BILGES, PUMPS, AUXILIARY POWER TAKE-OFFS, REFRIGERATION & PLUMBING

THE BILGE SYSTEM

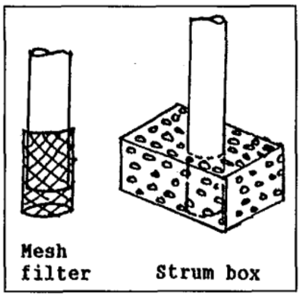


Fig 29.1
SUCTION FILTERS

FIG 29.1 (A)
STRUM BOX

FIG 29.2: IN-LINE WIRE MESH STRAINER

The purpose of a bilge system is to pump out the vessel's bilges. It allows pumping out of one or more compartments. High bilge level can lead to dangers such as vessel instability (see free surface effect in chapter 13); change of trim and draught; list, fire hazard and dangerous and explosive gases from oil in the water. It also leads to slippery work area, corrosion and wet and slimy machinery.

Bilge systems should have the following characteristics:

- A separate suction line from each compartment
- All lines fitted with non-return valves to prevent cross flooding or back flooding.
- All suctions installed in the lowest points in the bilges
- Overboard discharge fitted with a non-return valve to prevent back flooding from the sea
- An Isolating valve fitted on each line.
- Plastic or other non-metallic hoses should not be used (For reasons discussed in the "fuel system"). Flexible hoses must be made of woven wire casings with screwed hose fittings.
- A STRUM BOX, FILTER, STRAINER or MUD BOX must be fitted at each suction. Strainers and Mud Boxes in large vessels may be fitted with a perforated steel plate instead of a screen filter, and the bonnet may be bolted instead of being screwed in. The mud box has a recess to collect the dirt, preventing it from falling back into the bilge.

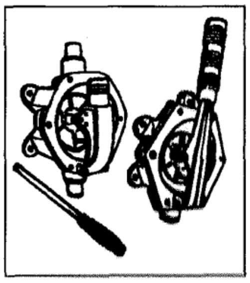


Fig 29.3
ECONOMY SINGLE ACTION MANUAL BILGE PUMP
(Through-deck or above-deck bulkhead-mounted)

Bilge pumps can be manual, electric or engine-driven. Most are *positive-displacement pumps. (NOTE: Pumps, valves and seacocks are discussed below).* They are mounted above the bilge where they are easily accessible and, if manual, wouldn't be tiring to operate. The removable handle of a manual pump should be secured where it will stay until needed. However, submersible rotary (centrifugal) bilge pumps are also around, which are of non-positive-displacement type.

Bilge suction is positioned low in the bilge, and the discharge high above the waterline so that it remains out of water at all angles of heel. A non-return valve must be fitted on the

discharge line, particularly in vessels with low freeboard where the discharge is likely to go underwater during heeling or rolling and cause back flooding. Fitting a very long discharge line on a small-volume bilge may return an excessive column of residual water to the bilge each time the pump stops. This would repeatedly activate the *level switch* (shown below), causing the pump to continue to cycle "on" and "Off". Overcoming this problem by fitting a *check valve* in the line is not desirable. These valves tend to stick and are inaccessible to maintain.

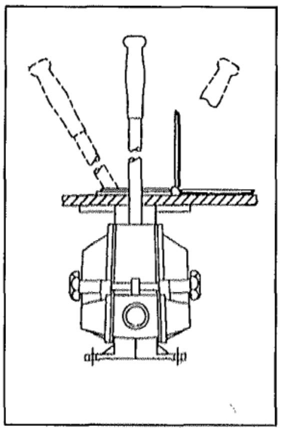


Fig 29.4
JABSCO MANUAL DOUBLE ACTION TWIN-DIAPHRAGM PUMP
(Through-deck or on-deck mounted)

On shutting down the bilge pump there is always some back flushing from the water column in the discharge line. To allow the heavier sediments to fall well below the filter, the *strum box* or the submersible bilge pump should be mounted on a small pedestal.

BILGE PUMPING SYSTEMS

1. DIAPHRAGM BILGE PUMPS - MANUAL

The old *rotary and semi-rotary manual bilge pumps* were tiring to operate. The *plunger-type manual pumps* have also now disappeared. Their leather sealing-flap suffered constantly from shrinking, cracking and loss of shape.

Manual bilge pumps today are mostly the *diaphragm pumps*. They can be mounted to bulkhead or deck. They are operated by moving a handle back and forth. A diaphragm attached to the handle moves with it to draw fluid into the pump chamber and then expel it out. One-way flap valves on the inlet and outlet allow the fluid to move in the correct direction. However, the flow direction can be revered by exchanging the inlet and outlet ports.

A double-diaphragm pump has a diaphragm and pump chamber on both sides of the lever. As one diaphragm moves in to draw water into one chamber, the other moves out to expel it from the other. These are double-action larger capacity pumps.

Manual pumps are the traditional mainstay of the small craft bilge pumping systems and can offer surprisingly good flow rates, as well as a variety of installation options. Yacht racing rules state that at least one pump must be capable of being pumped from the cockpit with all hatches shut. The best way to accomplish this is with a through deck kit which allows the pump to be installed safely below decks while the operator pumps from above. A well-designed manual bilge pump is very hard to block due to its large boreholes and valves and one-piece diaphragm. The larger manual pumps are also suitable for ballast and waste transfer.

2. DIAPHRAGM BILGE PUMPS - ELECTRIC (See Figure 29.22)

Mounted in a dry location, these pumps are excellent for shallow bilge boats where the water left behind by other types of pumps will slop from side to side. With the small size of inlet pipework they are very effective as bilge 'hoovers', removing all but the last drops of water. Diaphragm pumps can be run dry which removes the need to watch overboard outlets whilst the pump is running. The ability to self-prime means they can be mounted in an easily accessible position to aid in servicing.

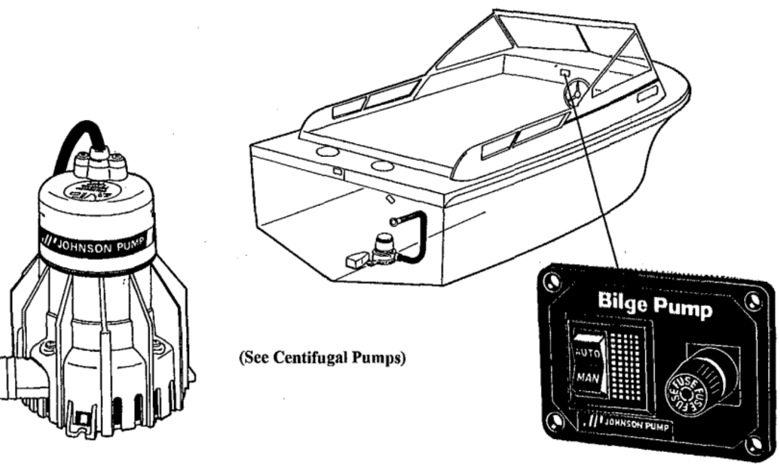


Fig 29.5: JOHNSON SUBMERSIBLE BILGE PUMP

3. SUBMERSIBLE CENTRIFUGAL BILGE PUMPS

By far the most popular type of electric bilge pumps, submersibles give very high outputs, are cheap to buy, have low amp draw and are easy to install. They are designed to fit in the lowest

part of the bilge and only require discharge pipework and electricity supply. However, flow rates decrease more rapidly than other types of pumps as the discharge head increases, so check the manufacturer's maximum discharge heads and if in doubt, always increase the size of the pump. Although modern submersibles can be run dry for an hour or two, pump life can be extended by avoiding dry running whenever possible. All submersibles can be operated using a float or hydro-air switch and remotely controlled outside the bilge compartment from a switch panel.

4. FLEXIBLE IMPELLER BILGE PUMPS

Flexible impeller pumps make excellent bilge pumps, principally because of their ability to handle bilge debris without damage. They also give the benefits of good flow, low cost, low size and weight, and are easily serviced and maintained. Flexible impeller pumps must not be run dry, as this will damage the impeller, which will require replacing. However, some pumps allow a few minutes of dry running after initial priming. As with submersible pumps, flexible impeller pumps can be operated using a float or hydro-air switch, and remotely controlled from outside the bilge compartment.

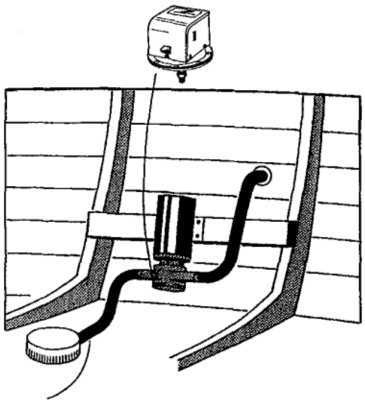


Fig 29.6: JABSCO FLEXIBLE IMPELLER BILGE PUMP WITH A VACUUM SWITCH
(In pumps not designed to run dry, a vacuum switch should be fitted to cut off current to the pump when the bilge is dry.)

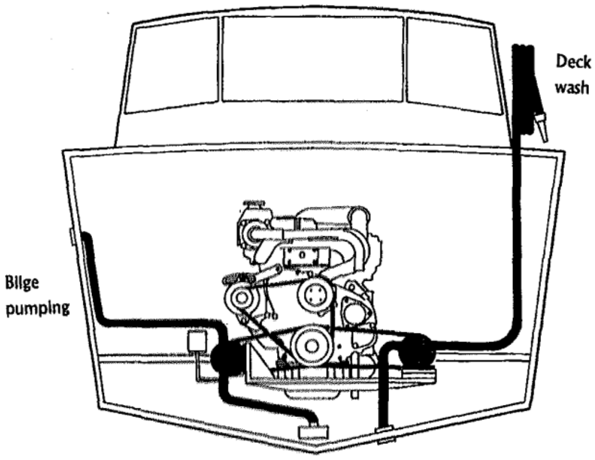


Fig 29.7: JABSCO ENGINE DRIVEN BILGE PUMP & DECK WASH SYSTEM

5. ENGINE DRIVEN BILGE PUMPS

Engine driven pumps are probably the strongest and most reliable pumps. Combined with other benefits such as self-priming and very high flow rates, these pumps are the firm favourites on commercial vessels. They come in a wide range of performances and sizes and can be direct driven by a clutch, pulley or hydraulic drive; or can be close coupled to a suitable power take off on the engine.

The illustration shows the bilge pumping system separated from the deck wash system. One is for pumping water out of the vessel and the other for pumping seawater on deck. However, in most small vessels, the two systems use a common pump with an *"L-port Cock" (a two-way cock)* fitted in the line to make sure that the pump suction is either on the sea suction or the bilge suction. When one is in use the other is automatically isolated. This prevents any possibility of bilges being flooded from the sea. Priming is necessary prior to sucking a distant bilge with a pump not designed to run dry. As mentioned earlier, running an impeller pump dry for any length of time would burn out the impeller vanes.

The outlet from the bilge pump should not be joined into any other outlet, such as the sink outlet of the galley. With the outlet below sea level due to vessel being heeled or otherwise, there is a risk of water siphoning back into the vessel after the bilge pump has been used. A further precaution is to fit non-return valves at both the suction and the outlet. It is unsafe to leave a water hose hanging over the side in water in an unattended vessel. Water may siphon back into the vessel.

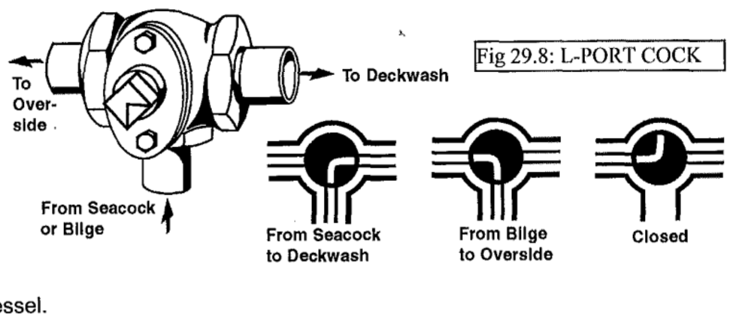


Fig 29.8: L-PORT COCK

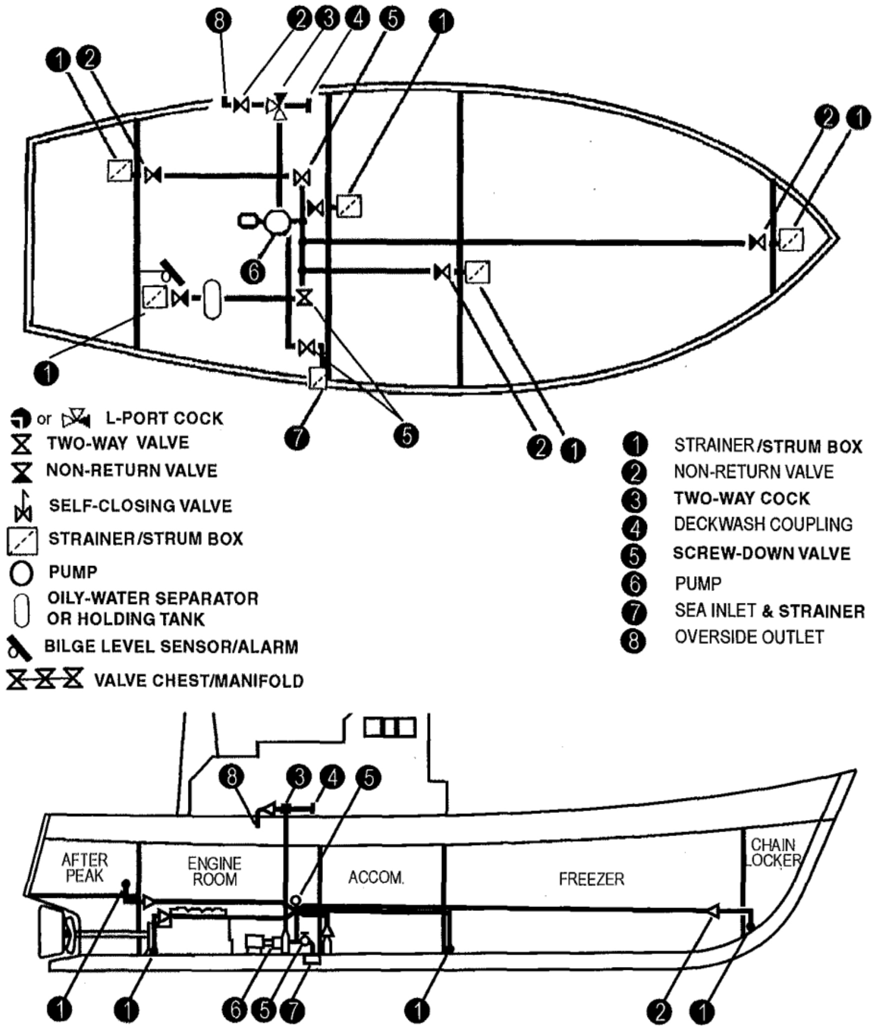


Fig. 29.9: TYPICAL BILGE PUMPING SYSTEM FOR MULTI-COMPARTMENT VESSELS

BILGE ALARMS must be fitted in bilges to sound an alarm when bilge water exceeds a preset level.

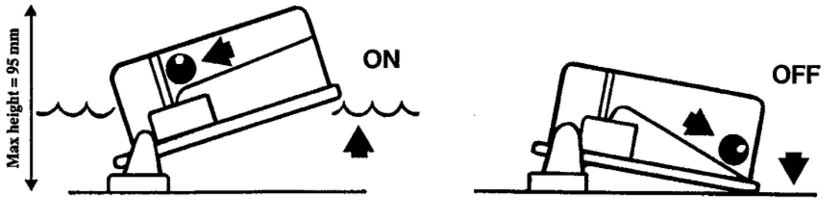
AUTOMATIC BILGE PUMPING

A switch can be attached to the bilge pump to automatically turn it on when bilge water reaches an acceptable level. The two common types of switches are: **HYDRO AIR SWITCHES** and **FLOAT SWITCHES**.

In a Hydro Air Switch, rising bilge water pressurises air in a bell and tube, which activates the diaphragm switch. In the case of a Float Switch, when water exceeds the acceptable level, the pump is turned on by a rolling steel ball, which changes the pressure on the micro switch.

A switch panel (shown above) provides a control for manual or automatic bilge pumping. Only the heavily insulated wiring should be used to avoid electrical leaks and the pump grounded to minimise electrolysis.

<u>A word of caution about the float switches</u>: They should be changed at least every 2 years, whether they appear to need it or not. Located in the grimy salt-water bilge, unused and unattended most of the time, the micro-switch may fail to operate, an electric cable may corrode or come undone, or the ball may fail to roll.



Water raises switch, ball rolls back, switch snaps on. Ball at rest, switch in off mode.

Fig 29.10: JABSCO AUTOMATIC BILGE PUMP SWITCH

BILGE MAINTENANCE

Bilges must be inspected on every watch and limber holes kept clean so that water from all sections of the bilge moves freely towards the bilge suction. Sediments settled below the suction filter must not be allowed to accumulate. All valves in the system should be opened and closed regularly and serviced when necessary, and piping and joints checked for condition and leaks. Open all non-return valves and check that the valve fits the seat to ensure that the opening will be sealed when the valve is close. Prior to departure, test the bilge pump(s) by pouring some water in each bilge well and pumping it out. Make sure the non-return valves are not left jammed open.

Sinking of boats on their moorings is not uncommon. A large amount of water can accumulate even from a slowly dripping stern gland. The bilge pump would operate a few times until the battery goes flat, the level switch fails or the fuse blows due to corrosion of the fuse holder. After that the water is free to fill the boat. *Wet-type batteries* are particularly prone to over-discharging in hot weather to the point of being useless within a few months.

Therefore, it is unwise to rely on bilge pumps on unattended vessels. It is better to make sure that water does not enter the vessel. Keep batteries charged and electrical circuits in good condition. A secondary high-level alarm system or a pump-timer may be a worthwhile investment.

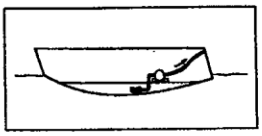
BILGE PUMP REQUIREMENTS FOR COMMERCIAL VESSELS (Fig 29.11)
(NSCV PART C Section 5 Subsection 5A)

Measured length of vessel (m)	Manual pumps		Powered pumps	
	Qty.	Capacity per pump, as installed, in kL/hr	Qty.	Capacity per pump, as installed, in kL/hr
Less than 7.5	1	4.0		
7.5 and over but less than 10	2	4.0		
10 and over but less than 12.5	1	5.5	1	5.5
12.5 and over but less than 17.5	1	5.5	1	11.0
17.5 and over but less than 20	1	8.0	1	11.0
20 and over but less than 25			2	11.0
25 and over but less than 35			2	15.0

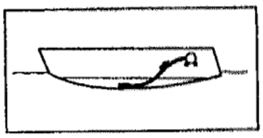
NOTE: The installed capacity of a bilge pump is normally less than the nominal figure specified by the manufacturer due to the head of the discharge above the suction and losses through valves and piping.

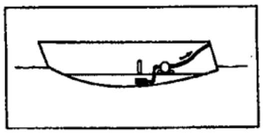
GOOD PUMPING PRACTICE
— BILGE PUMPS

Correct | *Incorrect*

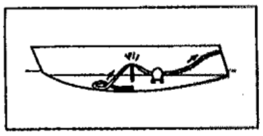


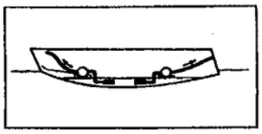
1. Install electric self-priming pumps as low as possible, consistent with a dry, ventilated & accessible location.



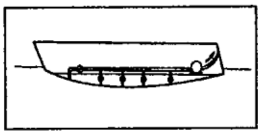


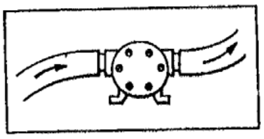
2. Keep suction pipework as short and straight as possible. Use reinforced hose that will not deform or collapse under suction conditions. Ensure that all connections are airtight.



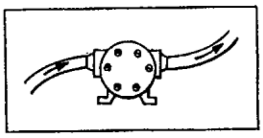


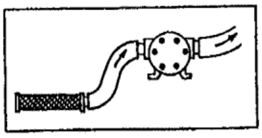
3. Keep pipework simple. Complex valving in the suction system increases the risk of air leaks and loss of priming ability.



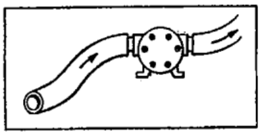


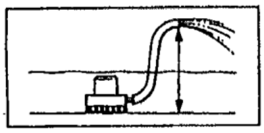
4. Use pipes of internal diameter at least as large as the nominal bore of the pump ports.



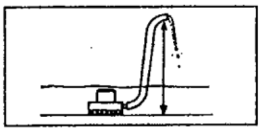


5. Always fit an adequately sized suction strainer to protect the pump from debris. Make sure that it is accessible, and remember to inspect it periodically.





6. Remember that small electric submersible pumps are rarely useful at more than 1.2m (4ft) vertical discharge head. Medium / large submersibles are similarly ineffective above 2m (7ft).



7. Always fit a manually operated bilge pump as a back-up to electric or engine-driven pumps.

GOOD BILGE PUMPING PRACTICE (Fig. 29.12)
(Recommended by Cleghorn Waring Pumps)

BILGES - TROUBLESHOOTING

SUDDEN APPEARANCE OF OIL OR OILY WATER IN BILGE

- Damage to the engine sump.
- Oil pipes damaged or disconnected.
- Spillage of stored oil.
- Damaged tank(s).

ACTION FOLLOWING SUDDEN APPEARANCE OF OIL IN BILGE

- Find and rectify cause.
- Check oil pressure gauge.
- Slow down, if necessary.
- Dip or check oil in engine and storage.
- Remove oil into a container for disposal - to comply with pollution regulations.

LOSS OF PUMP SUCTION

- Blocked suction strainer.
- Sheared impeller drive.
- Air leak in a valve gland or a pump gland or due to vessel rolling or damaged suction pipe.
- Pump not turning fast enough - drive belt slipping.
- Excessive clearance in pump impeller.

BILGE PUMP NOT DRAWING WATER FROM A FULL BILGE

- See "loss of pump suction".
- Incorrect or unnecessary valves open.
- Non-return valve seized in seat.
- Pump priming device not working - air lock in the system.

PUMP FAILURE

- If the pump is not turning, check the power supply and condition of wiring.
- If the pump is engine driven, check that the clutch or belt is engaged and not slipping.
- The pump may also not work due to poor wiring or corrosion.
- Its performance may be reduced by inadequate wire size, which can also cause overheating.
- Bare sections of wire exposed to moisture can lead to moisture wicking up inside the insulation, causing corrosion and increased resistance.
- As discussed below, flexible impeller pumps shed their vanes with age or due to having been run dry. If so, replace the impeller as per manufacturer's instructions.

AIR LEAKS

Air leak is a common problem caused by:

- Leaking glands on valves, cocks or pump drive shaft.
- Holes in pipes
- Valves left open or leaking in empty bilge compartments.

PUMPS

POSITIVE DISPLACEMENT PUMPS: Any pump that alternately increases and decreases its volume is referred to as a positive-displacement pump. For example, the flexible impeller pump discussed below.

SELF-PRIMING PUMPS: Self-priming pumps have the capability to draw fluid to themselves. They do not have to be installed below the liquid level they are to pump. In the following list all pumps are self-priming, except for the centrifugal pump. However, flexible impeller pumps, although self-priming, need to be primed before drawing water through a long pipeline. This can be achieved by installing a one-way check valve (non-return valve) in the suction line. However, a long pipeline is not recommended for the engine cooling line. Keep it as short and straight as possible, and fit an in-line strainer instead of a non-return valve. Risking running the pump dry for any period of time would not only damage the impeller vanes, but also the engine.

Remember that the self-priming ability of pumps usually deteriorates with age. Therefore, where self-priming ability is important, choose a pump with a slightly greater self-priming ability than needed.

The pump capacity is expressed in litres per minute.

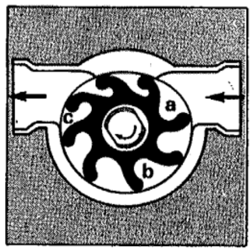


Fig. 29.13: FLEXIBLE IMPELLER PUMP (*Jabsco*)

TYPES OF PUMPS

1. FLEXIBLE IMPELLER PUMP

Almost all engine raw water pumps are of this type, as are the engine driven deckwash pumps. Carrying spares is therefore essential.

How it Works:

- Flexible impeller blades create a nearly perfect vacuum for instant self-priming.
- As the impeller rotates, each successive blade draws in liquid and carries it from intake to outlet port.
- As the flexible impeller blades come into contact with the offset cam they bend with a squeezing action, thus providing a continuous, uniform flow. It is therefore a positive displacement pump.

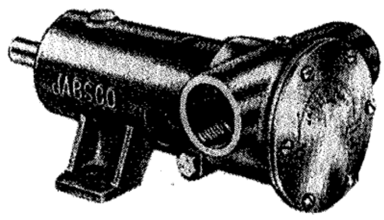


Fig. 29.14: FLEXIBLE IMPELLER PUMP HOUSING (*Jabsco*)

Features:

Versatile: The flexible impeller pump combines the priming features of positive displacement type pumps with the general transfer ability of centrifugals. It will pump either thin or viscous liquids and can handle more solids in suspension than other types of rotary pumps. The pump can be mounted at any angle and will pump in either direction with equal efficiency.

Self-Priming: Pumps instantly with dry suction lifts up to 3m (10 ft), up to 8m (25 ft) when wetted.

Simplicity: One moving part - a tough, long-life, wear-resistant flexible impeller.

Flexibility: The flexible impeller pump offers both high flow and high pressure according to motor and impeller design.

Good pumping practice: Pipe runs should always be kept as short and straight as possible, avoiding rising and dipping over obstructions, as this can lead to air-locks. Pipework should always be reinforced, non-collapsible hose of the recommended size. Electric pumps should always be installed in a dry, well-ventilated position as close to the liquid to be pumped as possible. Flexible impeller pumps must not be run dry.

A VACUUM SWITCH can be fitted to the pump to cut off the power to the motor when there is no fluid in the inlet pipe. Bilge pumps and cooling water pumps in particular must be fitted with a filter or strainer on the inlet pipework to protect them from debris. These should be fastened to the boat structure to ensure their permanent location. Mount flexible impeller pumps so that some water is left in the pump body when the pump is shut off. This will prolong impeller life and speed priming. Pumps must be installed with the overboard discharge well above the waterline (both static and heeled) to avoid water siphoning back into the vessel.

IMPELLER USAGE - IMPORTANT

- ENGINE COOLING: Use only neoprene compound rubber impellers.
- BILGES, ETC.: Use nitrile compound rubber impellers. Nitrile impellers are excellent for oil/water/diesel mixture. However, they are not suitable for engine cooling. Their flow capacity is 10 to 15% less than that of neoprene impellers, which could cause engine overheating, especially in larger engines.

FLEXILE IMPELLER PUMP DETAILS

1. Screw, End Cover
2. End Cover
3. Gasket
4. Impeller (neoprene or nitrile rubber)
5. "O" Ring
6. Wear plate
7. Screw
8. Cam
9. Pipe Plug
10. Body
11. Slinger
12. Bearing Seal (inner)
13. Ball Bearing
14. Retaining Ring
15. Retaining Ring
16. Bearing Seal (outer)
17. Seal Assembly
18. Shaft, Stainless Steel
19. Key

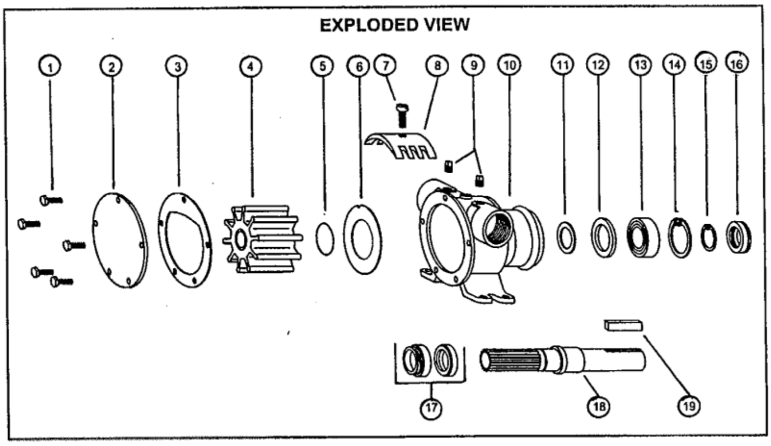


Fig 29.15: FLEXIBLE IMPELLER DETAILS (*Jabsco*)

FLEXIBLE IMPELLER REPLACEMENT

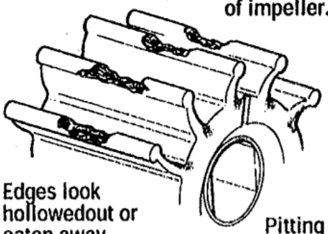
The flexible impellers should be replaced at least once every year. Spare impellers (of the correct part number) should be carried on board in the event of emergency. The impeller is one of the most vital components of the engine cooling system, and should always be treated as such. Replacing the impeller is easy. By removing the end cover screws, it is possible to remove the impeller either using a dedicated impeller removal tool, or a plumber's wrench that grips the impeller hub. It is not advisable to use two screwdrivers, as these will damage the face of the pump body causing leaks and can be dangerous in confined spaces. The Jabsco Flexible Impeller Removal Tool is the easiest way to remove impellers, especially when the pump is mounted in tight and cramped conditions.

The new impeller should be greased for two reasons: firstly it makes it easier to install the impeller into the pump bore, and secondly it gives added protection to the impeller whilst under initial prime. After replacing the gasket and end cover the pump is ready to use.

Impeller Trouble Shooting Guide

This guide is designed to help spot typical application problems that show up in flexible impellers during normal use.

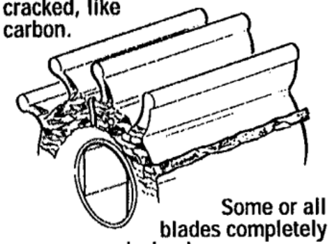
Problem 1



Causes:
- Cavitation, i.e. too much vacuum at pump inlet, fluid boils locally.

Remedies:
- Reduce pump speed.
- Increase inlet pipe diameter.
- Reduce inlet pipe length and restrictions.

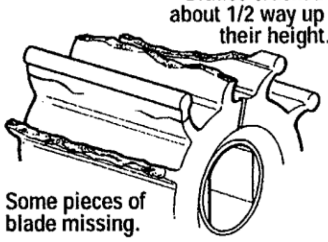
Problem 2



Causes:
- Dry running.

Remedies:
- Do not run more than 30 seconds without liquid in pump.
- Stop pump as soon as liquid is exhausted.
- Arrange pipe work to trap liquid in pump on discharge side. Prevents dry running for several minutes.

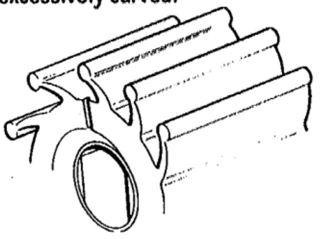
Problem 3



Causes:
- Normal end of useful life.
- Excessive outlet pressure reduces impeller life.
- A crease on trailing side of each blade can also indicate excessive pressure.

Remedies:
- Reduce pressure and/or pump speed.
- Increase outlet pipe diameter.
- Reduce outlet pipe length and restrictions.
- Can also be due to dry running.

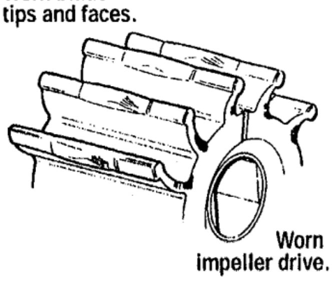
Problem 4



Causes:
- Long term storage in pump.
- Normal end of useful life (especially nitrile impellers).

Remedies:
- Remove impeller for long term storage.
- Refit impeller to rotate in opposite direction.

Problem 5



Causes:
- Abrasive wear from pump or fluid.
- Worn impeller drive can also be due to excessive pressure or dry running.

Remedies:
- Pump should continue to operate satisfactorily in worn condition.
- Replace severely worn pump parts.

Fig 29.16: FLEXIBLE IMPELLER TROUBLESHOOTING GUIDE (*Jabsco*)

2. CENTRIFUGAL PUMP

This is not a not positive displacement pump. The example of this type of pump is the submersible bilge pump. It is also common to find such a pump plumbed with the suction fitted with an L-port cock so that it can draw from the bilge or the sea, as required.

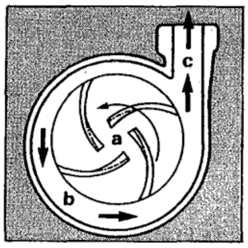


Fig. 29.17
CENTRIFUGAL PUMP
(*Jabsco*)

How it Works:

- Centrifugal pumps are not self-priming. Their inlet must be flooded before they can start pumping. They are thus usually submersible pumps. The pump can run dry periodically without damage. However, for maximum seal life, the dry run periods should be kept to a minimum. They can suck from a small height if initially primed and fitted with a non-return valve at the bottom of the inlet pipe.
- The rotating impeller gives velocity energy to the liquid. The liquid drawn into the centre of the impeller is forced to its periphery by centrifugal force and towards the discharge port.
- The momentum generated in the liquid keeps it moving and the pump continues to work.

Features:

High Volume Flow: Being of high-speed rotation, these pumps are always electric motor driven or belt driven from the main engine. They handle high volumes with a smooth, non-pulsating flow. The flow rate can be regulated from maximum output to no flow without any damage to the pump. It is an excellent pump for general transfer applications.

Low Maintenance: Few moving parts mean that wear due to operation is minimal.

Easy Installation: Compact size for flow rate. Option of port positions simplifies pipe runs.

Versatility: Centrifugal pumps can be built in submersible form making excellent bilge pumps. They can also handle dirty water. They do not generally stall unless physically jammed with debris. A coarse bilge strainer is therefore sufficient.

Low Power Consumption: Electric centrifugal pumps consume less power than most other bilge pumps.

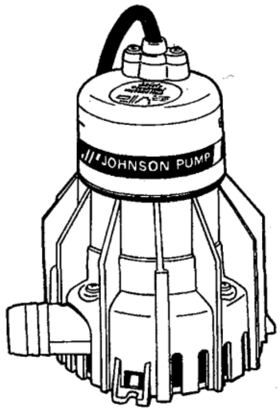


Fig. 29.18: CENTRIFUGAL PUMP HOUSING (*Johnson*)

INSTALLATION

Always use hose of the recommended size. Pipe runs should be kept as short and straight as possible, avoiding rising and dipping over obstructions as this can cause air-locks. However, modern pumps may incorporate an anti-lock design so that a dip or water-lock in the hose is cleared automatically when the pump is started. In fact, in some instances it is necessary to include a water-trap in the discharge hose to prevent exhaust fumes from blowing into the vessel through the bilge discharge when it is not in use.

Submersible bilge pumps should be located in the lowest part of the bilge. They must also be plumbed to a thru-hull overboard discharge that remains above the waterline at all angles of heel. This is to avoid water siphoning back into the vessel. Sailing vessels generally discharge through or below the transom.

MAINTENANCE

Submersible centrifugal pumps generally require no periodic maintenance other than occasionally checking and possibly cleaning the pump inlet port and the strainer base. This can usually be done by depressing the base release tabs and lifting the pump assembly from the strainer base. At the same time inspect the hose connections to ensure they are tight.

3. SLIDING VANE PUMP

Although now uncommon in small vessels, you may still come across them in applications such as manual fuel pumping into a header tank or the manual bilge pump.

How it works:

- The vanes create a partial vacuum for priming.
- As the rotor rotates, each successive vane draws and carries liquid from the intake to the discharge port.
- When the vanes contact the eccentric portion of the pump body, they force liquid out the discharge port.

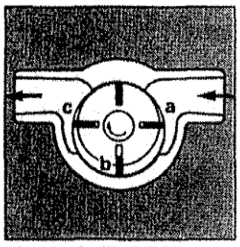


Fig 29.19: SLIDING VANE PUMP (*Jabsco*)

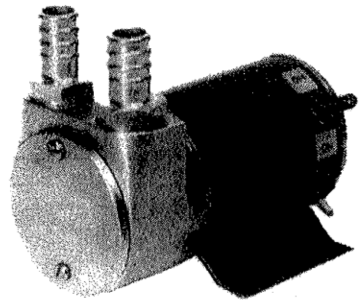


Fig 29.20: SLIDING VANE PUMP HOUSING (*Jabsco*)

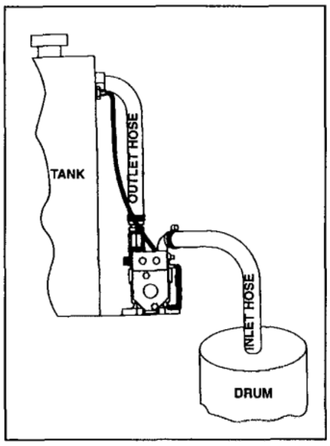


Fig 29.21: SLIDING VANE PUMP APPLICATION (*Jabsco*)

Features:

Durable: Heavy-duty construction gives long life.

Self-Priming: Self-priming up to 4m (13 ft).

Simplicity: There are few moving parts to replace. The liquid being pumped lubricates the rotor, vanes and seal. Full access to the pump head can be gained by loosening about 3 screws.

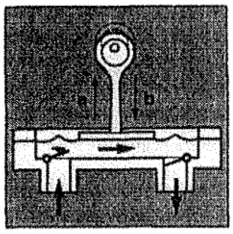
Versatile: An excellent compact unit for general utility or transfer applications which will pump thin or somewhat viscous liquids, and can be mounted at any angle and run in either direction.

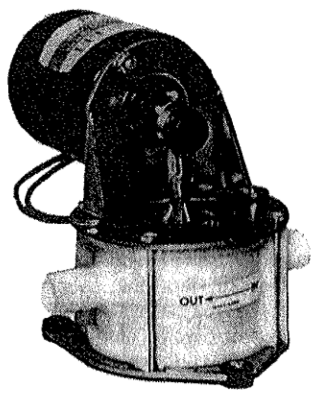
Good pumping practice: Pipe runs should be kept as short and straight as possible, avoiding rising and dipping over obstructions as this can cause air-locks. Always use hose of the recommended size and of a rigid or reinforced type that will not collapse under suction conditions. Electric pumps should always be installed in a dry, well ventilated, position as close as possible to the liquid to be pumped.

4. DIAPHRAGM PUMP

Examples of these self-priming pumps are the non-submersible manual and electric bilge pumps; pressurised water supply pumps and engine fuel lift pumps.

Fig. 29.22 (A) & (B)
DIAPHRAGM PUMP & HOUSING (Jabsco)





How it works:

- The pump may be fitted with one or more diaphragms, which are constructed of several layers of fabric. The diaphragm(s), pulled upwards by the movements of a piston or a handle causes a partial vacuum, opening the inlet port and closing the outlet, drawing in liquid.
- Downward movement of the diaphragm(s) pressurizes the liquid, closing the inlet valve and opening the outlet valve through which liquid is expelled by pressure.

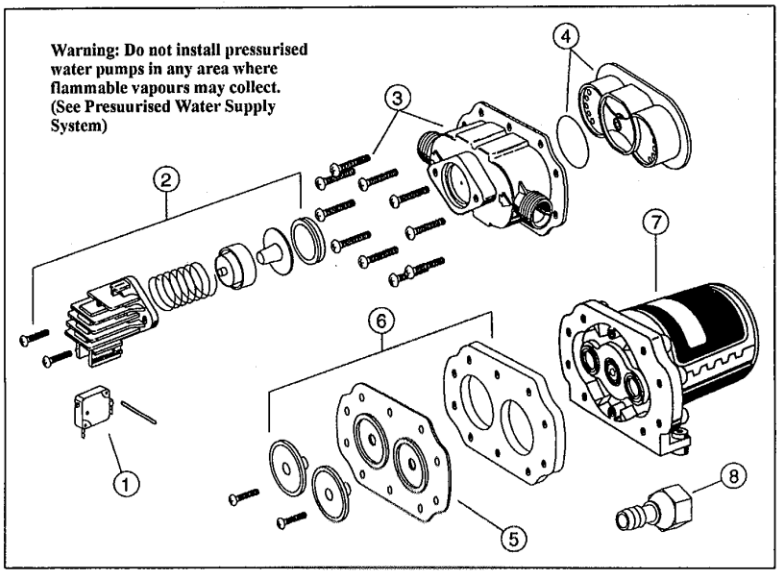


Fig 29.23
EXPLODED VIEW OF A TWIN-DIAPHRAGM PRESSURISED WATER SUPPLY PUMP (*Jabsco*)

1. Micro Switch
2. Pressure Switch
3. Body Kit
4. Valve Kit
5. Diaphragm
6. Plate/Piston Kit
7. Motor
8. Hose Adaptor

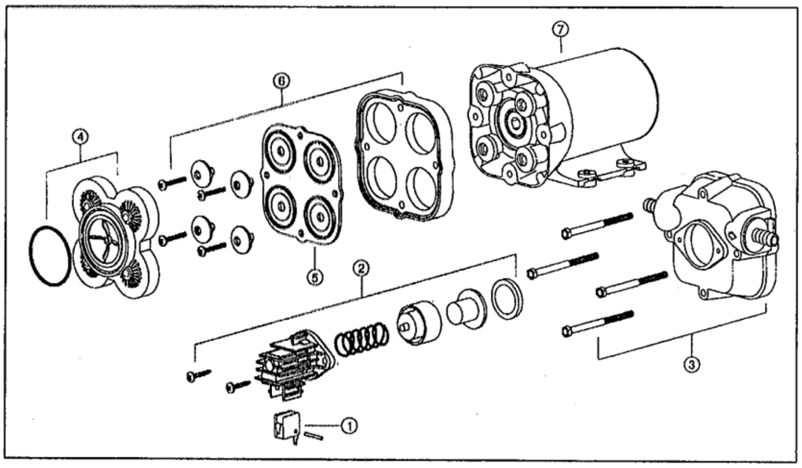


Fig 29.24
EXPLODED VIEW OF A FOUR-DIAPHRAGM PRESSURISED WATER SUPPLY PUMP (*Jabsco*)

1. Micro Switch
2. Pressure Switch
3. Body Kit
4. Valve Kit
5. Diaphragm Kit
6. Plate/Piston Kit
7. Motor

Features:

Self Priming: Vertical lift up to 5m (16 ft) for manual pumps and 1.5m (5 ft) for electric pumps.

Dry Running: Diaphragm pumps can be run dry for extended periods with no damage, therefore requiring less attention in use.

Versatility: Self-priming and dry running capabilities mean few limitations on use. However, they are best suited for low-pressure situations, such as bilges. Pumps with plastic bodies and synthetic diagrams are ideal for corrosive liquids such as saltwater and sewage. Larger manual diaphragm pumps have the ability to handle some solids in suspension. Electric diaphragm pumps are most widely used in pressurized freshwater systems. They also make excellent bilge pumps for boats with shallow bilges, virtually hoovering the bilges dry.

Quiet Running: Electric pumps feature pulsation dampeners, which smooth flow and reduce noise levels, resulting in less interference when in operation.

Good pumping practice: Electric pumps should always be installed in a dry, well-ventilated position as close as possible to the liquid to be pumped. Pipework should always be reinforced, non-collapsible hose of the recommended size. Bilge pumps and water pumps in particular should always be fitted with a filter and strainer on the inlet pipework to protect them from debris. These should be fastened to the boat structure to ensure their permanent location.

Pumps must be installed with the overboard discharge well above the waterline (both static and heeled) to avoid water siphoning back into the vessel. Electric diaphragm pumps can be run dry for up to 2 hours.

Maintenance: To maintenance a diaphragm pump, a regular check would indicate when to get a screwdriver out and replace the diaphragm or any of the flap valves. Make sure the glands and clamps are tight, and flap valves pliant and free moving. Check connecting rod bearing annually and add chassis lube as needed.

Winter Storage: Where possible, it is preferred that the complete pump be removed and stored in a warm dry place. If this is not possible, the pump must be completely drained, hoses removed and pump run until all water is expelled.

DIAPHRAGM PUMP – TROUBLESHOOTING

If the pump fails to prime, it could be due to:

- Air leak in the suction line.
- Bilge pickup not submerged.
- Intake hose kinked or plugged.
- Dirt preventing a valve from proper seating. (Fouled intake or discharge valve.)
- Rubber flaps swelled up due to chemicals or calcium build up.
- Flaps torn or becoming brittle with age.
- Diaphragm ruptured, delaminating or becoming brittle with age.
- Galvanic corrosion (due to stainless steel hinges and pins being used in cast aluminium pump housing and levers).

Rough or noisy operation can be due to:

- Intake or discharge hose kinked or plugged.
- Pump not mounted firmly.
- Loosened eccentric setscrew or worn connecting rod bearing.
- Ruptured or collapsed pulsation dampener.

VALVE REPLACEMENT

(Jabsco electric bilge pump, 37202-Series, illustrated above)

- Turn off power to pump. Remove four tie-down bolts.
- Expose valves by lifting motor mount and the attached diaphragm assembly from pump base.
- Remove and clean or replace valves.
- Install valves, making sure rubber flapper is UP on intake and DOWN on discharge. Replace valve-retaining plate.
- Replace motor-mount-diaphragm assembly and fasten evenly to base with the four tie down bolts.

DIAPHRAGM & CONNECTING ROD REPLACEMENT

(Jabsco electric bilge pump, 37202-Series, illustrated above)

- Turn off power to pump. Remove four tie down bolts.
- Lift motor mount and the attached diaphragm assembly from pump base.
- Remove two diaphragm retainer screws and the diaphragm retainer.
- Pull connecting rod and diaphragm from eccentric and remove from motor mount; then unscrew bolt to separate diaphragm and plates.
- Check diaphragm for cuts and cracks. Check rod assembly bearing and eccentric for breaks, cracks or excessive wear. Replace, if badly worn.
- During reassembly, ensure that eccentric is firmly seated on motor shaft and set screw is tightened firmly against flat side of shaft.
- Loosely reassemble diaphragm, diaphragm plates, washer and diaphragm bolt onto connecting rod. Slide connecting rod onto eccentric shaft with two thrust washers on shaft. Secure diaphragm to motor mount with the diaphragm retainer and two screws.
- Tighten connecting nod bolt while maintaining alignment of rod bearing and eccentric.

CAUTION: Avoid misalignment or twisting of rod on eccentric shaft or excessive bearing wear will result.

PULSATION DAMPENER REPLACEMENT

(Jabsco electric bilge pump, 37202-Series, illustrated above)

- Disconnect power leads from pump and remove from mount. Remove four tie down bolts.
- Remove bottom plate screw and the bottom plate. Pull out and replace pulsation dampener; position the 3-ribbed cavity on discharge side.
- Replace bottom plate and screw. Tighten evenly to base with the four tie down bolts.
- Reinstall pump and reconnect power leads.

5. LOBE PUMP

It too is a *Positive Displacement Pump.* The parting lobes of counter-rotating rotors draw in the liquid at the inlet. They carry it around the pump and then discharge it when they mesh at the discharge port.

You are unlikely to find this type of pump on board a vessel. Because of their hygienic construction (in 316 stainless steel), lobe pumps are more commonly used in the food and pharmaceutical industries. They are also known to be used in submarine ballast systems.

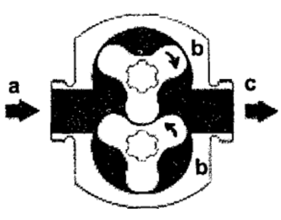


Fig 29.25
LOBE PUMP (*Jabsco*)

VALVES & SEACOCKS

It is not uncommon to find valves and seacocks seized in the open position or corroded to the point of being non-repairable. Such negligence can only lead to flooding of the vessel. Ideally, the valves should be of corrosion-resistant materials, which would make brass valves unsuitable. Even in metal hulls, reinforced plastic valves can be installed. If fitting brass valves and through-hull fittings, they must be insulated from the metal hull and piping to prevent galvanic corrosion. Valves in the ship's hull (overside valves) should be dismantled and overhauled whenever the vessel is on the slip.

1. SEACOCK & BALL VALVE

Traditionally all seacocks and skin fittings (through-hull fittings) in small vessels were made of bronze. The seacock was a tapered bronze plug with a hole through it. Turned one way, the hole in the plug lined up with the pipeline. Turned the other way it closed the pipeline. A quarter of a turn of its handle opened or closed the line. It was open when the handle was in line with the pipe, and closed when at right angle to the pipe. Such a seacock was susceptible to excessive friction due to the lubrication grease leaking out, over-tightening and the plug becoming wasp-waisted.

The traditional seacock has now been replaced by fittings such as ball valves, gate valves and globe valves, and they are made of materials such as stainless steels, brass (bronze), rubber and plastic.

The ball valve is the direct descendant of the seacock. It consists of a ball with a hole through it. Just like a seacock, it is opened or closed by turning the ball to line up the hole with or at right angle to the pipeline. Balls can be designed to direct flow in more than two directions. Ball valves are much more efficient and durable than the old seacocks. They are generally made of bronze or reinforced plastic, both with Teflon seals. Both types should be greased annually.

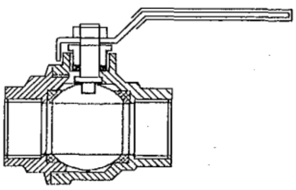
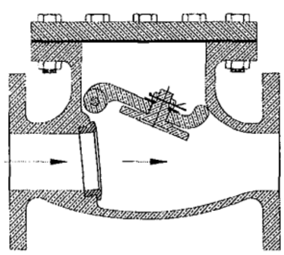
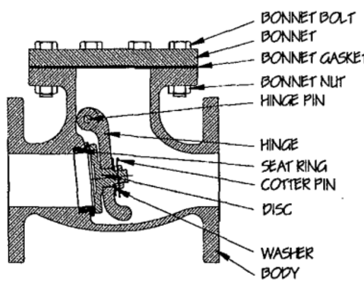


Fig. 29.26
BALL VALVE (*Dayco*)

2. NON-RETURN VALVES (NRV) AND SCREW-DOWN NON-RETURN VALVES (SDNRV)





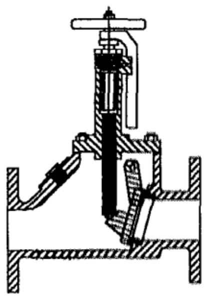


Fig. 29.27 (A): FLOW THROUGH A HINGED NON-RETURN CHECK VALVE (*Pima*)
Fig. 29.27 (B): PARTS OF A HINGED NON-RETURN CHECK VALVE (*Pima*)
Fig. 29.27 (C): A SCREW-DOWN HINGED NON-RETURN VALVE (*Pima*)

NRVs (or non-return check valves) permit only one-way flow of a fluid. They are employed to prevent back flooding into bilge compartments. They come in a variety of designs and are made of various materials. A NRV may consist of a hinged flap, as shown here, a spring loaded plunger or a valve sitting on a seat such that liquid flowing from the bottom inlet lifts it open while a back flow from the side outlet forces it against the seat. The hinged flaps are better in low-pressure applications, where the liquid pressure may be insufficient to lift the plunger or the 'sit-down' type of valve, especially if it is sticking to the seat. However, flaps must be mounted such that gravity will close them when the flow stops. Backpressure holds them closed.

SDNRVs are fitted on multi-bilge suction valve chests. They permit shutting off empty bilge suctions to prevent air being sucked from them when other bilges are pumped out. Screw-down non-return globe valves are discussed in Globe Valves below.

3. GATE VALVES (SCREW-LIFT VALVES)

A gate valve is a screw-lift valve. It has a tapered gate (metal disc) that slides firmly in a slot in the body of the valve. The gate is lowered and raised by turning a threaded spindle on which it rides. A small tightening nut around the stem allows the leaky gland to be tightened. The valve should be disassembled and inspected annually. It should be corrosion free, the spindle should be greased, and the gland repacked if necessary. Some gate valves are fitted with position indicators and limit switches.

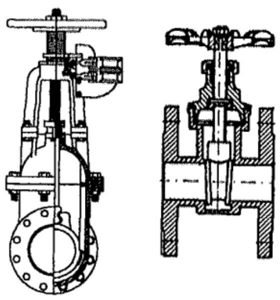


Fig 29.28 (A): GATE VALVE WITH DOUBLE LIMIT-SWITCHES (*Pima*)
Fig 29.28 (B): GATE VALVE (*Ernest Gopfert*)

4. GLOBE VALVES (SCREW-LIFT & SDNR VALVES)

Globe valves are similar to gate valves. They too are screw-lift valves. However, instead of a gate, there is a disc at the end of the spindle, which is screwed down against a seat to shut the valve. The valve maintenance is also similar to that of gate valves. In screw-down non-return globe valves the disc is not attached to the screw-down spindle. The disc can only be screwed down against the seat by the spindle; it cannot be lifted by it. Only the pressure of the liquid from the inlet can lift it.

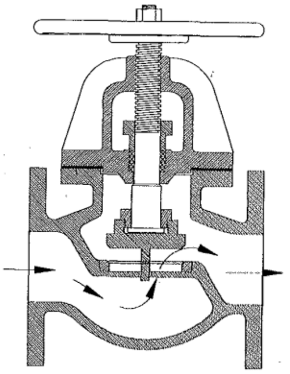


Fig. 29.29
GLOBE VALVE (*Pima*)

AUXILIARY POWER TAKE-OFF SYSTEMS

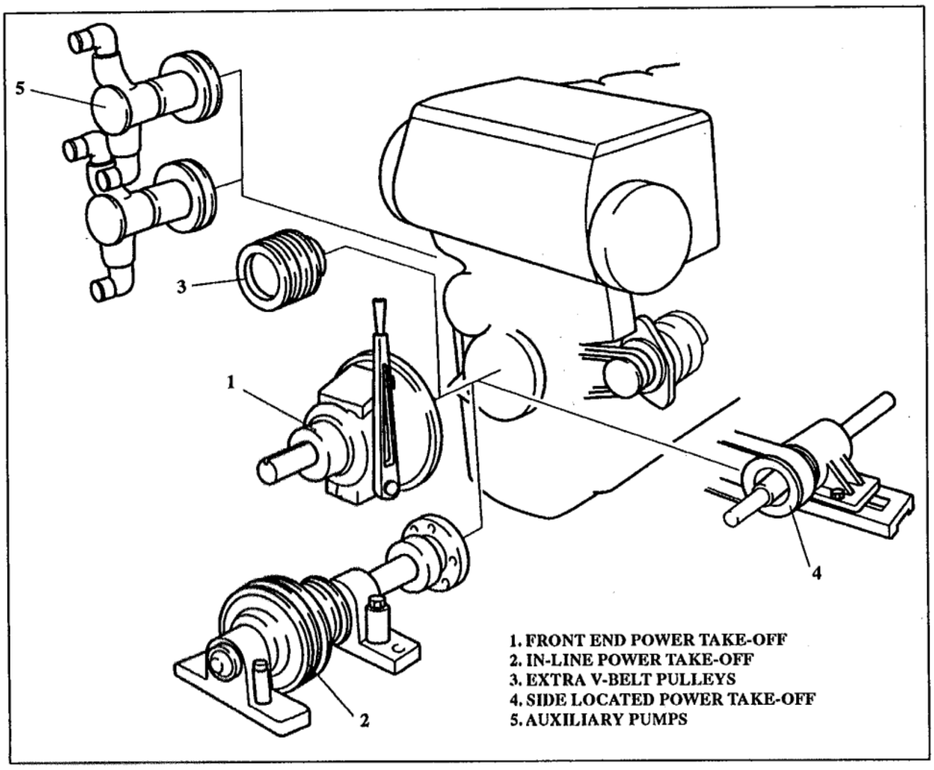


Fig 29.30: POWER TAKE-OFFS (*Volvo Penta*)

As discussed in Bilge Pumps, accessories such as water pumps, bilge pumps and steering pumps are often run from a power take-off groove on the main engine crankshaft pulley. They may also be run from a power take-off (PTO) auxiliary drive fitted to the main engine at its front end, in-line or at its side. A disconnectable power take-off (No. 1 in the illustration) is required if it needs to be engaged or disengaged while the engine is running.

V-belt types of transmissions are quite flexible. By using different pulley sizes, they can be easily adapted for different ratios. They have low noise level and are relatively free of maintenance, as long as they have been carefully aligned to allow the V-belt tension to be easily adjusted. Insufficient installation tension can reduce belt life and cause it to slip at high speed. Equally, excessive belt tension on the auxiliary drive may cause excessive side loads, which may result in crankshaft failure.

The illustration shows bilge and flushing pumps mounted on the engine PTO at the back of the timing gear casing. The pumps are impeller-type. The power is transferred through an electromagnetic clutch. A vacuum switch monitors the connection timing of the bilge pump. At start, the switch is held down for about 20 seconds. It then automatically breaks the current to the magnetic coupling when the liquid has been pumped out. The flushing pump is used for services such as deck washing and fish washing.

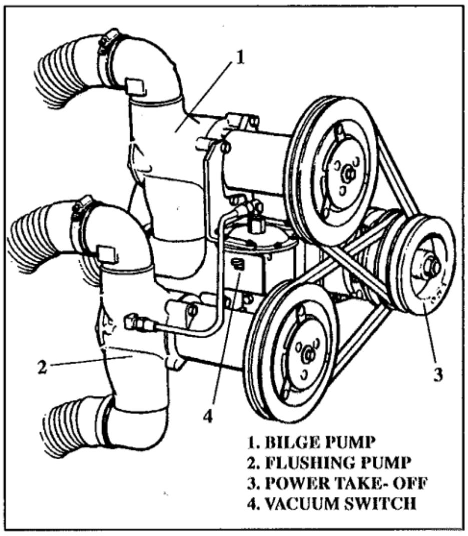


Fig 29.31
V-BELTS DRIVEN PUMPS (*Volvo Penta*)

The belt tension can be estimated by applying pressure to it midway between the pulleys, and adjusted until the belt deflects by the amount shown in the table. IDLER PULLEYS used for tensioning the V-belts should be fitted on the slack side of the belt. They should not be smaller than the recommended diameter. A spring-loaded idler pulley is preferable to one that is adjusted and clamped, especially with larger PTO values or where there could be movement between a flexibly mounted engine and the drive PTO drive mounted on a separate chassis.

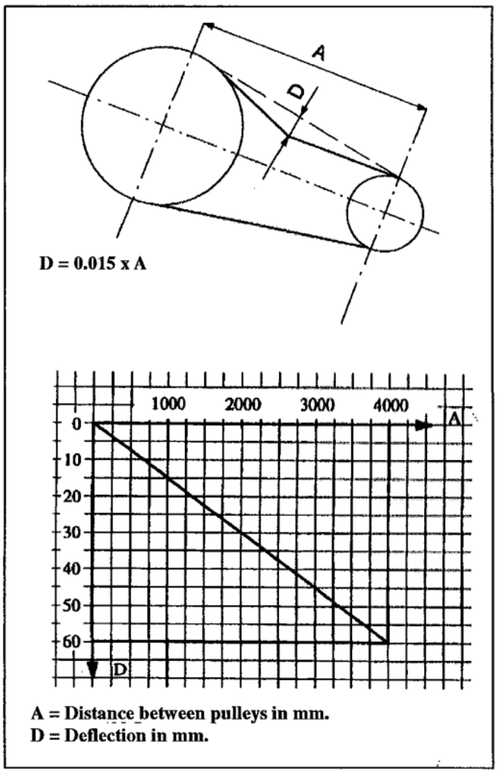


Fig 29.32
BELT TENSION (*Volvo Penta*)

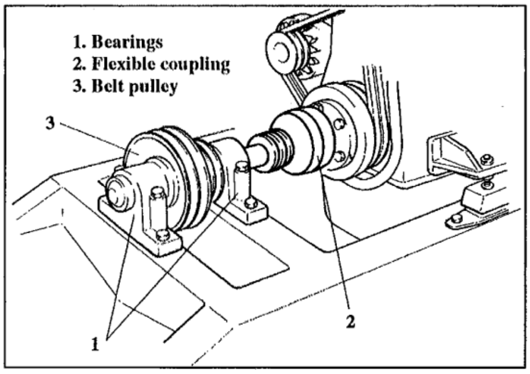


Fig 29.33
IN-LINE POWER TAKE-OFF (*Volvo Penta*)

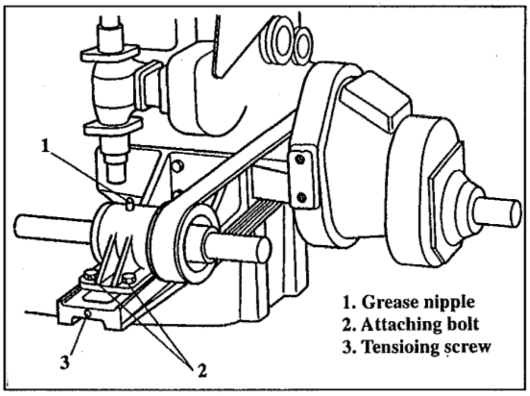


Fig 29.34
SIDE-MOUNTED POWER TAKE-OFF
(*Volvo Penta*)

WATER HEATERS & CABIN HEATERS

The volume of an engine's cooling water (freshwater) can usually be expanded by fitting a larger expansion tank (in consultation with the manufacturer). This allows additional circuits for *cabin heaters* and *calorifiers*, to be fitted. (Calorifier is a heat exchanger for heating potable water). When a cabin heater is installed, it must always have a manual-venting nipple (4) at its highest point. The system is vented once pressurised. The heater or the calorifier must not be higher than the specified maximum height above the expansion tank. In large heating systems, a hose thermostat (5) should be mounted in the line of the hot water circuit. This ensures that the engine quickly reaches its operating temperature. Incorporating shut off valves (2, 3) is useful when it is time to repair or service the system.

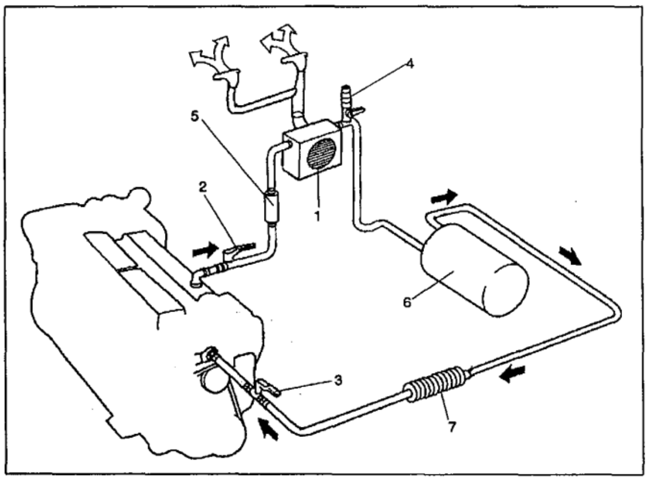


Fig 29.35: HOT WATER CONNECTIONS (*Volvo Penta*)
Components: (1) Cabin heater with defroster unit. (2) Outlet valve. (3) Inlet valve. (4) Venting nipple. (5) Hose thermostat. (6) Calorifier. (7) Radiator.

FRESH WATER SUPPLY

Fresh water, fuel and ballast water storage tanks must be dedicated and separate tanks with no chance of contamination by accidental pumping of any of these fluids into the wrong tank. As discussed in chapter 3, in case of adjoining tanks carrying different liquids, they must be separated from each other by a cofferdam so that a leakage of one fluid does not contaminate the other.

Fresh water storage tanks were traditionally internally coated (brushed) with a liquid cement wash to protect the tank from corrosion and to maintain water quality. These days it is more common to apply a proprietary brand coating, which should be inspected and repaired or renewed at regular intervals.

In order to maintain water quality for human consumption, it is also a common practice to filter and chemically treat it with a recommended amount of chlorine. In some cases a UV steriliser is used.

To prevent the fresh water pump from starting and stopping every time a water tap is used, a pressure tank or "nu-press" system is incorporated in the water supply system. This tank has a buffer of compressed air, which allows water

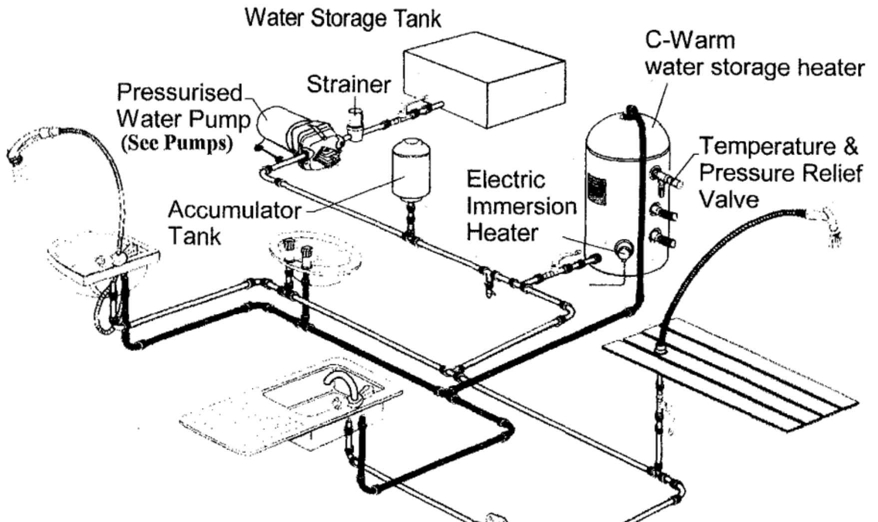


Fig 29.36: JABSCO PRESSURISED WATER SUPPLY SYSTEM

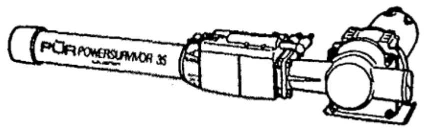
to be supplied under pressure with the pump operating periodically to replenish the tank.

REVERSE OSMOSIS WATER MAKERS

Reverse Osmosis desalination watermakers convert seawater to fresh water. They consist of a pump which forces seawater at very high pressure (800 psi or 5516 KPa) through a semi-permeable membrane, which excludes the passage of, dissolved salts in seawater. The product is fresh water suitable for drinking but not as tasty as normal fresh water.

Only about 10% of water passes through as fresh water. The remaining waste brine, still under high pressure, is either discharged overboard through a pressure-reducing valve or redirected to assist in pressurising the pump for better efficiency. Because of the high pressure involved, manual operation requires much energy and is very exhausting. Cruising vessels are more likely to carry a battery-operated unit. A hand operated Reverse Osmosis pump, weighing about 1 kilogram, can produce about half a litre of fresh water in 30 minutes. A 12-Volt battery operated pump drawing 4 amps can produce about 6 litres in an hour. The hand-operated units are included in some sophisticated liferafts.

The unit's pre-filter cartridge needs replacing after a specified period of use. The membrane in the pump, once used, needs regular cleaning to prevent biological growth.



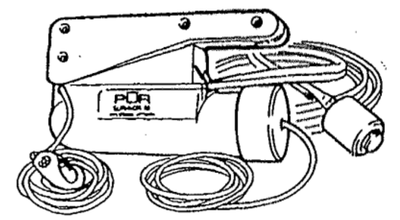


Fig 29.37: "PUR" WATER MAKERS
(HAND & BATTERY OPERATED MODELS)

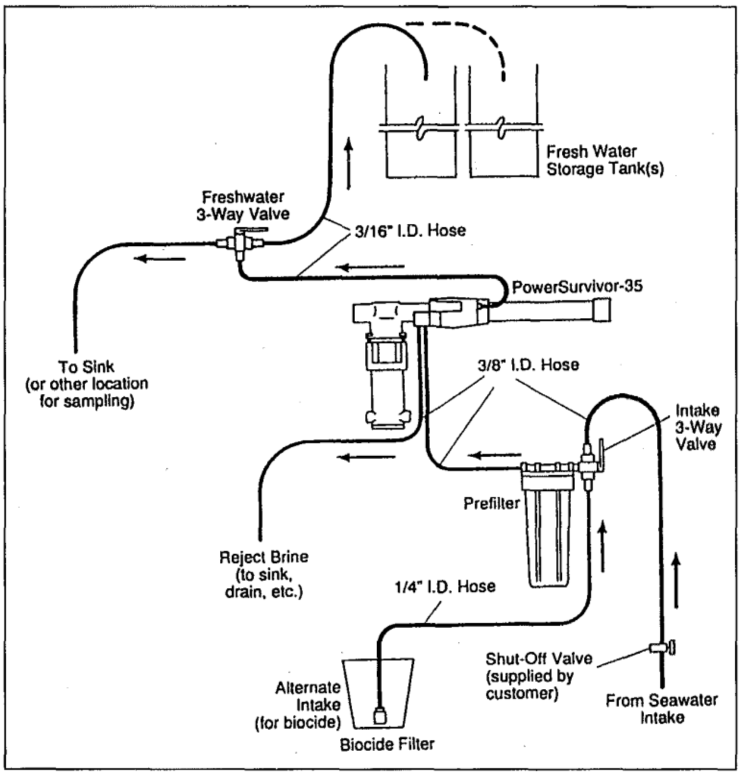


Fig 29.38: THE WATER MAKER PLUMBING DIAGRAM