9470.137 STUFFING BOXES AND PACKING

1. The stuffing boxes on a centrifugal pump serve two purposes. When the pump is working under a positive suction head, the purpose of the packing is to prevent liquid from leaking out of the pump. When pressure at the inner end of the stuffing box is below atmosphere, the stuffing box must prevent air from leaking into the pump.

2. When a pump is designed to work on a suction lift, stuffing boxes are fitted with lantern rings or seal cages usually located near the center of the stuffing box to prevent air leakage and to lubricate the packing. Sealing liquid is injected to this seal cage.

3. When the pump handles clean, cold water, the seal is usually connected to volute casing of the pump. On multistage pumps the connection is to the first stage to avoid excessive pressure.

4. An independent external liquid sealing supply is desirable under any of the following conditions:

a. High suction lifts.
b. Low discharge pressure.
c. Condensate pumps.
d. Hot water.
e. Liquid contains abrasives or foreign matter.
f. Corrosive or volatile liquids are handled.

5. Particular care must be taken to ensure that water piping to seals or stuffing boxes is open and clear; otherwise there is a probability that the seal or the stuffing-box packing will wear very rapidly, the shaft will be scored, and the air will be drawn in. Therefore, when the pump is running, a little water should be allowed to trickle out of the stuffing box. The efficiency of the seal may be tested with a candle flame to detect if air is being drawn into the pump. **This should not be tried on a pump handling oil, gasoline, or other inflammahle liquid.**

6. Even with pump under a positive suction head, water should be allowed to drip from the stuffing box in order to lubricate and cool the packing.

7. Packing should be occasionally changed.

9470.138 VENTS

The petcocks at the highest point of the discharge and at the pump casing may need to be opened frequently to release entrained air. If so, it is a good plan to keep them cracked so as to allow a continuous leakage of air and water. This may be piped to a proper drain system or to bilge.

9470.139 BYPASS

1. In any centrifugal pump the difference between the shaft horsepower input and the liquid horsepower output is lost in the unit and converted to heat. This frequently results in unacceptable temperature rises at low capacities particularly for high pressure pumps. Boiler feed pumps, and in some instances fire pumps, which may develop high temperatures due to operating at low capacity or shut off for substantial periods are protected by a bypass from pump discharge back to the source of suction supply. In the case of feed pumps, this bypass is led from pump discharges through an orifice back to the deaerating feed tank or feed heater. The orifice is designed to bypass the minimum quantity of water necessary to protect the pump and may vary from 5 to 15 percent of pump rated capacity depending on the individual pump characteristics. Fire pumps are generally protected by a bypass of one to two percent.

2. The bypass line on feed pumps must be kept open at all times the pump is operating. The bypass line on fire pumps may be manually controlled and opened when pump is to be operated at or near zero capacity for several minutes or more under standby conditions.

3. Some feed pump installations have been fitted with automatic bypass valves designed to open only as the pump output approaches the minimum permissible capacity. These are mostly of the Hammel-Dahl type and are installed on various Maritime commission tankers converted to naval use.

9470.140 PARALLEL OPERATION

1. When two or more centrifugal pumps are installed and arranged for parallel operation, a stop and a check valve are provided in the discharge of each pump in order that an operating pump may not discharge through one not in operation should the stop valve be left open.

2. Pumps intended to operate in parallel should be designed to have similar characteristics curves with practically the same shutoff head.

3. Operation of several pumps in parallel at very low capacities should be avoided due to the possibility of any unit having slightly lower head being pushed off the line resulting in that unit running at shutoff and developing high temperature.

9470.141 PRIMING

Before starting any centrifugal pump, the pump should be fully primed. The casing and the suction piping must be filled with the liquid to be pumped. There are various ways of priming centrifugal pumps, as follows:

1. If the pump is installed so as to have a positive head on the suction, the pump will prime itself when the vent on the top of pump casing is opened. After all entrapped air has escaped, close the vent valve or air cocks.

2. If the pump operated on a suction lift, prime the pump by the means provided, some of which are as follows:

a. If the suction line has a foot valve or check valve and discharge line contains liquid, fill pump casing by opening bypass valve around discharge valve. Open vent valves or air cocks at top of pump case. Close valves or cocks after all entrapped air has been released. If discharge line has no liquid, open valve to independent supply, if provided, or fill casing by pouring liquid into a funnel inserted in vent connections on casing.

b. If pump is fitted with an air ejector, keep discharge valve closed, open valve to ejector from pump casing, and then turn on steam or air to the ejector. Pump may be started as soon as eductor throws liquid continuously. Ejector should be secured after pump has been started.

c. If pump is connected to a central priming system, open valve to the central priming tank putting vacuum on the pump case.

d. If pump is fitted with or connected to a wet-vacuum pump, follow instructions for the specific unit.

3. If a pump does not build up a pressure after priming, it should be stopped and primed again. While priming, the pump should be turned over by hand to allow air entrained in the impeller to escape.

4. If the pump is the "self-priming" type, then the pump is designed to prime itself automatically by some internal hydraulic device, or by recirculation. This type pump is occasionally installed on smaller vessels. Follow the manufacturers' instructions for the specific unit installed.

9470.142 OPERATION AT BEST EFFICIENCY POINT

1. Centrifugal pumps should be operated as much of the time as possible at or near their design rated conditions which is usually the point of best efficiency. Impeller vane angles and the size of pump waterways can be correctly designed for only one point of operation. For any other point of operation these angles and waterways are either too large or too small.

2. **Excess capacity.** Any pump if operated at excess capacity and lower head will surge and vibrate causing bearings and shaft troubles and take excess power.

3. **Reduced capacity.** When operating at reduced capacity and higher head, the incorrect vane angles cause eddies in the impeller and the casing and will result in erosion in the impeller, casing, and wearing rings. The radial thrust on the rotor increases causing higher shaft stresses, increased shaft deflection and accelerated wear on wearing rings.

9470.143 MAIN CIRCULATING PUMP ON BILGES

In the case of main circulating pumps operating on bilge suction, the pump should be started the same as for main condenser circulating service, then the main injection valve should be gradually closed and the bilge suction valve opened. When the pump is operating on a high suction lift, as when pumping bilges, the speed should be reduced to about two-thirds of rated speed and even when so operated, the pump will be noisy. This cannot be avoided, but can be minimized by slowing the pump.

9470.144 STARTING BOILER FEED PUMPS

1. If the feed system is of the closed type, before starting a main feed pump see that the proper feed booster pump has previously been started and is maintaining the required pressure on the feed pump suction main.

2. If the feed system is of the open, semi-closed type or if the feed heater is connected directly to feed pump suction without booster pumps, see that feed suction line valves at the surge tank or heater is wide open and that water flows freely from pump casing vent valves when open. After the feed pump has been started as previously outlined and has been warmed up, the throttle valve should be opened and the unit brought up to speed slowly until the feed discharge pressure is about 10 psi above the pressure in the combined feed discharge line. Then open the feed discharge valve, or if the stop valve is not fitted, the stop feature of the combined stop check valve on the pump discharge. When this valve is open, the pump discharge pressure should drop to the pressure in the combined discharge line. The pump is then cut in on the line.

9470.145 CHECK VALVE OPERATION

In order to check the operation of the feed pump discharge check valve, close the throttle slightly, lowering the speed and pump discharge pressure to ensure that if pump is tripped off the line, the check valve will close and prevent backflow of water, from the feed discharge mains through the pump, The operation of this check valve can be noted by an indicator if fitted or by hearing or feeling it close. A slight water hammer will often accompany the closing of this check valve. The operation of the check valve may also be determined by noting the pressure on the gages, showing that the discharge pressure of the pump is less than that of the combined feed discharge main.

9470.146 PUTTING FEED PUMP ON LINE

After the check valve has been found to operate satisfactorily, open the throttle, speed up as before, and cut in the pump on the discharge line. If the pump is not fitted for operating with a pressure governor, throttle it to the speed necessary to maintain the required feed discharge pressure. If fitted with a pressure governor, such governor should be put in operation by closing the bypass, or pull-open device, and setting the governor to give the required feed discharge pressure. (See section IV.) The throttle then should be opened wide to ensure that the pump pressure governor takes control. Check all pressures, temperatures, speed, and lubrication to see that normal conditions exist throughout. With the pump pressure governor in operation, the unit should require no further attention insofar as discharge pressure is concerned; however, discharge pressure should be checked carefully to see that it is normal. Where no pump pressure govenor is fitted, the unit will require close attention to throttling to maintain the required feed discharge pressure especially if the ship is maneuvering.

9470.147 STARTING FEED BOOSTER PUMPS

Before starting a feed booster pump, see that booster pump vent line valves are open, valves in suction line from deaerating feed tank to pump are open, discharge valve is closed, and recirculating line valve, if fitted, is open; also that shaft stuffing box sealing water connections, if fitted, are open. Then start pump gradually increasing speed and pressure to normal. Open the discharge valve and see that pressure is built up on the feed pump suction main.

9470.148 STARTING CONDENSATE PUMPS

Before starting a condensate pump, see that there is ample water available in the condenser hot well so that the condensate pump will not run dry. If there is no water in the condenser, about 50 to 150 gallons should be run down to the condenser from the surge tank or feed tank. The pump may then be started as follows:

1. See that condensate pump vent line to condenser shell is open.

2. Open condensate pump shaft packing sealing water connections.

3. If fitted, open recirculating line valve in the recirculating piping from the discharge of air ejector condensers to main or auxiliary condensers.

4. If water to air ejector condensers is supplied by the condensate pump, start condensate pump, then start air ejectors and increase vacuum on condensers.

5. Lower the water level in condensers to normal by allowing surplus to be discharged, taking care that there is sufficient recirculation to prevent the pump from running dry.

9470.149 OPERATING CONDENSATE PUMPS

1. Condensate pumps are generally designed to be self-regulating as to capacity. That is, their capacity is a function of the submergence or height of water in the hot well. Figure 9470-33 is a typical main condensate pump characteristic curve with a super-imposed system head curve. It will be noted that for submergence up to 22-1/2 inches there is a definite maximum capacity for a specific submergence and

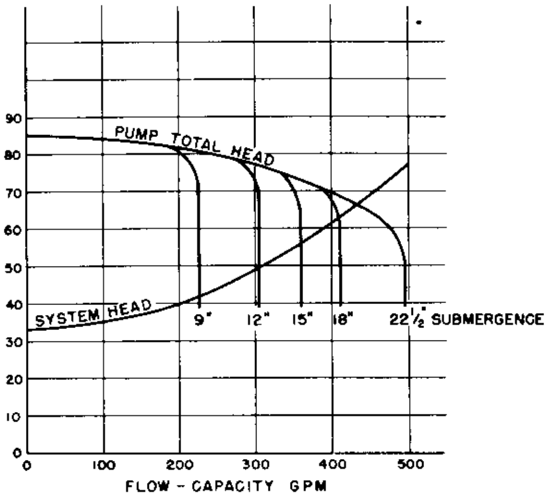


Figure 9470-33

the head-capacity "curve" at this submergence is nearly vertical. If a pump is operated at the maximum capacity for a given submergence and at a lower than normal total head, the pump is cavitating. At least four different basic methods are employed on various naval ships. These methods are:

Method 1. By keeping the discharge valve wide open and varying the pump speed and disregarding submergence entirely.

Method 2. Maintaining constant speed, keeping the discharge valve wide open and disregarding submergence entirely.

Method 3. Maintaining constant speed and throttling the discharge valve in order to keep the liquid level in the condenser visible in the gage glass.

Method 4. Maintaining constant speed, discharge valve wide open, and recirculating to maintain constant submergence.

2. Because of the dissimilarity of condensate pump installations and their related piping systems on various naval ships, the Naval Ships Systems Command will not standardize by hard and fast rules any one method to be used. It is considered that many factors other than operation of the pump alone must be given consideration in establishing operating methods for condensate pumps and systems on each particular ship. However, it is recommended that methods 2 and 4 are preferable for reasons discussed below.

Method 1. (See figure 9470-34.) Considered the worst of all methods of operation. When operating at reduced rpm along head capacity curve H′, pump cannot respond to increased load beyond point B on the system curve S with increase in speed. This requires constant manning of the throttle to handle variations in capacity.

Method 2. (See figure 9470-35.) Preferred to all other methods provided pumps are not over-designed or overrated as to head, and provided the combination of pumps and systems can be demonstrated to work satisfactorily without adjustment for variations in load. Pump at reduced capacity will operate in cavitation at the intersection of the system curve S and the vertical portions of the head capacity curve, and submergence and capacity are self-regulating within limits. When pump is overdesigned or when actual system resistance is less than rated so that system S′ obtains, then pump operation is adversely affected with increased cavitation noise and still further reduced submergence.

Method 3. (See figure 9470-36.) Considered undesirable but preferable to method 1. Purpose is to keep pump from severe cavitation at reduced loads by steepening system curve S to S′, S″, etc., in proportion to load so that pump operations at points B or B′. The great objection to this

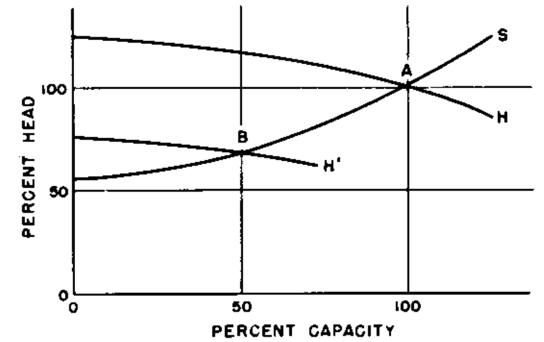


Figure 9470-34

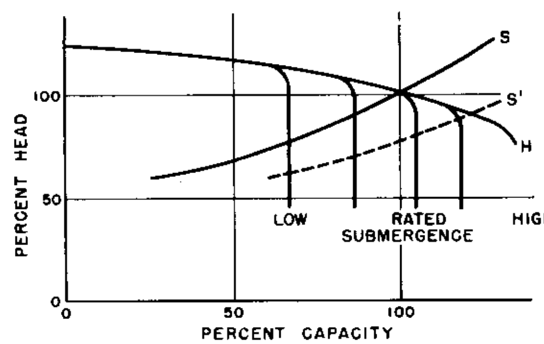


Figure 9470-35

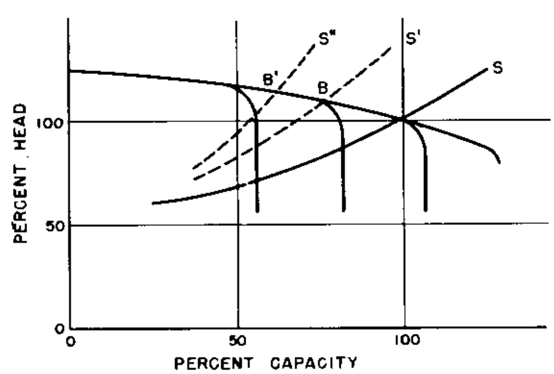


Figure 9470-36

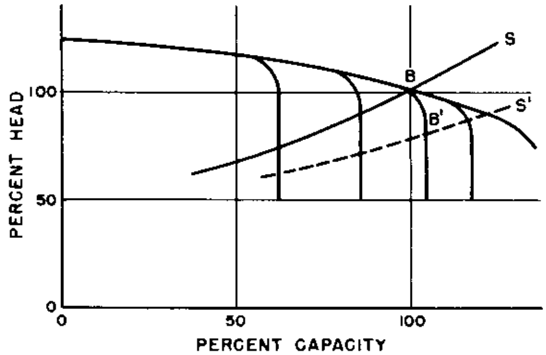


Figure 9470-37

method is the inability of the pump to handle increased capacity without manipulation of the discharge valve.

Method 4. (See figure 9470-37.) Preferred to methods 1 or 3. Increase the submergence by increasing the gross capacity of the pump. Also has the effect of cutting down on the available capacity of the pump by an amount equal to 50 to 100 percent of the quantity recirculated depending on the point in the system from which recirculation takes place. The system curve when recirculating (S′) is to the right of the normal system curve S. Since the amount of recirculation is limited by the size of the recirculating line, this method is not as critical in adjustment as method 3.

Part 3. Maintenance (where 3-M system is installed, conduct preventive maintenance in accordance with 3-M cards)

9470.161 USE OF MANUFACTURERS' INSTRUCTION BOOKS

Manufacturers' instruction books are furnished for all but the simplest types of pumps. These instruction books contain detailed information concerning the operation, maintenance, and repair of the specific pumps installed. They should be studied carefully before attempting to operate or service the unit. If the instructions given in this chapter conflict with manufacturers' instruction books, the Naval Ships Systems Command should be consulted.

9470.162 OBSERVATIONS IN SERVICE

Make frequent regular inspections of pumps while operating. Investigate immediately any change in the sound of a pump. At least once an hour check:

1. Bearing temperatures.
2. Stuffing boxes.
3. Pressure gages.

9470.163 SHAFT PACKING

The packing in pump stuffing boxes should be renewed about once every two months to make sure that it does not get hard and score the shaft. When repacking a pump stuffing box, install packing of the proper length to give uniform thickness all around the shaft sleeves. Install rings with joints staggered. When installing new packing, the stuffing box should be packed loosely and the packing gland set up lightly, allowing a liberal leakage for stuffing boxes subjected to pressure above atmosphere. Then, with pump in operation, tighten the gland in steps so as to compress the packing gradually, thereby avoiding excessive heating and possible scoring of shafts or shaft sleeves. After packing has been compressed, it will usually be found necessary to add more packing. All pumps should be run with a slight drip from stuffing boxes in order to lubricate and cool the packing.

9470.164 LANTERN RINGS, SLEEVES, AND FLINGERS

1. Where a stuffing box is fitted with a lantern ring, be sure to replace the packing beyond the lantern ring at the bottom of the stuffing box and see that the sealing water connection to the lantern ring is not blanked off by the packing.

2. Usually pump shafts are fitted with sleeves in way of shaft packing. See that shaft sleeves are tight on shafts. These are usually secured by keying to shafts or by screw threads cut to the hand opposite to the shaft rotation. Care should be taken to see that water does not leak between shaft and shaft sleeves. If shafts or sleeves in way of packing are roughened or grooved, they should be turned or ground to give a smooth surface; otherwise, difficulty will be experienced in keeping tight.

3. Water flingers are always fitted on shafts outboard of stuffing box glands to prevent leakage from the stuffing box from following along the shaft and entering the bearing housings. Care should be taken to see that flingers are tight on the shafts. If flingers are fitted on the shaft sleeves instead of on the shafts, see that no water leaks under the sleeves. If leakage occurs, a fiber or asbestos washer should be fitted between the end of sleeve and the shaft shoulder or impeller nut and all clearance between shaft and sleeve filled with white or red lead to exclude water.

9470.165 IMPELLER AND CASING WEARING RINGS

The clearance between the impeller and the casing wearing rings should be maintained as shown on the manufacturers' plans. On low-pressure pumps such as circulating, flushing, condensate, and others where the drop in pressure across the wearing rings does not exceed 150 psi, the wearing ring diametral clearance may wear as much as 0.015 to 0.030 inch without appreciable effect on the capacity of the pump; hence with this class of pump wearing ring renewel should not be undertaken until wear or increased clearance has exceeded these figures. For pressures up to 75 psi, a wear of 0.030–0.050 inch is permissible; for pressure of 75 to 150 psi, a wear of 0.020 to 0.030 inch is allowable. However, the capacity of the pump should be taken into consideration since it is evident that the percentage leakage with 0.030 inch clearance is comparatively large for a small pump, but would be negligible for a large capacity pump. The engineer officer should decide, in each case, whether or not the amount of wear of clearance rings dictates renewal. For high pressure boiler feed pumps, however, the effect of increased wearing rings clearance makes itself felt by reduction in the efficiency and in the maximum capacity of the pump. For this class of service, the wearing rings should be renewed when the clearance shown on manufacturers' plans is exceeded by more than about 100 percent. However, in no case is it considered that wearing rings need to be renewed unless the wear amounts to 0.015 inch.

9470.166 LUBRICATION

1. Before refilling a forced lubrication system with clean oil, the system should be thoroughly flushed out with hot

oil, Symbol 2075 or 2110, by pumping such flushing oil through the system. Immediately after flushing, the flushing oil should be drained from all parts of the system, the sump tank thoroughly wiped with clean, dry rags, and the system filled with clean lubricating oil which should then be pumped through the system for a few minutes. Where flushing oil is not available, a light grade of lubricating oil cut with an equal quantity of kerosene may be used; however, it should be noted that when the kerosene mixture is used, there is danger of damage to gears and oil pump if the unit is run at high speed, particularly if a worm gear drive is used.

2. The oil reservoir should be checked frequently to ensure that it is free of water. If water is found in the oil, check carefully for leakage from pump and turbine glands and leaky oil cooler. Clean the oil filters or strainers frequently; with edge filtration (Cuno or similar) type filter, drain out sludge and sediment which occasionally accumulates in bottom of filter when the unit is not running.

3. Housings of grease lubricated ball bearings should be checked occasionally to ensure that the housing is free of water and foreign matter. At the same time check to ensure that bearings are properly locked on the shafts. If water is found in the bearing housing, it should be traced to its source. It is usually caused by leakage from pump packing. Effective means should be taken to prevent water from entering the housing. The frequency with which grease must be added depends on the service of the machine and the tightness of the housing seals, and should be determined for each machine by the engineer officer. Ordinarily, the addition of grease will not be necessary more often than once in six months. The use of excessive quantities of grease is to be avoided because it has been a major cause of bearing failures. When a bearing housing is too full of lubricant, the churning of the grease generates heat which in turn causes deterioration of the grease. Under these conditions the grease separates into oil and minute abrasive particles, becomes increasingly sticky, and tends to seal the bearing against fresh lubricant until the resulting friction, heat, and wear cause failure of the bearing. To avoid the difficulties caused by an excessive amount of grease, grease should be added only when necessary, and, when grease is added, it should be done as follows:

a. Remove bearing drain plug, and make sure the passage is open by probing with a clean screw driver or similar implement.

b. Clean the grease cup thoroughly. Install bottom portion of grease cup on the grease pipe. Put in the top portion of the grease cup no more grease than will half fill it.

c. Empty and clean out the receptacle of the grease fitting down to the neck, then fill with clean grease.

d. Replace the grease cup and **screw it down as far as it will go.** The purpose of screwing the grease cups down is to protect the machine from being over-greased due to accidental or unauthorized turning of the grease cup.

e. Run the machine and let grease run out of drain hole until drainage stops (normally about 30 minutes). Replace the drain plug.

4. Oil in the lubricating-oil system should be renewed whenever it becomes emulsified or foams excessively, or when it contains sludge, dirt, or foreign matter.

9470.167 BEARINGS, OIL-LUBRICATED

Check bearing clearance with leads, and take bridge gage readings (where bridge gages are furnished) of all sleeve- or shell-type bearings at least every six months. Clearance should be maintained as shown on manufacturers' plans. In the absence of information on plans, the instructions in chapter 9005, table B-4, should be followed.

9470.168 THRUST BEARINGS

Thrust bearings should be examined quarterly and the position of rotors checked. When checking rotor position due allowance should be made for expansion of shaft from cold condition to hot running condition.

9470.169 INTERNAL WATER-LUBRICATED BEARINGS

1. Most designs of vertical condensate main circulating pumps are fitted with an internal water-lubricated bearing inside the pump casing. Where this type of bearing is fitted in a pump, it is of particular importance that an adequate supply of clean water for lubricating and cooling be supplied to the bearing. A number of different materials have been used for internal water-lubricated bearings including:

a. Laminated phenolic material grade FBM (fabric base bakelite or micarta).

b. High lead content bronze.

c. Graphited bronze.

d. Lignum vitae bearings are also satisfactory; however, due to greater difficulty of installation, its use except in an emergency, is not recommended.

2. The condition of all types of internal water-lubricated bearings should be checked frequently to guard against excessive wear which would cause misalinement and possibly shaft failure.

9470.170 COOLING WATER

A liberal supply of clean cooling water, usually sea water should be supplied to the oil coolers, or to the oil cooling coils, of all units fitted with oil cooling arrangements. A frequent check of oil temperatures should be made to ensure that the cooling system is functioning satisfactorily. This is particularly important on high speed boiler feed pumps and on turbine-driven units fitted with worm gear type of reduction gear.

9470.171 CARE OF DRIVING UNITS

Instructions for the maintenance of driving engines, turbines, motors, and controllers will be found in other chapters of this manual and should be followed.

9470.172 COUPLINGS

1. When the driving unit is connected to the pump by means of a flexible coupling, it should be borne in mind that flexible couplings are intended to take care of but slight misalinement. Where misalinement is small, the coupling should operate satisfactorily without requiring frequent renewal of coupling parts; but if misalinement is excessive, the coupling parts are subjected to severe punishment, necessitating frequent renewal of pins, bushings and bearings.

2. Couplings with self-contained oil have been in use over a period of years and if kept lubricated have proved satisfactory. However, some couplings fail due to loss of

oil or because no oil has been added, resulting in wear and breakage of teeth. It is therefore recommended that the following precautions be observed:

a. Inspect the flexible coupling monthly by removing filler plug to ascertain that there is an adequate supply of lubricant.

b. Whenever coupling is dismantled, inspect teeth to see that they are in good condition. Care should be taken to assure that coupling is reassembled to suit match marks. When reassembling coupling, check alinement of turbine and pump to prevent excessive coupling wear.

9470.173 ALINEMENT

Shaft alinement should be checked frequently and if it is found that shafts are out of line or inclined at an angle to each other, realinement of the unit should be undertaken in order to avoid shaft breakages and renewal of bearings, pump casing wearing rings, and throat bushings. Whenever practical, the alinement should be checked with all piping in place, all tanks and piping filled. Due allowance should be made for change in position of parts from the cold-check condition to the hot-operating condition. Such allowance for change in alinement caused by changes in temperature is assuming an ever-increasing importance owing to the higher steam, exhaust, and water temperatures now used. The necessity for allowing for expansion of parts cannot be overstressed.

9470.174 SPEED-REGULATING, SPEED-LIMITING GOVERNORS

All turbine-driven units are fitted with a speed-regulating or speed-limiting governor. The governor should be set to give rated speed at rated load conditions. With the governor set as above, the turbine speed should not exceed the rated speed by more than five percent for any condition of load, including shutoff of the pump. If the governor will not function within the above limit, it should be overhauled and the cause of faulty operation located and remedied. For satisfactory parallel and series operation of feed booster pumps and boiler feed pumps, it is essential that the governors of all identical pumps be set for the same speed.

9470.175 PUMP PRESSURE GOVERNORS

In addition to the governors previously mentioned, turbine-driven boiler feed pumps and fire pumps are fitted with pump pressure regulating governors. (See section IV.)

9470.176 TESTS AND INSPECTIONS (CENTRIFUGAL PUMPS)

1. **Weekly.**

a. Operate all pumps by steam or power. If power is not available, move by hand.

b. Lubricate the pressure regulating governor, if of a type requiring lubrication.

c. Check lubricating oil for water and for condition of oil by sampling.

2. **Quarterly.**

a. Check thrust position of pump rotor.

b. Sound and set up as necessary all foundation bolts and secure all foundation dowel pins.

3. **Annually.**

Check bearing clearances by leads or crown thickness measurements.

4. **Overhaul cycle.**

a. Check internal water lubricated bearings and shafts in way of same for wear and scoring.

b. Open pump and reduction gear casings; inspect and clean.

c. Check clearances of all diaphragms and casing throat bushings, impeller and casing wearing rings, pressure break-down drums and bushings, and renew as necessary.

NOTE: These tests and inspections are the minimum necessary to give adequate assurance of safe reliable operation of equipment. Indications of low discharge pressure or other manifestations of improper operation should indicate more frequent or extensive tests and inspections. Salt water and brine pumps should be opened and inspected more often as performance indicates. In general, pumps should be turned over and lube oil checked each time a unit is placed in service. Cleaning of lube oil sumps should be dictated by condition of oil. The degree of oil contamination will dictate the necessity for further inspection of bearings and journals. For tests and inspections of turbines, see chapter 9500, article 9500.47.

Part 4. Repairs

9470.181 ASSEMBLY DRAWINGS

When repairing or making an interior examination of a pump, it is essential that all drawings and available dimensional data relative thereto be at hand. Frequently, important dimensions become altered such as bridge gage readings of bearings, clearance between impeller and casing wearing rings, water seal or gland adjustment. This results in poor operation, which will naturally continue in spite of other major repairs unless the real cause of the trouble is rectified.

9470.182 RENEWAL OF WEARING PARTS

The parts of a centrifugal pump most frequently requiring repair or replacement are:

1. **Casing rings and impeller rings.** As the purpose of these is to keep the internal bypassing of the liquid to a minimum, the clearances should be checked periodically and whenever the pump casing is opened up.

2. **Shaft sleeves.** Operating personnel frequently take up too hard on the packing in at attempt to stop stuffing box leakage. This causes scoring of shaft sleeves. Sleeves should be examined whenever pump is opened up. If not badly scored, they should be smoothed up. When worn, they should be replaced.

3. **Bearings.** Worn sleeve bearings cause the rotor to drop, which causes wear of casing and impeller rings. Bearings of centrifugal pumps should be rebabbitted in accordance with the table in chapter 9400, when bridge gage readings or leads show that maximum allowable wear has occured. The oil clearances for bearings will be found on the manufacturers' plans or instruction book. However, in the absence of such data, the table of tolerances and clearances, chapter 9400, should be followed.

4. **Bushings.** Bushing clearances should be measured whenever the pump is opened up. Bearing wear will probably cause bushing wear, and bushing should be renewed provided bearings are restored to their original readings.

9470.183 EMERGENCY REBABBITTING OF SMALL BEARINGS

To rebabbitt a small bearing in an emergency, coat the journal heavily with banana oil and, with the shaft properly centered in the bearing housing, pour the babbitt around the journal. The bearing will break clean from the journal and can then be used with little or no scraping in.

9470.184 CENTERING OF IMPELLERS

It is essential to the best operation of a centrifugal pump that the center of the impeller exit passages line up accurately with the center of casing or diffuser waterways. Otherwise excessive turbulence and friction losses may obtain and thrust load increased.

9470.185 ALINING PUMP

Pumps should be periodically checked for alinement since piping strains may develop distorting the unit. Bearing wear and distortion of supporting structure may also contribute to misalinement. In general flexible and rigid coupled units may be lined up by disconnecting couplings and checking rims by straight edge and faces for parallelism by feeler gage. Other types of pumps should be alined in accordance with manufacturers' instructions.

9470.186 BALANCING

All pump and driving unit rotating parts are balanced dynamically for all speeds from 0 to 125 percent of rated speed. The parts are usually balanced on a balancing machine to ensure accurate balance. Balancing machines are usually available only at naval shipyards. A portable balancing outfit (Davey vibrometer) is available on tenders for use of individual ships. With a portable unit, the pump and turbine rotors may be balanced in place. Whenever possible the balancing machine or portable balancing outfit should be used in preference to any other method of balancing.

Part 5. Safety Precautions

9470.191 PRECAUTIONARY INSTRUCTIONS

1. Test relief valves, where fitted, to function at the designated pressure.
2. Never attempt to jack a pump by hand while the steam valve to the pump is open.
3. Boiler feed pumps and other pumps in the feed system shall not be used for purposes other than those connected with boiler of feed water service, except in an emergency.
4. Do not tie down or otherwise render inoperative the overspeed trip, speed-limiting or speed-regulating governor.
5. See that overspeed trips, where fitted, are set to shut off steam to the unit when rated speed is exceeded by 10 percent.
6. See that speed-limiting and speed-regulating governors are set to limit the speed of the unit to rated speed under rated conditions, and that rated speed is not exceeded by more than five percent for any condition of loading.
7. Check the setting of overspeed trip and speed-limiting governors at least quarterly.
8. When inspecting or overhauling **vertical** rotary pumps never rely on a flexible coupling to support the total weight of the pump rotors. Always support the pump rotors by means of wire rope slings, block and tackle, or chocks before working on the pump.

SECTION III. ROTARY PUMPS

Part 1. General

9470.201 INTRODUCTION

Positive displacement rotary pumps have largely supplanted reciprocating pumps for pumping all viscous liquids on naval ships. Rotary pumps are also used for gasoline or other low viscosity volative liquids where a high suction lift is required and the service is intermittent. Rotary pumps are not suitable for handling corrosive liquids nor liquids containing abrasive solids. In general, rotary pumps are self-priming.

9470.202 DESCRIPTION

Rotary pumps consist of a casing containing a rotating assembly running in close clearances and in such manner that liquid is trapped in a moving space formed by the rotor and casing and carried to the discharge side where the liquid is pushed or squeezed from the pumping space to the discharge. The rotor assembly may consist of pairs of intermeshing gears, screws, vanes, lobes, and cams; or sliding pistons, vanes, blocks, or other forms. Those more common to the naval service are described below.

9470.203 CLASSIFICATION AND TYPES

Rotary pumps are classified as to:

1. Service, application.
2. Manufacturers' name or trade name.

This method of identification is indeed more in common use for rotary pumps than for other types of pumps or even other equipment. Most manufacturers specialize in only one or two types and these have significant design characteristics.

3. Type rotor.
    a. Cam and plunger (figure 9470-38).
    b. Screws with timing gears (figures 9470-39 and 9470-40).
    c. Screws without timing gears (figure 9470-41).
    d. Impellers (cams, lobes, or special tooth forms) with timing gears (figures 9470-42 and 9470-43).
    e. Gears (spur helical, herringbone) (figure 9470-44).
    f. Gears with separate timing gears (figure 9470-45).
    g. Axial or radial piston variable displacement (figure 9470-46).
    h. Internal gears (figure 9470-47).
    i. Vanes (figures 9470-48 and 9470-49).
4. Shaft position.
    a. Horizontal.
    b. Vertical.
    c. Inclined.
5. Type of drive and power.

9470.204 SERVICE CLASSIFICATION

Rotary pumps are used in the naval service for the following applications:

1. Boiler fuel oil service.
    a. Main.
    b. Port and cruising.
2. Fuel oil booster and transfer service.
3. Diesel oil service and transfer.
4. Fuel oil tank drain (stripping).
5. Lubricating oil service and transfer.
6. Fuel oil, gasoline, or water cargo.
7. Cargo stripping.

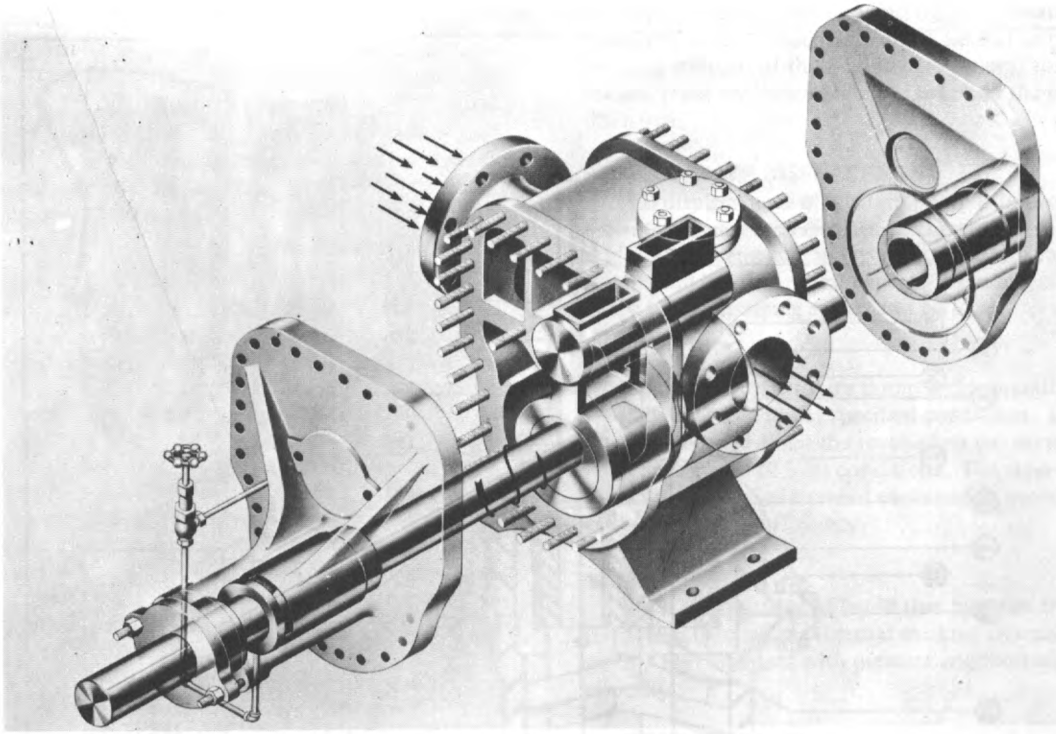


Figure 9470-38

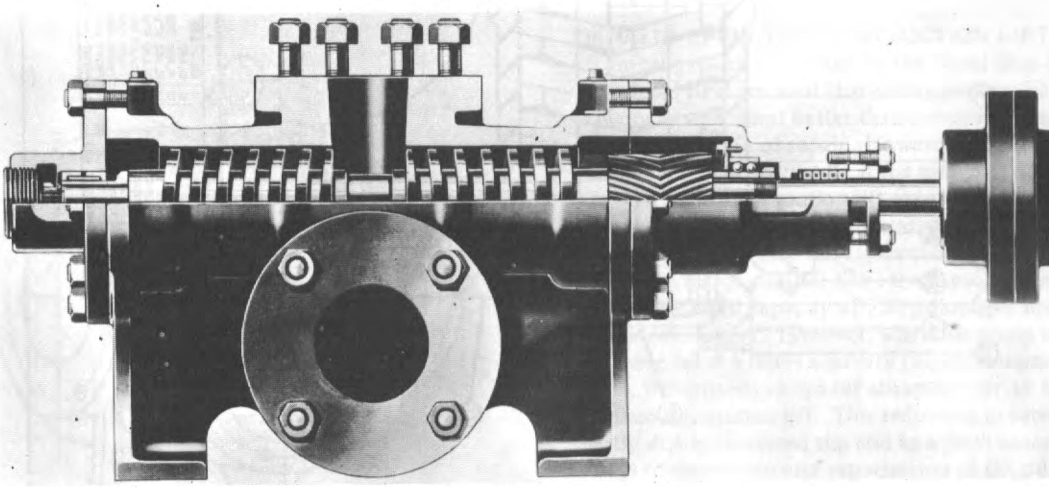
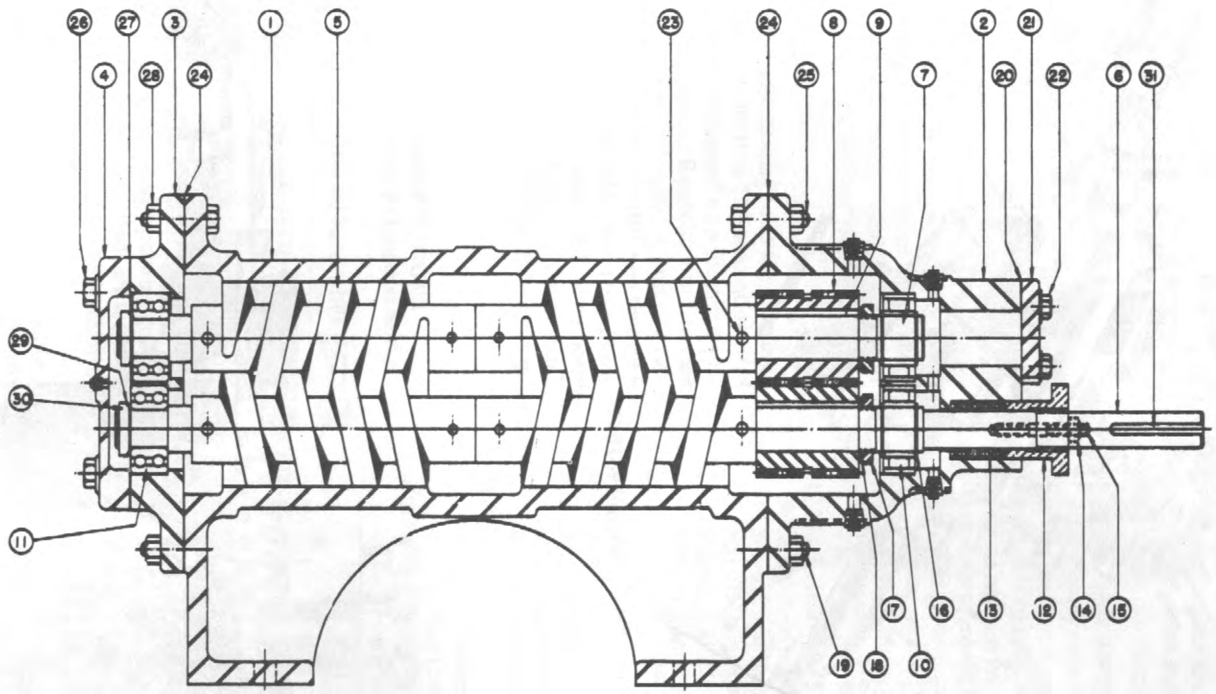


Figure 9470-39



NO	PART	NO	PART	NO	PART	NO	PART
1	PUMP BODY	11	BALL BRG	21	FRONT HEAD CAP	31	COUPLING KEY
2	FRONT HEAD	12	GLAND	22	FRONT CAP & HEAD BOLT		
3	REAR HEAD	13	GLAND PACKING	23	PUMPING SCREW DRIVE PIN		
4	REAR HEAD CAP	14	GLAND STUD NUT	24	BODY & HEAD GASKET		
5	PUMPING SCREW	15	GLAND STUD	25	BODY & HEAD BOLT		
6	DRIVING SHAFT	16	ROLLER BRG RETAINING RING	26	REAR CAP & HEAD BOLT		
7	DRIVEN SHAFT	17	TIMING GEAR LOCKNUT	27	REAR CAP & HEAD GASKET		
8	TIMING GEAR	18	TIMING GEAR L'WASHER	28	REAR HEAD & BODY BOLT		
9	TIMING GEAR KEY	19	FRONT HEAD & BODY STUD	29	BALL BRG L'WASHER		
10	ROLLER BRG	20	FRONT CAP & HEAD GASKET	30	BALL BRG LOCKNUT		

Figure 9470-40

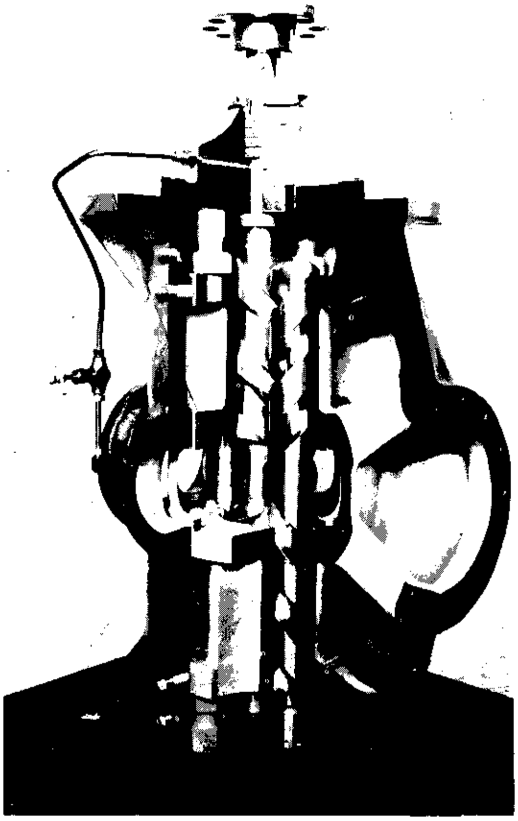


Figure 9470-41

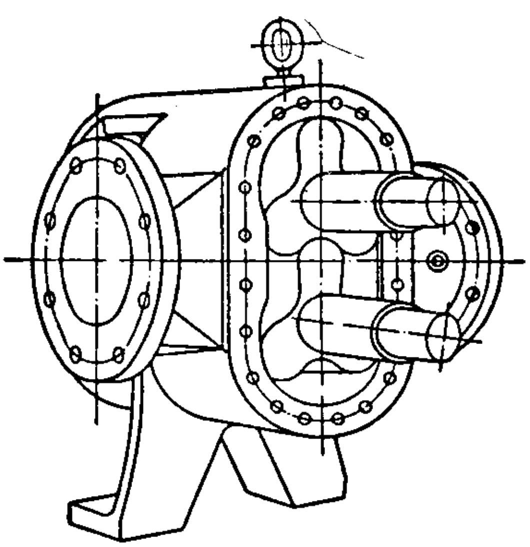


Figure 9470-42

9470.205 GENERAL CHARACTERISTICS

Rotary pumps are of the positive displacement type and their capacity is directly proportional to the pump speed subject to losses described below. The pressure developed by rotary pumps is that imposed by the resistance of the system to which it discharges and is limited only by the bursting strength of the pump or power available. For this reason, relief valves are generally fitted on the pump discharge.

9470.206 PUMP DISPLACEMENT

This displacement of a rotary pump is the volume that the rotating elements displace per revolution of the rotor shaft. Displacement is independent of all operating conditions and is a theoretical capacity assuming complete filling of the pumping spaces and no losses.

9470.207 CAPACITY

The capacity of a rotary pump is the quantity of liquid actually delivered under specified conditions. It is equal to the displacement times the revolutions per minute minus losses due to slip or inlet conditions. The ratio of the actual capacity to the displacement expressed in percent is known as the volumetric efficiency.

9470.208 SLIP

Slip is the quantity of liquid that bypasses from discharge to suction through the internal working clearances of the pump. Slip increases with pressure and inversely with viscosity.

9470.209 INLET CONDITIONS

The conditions of the liquid at the suction of the pump are most important to its performance. These factors include suction pressure or lift, viscosity, vapor pressure at operating temperature, amount of entrained of dissolved air or gas. Capacity losses due to inlet conditions are caused by incomplete filling of the pumping element and are not considered as slip.

9470.210 EFFECT OF HIGH SUCTION LIFT

Investigations conducted by the Naval Ship Systems Command have revealed that rotary pumps will lift oil equally as well if not better than a reciprocating pump in average condition or repair. However, the volumetric efficiency will drop off rapidly if the pump is required to operate on a vacuum or suction lift exceeding that for which it is designed. This is clearly indicated by figure 9470-50. The upper curve A on this figure shows that with the pump handling viscous oil (700 SSF) the capacity is maintained well above rated capacity of 250 gallons per minute at 25 inches of mercury. However, when the pump is handling the same oil at a lower viscosity (higher temperature) (70 SSF), the capacity drops off abruptly over 19 to 20 inches of mercury, suction lift. This reduction in capacity is only partly due to increased slip and to a great extent to the effect of deaeration and vaporization of the oil.

9470.211 EFFECT OF ENTRAINED OR DISSOLVED GASES

1. Most liquids will contain a varying amount of air or gas by entrainment or in solution. If the suction lift is high, entrained gas will expand and dissolved gas will come

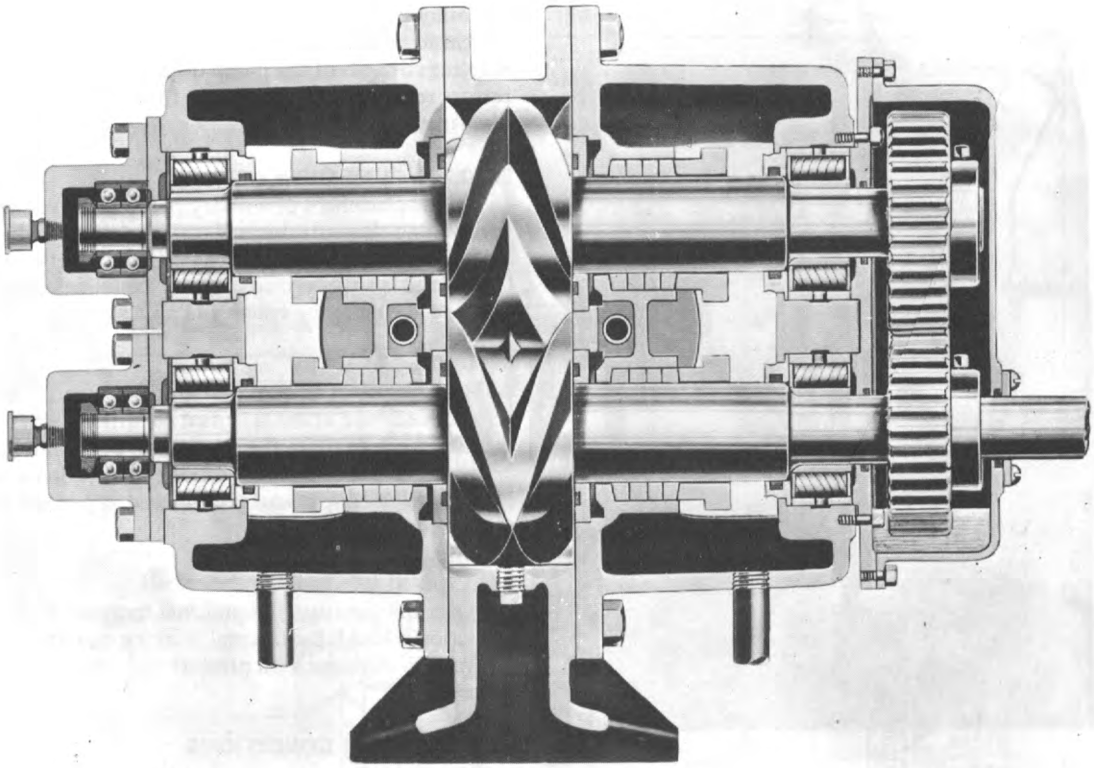


Figure 9470-43

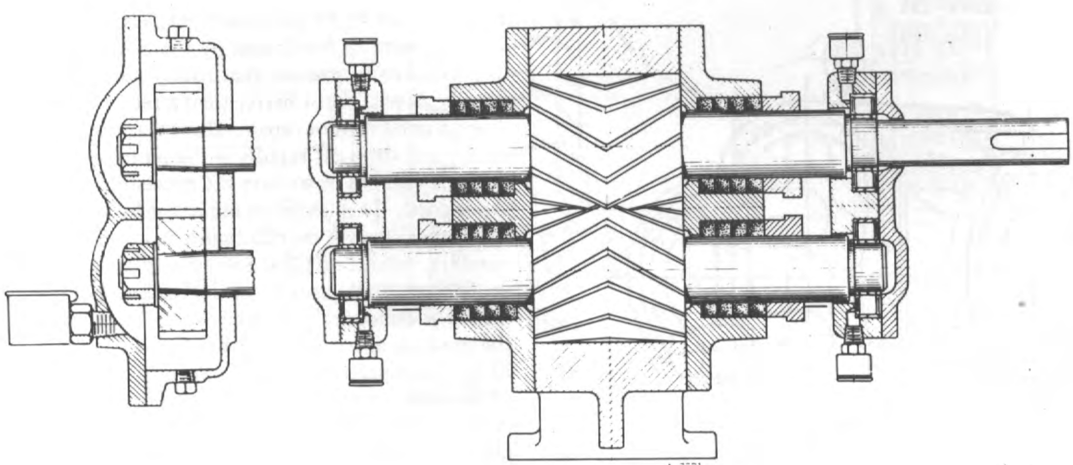


Figure 9470-44

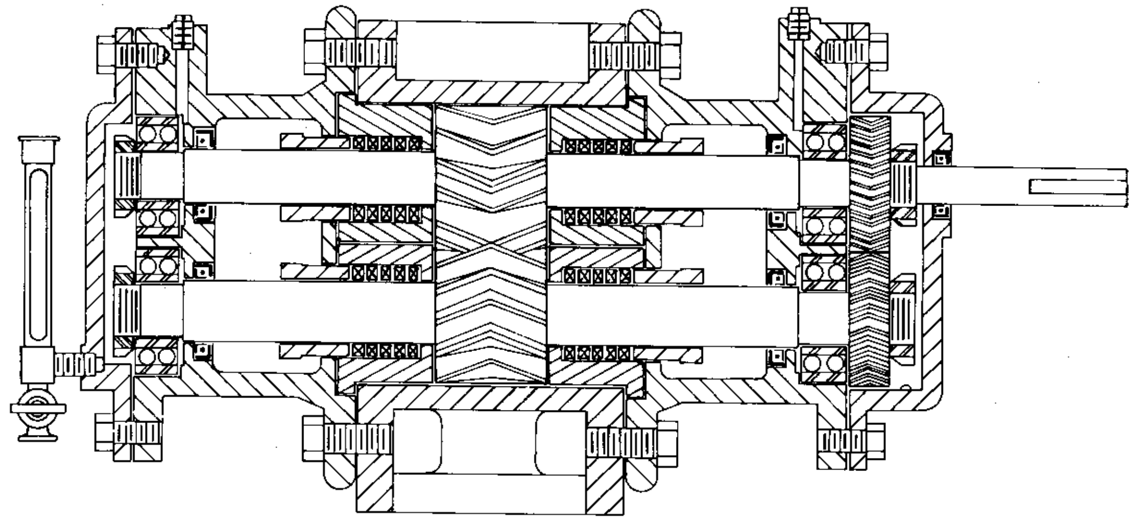


Figure 9470-45

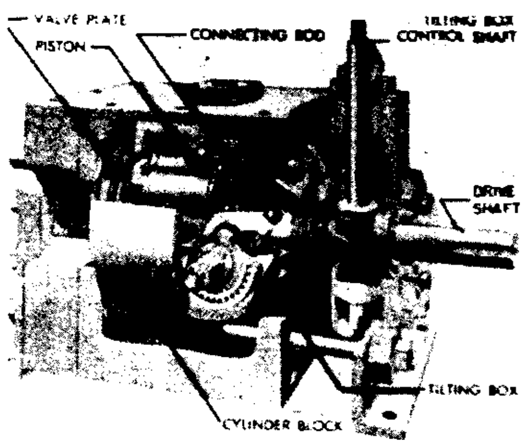


Figure 9470-46

out of solution. This reduces the pump's liquid capacity and will result in noise, vibration, and pressure pulsations. Under some conditions these pressure pulsations can attain a high magnitude which will cause damage to piping or to the pump itself. The magnitude of these pulsations is dependent on pressure pump speed and number of closures of the rotor element per revolution.

2. **Entrained gases.** The amount of entrained air or gas contained in the liquid handled varies greatly and depends on the viscosity, type of liquid, the extent of agitation and exposure, and the type of system. Main lubricating oil systems are highly susceptible to air entrainment and foaming. Figure 9470-51 shows the reduction in liquid capacity plotted against suction lift for different amounts of air or gas entrained.

3. **Dissolved gases.** The amount of air or gas contained in a liquid by solution varies with the type of liquid, and the time and conditions of exposure. Gasoline may dissolve

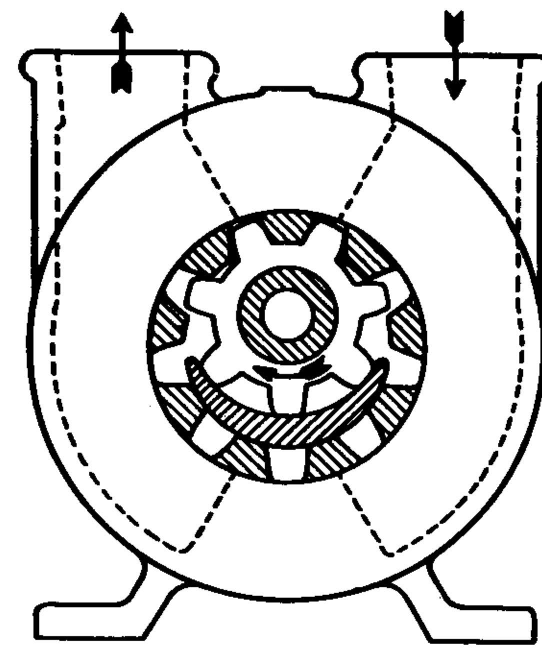


Figure 9470-47

up to 20 percent of air by volume; lubricating oil may contain 10 percent by volume. These figures are approximate. Figure 9470-52 shows the reduction in liquid capacity plotted against suction lift for different amounts of air or gas in solution. Note that whereas the amount of entrained air affects the capacity even at 0 suction lift, the dissolved air remains in solution until the pressure is lowered.

9470.212 EFFECT OF VISCOSITY

Rotary pumps are suitable for handling liquids over a wide range of viscosities. The power required increases

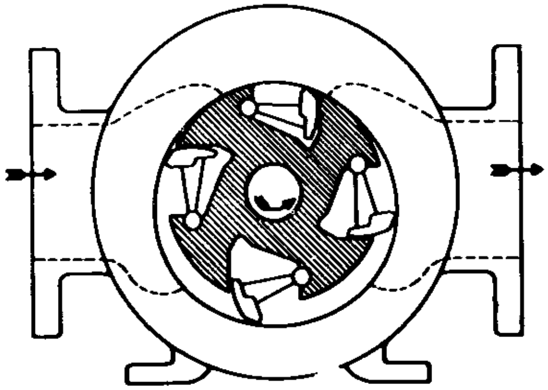


Figure 9470-48

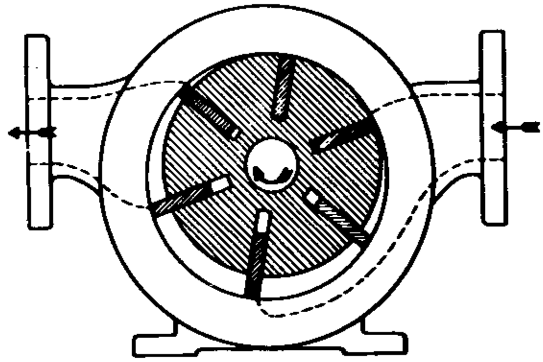


Figure 9470-49

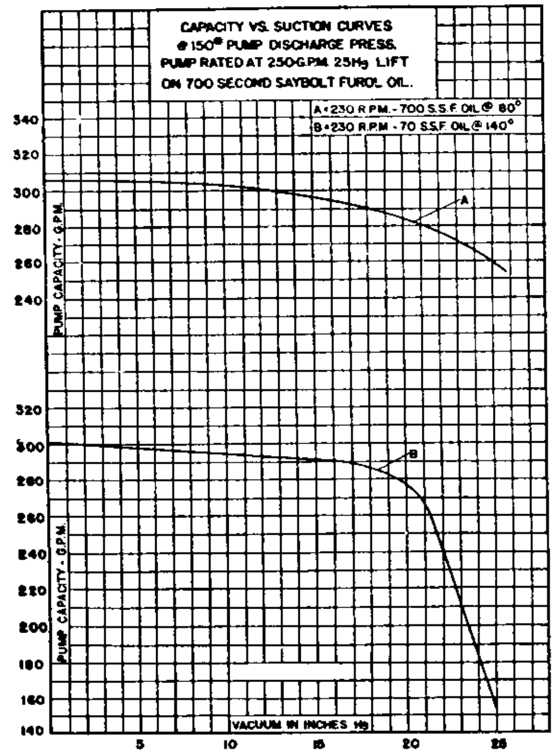


Figure 9470-50

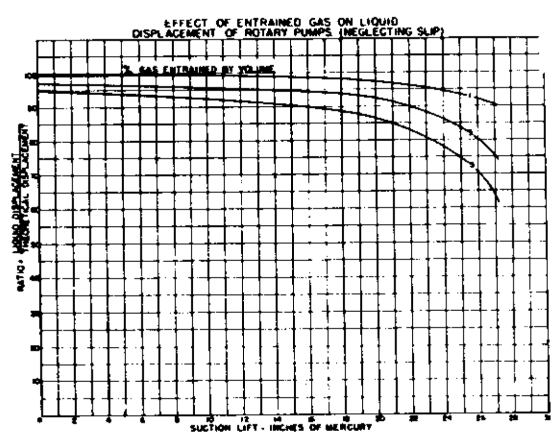


Figure 9470-51

with viscosity due to increased friction within the pump. The speed of the pump should be reduced when handling increased viscosity in order to allow the rotors time to fill. The Naval Ships Systems Command has made extensive tests on the maximum rubbing or pitch line speed for different oils and these limitations are incorporated into specifications for rotary pumps for naval service.

9470.213 MAIN FUEL OIL SERVICE

For boiler fuel oil service, screw type pumps, figures 9470-39, 9470-40, and 9470-41, are extensively used in naval service.

To a lesser extent, the Kinney rotary pump, figure 9470-38, and gear pumps, figure 9470-44, are used. Other types, such as the three-lobe, figure 9470-42, and the heliquad, figure 9470-43, are not inherently suited for high pressure fuel oil service due to their larger diameter rotors, which cause excessive shaft deflection and heavy bearing loads. Pumps for this service are designed for suction conditions up to 20 inches suction lift and for discharge pressures of 350 or 1050 pounds per square inch gage depending on the burner system for the particular ship on which they are installed.

9470.214 PORT AND CRUISING FUEL OIL SERVICE

Two types of port and cruising fuel oil service pumps are in current use. Some ships have installed motor-driven, variable delivery, axial piston type pumps similar to figure 9470-46. This type is intended to operate with varying capacity at constant motor and pump speed. This is accomplished by means of a constant pressure governor which varies the capacity of the pump through a stroke adjusting mechanism in response to burner demands. This control

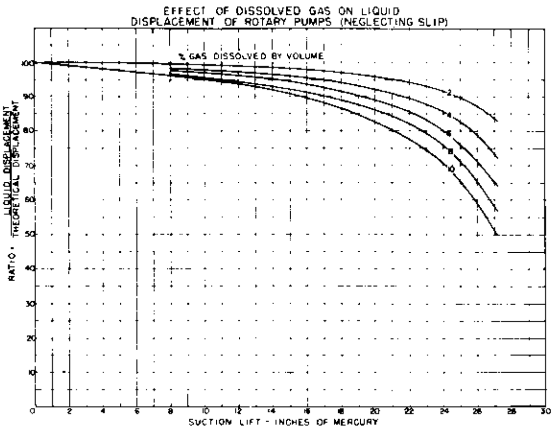


Figure 9470-52

is usually augmented by a manually-operated capacity control by means of which the pressure control can be made inoperative and the capacity adjusted by hand to meet the demand. The majority of ships, including those of latest design, are equipped with pumps of a constant delivery type, similar to those for main fuel oil service, driven by two-speed motor and capacity further adjusted by means of a bypass valve, which returns the unused portion of the oil from the burner line to the pump suction.

9470.215 FUEL OIL BOOSTER AND TRANSFER PUMPS

1. Fuel oil booster and transfer pumps most extensively used in the service are:

   a. The Kinney cam and plunger (figure 9470-38).

   b. The DeLaval IMO pump (figure 9470-41).

   c. The Quimby or Sier-Bath screw pump (figures 9470-39 and 9470-40).

   d. The Northern cycloidal (figure 9470-42).

   e. The Kinney heliquad (figure 9470-43).

2. Fuel oil booster and transfer pumps encounter severe operating conditions. They are required to pump oil through long lengths of suction lines which may have a number of pockets or traps. The oil may have a high viscosity which results in high friction loss with high net suction lift at the pump inlet. For this reason, such pumps are usually driven by multispeed motors or steam turbines to ensure a wide range of capacities to avoid operating at too high a suction lift with cold oil.

9470.216 DIESEL OIL SERVICE

This is not difficult service, and most pumps described in preceding paragraphs are suitable. For economy of space and weight, those shown in figures 9470-44, 9470-45, 9470-47, 9470-48, and 9470-49 are usually applied to these services.

9470.217 FUEL OIL TANK DRAIN PUMPS

Fuel oil tank drain pumps are used for stripping fuel oil tanks and must handle mixtures of oil, sludge, salt water, and sediment. These pumps are usually Northern "Cycloidal," figure 9470-42, or Kinney "Heliquad," figure 9470-43. These pumps have timed rotors which prevent metal-to-metal contact of the rotors and is a necessary feature for pumps handling abrasive fluids such as encountered in this application.

9470.218 LUBRICATING OIL

Main lubricating oil pumps for surface ships, particularly those of recent construction, have been subjected to severe operating conditions due to entrained air of the lubricating oil. This has been particularly noticeable in the case of constant speed, motor-driven, lubricating oil pumps which must run at maximum capacity regardless of the operating conditions or demands of the system. The principal effect of pumping these air-oil mixtures has been pulsating discharge pressures causing vibration of the pump and pipe, and in extreme cases breakage of lines. Action which has been taken to reduce the effect of these pulsations has included reduction of suction lift by increasing size of suction lines, and improvement of entrance conditions in the pump suction, elimination of dead end relief valve lines, and greater use of turbine-driven pumps in new construction. Pumps shown in figures 9470-39, 9470-40, and 9470-41 are used for this service.

9470.219 CARGO

Main cargo pumps are frequently of centrifugal type in view of the weight and space saving possible in the large capacity pumps now required in tanker service. For moderate and small ships, pumps shown in figures 9470-42 and 9470-43 are used.

9470.220 CARGO STRIPPING

For cargo stripping, service pumps must maintain a suction lift, or act as continuous priming pumps for centrifugal main cargo pumps. As the liquid level in the tank begins to get low, pumps, figures 9470-42, 9470-43, 9470-45, and 9470-48 are used for this service.

9470.221 BEARINGS

Rotary pump bearings are classified as either "external" or "internal" type. External bearings are separated from the liquid pumped by shaft packing or mechanical seals. Internal bearings are located between the rotor elements and the packing and depend on the liquid pumped for lubrication. Internal bearings are not suitable for pumps handling liquids containing abrasives or having low viscosity lacking in lubricating qualities.

9470.222 GLAND SEALING

Where pumps are required to take suction at lower than atmospheric pressure, it is important that the shaft stuffing boxes be fitted with a lantern ring and sealed by the liquid being pumped to prevent the entrance of air into the pump. Stuffing box gland sealing liquid is taken from the discharge of the pump.

Part 2. Operation

9470.251 USE OF MANUFACTURERS' INSTRUCTION BOOKS

The instructions contained in this chapter for operation, maintenance, and repair of pumps are general for all makes and types. For all pump applications except some small miscellaneous service motor-driven pumps, manufacturers' instruction books are furnished with the plans. These instruction books contain detailed information concerning the specific pump installed. If any conflict exists between the instructions given in this chapter and the manufacturers' instruction book, NAVSHIPS should be consulted.

9470.252 PREPARING PUMP FOR OPERATION

Before starting a rotary pump for the first time, proceed as follows:

1. Clean all external surfaces of the pump and driver.
2. Check the auxiliary piping such as lubrication lines, gland sealing connections, water supply to oil coolers, etc.
3. Examine bearings to ensure they are properly lubricated.
4. Make sure stuffing boxes are properly packed.
5. Stuffing box glands should not be drawn too tight.
6. Pump should be primed from the discharge side using the same liquid as that to be pumped. This is necessary to lubricate the rotating elements and to seal the clearances.
7. Discharge side of the pump should be vented during the initial starting so as to be free to discharge the air from the pipe system.

9470.253 STARTING

To start a rotary pump proceed as follows:

1. Check lubricating oil level in sump or bearing housing. Fill oil cups or reservoir if fitted. If external supply of lubrication is provided, open and adjust all delivery and return valves.
2. Open steam and exhaust casing drains on turbine.
3. Open valves to pump packing gland seals, where fitted.
4. Open steam and exhaust root valves.
5. Open turbine exhaust valve.
6. Lift all relief and sentinel valves by hand.
7. Open pump discharge valve.
8. Open pump suction valve.
9. a. For turbine-driven pumps, crack turbine throttle valve sufficiently to free lines, steam chest, and exhaust casing of condensate.
   b. As soon as turbine is free of condensate, close all drains, then open throttle slowly and bring unit up to speed.
   c. For motor-driven pumps start motor. (See instructions for operation of motors and controllers, chapter 9630.)
10. Check lubricating system to see that all bearings are supplied with oil and that oil pressure is correct.
11. Check all gages to see that proper pressures are being developed.
12. For turbine-driven pumps, check revolutions per minute to see that rated speed is not exceeded by more then five percent.
13. Adjust pump shaft packing glands and gland sealing needle valve when fitted.
14. Where unit is fitted with a constant pressure governor, all the preceding operations shall be performed with the governor bypassed or the governor valve pull-open device wide open.
15. The pressure governor, if it is to be used, should now be put in operation by opening the valves in the governor actuating lines between the discharge of the pump and the governor and closing the governor bypass or pull-open device. The governor should then be adjusted to give the required pump discharge pressure.
16. After pressure governor is in operation and is functioning properly, the throttle valve should gradually be opened wide to ensure that pressure governor takes control.
    Then check all pressures, temperatures, speed, and lubrication to see that normal conditions obtain through-out. With pressure governor in control, the unit should require no further attention insofar as discharge pressure is concerned. However, the operation of the unit should be checked frequently during each watch to see that all is normal.
17. If no pressure governor is fitted, the unit will require close attention to throttling to maintain the required discharge pressure, especially if the ship is maneuvering, transferring fuel, or pumping tanks.

9470.254 STOPPING AND SECURING

To stop and secure, proceed as follows:

1. Close throttle gradually, or stop motor, being sure that the pump discharge check valve closes, to prevent a backflow through the pump being secured from another pump which may be discharging into same line.
2. Close pump discharge stop valve.
3. Close exhaust valve.
4. Close pump suction valve.
5. Open turbine drains.
6. Close all supply and return valves when unit is lubricated by a detached pump or by a main lubricating oil system.
7. Close steam and exhaust root valves.
8. Close steam drains after turbine is completely drained.
9. Close pump governor actuating line valve and open governor by-pass valve or pull-open device.
10. After the unit is secured as above, read the turbine exhaust casing pressure gage and pump suction combined pressure and vacuum gage, to ensure that steam does not leak through exhaust valves and build up pressure in the exhaust casing or turbine, or that pump casing is subjected to pressure due to leakage through pump discharge stop and check valves.

9470.255 PUMP FAILS TO DELIVER LIQUID

If pump does not discharge liquid when first started, proceed as follows:

1. Stop the pump.
2. Make sure pump is primed.
3. Suction lift may be too high. Check suction with a vacuum gage at pump suction. If suction lift is too high, the liquid may be vaporizing.
4. Check direction of rotation on a motor-driven unit.
5. Check pump and suction lines for air leaks.
6. Pump suction may be clogged.
7. Bypass relief valve may be lifting or held off seat by foreign matter.
8. Keep air vents open until pump discharges.

9470.256 PUMP NOT UP TO CAPACITY

If pump discharges but does not deliver sufficient capacity, one or more of the following principal causes may be responsible:

1. Air leaks in suction or through pump stuffing boxes.
2. Pump speed too low.
3. Suction lift too high.
4. Suction strainer, if fitted, may be too small or clogged.

5. End of suction pipe not submerged deep enough in liquid supply.
6. Pump damaged or badly worn or packing defective.
7. Relief valve improperly adjusted or held off seat. Bypass line to suction partly open.

9470.257 PUMP STARTS THEN CEASES TO DELIVER

If pump delivers liquid for a while and then loses its suction or fails to deliver, the following may be the cause:

1. Leaky suction lines.
2. Suction lift too high, causing liquid to vaporize.
3. Air or gas evolves into pockets in suction lines.

9470.258 PUMP TAKES TOO MUCH POWER

If pump takes too much power to operate, check the following:

1. Pump speed too high.
2. Liquid is heavier or more viscous than specified. Heating the liquid to reduce the viscosity should be undertaken if feasible. Reduce pump speed.
3. Suction or discharge lines are obstructed. Check pressures developed by pump. If no obstructions or partly closed valves are located, refer to the Naval Ships Systems Command giving complete data as to pressures, pump speed, viscosity, and temperature of liquid, and dimensioned sketch of system in use. Reduce pump speed to reduce load.
4. Mechanical defects such as bent shaft, binding of rotors, stuffing box packing too tight, misalinement on foundations or of piping connections resulting in distortion of casing and interferences within pump.

9470.259 PUMP IS NOISY

If pump is noisy, check the following points:

1. Air or gas in the liquid.
2. Air leaking into suction.
3. Liquid vaporizing in suction. Reduce suction lift.
4. Mechanical defects such as misalinement, rotor interference, high spots rubbing, or bent shaft.
5. Relief valve chattering.

9470.260 PUMP WEARS RAPIDLY

If pump wears excessively, check the following:

1. Liquid pumped contains sand or other abrasive and foreign matter.
2. Misalinement.
3. Pump operating at greater than rated pressure.
4. Operation on liquid of lower than specified viscosity.
5. Liquid is corrosive.
6. Pump has run dry or with insufficient liquid.

9470.261 VAPOR LOCK IN SUCTION LINE

When a pump is in good condition and builds up a good vacuum on suction, but does not build up discharge pressure after all previously outlined possible troubles are corrected, the possibility of vapor lock in the suction piping should be investigated, particularly in long lengths of fuel oil suction piping, and especially after new oil cargo has been taken on or the oil has been heated up. First, shift suction to another tank or group of tanks nearer the pump. It will usually be found that the pump will readily build up pressure. If no nearer tank is available, build up an air pressure in the tank, taking particular care that pressure on the tank does not exceed the limits set by NAVSHIPS.

9470.262 VAPORIZATION OF OIL

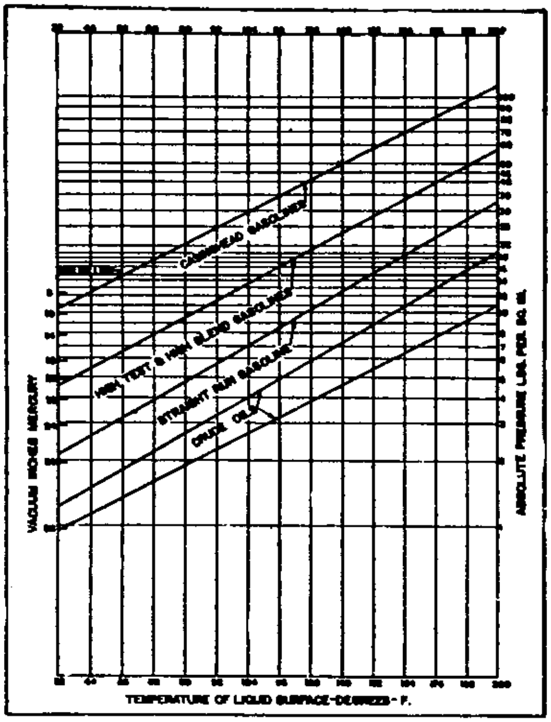
1. The relationship between the temperature and vapor pressure of various petroleum products is shown in figure 9470-53. It can be seen that the lighter hydrocarbons such as gasoline have a much higher vapor pressure than the heavier fuel oils at the same temperature. If heavy pounding of the pump occurs when pumping fuel oil, it will usually be found that the vacuum on the suction side of the pump is excessively high or that the temperature of the oil is high for the type of oil being pumped causing partial vaporization in the suction line or pump casing.

2. Suction lift should not exceed a value such that the resulting absolute suction pressure is less than the sum of the vapor pressure at the pumping temperature plus 2 psi (approximately 4.1 inches of mercury). For example: A pump handling gasoline with a vapor pressure of 11 psi absolute should not have a suction lift exceeding 14.7–(11 + 2)=1.7 psi, or 3.5 inches of mercury suction lift.

3. Vapor lock is most apt to occur in pockets where the suction line overpasses other piping or ship's structure particularly in the proximity of the pump. It will be difficult for the operator to determine whether the maloperation resulting in noise and pounding is due to deaeration or vaporization but whatever is done to reduce the suction lift, such as reducing pump speed, will alleviate the condition.

9470.263 GAGES ON SUCTION

All fuel oil pumps should have compound gages installed at the pump suction manifolds in order to ascertain whether or not the suction lift vacuum is so great as to affect the pump capacity.



VAPOR PRESSURE CHART FOR DIFFERENT FUELS

Figure 9470-53

9470.264 PACKING GLANDS

Do not draw packing glands too tight. Packing should be kept adjusted so that there is a small amount of leakage of the liquid handled or of the sealing liquid. Watch stuffing boxes carefully on starting the pump. At the first sign of overheating, shut the pump down and let the stuffing boxes cool down before restarting. When stuffing box leakage is not permissible because of highly volatile and inflammable liquid pumped, the packing should be replaced frequently to avoid the packing scoring the shaft.

Part 3. Maintenance (where 3-M system is installed, conduct preventive maintenance in accordance with 3-M cards)

9470.281 REFERENCES

Instructions for the use of manufacturers' instruction books, as outlined in part 2 of this section, should be followed in the maintenance of rotary pumps. Instructions for care of shaft packing, lantern rings, shafts, lubricating and oiling system, bearings, thrust bearings, water cooling systems, couplings, and alinement as contained in section II, part 3 of this chapter, should be followed since they apply in general to rotary pumps as well as to centrifugal pumps.

9470.282 WEARING PLATES AND LINERS

The clearances between pump rotors and casing wearing plates and cylinder liners should be maintained as shown on manufacturers' plans. On low pressure, low suction lift pumps, such as lubricating oil, diesel oil supply, and tank drain pumps, the drop in pressure across the clearance spaces does not usually exceed 50 psi, and with this type of pump the clearance between parts may wear to as much as 0.005 to 0.010 inch without appreciable effect upon the capacity of the pump; hence, for this class of pump, wearing plate and liner renewal should not be under-taken until wear or increased clearance has exceeded these figures, or, in the case of fuel oil tank drain pumps, until the pump will not pull a vacuum of at least 16 inches mercury with suction valve closed. The engineering officer should decide in each case whether or not the amount of wear of clearance parts dictates renewal. For boiler fuel oil service pumps, however, the effect of increased clearance makes itself felt by reduction in the efficiency and in the maximum capacity of the pump. For this class of service the wearing parts should be renewed when the clearances exceed the designed clearances shown on manufacturers' plans by about 100 percent.

9470.283 THRUST BEARINGS

See comments concerning thrust bearings under section II, part 3 of this chapter. In pumps of the type shown in figures 9470-42 and 9470-43, the importance of the proper setting of the thrust bearings, which serve to hold the pumping elements centrally in the pump casing, cannot be overstressed.

9470.284 TIMING GEARS

In pumps of the type shown in figures 9470-39, 9470-40, 9470-42, 9470-43, and 9470-45, timing (or synchronizing) gears are fitted to the rotor shafts to maintain correct clearances between the two pumping rotors during operation. To accomplish this, the gears must be securely locked to the rotor shaft in their exact position to maintain a clearance between the rotor elements as the shafts make a complete revolution; therefore, no lost motion is permissible in way of keys or pins holding the rotors and gears in position on the shafts.

9470.285 MOTORS AND CONTROLLERS

The instructions for care of controllers and motors, chapter 9630, should be followed for motor-driven units.

9470.286 TURBINES

The instructions for care and operation of auxiliary turbines as contained in chapter 9500 should be followed where turbine-driven units are involved.

9470.287 PUMP PRESSURE GOVERNORS

Boiler fuel oil service, lubricating oil pumps, and some fuel oil booster pumps are fitted with adjustable constant pressure-type pump governors (chapter 9470 section IV) in addition to turbine governors mentioned in section II, part 3 of this chapter.

9470.288 TESTS AND INSPECTIONS (ROTARY PUMPS)

1. **Weekly.** Test operate idle pumps at normal conditions to inspect for mechanical seal leakage. Operate all pumps by steam or power. If power is not available, move by hand.

2. **Quarterly.**

a. Lift all relief valves by water or oil as appropriate.

b. Check thrust position of pump rotor.

c. Sound and set up as necessary all foundation bolts and secure all foundation dowel pins.

3. **Annually.**

a. Check bearing clearances by leads or crown thickness measurements.

b. Check wear of internal parts by slowly throttling suction valve with pump running at normal speed. Do not close the suction valve completely as this may result in damage to the pump rotating elements and mechanical seal. A vacuum of at least 12 inches of mercury should be developed by fuel service pumps and 15 inches of mercury by the fuel booster and transfer pumps with NSFO and 5 inches of mercury should be developed with Distillate fuel by either fuel pump. Not less than 6 inches of mercury should be observed at the pump suction for lubricating oil service pumps. If pump will not pull the required vacuum, it should be opened, clearances measured, and necessary steps taken, either by renewal of parts, adjustment of rotors, or taking a cut off casing or cover as applicable, to restore designed clearances. In making this test be sure that pump is filled with oil before throttling the suction valve.

4. **Overhaul cycle.**

a. Open pump and reduction gear casings; inspect and clean.

b. Check clearances of all wearing plates and liners, casing throat bushing, rotors, casing liners, and bushings, and renew parts as necessary.

c. Examine all pump rotors, shafts, bearings, timing gears, keys, and reduction gears, particulary worms and worm wheels.

NOTE: These tests and inspections are the minimum necessary to give adequate assurance of safe and reliable operation of equipment. Indications of low discharge pressure or other manifestations of improper operation should indicate more frequent or extensive tests and inspections. For tests and inspections of turbines, see chapter 9500, article 9500.47.

Part 4. Repairs

9470.301 ASSEMBLE DRAWINGS

When repairing or making an interior examination of a pump, it is essential that all drawings and available dimensional data be at hand. Frequently, such important dimensions as bridge gage readings, clearance between rotors and casing wearing plates and liners, shaft seal or gland adjustment became altered, resulting in poor operation. Such poor operation will naturally continue in spite of other major repairs unless the real cause of trouble is rectified.

9470.302 PACKING THE STUFFING BOX

The packing around the shafts of rotary pumps may be of stuffing box type, the labyrinth type, the rotary seal type, or a combination of types. As an additional precaution against entrance of air to the pump, seals filled with the liquid pumped are installed on the shaft. The shaft revolving at a high speed throws the sealing medium against the gland casing completing the seal. Failure to supply the packing of the stuffing box, or seals, with the sealing and lubricating liquid may cause the packing to become hot from excessive friction, seriously damaging the packing, and scoring the shaft or sleeve.

9470.303 RENEWAL OF WEARING PLATES AND LINERS

Whenever the pump casing is opened, the clearance between casing liners and plates, and various parts of the rotors and shaft, should be measured to see if excessive wear has taken place and if renewal is necessary. Should the bearings be worn excessively, it is reasonable to expect that the renewal of the liners is necessary. They should not be renewed, however, unless the pump bearings that may be down are first restored to their original readings. The required oil clearance for bearings is usually given on the manufacturers' plans. In the absence of such data, the table of tolerances and clearances (see chapter 9005) should be followed.

Part 5. Safety Precautions For Rotary Pumps

9470.311

1. See that relief valves, where fitted, are tested and that they function at the designated pressure.
2. Never attempt to jack a pump by hand while the steam valve to driving unit is open.
3. Do not tie down, or otherwise render inoperative, the overspeed trip, speedlimiting or speed-regulating governors.
4. Check setting of overspeed trip, if fitted, at least quarterly. See that overspeed trips are set to shut off all steam to the unit when rated speed is exceeded by 10 percent.
5. Check setting of speed-limiting and speed-regulating governors, where fitted, at least quarterly. See that they are set to limit the speed of the unit to rated speed under rated conditions, and that rated speed is not exceeded by more than five percent for any condition of loading.
6. Never operate a positive displacement rotary pump with discharge valve closed unless the discharge is protected by a properly set relief valve of size sufficient to prevent a dangerous rise in pressure.
7. When inspecting or overhauling **vertical** rotary pumps **never** rely on a flexible coupling to support the total weight of the pump rotors. **Always** support the pump rotors by means of wire rope slings, block and tackle, or chocks before working on pumps.

SECTION IV. PUMP PRESSURE-REGULATING GOVERNORS

Part 1. Description of Types and Services

9470.351 PRINCIPLE OF OPERATION

A pressure-regulating governor is essentially an automatic throttling valve installed in the steam supply line to a pump's driving unit. The governor is affected by the pump discharge pressure in such a manner that any variation in discharge pressure, or in pressure differential (article 9470.373) will actuate the governor causing it to regulate the pump speed by varying the flow of steam to the driving unit.

9470.352 GENERAL SERVICES

Pressure-regulating governors used in the service are applied almost exclusively to steam-driven pumps, both direct-acting reciprocating and turbine-driven rotary and centrifugal types. There are some pressure regulators fitted to motor-driven port and cruising fuel oil service pumps; however, regulators for this service are usually built as an integral part of the pump. It is suggested that, for the description and instructions relative to the care and operation of this latter type of pressure regulator, reference should be made to the manufacturers' instruction pamphlet for the pump.

9470.353 TYPES

There are normally two types of pressure-regulating governors provided, as follows:

1. A constant pressure (CP) type, which is designed to maintain a constant predetermined pump discharge pressure by control of the steam supply to the driving unit regardless of variation in steam pressure and load.
2. A differential pressure (DP) type, which is designed to maintain a constant predetermined difference in pressure between two selected points in the pump discharge line (or pump discharge line and boiler) by control of the steam supply to the pump driver, regardless of variation in steam pressure and pump load.

9470.354 APPLICATIONS, CP GOVERNORS

Constant pressure (CP) governors are applied to control the discharge pressure of fuel oil service pumps, fuel oil booster and transfer pumps, lubricating oil service pumps, fire and bilge pumps, main boiler feed pumps, and fire and flushing pumps.

9470. 355 APPLICATIONS, DP GOVERNORS

Differential pressure (DP) governors are applied mainly to the control of boiler feed pumps in order to maintain the desired pump output pressure.

9470.356 CLASSIFICATION

Pump pressure regulating governors are further classified as follows:

1. **Types**
   CP–Constant Pressure.
   CPAST–Constant pressure with automatic start.
   CPASP–Constant pressure with automatic stop.
   DP–Differential Pressure.
   DPAST–Differential pressure with automatic start.
   DPASP–Differential pressure with automatic stop.
2. **Classes**
   Class 1–Self-contained piston operated.
   Class 2–External pilot actuated.
   Class 3–Self-contained direct acting diaphragm.
3. **Series**
   Series 1500–Steam service 1500 psig max., 1000° F max.
   Series 600–Steam service 600 psig max., 850° F max.
   Series 600–Steam service 600 psig max., 750° F max.
   Series 300–Steam service 300 psig max., 750° F max.

9470.357 CP GOVERNOR DESCRIPTION

The design of constant pressure governor most used in service is the Leslie type (figure 9470-54).

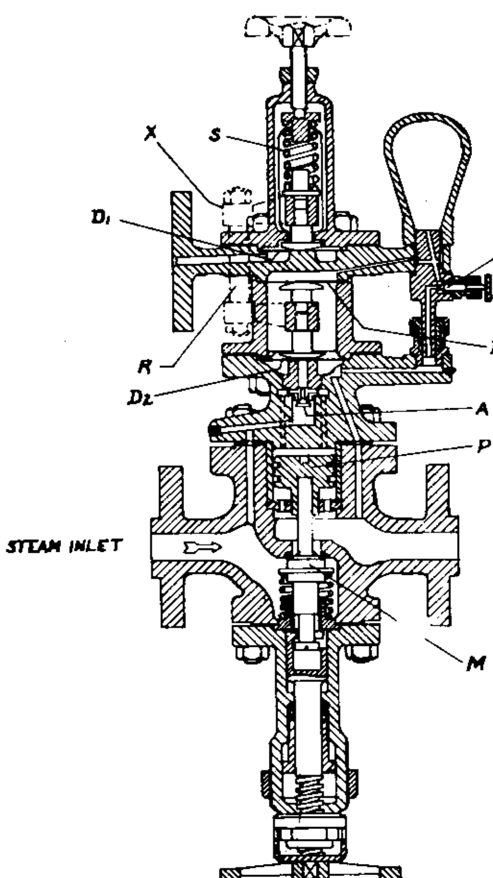


Figure 9470-54

9470.359 LESLIE CP GOVERNOR

1. The Leslie-type of constant pressure governor is illustrated in figure 9470-54. From an inspection of this figure, it will be noted that steam enters the left hand side of the valve, while the pump discharge pressure which is to be controlled is applied to the under side of the top diaphragm D_1 through a pressure-actuating line connected to the pump discharge. The force exerted on the under side of the top diaphragm is balanced by the pressure-adjusting spring S located at the top of the governor valve. Any movement of the top diaphragm is transmitted through the crossheads X and the connecting rods R to the lower diaphragm D_2, which in turn contacts and causes a corresponding movement of the pilot valve A. Operation is as follows: Steam from the inlet side of the governor is led through drilled passages to the under side of the pilot valve A. The pump discharge pressure, assumed to be lower than that for which the governor is set, acts on the under side of the top diaphragm D_1. As this pressure is not sufficient to overcome or balance the force of the pressure-adjusting spring S, the diaphragm and top crosshead X will move downward. This downward movement is transmitted through the connecting rods R and lower crosshead to the lower diaphragm D_2, which causes the pilot valve A to open, admitting steam from the inlet side to the top of the main valve operating piston P, which is forced down and opens the main valve M wider, thus admitting more steam to the pump and causing it to speed up and build up the discharge pressure. With pressure increase on the under side of the top diaphragm, the force acting under this diaphragm is increased sufficiently either to overcome or to balance the adjusting spring pressure, resulting in upward movement of the diaphragm, crossheads, and pilot valve, thus cutting off or reducing steam flow to top of the main valve operating piston, which causes the main valve to close partially and reduce pump discharge pressure to that for which the governor is set.

2. It will be noted that an intermediate diaphragm D_3 is fitted in the governor superstructure, the top of which is connected to the under side of the lower diaphragm through a passage fitted with a needle valve N. The under side of the lower diaphragm is in turn connected through passages to the steam outlet side of the governor valve. The purpose of this arrangement is to reduce hunting and erratic operation of the governor and also to improve regulation by causing the governor to respond more quickly to pump discharge pressure changes. The stabilizing needle valve and steam chamber between the upper and lower steam diaphragms are usually fitted on governors used in connection with turbine driven pumps. Turbine driven pumps operate at widely varying chest pressures and respond relatively slowly to steam pressure changes. Therefore, the governor must have a corresponding speed of response. The needle valve and steam chamber accomplish this by delaying the balancing of the diaphragms after a change in pump discharge pressure. This feature prevents over-regulation or hunting without reducing sensitivity.

3. Reciprocating pumps require a relatively constant steam chest pressure regardless of speed, and the governors have a simple, unrestricted connection between the upper and lower steam diaphragms maintaining constant balance.

4. A valve stem and handwheel are fitted below the main valve, the purpose of which is to open the governor

main steam valve, rendering the governor inoperative and allowing a full flow of steam through the governor. This device is intended to be used in case the governor fails to operate as intended. For normal operation the valve stem should be in its uppermost position to permit automatic operation of the governor. Where no pull-open device is provided, a bypass line is usually installed.

5. Some lubricating oil systems are supplied by a combination of turbine driven lubricating oil service pumps and a shaft driven pump. To permit the independent turbine-driven pumps to remain warm and in a condition to immediately supply oil to the system if required, the turbine driven pump pressure governors have a one-eighth inch diameter hole drilled in the valve disc, permitting the turbine driven pumps to idle at about 20 revolutions per minute.

9470.360 AUTOMATIC SHUTDOWN DEVICE

The Leslie Company has developed an auxiliary pilot valve for use in conjunction with constant pressure governors on boiler feed systems which have separate main feed and booster pumps. The assembly of the auxiliary pilot valve and the governor which has a special top cap has been termed an automatic shutdown device. Figure 9470-55 shows the arrangement of this device. Figure 9470-56 shows the auxiliary pilot valve. The function of the auxiliary pilot valve is to control the flow of steam to the top side of the governor piston which operates the main valve. The special top cap takes actuating steam from the auxiliary pilot valve instead of through the main body as in the conventional top cap. Otherwise the governor functions in normal fashion. It will be noted that the auxiliary pilot valve has an actuating line to the booster pump discharge. The purpose of this device is to protect the main feed pump against damage in event of loss of booster pump pressure. The automatic shutdown devices have demonstrated on service tests that they will shut the main feed pump down in event of loss of or inadequate booster pump pressure. The latest design of the automatic shutdown device combines the functions of the two units into a single governing valve with automatic trip feature. Figure 9470-57 is typical of such an installation for a system using a series 1500 governor.

9470.361 DP GOVERNORS

There are relatively few differential pressure governors in service and the discussion will be limited to a typical example of this type of governor.

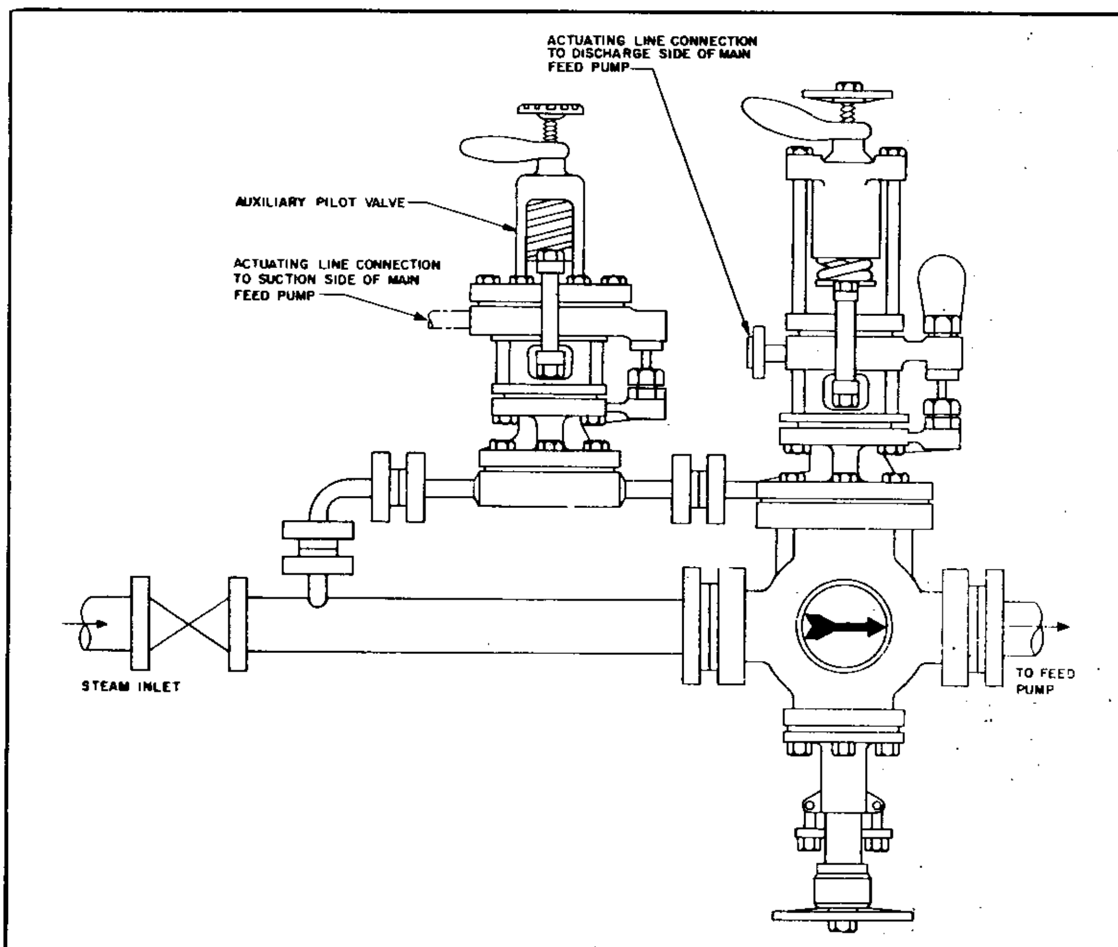


Figure 9470-55

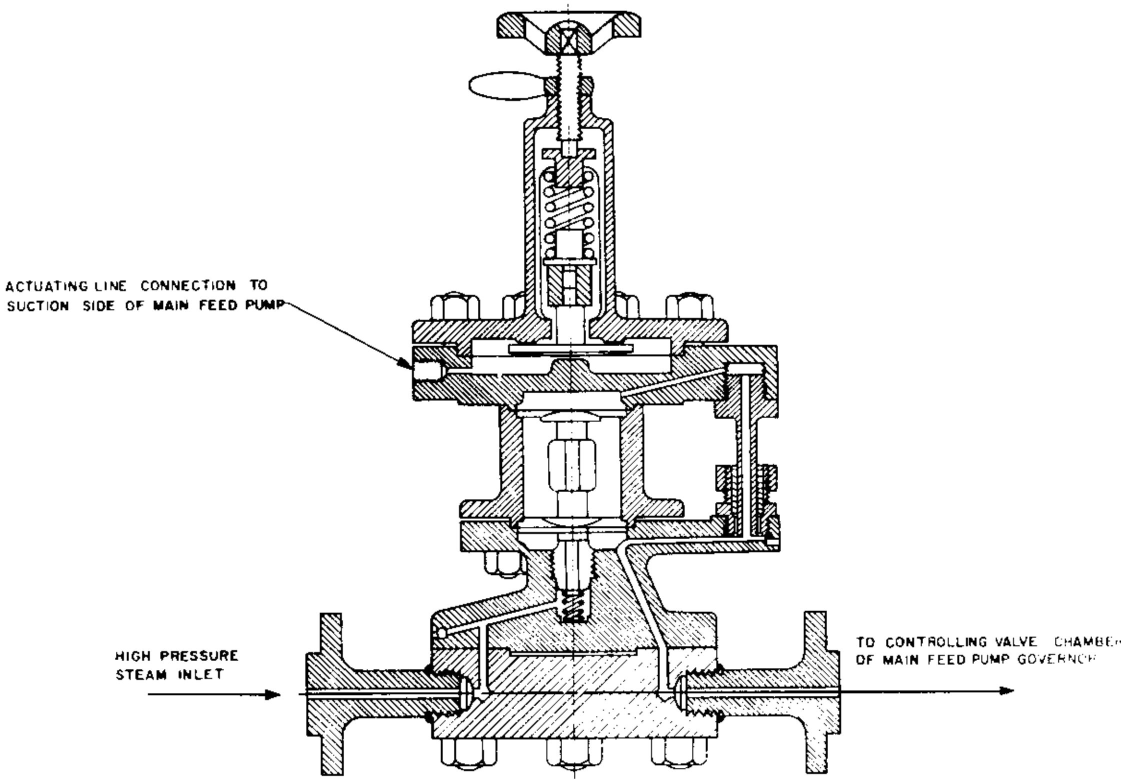


Figure 9470-56

1. The Leslie differential pressure governor is similar in design to the constant pressure type except that an additional diaphragm is fitted at the top of the superstructure to sense the difference in pressure between two selected points in the pump discharge line or pump discharge line and boiler pressure.

2. The lower pressure acting downward on the top diaphragm moves the external yoke downward and opens the controlling valve. This valve admits high pressure steam from the inlet body port to the top of the piston, opening the main valve and admitting steam pressure to the turbine. The pump discharge pressure acts upward under its diaphragm and balances the lower pressure. Compressing the adjusting spring by the handwheel adds to the downward force of the lower pressure, thereby increasing the pump discharge pressure necessary to balance it. When the pump discharge pressure balances the lower pressure plus the spring force, the controlling valve throttles so that the necessary volume of steam is delivered to the turbine to maintain this constant differential pressure. Ordinary fluctuations in the inlet pressure do not change the differential pressure setting; only a change in the differential pressure affects governor action.

9470.362 LESLIE GOVERNOR SYMBOL DESIGNATIONS

All Leslie governors are classified by certain symbol designations and since these governors are used most extensively in service, the following information will assist in their ready identification:

P = Constant pressure under 400 pounds.
T = Turbine
L = Low pressure—150 pounds (maximum) controlled pressure.
N = Navy (United States).
S = Steel.
H = High pressure—150 pounds (minimum) controlled pressure.
X = Differential pressure.
R = Reciprocating.
C = Constant pressure over 400 pounds.
Z = Low pressure suction trip.

Number after symbol means modification. No "S" in class indicates bronze body.

Part 2. Operation.

9470.371 LESLIE PRESSURE REGULATING GOVERNORS

1. Instructions for cutting in governor:

a. Set the manual pull-open device on the main valve for automatic operation.

b. Open the shutoff valves in the steam and liquid actuating lines to the pressure governors.

c. Open steam throttle valve gradually until further opening of throttle valve causes no further increase in speed or discharge pressure of the unit. (See instructions for starting various pumps as contained in sections I, II, and III of this chapter.)

d. Operate under this condition for a few minutes to make certain that the governor is operating satisfactorily, then open the throttle valve wide.

e. For constant pressure governors, adjust the handwheel so that the desired pump discharge pressure is obtained. Screw the handwheel downward to increase and upward to decrease pressure. Lock with lock nut.

NOTE: If the governor is shut down for maintenance, the inlet root valve is closed and the turbine exhaust valve secured. Any steam in the turbine casing is bled out through the turbine casing drain valve.

f. For excess pressure governors, adjust the handwheel so that the pump discharge pressure is the desired amount above the boiler pressure. Screw the handwheel downward to increase and upward to decrease the differential between pump discharge pressure and boiler pressure. Lock with lock nut.

g. If the governor surges or hunts, throttle the needle valve (N) (if fitted) in the equalizing passage connecting the under side of the bottom diaphragm with the upper side of the intermediate diaphragm (Figure 9470-54) until discharge pressure becomes steady. **Never** shut the needle valve tight. When pumping minimum flow, adjust the needle valve approximately 1/4 turn open so that there is no "hunting" and the governor action is smooth and even.

NOTE: In some makes of governors the throttling effect required to steady the pressure is inherent in the governor design and no needle valve will be found on the governor.

h. If the governor fails to control the pump discharge pressure properly, it should be made inoperative in the open position by the manual pull-open device on the button of the governor. Then control the pump discharge pressure by the hand throttle valve.

NOTE: Some makes of governors and those of early design have no manual pull-open device; in such cases the governor can be forced wide open by shutting off the liquid actuating line, and increasing the adjusting spring pressure by means of the hand wheel.

2. Instructions for cutting out a governor:

a. If the pump is to be kept in operation, choke the throttle valve until the pump starts to slow down; close the steam throttle valve if the pump is to be secured.

b. Close the steam actuating line valve.

c. Close the liquid actuating line valve.

d. Throw the governor valve wide open by means of the pull-open device, if fitted.

e. Open drain valve (where fitted) if pump is to be secured.

9470.372 LESLIE PRESSURE REGULATING GOVERNOR WITH LOW PRESSURE SUCTION TRIP—OPERATION INSTRUCTION

Instructions for cutting in feed pump governor with integral low pressure suction trip:

1. Follow general preliminary pump start-up procedures as outlined by pump manufacturer for the particular pump, making sure that the pump recirculating and discharge lines are open.

2. Before starting pump pressure governor, have all compression off the adjusting spring by turning upper handwheel counterclockwise and lower handwheel all the way clockwise. Open the stop valves in steam supply and actuating lines fully. Allow a short time for condensate reservoir of bottom cap to fill with condensate.

3. Supply suction pressure to actuator diaphragm of trip device. Engage trip mechanism by lifting trip gag pin and pushing the handle inward until pin enters hole for automatic operation. Turn upper handwheel slowly clockwise until desired pressure is obtained. Tighten half wing locknut.

4. Adjust trip device for the correct trip-out pressure by screwing the adjusting nut upward to compress actuator adjusting spring until the correct trip-out pressure is reached. Test by varying the suction pressure. Recommended trip-out pressure is 40 psig (unless otherwise specified).

5. Speed limiting governor of turbine must be set at a correct value above maximum operating so as not to interfere with pump governor as specified in the pump manufacturer's instruction book.

6. Handwheel at lower end of pump governor is for emergency operation only. By screwing the stem out counterclockwise, main valve is pulled off it's seat when indicator plate reads "open." Normally, the stem must be all the way in so that indicator plate will read "auto" when pump governor works automatically.

7. In the event of loss in suction pressure on the actuator diaphragm, trip mechanism will operate to close pump governor.

8. When suction has been returned to normal, the trip mechanism must be manually returned to automatic operation position by pressing trip reset handle down.

9470.373 PERFORMANCE REQUIREMENTS

1. Centrifugal boiler feed pumps.

a. For centrifugal boiler feed pumps operating under steady steam pressure and with the governor set for the rated discharge pressure at rated capacity, the pump discharge pressure shall rise from rated capacity of the pump to shut-off by an amount not less than 2.5 percent nor more than 4.0 percent. This rise in pressure shall be continuous; that is, at no point of the curve from rated capacity to shut-off shall there be a drop in the characteristic. (This requirement is based on pumps having constantly rising head-capacity curves with shut-off, at constant rated speed, not less than 15 percent greater than rated discharge pressure.) The pressure-capacity characteristic curves of the pump, with its governor in control, when determined from rated capacity to shut-off and from shut-off to rated capacity, shall not vary at any given capacity by an amount in excess of 0.67 percent of the rated discharge pressure for pumps rated at 750 psig or less, and 1.0 percent for pumps rated at more than 750 psig.

b. Under steady operating conditions the constant pressure for which the governor is set shall not vary more than plus or minus 0.67 percent of the governor setting. Maximum momentary variation in pump discharge pressure due to sudden major changes in capacity shall not exceed plus or minus 10 percent of the rated pump discharge pressure, and such fluctuations shall settle down to normal within 10 seconds. During a gradual reduction in steam

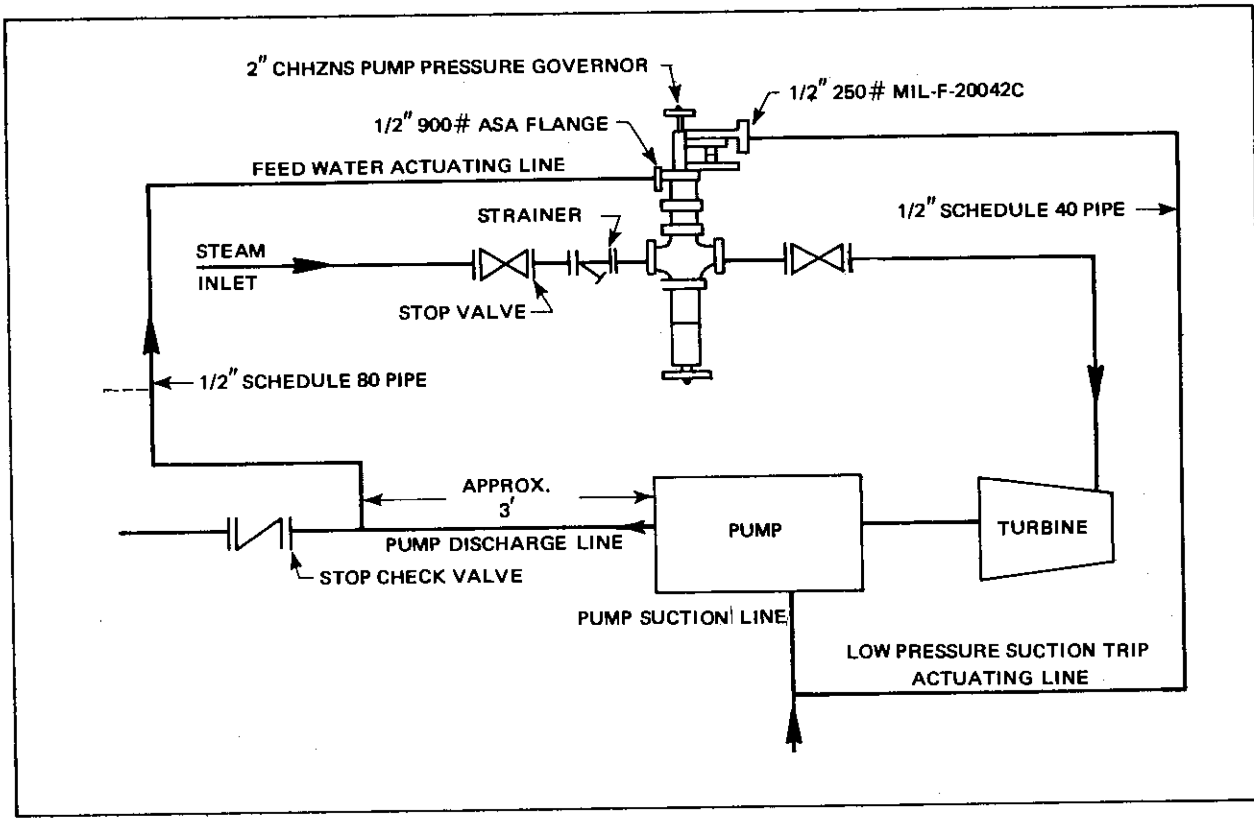


Figure 9470-57. Schematic Piping Diagram

pressure of 20 percent, and vice versa, the pump discharge shall not vary more than plus or minus 1.5 percent with turbine overload nozzle open.

c. For requirements as to paralleling and load distribution for boiler feed pumps equipped with constant pressure governors, see section II.

2. Fuel oil service pumps.

a. Under steady operating conditions the pump discharge pressure shall not vary more than plus or minus two percent.

b. Under steady normal operating conditions with any setting of pump discharge pressure within the specified range of adjustment, the pump discharge pressure shall rise not less than 2.8 percent nor more than 5.7 percent during gradual changes from full load to 25 percent load and vice versa, and under these conditions the governor shall be stable from full load to minimum load and vice versa. During a gradual reduction in steam pressure of 20 percent and vice versa, the pump discharge pressure shall not vary more than plus or minus 2.8 percent of the rated discharge pressure.

c. Maximum momentary variation in pump discharge pressure due to sudden major changes in capacity with steady steaming conditions shall not exceed plus or minus 10 percent of the governor pressure setting and such fluctuations shall settle down to normal within 10 seconds.

3. **Other pumps.**

a. Under steady operating conditions the pump discharge pressure shall not vary more than 1 p.s.i. total for LO service, and plus or minus 2 percent, or 5 p.s.i., whichever is greater, for FS service.

b. Under normal operating steam conditions, with any setting of the governor, the pump discharge pressure shall be maintained within a tolerance of plus or minus five p.s.i. for series 300 and 600 governors, and 7.5 p.s.i. for series 1500 governors during gradual changes from 25 percent load to full load and vice versa, also during a gradual reduction in steam pressure of 20 percent and vice versa. The same pump discharge pressure tolerances shall be maintained.

c. Maximum momentary variation due to sudden major changes in capacity with steady steam conditions shall not exceed plus or minus 10 percent of the pump discharge pressure for pressures above 100 psig or above or plus or minus 10 p.s.i. for lower pressure; and such fluctuations shall settle down to normal within 10 seconds.

Part 3. Installation, Care and Repair

9470.381 USE OF MANUFACTURERS' PAMPHLET

The instructions for installation, operation, care, and repair of pressure governors contained in this chapter are general for all makes and types of governors. The manufacturers of the various types of governors issue pamphlets which contain specific instructions for each type of governor. Engineer officers should see that these pamphlets are on board and should use them in conjunction with these instructions. (See comments under section II of this chapter.)

9470.382 LIQUID AND STEAM GOVERNOR ACTUATING PIPES

The actuating pipe lines for various services should in all cases be connected as follows:

1. For boiler feed service:

a. (Constant pressure governor only.) The water actuating line should be taken from the discharge of the pump between the pump discharge flange and discharge check valve for centrifugal pumps, and from the discharge of the pump between the discharge flange and the discharge stop valve for reciprocating pumps.

b. (Differential pressure governor only.) The actuating lines sense the difference in pressure between two selected points in the pump discharge line or pump discharge line and boiler pressure. Refer to 9470.361.

2. For boiler fuel oil service (constant pressure governor only), the oil actuating line should be taken from the discharge of the pump beyond the check valve between the pump and discharge stop valve.

3. For fuel oil booster service (constant pressure governor only), the oil actuating line should be taken from the discharge of the pump between the pump discharge flange and the discharge stop valve.

4. For lubricating oil service (constant pressure governor only), the oil actuating line should be taken from the lubricating oil main beyond the lubricating oil discharge strainer and the lubricating oil cooler, except when otherwise shown on approved plans.

5. For fire pump service (constant pressure governor only), the water actuating line should be taken from the discharge of the pump between the pump discharge flange and its discharge check valve.

9470.383 CONTROL VALVES AND SEATS

1. The control or pilot valve is continuously throttling or wiredrawing the steam passing through it, and hence the valve and valve seat are subjected to considerable erosion; therefore, they should be inspected periodically. New parts when needed should be of hardened CRES steel as detailed in manufacturer's drawings.

2. Incident to the Leslie governors some difficulties have been experienced in reassembling the control valve assembly within the top cap and maintaining a tight joint between the control valve seat on the top cap casting. The following instructions are given to remedy this difficulty: If the thread fit of the valve seat in the top cap does not seem to be tight enough to prevent the valve seat from backing out, it should be staked or otherwise locked in place in the cap. The following important points should be noted in cleaning and reassembling the top cap assembly (figure 9470-58):

a. In order to obtain continually satisfactory service, the joint "X" between the controlling valve seat and top cap must be maintained perfectly steam tight at all times.

b. Clean all parts, including threads with solvent.

c. Polish joint faces at "X" with crocus cloth for metal-to-metal joint.

d. When installing controlling valve seat, tighten firmly with wrench furnished for this purpose, and, when all the way down, tap wrench to ensure dead tight joint.

e. Correct clearance between top of controlling valve stem and diaphragm seat is 0.001 inch to 0.002 inch.

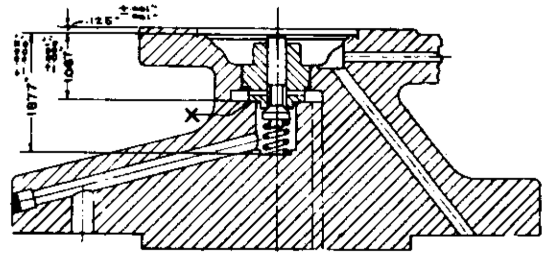


Figure 9470-58

f. If necessary to remachine top cap, tolerance given must be adhered to. Joint face "X" must be square with axis of thread and have straight smooth finish without any tool marks.

9470.384 CONTROL VALVE SPRING

Control valve springs should be examined occasionally to see that they are in good condition. In some of the earlier governor designs, the space around the spring was not properly drained of condensate and frequent breakage of the spring resulted.

9470.385 MAIN VALVES AND SEATS

Governors are inherently throttling devices; hence, main steam valve will be subject to erosion due to wire drawing of steam. Where erosion is excessive, the valves and seats should be replaced with materials as prescribed above for control valves and seats. However, new main bodies (steel) are furnished with stellited seats welded integral with the body. In this instance only the main valve is renewable.

9470.386 PISTON AND CYLINDER LINERS

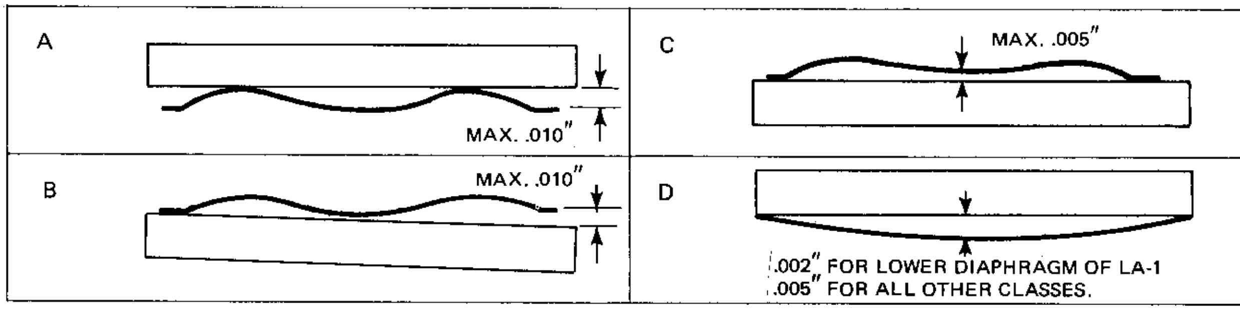
The main valve operating pistons and cylinder liners frequently cause faulty governor action due to accumulation of foreign matter which causes sticking or to excessively worn cylinder liners. The latter is frequently the result of wearing of grooves in the liner due to the movement of the piston through a short travel, as when the pump is operated at reduced capacity. Then, when the governor attempts to open the main valve wide for full pump capacity, the travel of the valve is limited to the width of the grooves, because the piston rings cannot get past the ridges. Thus the governor fails to open wide. This is frequently caused by the cylinder liner being softer than the piston and piston rings. Where this condition is found or where replacement of parts is necessary, the cylinder liner should be made of corrosion-resisting steel, grade 5, hardened to 475 Brinell, the piston of CRES 400 series and the piston rings of high test grey iron. Liners of CRES steel should be substituted for bronze cylinder liners which were installed as a war time substitute for the proper material in most steel governors.

9470.387 DIAPHRAGMS

1. Whenever governors are disassembled, all diaphragms should be carefully inspected. If indications of incipient failure are found, the affected part should be renewed. However, relative to the routine overhaul of Leslie pump governors, many serviceable diaphragms are being replaced, due to the fact that the removed diaphragms are distorted as a result of normal operating pressure.

2. Distortion of diaphragms, within certain limits, is normal, and such distortion has no adverse effect on the operation of the governor. Figure 9470-59 shows the permissible distortion for various types of diaphragms. Unless distortion beyond the limits indicated is found, replacement of diaphragms is not necessary.

3. The importance of replacing diaphragms with ones of the proper thickness and of specified material is stressed. Unless manufacturer-furnished spares are used, reference should be made to finished plans for guidance as to proper dimensions and materials. For further information there is listed in figure 9470-59 diaphragm dimensions and materials used on various types of Leslie regulators.



PERMISSIBLE LIMITS OF PERMANENT SET are shown in the four drawings A to D. The set should be measured with straight edge and feeler gages.

TABLE FOR DIAPHRAGMS USED IN LESLIE REGULATORS

LESLIE CLASS	REFERENCE NUMBER	THICKNESS Inch	DIAMETER Inches	MATERIAL
LT, LT-1, LT-3, LTP-3, J, J-1, JA, L, L-1, L-2, L-3, LE-3, LN, (E, EK, EKX, F, FK up to 1-1/2") L-1A, LE-3A, L-3A, EK-42	4552	0.025	2-33/64	CRES 302
EK, EK-28, FK, FK-28 (over 2")	Disc.	.032	3-3/32	CRES 302
EK-28RI, EKL, FK-28RI	Disc.	.020	4-5/16	CRES 302
L-RI, L-1, RI, LL, LL-3, LT-RI	4995	.020	3-3/32	CRES 302
LTC, JTC, JL, JAL	12007	.0125	2-33/64	CRES 302
LTCO JTCO	9120	.020	2-33/64	CRES 302
LT, LT-1, LT-RI, LT-3, LTP-3, LTL-3 (upper diaphragm)	9945	.025	5	
PTH, PRH, PTL, PRL, LS, LL-S, LB, LX, LB-1, PR, CTH, CRH, XTH, XRH	4552	.025	2-33/64	CRES 302
PTL, PRL, PTL(N)S, PRL(N)S (upper diaphragm)	9814	.025	4-5/16	Monel
LAS, CTH(N)S, CRH(N)S, PTH(N)S, LAS-2, PTL(N)S, PRL(N)S, XTH(N)S XRH(N)S, LA, LA-1, LAS-3, LNS-2	10425	.032	2-33/64	CRES 302
LTCS	12007	.0125	2-33/64	CRES 302
LTCSO	9120	.020	2-33/64	
EKX-42	10425	.032	2-33/64	
PLNS, PLNS-3, PLNS-13 (diaphragm upper)	14090	.007	7-1/4	Phos. Brz.
PTLNS-13 (upper diaphragm) (two leaf diaphragm each .006)	14270	.012	4-5/16	Phos. Brz.
LTCL	4787	.0125	3-3/32	CRES 302
LTCLS	Disc. 4993	.018	3-3/32	CRES 302
1/2" to 1-1/2" DF, DFS	13246	1/16	9-3/4	Rubber
2-1/2" to 5" D-1, DS-1 & 2" to 6" DF, DFS	13247	1/16	14-3/4	Rubber
6" D-1	16086	1/16	14-3/4	Rubber
PD & PR diaphragm for nozzle	12368	.025	1-47/64	Neoprene
PD & PR diaphragm for nozzle disc	12369	.007	3.091	Phos Brz.
Diaphragm upper, control Pilot 1/2 to 6 lbs.	13004	1/16	8-1/8	Neoprene
Diaphragm upper, control Pilot 2 to 20 lbs.	12476	3/64	4-31/32	Neoprene
Diaphragm upper, control Pilot 15 75, 50 to 125 lbs.	13257	3/64	4-15/32	Neoprene
Diaphragm upper, control Pilot 100 to 200, 175 to 300, 275 to 450 lbs.	13226	1/16	3-7/32	Neoprene
Diaphragm for thermostats D, D1, R, R1	10895	.008	1.872	Phos Brz.

Figure 9470-59

CHAPTER 9470 – PUMPS

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