking joints of flammable liquid lines.
6. Proper ventilation is ensured before joints are broken in closed compartments.

These precautions may prevent serious explosions, severe scalding of personnel, or flooding of compartments. You should thoroughly clean all sealing and bearing surfaces for the gasket replacement. Check the gasket seats with a surface plate, and scrape as necessary. This affords uniform contact. Replace all damaged bolt studs and nuts. In flange joints with raised faces, the edges of gaskets may extend beyond the edge of the raised face.

O-RINGS

Another method of preventing leakage in fluid systems is by use of O-ring seals. Figure 9-64 shows an O-ring seal with two cross-sectional views. An O-ring is a doughnut-shaped, circular seal (view A of fig. 9-64) that is usually a molded rubber compound. An O-ring seal has an O-ring mounted in a groove or cavity (usually called a gland).

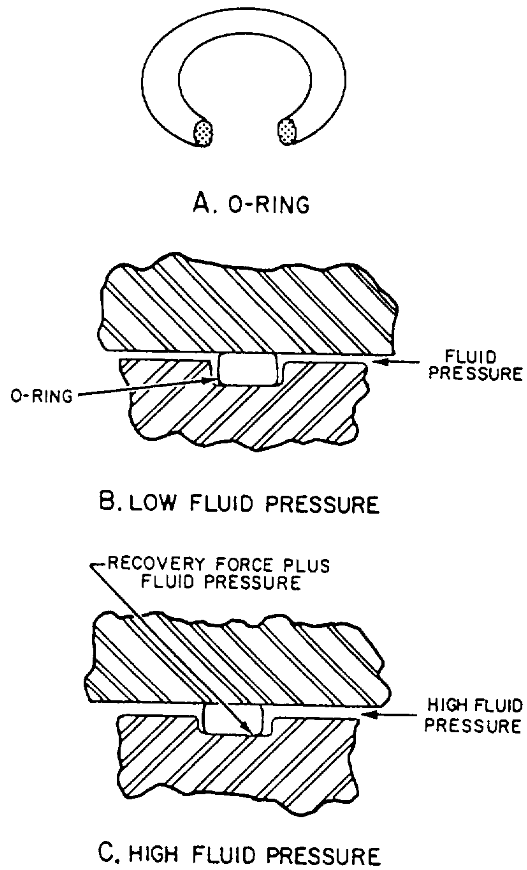


Figure 9-64.—O-ring seal with two cross-sectional views.

When the gland is assembled (view B of fig. 9-64), the O-ring cross section is compressed. When installed, the compression of the O-ring cross section enables it to seal low fluid pressures. The greater the compression, the greater is the fluid pressure that can be sealed by the O-ring. The pressure of the O-ring against the gland walls equals the pressure caused by the recovery force of the compressed O-ring plus the fluid pressure.

The fluid pressure against the walls of the gland and the stiffness of the O-ring prevent fluid from leaking past the O-ring. If the downstream clearance is large, the O-ring is forced into this clearance (view C of fig. 9-64). The stiffness of the O-ring material prevents the O-ring from being forced completely through the downstream clearance unless that clearance is abnormally large or the pressure is excessive.

O-rings are commonly used for sealing because of their simplicity, ruggedness, low cost, ease of installation, ease of maintenance, and effectiveness over wide pressure and temperature ranges.

Failure of an O-ring can sometimes begin with the removal of an old O-ring. If you incorrectly remove an O-ring with pointed or sharp tools, you can scratch or dent critical surface finishes that can result in seal failure.

Before installing a new O-ring, inspect the sealing surfaces for any abrasions and wipe them free of any dust, dirt, or other contaminants. Before installation, inspect the O-ring for any damage. If faulty, discard it.

When you install the O-ring, lubricate it. In most cases it is already coated with the system fluid or petrolatum grease. Do not stretch the O-ring more than twice its original size during installation, and do not roll or twist it into place. This may leave a permanent twist in the O-ring and reduce its effectiveness and shorten its life.

When installing an O-ring, take extreme care to avoid forcing it over sharp edges, corners, and threaded sections. You should use some type of sleeve or cover to avoid damaging the O-ring.

FASTENERS

The proper use of fasteners is very important and cannot be overemphasized. Many shipboard machinery casualties have resulted from fasteners that were not properly installed. Machinery vibration, thermal expansion, and thermal contraction will loosen the fasteners. At sea, loosening effects are increased by the pitch and roll of the ship. You are familiar with such standard fasteners as nuts, bolts, washers, wingnuts, and screws. In this section we will discuss some of the new developments in fastener technology, such as the various types of locknuts, which you may not be familiar with.

THREADED LOCKING DEVICES

An important part of fastener technology has included the development of several methods for locking mated threads of fasteners. Many of the latest methods include the locking device or method as an integral part of the fastener assembly and are referred to as self-locking nuts or bolts. Self-locking fasteners are more expensive than some older methods but compare favorably in cost with pin or wiring methods.

Length of Protrusion

Male threads on threaded fasteners, when installed and tightened, will protrude the distance of at least one thread length beyond the top of the nut or plastic locking ring. Excessive protrusion is a hazard, particularly where necessary clearances, accessibility, and safety are important. Where practicable, the number of threads protruding should not exceed five. In no case should thread protrusion exceed 10 threads unless specifically approved by the work supervisor. (This is the 1-to-10 rule.)

Where screw threads are used for setting or adjusting (such as valve stem packing glands and travel stops) or where installed threaded fasteners do not strictly follow the 1-to-10 rule but have given satisfactory service, the rule does not apply. An example of an acceptable existing installation would be where a male thread is flush with the top of a nut or where more than 10 threads protruding is of no foreseeable consequence.

Repair of Damaged Threads

You can remedy damaged external threads by replacing the fastener. In large equipment castings you must repair damaged internal threads to save the part. You can repair internal threads by redrilling the damaged thread; clean and either install a solid wall insert or tap for a helical coil insert. These inserts, in effect, return the tapped hole to its original size so it takes the original mating fastener.

LOCKNUTS

Locknuts are used in special applications where you want to ensure that the components joined by the fasteners will not loosen. Two types of locknuts are in common use. The first type applies pressure to the bolt thread and can be used where frequent removal may be required. The second type deforms the bolt thread and is used only where frequent removal is unnecessary. The first type includes plastic ring nuts, nylon insert nuts, jam nuts, spring nuts, and spring beam nuts. The second type includes distorted collar nuts and distorted thread nuts; they are not commonly found in gas turbine equipment and will not be covered in this section.

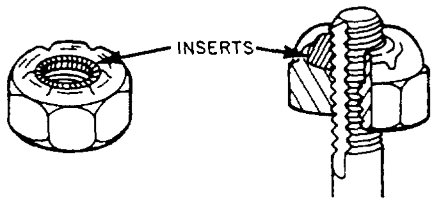


Figure 9-65.—Plastic ring nut.

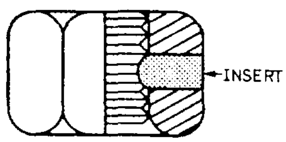


Figure 9-66.—Nylon insert nut.

Plastic Ring Nuts

Plastic ring nuts (fig. 9-65) deform the plastic insert when they are installed. The resilient plastic material is forced to assume the shape of the mating threads, creating large frictional forces.

Nylon Insert Nuts

Nylon insert nuts (fig. 9-66), have plastic inserts (plugs) that do not extend completely around the threads. They force the nut to the side, cocking it slightly. This produces frictional forces on one side of the bolt thread. Although the plastic insert locks without seating, proper torque applied to the nut stretches the bolt, creating clamping forces that add to the locking abilities of the nut. Before reusing nylon insert nuts, check the inserts. If worn or torn, discard the nut. Install the nut (on clean lightly lubricated threads) finger tight. If you can install the nut to the point where the bolt threads pass the insert without a wrench, discard the nut and use a new one.

Jam Nuts

You should install jam nuts (fig. 9-67) with the thinner nut to the working surface and the thicker nut to the outside. The thin nut is deformed by the wider nut and pressed against the working surface and threads.

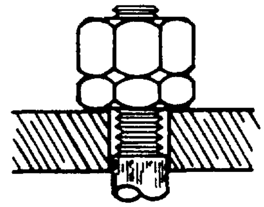


Figure 9-67.—Jam nuts.

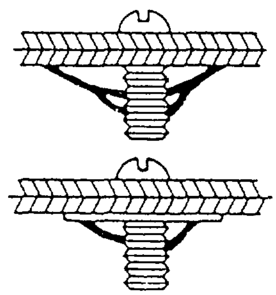


Figure 9-68.—Spring nuts.

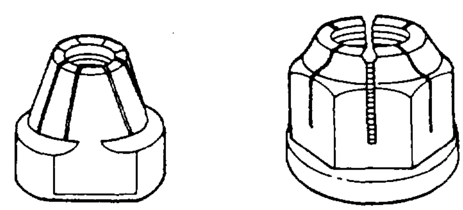


Figure 9-69.—Spring beam nuts.

Spring Nuts

Spring nuts (fig. 9-68) lock by the side grip on the bolt. When tightened, the spring nut flattens, or straightens, a spring section. Many types of spring nuts use curved metal springs, bellows, and coil springs. All spin on and off without locking until the pressure against the working surface straightens the spring.

You should always consult equipment manuals for the proper torque value. Be sure threads are always clean and lightly lubricated with the proper lubrication. Discard any with damaged threads.

Spring Beam Nuts

Spring beam nuts (fig. 9-69) are formed with a light taper in the threads toward the upper portion of the nut. Slots are cut in the outer portion, forming segments that can be forced outward when the nut is installed. Elastic reaction causes the segments to push inward, gripping the bolt. Like the nylon insert nut, this nut does not deform the bolt threads and can be used on frequently removed items. If you can thread the nut past the deflection segments without a wrench, discard the nut and replace it with a new one.

LOCKWASHERS

Many installations on board naval ships still use lockwashers to prevent threaded fasteners from loosening. If loosening has not been a problem, you may replace worn lockwashers with an identical type; however, if loosening has been a problem, you should use self-locking fasteners instead of lockwashers.

The most common lockwasher used is the helical spring washer. Other types are the conical and toothed tab.

Helical Spring Lockwashers

The helical spring lockwasher (split ring) (fig. 9-70) is flattened when the bolt is torqued down, When torqued, it acts as a flat washer contributing normal friction for locking the screw or bolt and the working surface; it also maintains the tension on the bolt. Because of the helical spring lockwasher's small diameter, it is usually not used on soft materials or with oversized or elongated holes.

Curved or Conical Spring Lockwashers

Curved or conical spring lockwashers have almost the same properties as the helical spring lockwasher. They provide a constant tension on the bolt or screw when loosened. The tension produced is usually less than that produced by the helical spring lockwasher. Like any locking device relying on tension, spring lockwashers may loosen on shock loading. When the bolt stretches more

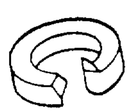


Figure 9-70.—Helical spring lockwasher.

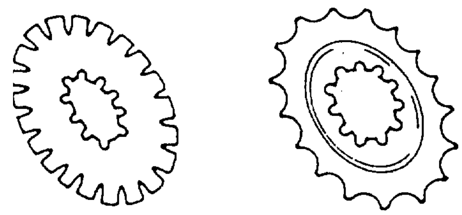


Figure 9-71.—Toothed lockwashers.

than the spring distortion from the shock loading, the washer serves no further purpose. Recheck the washer, where possible, when shock is sufficient to suspect loosening. Some spring lockwashers have teeth on the outer edge. These teeth do not aid in locking, but they prevent side slippage and turning.

Toothed Lockwashers

Toothed lockwashers (fig, 9-71) have teeth that are twisted or bent to prevent loosening. Cutting edges engage both working surfaces on the nut and bolt or screw. Some have teeth on the inner diameter for applications where teeth projecting beyond the nut are not desired, The most common type have teeth on the outer diameter. Washers with teeth on both inside and outside diameters are used for soft materials and oversize holes. The teeth are twisted, so as the nut is installed and torqued down, the rim of the washer supports the pressure. Any backing off of the nut or bolt releases tension that allows the teeth to dig into the working surfaces of the nut and bolt.

INSULATION

The purpose of insulation is to retard the transfer of heat FROM piping that is hotter than the surrounding atmosphere or TO piping that is cooler than the surrounding atmosphere. Insulation helps to maintain the desired temperatures in all systems. In addition, it prevents sweating of piping that carries cool or cold fluids. Insulation also serves to protect personnel from being burned by coming in contact with hot surfaces. Piping insulation represents the composite piping covering, which consists of the insulating material, lagging, and fastening. The INSULATING MATERIAL offers resistance to the flow of heat; the LAGGING, usually of painted canvas, is the protective and confining covering placed over the insulating materials; and the FASTENING attaches the insulating material to the piping and to the lagging.

Insulation covers a wide range of temperatures, from the extremely low temperatures of the refrigerating plants to the very high temperatures of the ship's waste heat boilers. No one material could possibly be used to meet all the conditions with the same efficiency.

INSULATION MATERIALS

The following QUALITY REQUIREMENTS for the various insulating materials are taken into consideration by the Navy in the standardization of these materials:

1. Low heat conductivity
2. Noncombustibility
3. Lightweight
4. Easy molding and installation capability
5. Moisture repellant
6. Noncorrosive, insoluble, and chemically inactive
7. Composition, structure, and insulating properties unchanged by temperatures at which it is to be used
8. Once installed, should not cluster, become lumpy, disintegrate, or build up in masses from vibration
9. Verminproof
10. Hygienically safe to handle

Insulating material is available in preformed pipe coverings, blocks, batts, blankets, and felts. Refer to *NSTM*, Chapter 635, "Thermal, Fire, and Acoustic Insulation," for detailed information on insulating materials, their application, and safety precautions.

The insulating cements are comprised of a variety of materials, differing widely among themselves as to heat conductivity, weight, and other physical characteristics. Typical of these variations are the asbestos substitute cements, diatomaceous cements, and mineral and slag wool cements. These cements are less efficient than other high-temperature insulating materials, but they are valuable for patchwork emergency repairs and for covering small irregular surfaces (valves, flanges, joints, and so forth). Additionally, the cements are used for a surface finish over block or sheet forms of insulation, to seal joints between the blocks, and to provide a smooth finish over which asbestos substitute or glass cloth lagging may be applied.

REMOVABLE INSULATION

Removable insulation will be found on the bleed air systems and waste heat boiler systems. Removable insulation is also installed in the following locations:

- Flange pipe joints adjacent to machinery or equipment that must be broken when units are opened for inspection or overhaul

- Valve bonnets of valves larger than 2 inches internal pipe size (IPS) that operate at 300 psi and above or at 240°F and above

- All pressure-reducing and pressure-regulating valves, pump pressure governors, and strainer bonnets

GENERAL INSULATION PRECAUTIONS

You should observe the following general precautions relative to the application and maintenance of insulation:

1. Fill and seal all air pockets and cracks. Failure to do this will cause large losses in the effectiveness of the insulation.
2. Seal the ends of the insulation and taper off to a smooth, airtight joint. At joint ends or other points where insulation is liable to be damaged, use sheet metal lagging over the insulation. You should cuff flanges and joints with 6-inch lagging.
3. Keep moisture out of all insulation work. Moisture is an enemy of heat insulation just as much as it is in electrical insulation. Any dampness increases the conductivity of all heat-insulating materials.
4. Insulate all hangers and other supports at their point of contact from the pipe or other unit they are supporting; otherwise, a considerable quantity of heat will be lost via conduction through the support.
5. Keep sheet metal covering bright and unpainted unless the protective surface has been damaged or has worn off. The radiation from bright-bodied and light-colored objects is considerably less than from rough and dark-colored objects.
6. Once installed, heat insulation requires careful inspection, upkeep, and repair. Replace lagging and insulation removed to make repairs as carefully as when originally

installed. When replacing insulation, make certain that the replacement material is of the same type as had been used originally.

7. Insulate all flanges with easily removable forms. These forms are made up as pads of insulating material, wired or bound in place, and the whole covered with sheet metal casings, which are in halves.
8. Asbestos control: Inhalation of excessive quantities of asbestos fibre or filler can produce severe lung damage in the form of disabling or fatal fibrosis of the lungs. Asbestos has also been found to be a casual factor in the development of cancer of the membrane lining the chest and abdomen. Lung damage and disease usually develop slowly and often do not become apparent until years after the initial exposure. If your plans include a long and healthy Navy retirement, you have no business doing asbestos lagging rip-out without proper training, protective clothing, and supervision. Most systems of today's modern Navy have been purged of asbestos and an asbestos substitute material installed in its place. Some of the older class vessels may still have some asbestos insulation installed. Use caution when handling lagging and insulation from these vessels. If in doubt, contact your supervisor and request the medical department conduct a survey of the material in question.

SUMMARY

This chapter has given you general information on pumps, valves, and piping. It would be a good idea to get some hands-on experience aboard your ship. Trace various systems out and see how they are set up. Ask your LPO to explain the systems and how each part in the system works. The key phrase here is ASK QUESTIONS!