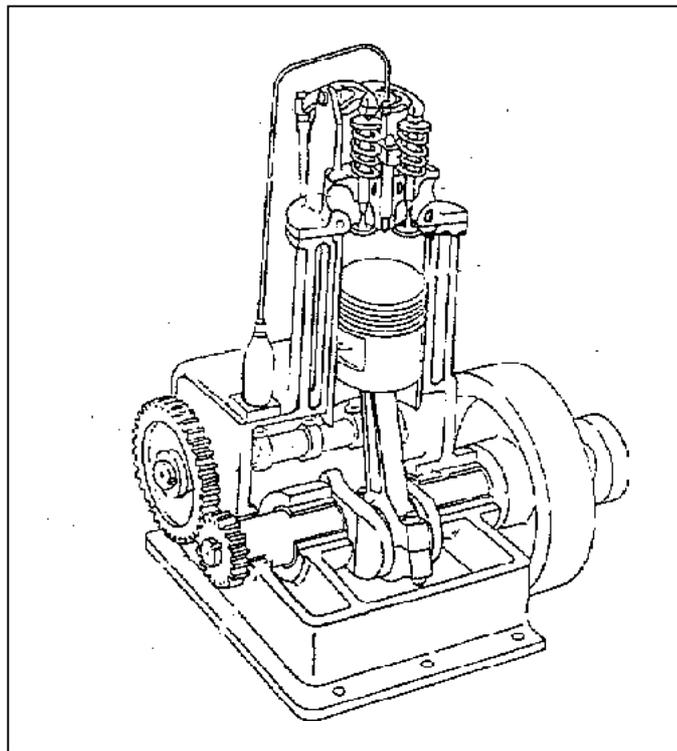


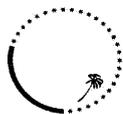
DIESEL ENGINEERING

FOR PACIFIC ISLAND MARINERS

**RESTRICTED CLASS 6-MASTER/ENGINEER
SPC 022B**



LEARNER'S GUIDE



SECRETARIAT OF THE PACIFIC COMMUNITY



GOVERNMENT OF TAIWAN/ROC

TABLE OF CONTENTS

GENERAL INFORMATION	4
1. INTRODUCTION	4
2. PROGRAMME DEVELOPMENT	4
COURSE INFORMATION	5
1. MODULE NAME	5
2. PREREQUISITES	5
3. COURSE DURATION	5
4. ASSESSMENT	5
5. RECOGNITION OF PRIOR LEARNING (RPL)	5
6. RESOURCES	5
SECTION 1 MANAGEMENT OF A MARINE DIESEL ENGINE	6
INTRODUCTION	7
PROGRAMME DEVELOPMENT	7
1.1 PRINCIPLES OF DIESEL ENGINES	
1.2 DIESEL ENGINE PARTS AND FUNCTIONS	7
1.3 LUBRICATION SYSTEMS	7
1.4 FUEL SYSTEMS	7
1.5 COOLING SYSTEMS	22
SECTION 2 ENGINE OPERATION	24
INTRODUCTION	25
SECTION CONTENTS	25
2.1 CHECKS AND PROCEDURES BEFORE STARTING ENGINES	26
2.2 IF AN ENGINE FAILS TO START	27
2.3 ENGINE GAUGE READINGS	30
2.4 WARM UP AND COOL DOWN PERIODS	31
2.5 ENGINE OVERHEATING SYMPTOMS	31
2.6 SLOWING WHILST UNDER WAY	34
2.7 IDENTIFYING LOW OIL PRESSURE	35
SECTION 3 ROUTINE MAINTENANCE PRACTISES	37
INTRODUCTION	38
SECTION CONTENTS	38
3.1 ENGINE ROUTINE MAINTENANCE	39
3.2 DECK/ENGINE ROOM ROUTINE MAINTENANCE	40
3.3 SPARE PARTS AND TOOLS	40
3.4 MAINTAINING THE DRIVE CHAIN	41
3.5 MAINTENANCE WHEN ON THE SLIP	43

SECTION 4 STEERING SYSTEMS	44
INTRODUCTION.....	45
CONTENTS	45
LEARNING OUTCOME	45
4.1 REQUIREMENTS FOR STEERING GEARS.....	46
SECTION 5 BILGE SYSTEMS	51
INTRODUCTION.....	52
CONTENTS	52
5.1 STATUTORY REQUIREMENTS.....	52
5.2 TYPICAL BILGE SYSTEMS AND TROUBLE SHOOTING THESE SYSTEMS	52
5.1 STATUTORY REQUIREMENTS	53
5.2 TYPICAL BILGE SYSTEMS AND TROUBLE SHOOTING THESE SYSTEMS	53
5.3 BACK FLOODING.....	56
SECTION 6 DC BATTERY SYSTEMS	57
INTRODUCTION.....	58
CONTENTS	58
6.1 FITTING AND CARE OF THE BATTERY	59
6.2 ASSESSING THE CONDITION OF A BATTERY	59
6.3 SAFETY PRECAUTIONS WITH BATTERIES	60
SECTION 7 FIRE FIGHTING AND SAFETY SYSTEMS	62
INTRODUCTION.....	63
CONTENTS	63
7.4 PRECAUTIONS WITH LP GAS LEAKS.....	63
7.1 THE CAUSES OF FIRE IN AN ENGINE ROOM	63
7.2 ACTION ON FINDING FIRE	64
7.3 PORTABLE FIRE EXTINGUISHERS IN THE E.R	65
7.4 PRECAUTIONS WITH LP GAS LEAKS.....	67

GENERAL INFORMATION

1. Introduction

The Diesel Engineering module of the Restricted Class 6 Master/Engineer certificate has been designed and is intended for the skippers of small boats (less than 15 meters in length), powered by diesel engines and operating in near coastal waters. The content of the module has been modeled on Engineering module (SPC 022A) of the Class 6 Master/Engineer course developed by the Regional Maritime Programme of Secretariat of the Pacific Community. It has been modified to meet the requirements of the Pacific Island skippers who use small diesel engines as the main form of boat propulsion.

This Learner's Guide is designed for students who are being trained and assessed on the Diesel Engineering module (SPC 022B), as part of a Restricted Class 6 Master/Engineer course. Attendance at the module sessions and studying of the Learner's Guide should be sufficient for understanding the operation of a small diesel engine and being well skilled in maintenance procedures.

2. Programme development

The resources materials were produced with financial support from the Government of Taiwan/ROC and compiled by Alastair Robertson, tutor at the New Zealand School of Fisheries, Nelson, New Zealand.

The materials were developed through consultation with staff of the Fisheries Training Section, Coastal Fisheries Programme, Secretariat of the Pacific Community and regional experts on fishing and maritime training. Resources from Australia and New Zealand, SPC training materials and valuable resource material such as the *Australian Boating Manual* by Captain Dick Gandy were used as a guideline in developing materials that were relevant to small-boat operators in the Pacific Island region.

COURSE INFORMATION

1. Module name

Diesel Engineering SPC 022B.

2. Prerequisites

There are generally no prerequisites for completing the Diesel Engineering module however, the prerequisites for the Class 6 Master/Engineer certificate (Full or Restricted) are a Safety Certificate and some sea time. Refer to local regulations for any specific country requirements.

3. Course duration

4 days (at the discretion of the course provider).

4. Assessment

Candidates doing the Diesel Engineering module will be assessed as they are completing the competencies.

5. Recognition of Prior Learning (RPL)

If students have been assessed previously for some of the learning outcomes or believe that they are already competent in certain areas, they can apply to the trainer/assessor to have these particular skills recognised.

6. Resources

The resources required by anyone attending the Diesel Engineering module are minimal. An in-depth study of this Learner's Guide and attendance at all sessions of the training should be sufficient for a candidate to successfully complete the module. Candidates should check with the training institution offering the course with regard to clothing requirements for the practical components.

Anyone wanting additional resource materials could borrow or purchase a copy of *The Australian Boating Manual* by Captain Dick Gandy.

Section 1

Management of a Marine Diesel Engine

SECTION 1 MANAGE A MARINE DIESEL ENGINE

Introduction

In this section you will learn about diesel engines and recognise their major components. The layout and components of their systems will be identified as will the common problems that occur.

The purpose of the above knowledge is to enable you to safely and effectively operate diesel engines and carry out basic troubleshooting and regular user maintenance.

Section Contents

- 1.1 Principles of diesel engines
- 1.2 Diesel engine parts and functions.
- 1.3 Lubrication systems
- 1.4 Fuel systems.
- 1.5 Cooling systems

1.1 Principles of Diesel Engines, 2 Stroke and 4 Stroke

Diesel engines have become the common engines used in commercial and larger private vessels. Some of the advantages of diesel engines over alternative power sources such as petrol or LPG engines are:

- proven performance and reliability under working conditions,
- lower fuel consumption in relation to power output,
- greater torque for longer periods,
- diesel engines generally burn fuel more efficiently than petrol engines increasing power and economy,
- diesel fuel is less flammable than petrol (although diesel fuel will still ignite and burn),
- fumes from diesel engine exhausts are less toxic and polluting than those emitted from petrol engines.

To operate and maintain an engine, you will need to understand how it works. Diesel engines are simple in principle and will prove very reliable if properly maintained.

The diesel engine uses a piston to compress and heat air in the cylinder, which ignites fuel forced into a combustion chamber in the cylinder head.

As the fuel ignites, pressure within the cylinder increases, forcing the piston back down the cylinder, completing a power stroke.

The basic principle driving diesel engines is the conversion of up and down motion to rotary motion. This is achieved by the compression ignition cycle of the pistons which are converted to a rotary movement through the crankshaft.

There are two types of diesel engines, a two stroke and a four stroke.

Two Stroke Diesel Engine

There are several types of two stroke engines. A common example is the uniflow type where ports are used to introduce air into the cylinder and a valve is used for the exhaust. The working cycle of that engine is:

1. Exhaust and Inlet
2. Compression and Power

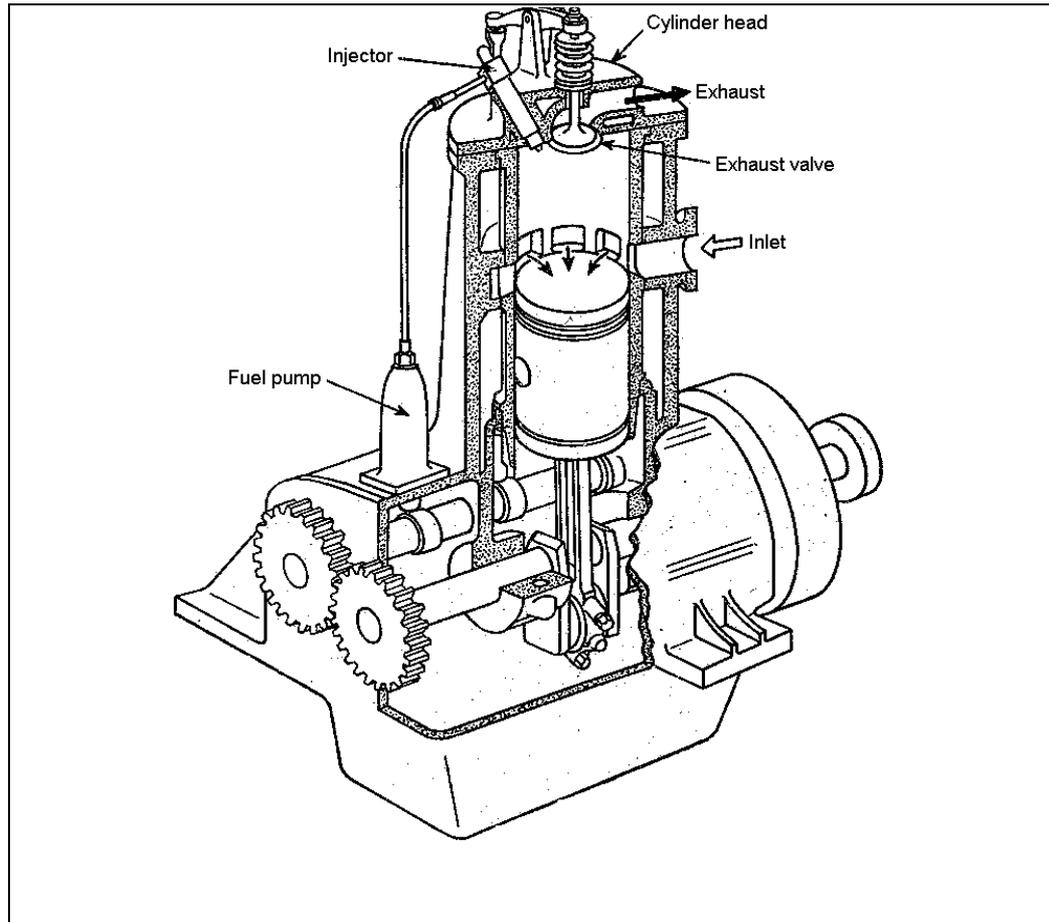


Fig 1.1.1

Stroke	Description
1. Exhaust and inlet	<p>As the piston approaches the bottom of its stroke (BDC - bottom dead centre) exhaust valves are opened and the exhaust gases are released.</p> <p>As the piston moves to the BDC position, inlet air drives in from uncovered ports forcing out any remaining exhaust gases and filling the cylinder with clear air.</p>
2. Compression and Power	<p>As the piston passes the BDC position, exhaust valve and inlet ports are sealed with the cylinder full of fresh air.</p> <p>As the piston moves upward to the top of its stroke (TDC - top dead centre) the air becomes compressed, igniting fuel which is injected into the top of the cylinder. The exhaust gases then expand rapidly, forcing the piston back down the cylinder.</p>

Here is a list of parts and functions of a two stroke engine :

Parts	Function
Inlet ports	<p>A four stroke engine has an inlet valve whereas a two stroke engine has inlet ports cut into the cylinder liner just above the piston when it is at bottom dead centre.</p> <p>As the piston descends in the cylinder liner, it uncovers the inlet ports and allows air into the cylinder. As the piston rises in the cylinder liner, it covers the inlet ports, and the compression stroke commences.</p>
Piston ring locating pin	<p>The piston ring grooves have a small locating pin in them. The pin stops the ring from rotating and also lines the gap up so that it does not pass over an inlet port. If the ring gap was allowed to pass over an inlet port, it could cause the piston ring to fracture.</p>
Exhaust ports or exhaust valves	<p>While exhaust ports can be cut into the cylinder liner the same fashion as the inlet ports, with the piston opening and closing the ports as it uncovers and cover, them, it is common in marine engines for exhaust valve/s to be fitted and operated in the same manner that of the four stroke cycle engine.</p>
Scavenge blower	<p>In a two stroke engine, air has to be forced into the cylinder. To achieve this a scavenge blower is used.</p> <p>This consists of an engine driven air pump, commonly known a supercharger (fig 1.1.2).as</p>

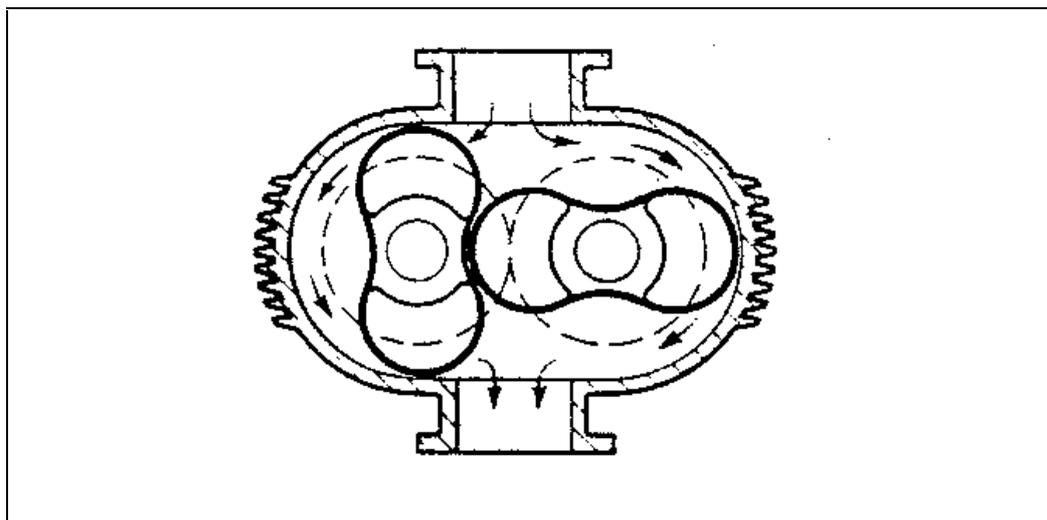


Fig 1.1.2 Supercharger

Four Stroke Engine Valves

- On the induction stroke, the inlet valve is open, the exhaust valve is closed.
- On the compression stroke, inlet and exhaust valves are closed.
- On the power stroke, both inlet and exhaust valves remain closed.
- On the exhaust stroke, the exhaust valve is open, the inlet valve is closed.

Each engine has different timing of valve opening and closing depending on the operating requirements of the engine, and whether it is Turbocharged or naturally aspirated.

Looking at the 4 stroke cycle there is one power stroke for every two revolutions of the crankshaft. The power stroke is the only stroke that turns the propeller.

The exhaust, induction and compression strokes do not contribute to the power of the engine so means are required to revolve the engine through these strokes, to do this a flywheel is fitted to store energy and continue to rotate the engine through the other 3 strokes by the inertia of the rotating mass.

1.2 Diesel Engine Parts and Functions

Diesel engines comprise many parts and systems which all serve particular functions. These parts and systems range from small screws through to complete fuel or cooling systems.

You need to be aware of the condition of all engine parts with particular attention given to signs of wear or fatigue. However, it will be the larger moving engine parts and systems which will require regular maintenance.

The basic engine components have been identified in the following diagram, together with a description and explanation of each component.

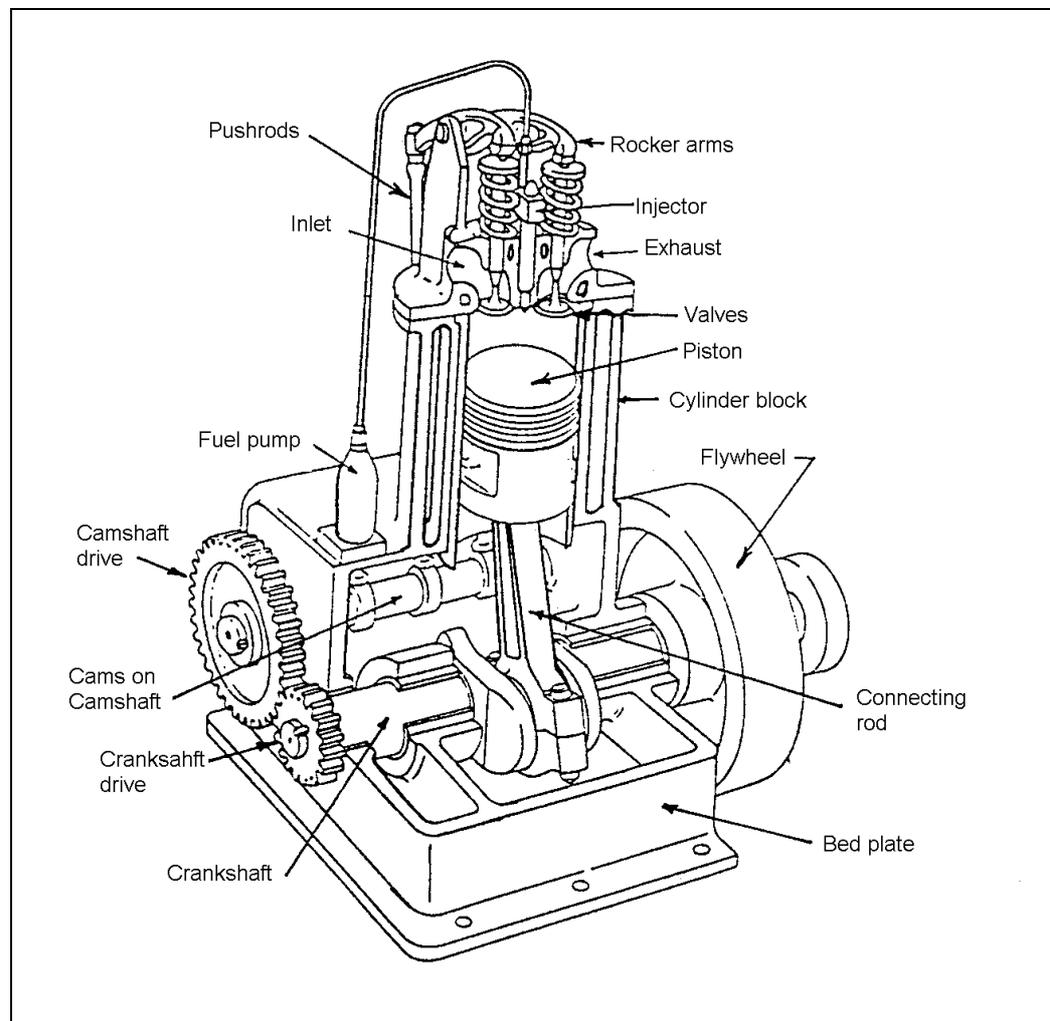


Fig 1.2.1

Note: Not all components appear on the diagram.

Part Name	Function
Sump	Is a reservoir to store the lubricating oil and is attached to the bottom of the block.
Block	Is a casting to house the cylinder liners and allows the fresh water cooling to circulate. The bottom of the block is accurately machined to take the main bearing slippers that house the crankshaft and to attach the sump.
Cylinder head	Is attached to the top of the block with a cylinder head gasket between the two. It houses inlet valve/s, exhaust valve/s and a fuel injector for each cylinder..
Camshaft	Is chain or gear driven from the crankshaft and does one revolution for every two revolutions of the crankshaft.
Inlet valve/s	One or two are fitted in the cylinder head for each cylinder and open to allow the intake of air into the cylinder on the induction stroke.
Exhaust valve	One or two are fitted in the cylinder head for each cylinder to allow the exhaust gases to be discharged into the exhaust manifold on the exhaust stroke.
Fuel injector	One is fitted in the cylinder head for each cylinder and is like a spring loaded valve. It allows fuel to be sprayed into the cylinder at the precise moment in an atomised form.
Fuel injection Pump	Can be a multi element type driven by a chain or gears from the crankshaft or camshaft. Each element is connected to a fuel injector. In some engines there is a pump for each cylinder and it is driven off the camshaft. The fuel pump accurately meters the fuel and delivers it under high pressure at a precise moment to the spray nozzle of the fuel injector.
Fuel lift pump	Unless a day tank is fitted where the fuel is fed by gravity to the engine, it will be necessary to have a fuel lift pump to get the fuel from the tanks to the fuel pump. A fuel lift pump can be a gear, diaphragm or plunger type.
Governor	Is fitted to maintain the engine speed at a predetermined setting. It is connected to the rack on the fuel injector pump.

Heater plugs	Sometimes called glow plugs. One is fitted to each cylinder on pre-combustion chamber engines. They are fitted to assist in the ignition of fuel to start the engine when the engine is cold.
Cylinder liners	Are fitted to the block and sealed at the top by a face to face joint or a thin copper gasket and the bottom by "O" rings. The piston moves up and down in the cylinder liner and fresh water cooling circulates on the outside of the liner.
Piston	Moves up and down in the cylinder liner and is sealed by piston rings. It is connected to the connecting rod by a gudgeon pin. Piston rings are fitted to grooves machined in the piston. The number of rings can vary but have compression rings at the top and usually one oil scraper ring on the bottom.
Connecting Rod	Sometimes referred to as con rods are fitted between each bottom end journal where a bearing is attached and the gudgeon pin housed in the piston.
Crankshaft	Consists of main and bottom or big end journals separated by webs. It is attached to the bottom of the block by main bearings.
Flywheel	Is attached to one end of the crankshaft to provide inertia to keep the engine turning through the 3 non power strokes.
Exhaust Manifold	Is attached to one side of the cylinder head and allows for the passage of gas from all cylinders to the exhaust system. In some engines it is water jacketed to stop heat radiating into the engine room.
Intake Manifold	Is attached to the other side of the cylinder head and allows air into the cylinder when the inlet valve opens
Air cleaner	Is attached to the end of the intake manifold and removes any particles in the air so they do not go into the cylinder.
Turbo charger	If fitted, is situated at the end of the exhaust manifold. It is a centrifugal air compressor forcing air into the intake manifold and is mounted on the same shaft as a turbine driven by the exhaust gases of the engine. They operate at high temperature and at speeds around 100,000 rpm (revolutions per minute).

Inter cooler	Sometimes called an after cooler by some manufacturers. Is only fitted if the engine is turbo charged. It is fitted between the air compressor of the turbo charger and the intake manifold to cool the incoming air to provide a more dense intake charge.
Lubricating oil pump	Is driven off the engine, and supplies oil to all parts of the engine requiring lubrication. The oil forms a film between moving parts thereby reducing wear and friction.
Jacket water pump	Is driven off the engine and is fitted to circulate cooling water throughout the engine.
Thermostat	Is fitted in the cooling water system to maintain the operating temperature of the engine, by by-passing the cooler when required.
Sea water Pump	Is driven off the engine and is fitted to pump sea water through the fresh water cooler when required.
Starter Motor	May be electrically or pneumatically driven to turn the engine over to start it.
Rocker cover	Fits over the top of the rocker gear to contain the oil that is splashed around.
Rocker gear	Is fitted to the top of the cylinder head. There is a rocker arm for each inlet and exhaust valve and the arm pivots on a rocker shaft. The lobe of the cam on the camshaft pushes up on one side of the rocker arm through a cam follower and a push rod.
Alternator	Is driven off the engine, supplies electrical power to the electrical system and charge the batteries.

1.3 Lubrication Systems

Lubrication is used to:

- prevent contact between metal surfaces reduce friction wear and heat,
- remove foreign agents (metal shavings etc.) which might otherwise damage parts

Components of a lubricating system for an inboard marine engine include:

- sump
- dipstick
- cooler
- pressure gauge
- relief valves
- oil pump
- suction strainer
- filter
- temperature gauge

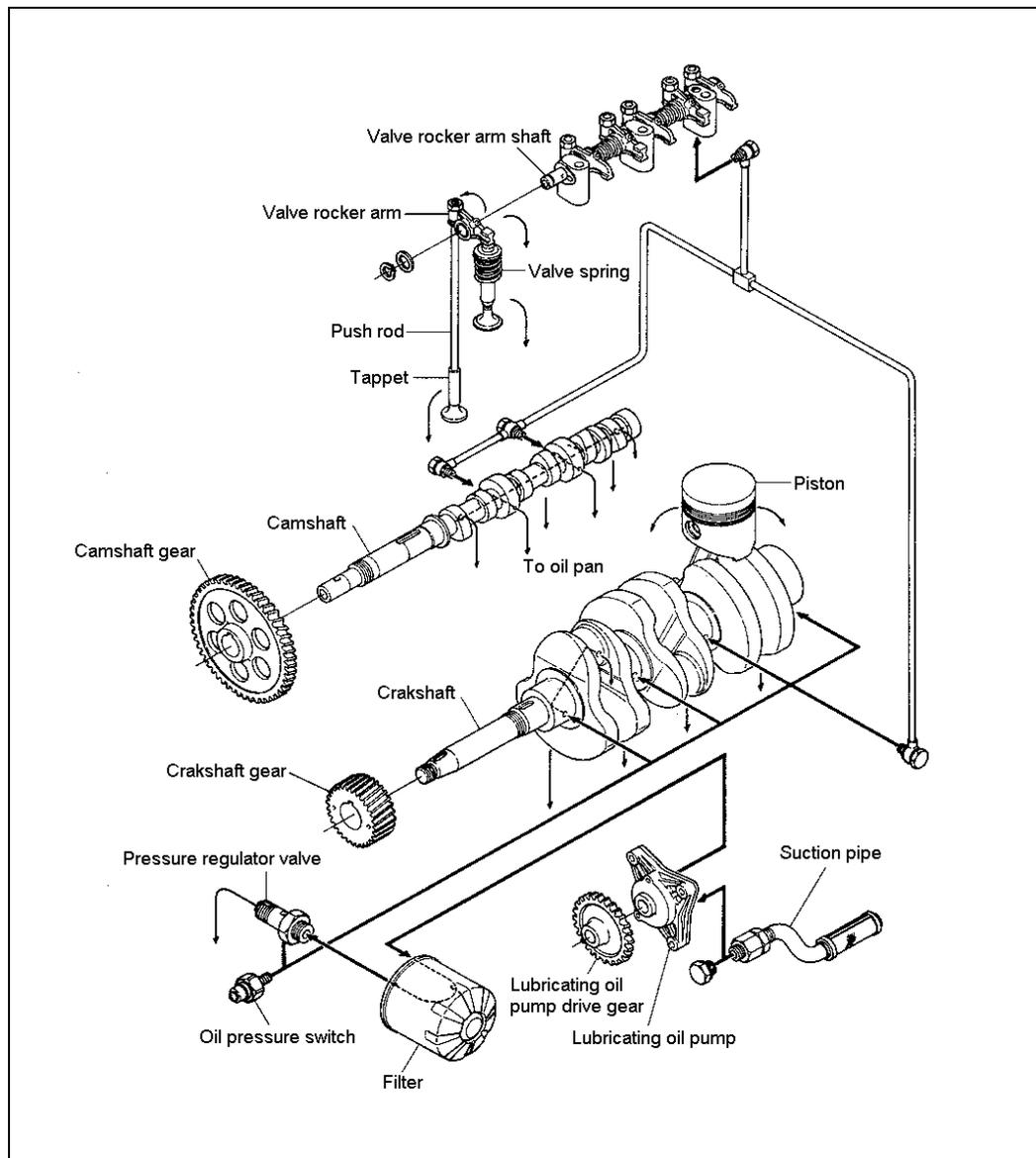


Fig 1.3.1

Oil is drawn from the sump through a suction strainer by the oil pump which is driven by either the camshaft or crankshaft. The oil is pumped to the engine circuit. A pressure relief valve is fitted which will open when the pressure in the circuit exceeds the recommended pressure. This can happen when oil is cold. As the oil heats up the pressure reduces and the valve closes to maintain recommended pressure.

Oil is pumped to the cooler which the oil temperature the oil then passes through a filter to remove small foreign particles before it enters the engine.

Some filters are fitted with relief valves which open to allow oil into the engine if the filter becomes blocked. Most filters are of a disposable type and must be replaced at regular intervals as specified by the manufacturer.

A pressure gauge is fitted between the oil cooler and the engine for monitoring purposes

Oil is fed into the engine through a pipe which runs the length of the engine with distribution pipes to each main bearing. Alternatively, oil might be fed to the main bearings by galleries cast in the block. This lubricates the main bearings and the oil then flows through to lubricate the bottom or big end journal. Oil then flows up a hole inside the connecting rod to lubricate the gudgeon pin or little end at the piston.

Excess oil from here helps lubricate the piston rings. Oil and vapour from the sides of the revolving bottom end bearing are thrown onto the cylinder liner and onto the underside of the piston lubricating the gudgeon pin and piston rings. In smaller engines, there is no hole drilled in the connecting rod and relies on the oil thrown from the bottom end bearing.

Camshafts, driving gears and valve gears are lubricated in a similar manner i.e. galleries and pipes to maintain lubrication at all metal to metal contact parts.

Some manufacturers cause the oil to flow from an open pipe onto the underside of the piston as an additional means of piston cooling.

The oil return to the sump is by gravity through drain holes and open galleries.

1.4. Fuel Systems

In most vessels fuel may be stored in a number of tanks which may either form part of the hull or be free standing as shown in Figure 1.6. Note: that Figure 1.6 depicts all the fittings that a tank can have, but are not always fitted.

e.g. double bottom tanks don't have a save all.

Tank components

15, 16, & 17 Tank Venting

All fuel tanks are required to be vented to atmosphere (not into the vessel). The vent or breather will terminate in a gooseneck or similar arrangement, which prevents water from entering the tank down the vent. If the vent pipe is greater than 18 mm in diameter, the outlet will be fitted with a wire gauze screen or 'flame trap'.

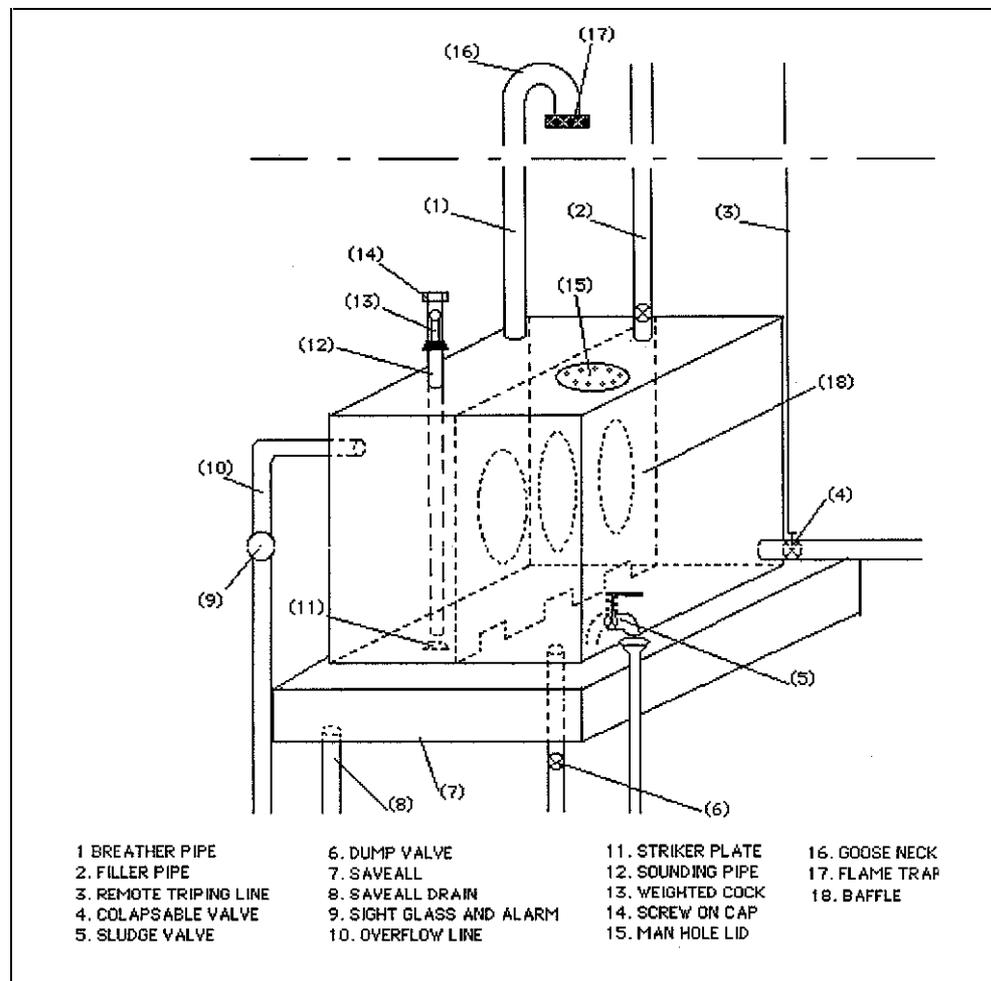


Fig 1.4.1

These are arranged so that any spillage will not enter the vessel. Therefore, the inlet or delivery end of the filler pipe is located outside the vessel and will have a valve and/or a water tight cap/blank.

The pipe between the deck and the top of the tank may be flexible if necessary, but must be of reinforced synthetic type secured with corrosion resistant clips at each end.

Note:- When transferring or re-fueling, all precautions must be observed to prevent fire or spillage.

This will comprise of all fire, pollution and spill control devices being ready. However, the best way to prevent these from happening is to ensure that the personnel involved are competent with the operation, procedures and safe working practices.

3. & 4. Tripping Line and Delivery valve or cock

All fuel tanks with discharges above the bottom plates have shut off valves or cocks fitted as close as possible to each tank (preferably on the tank). These can be operated from a position outside the engine room, via a non-flammable connection, such as a steel wire

5. Sludge valve

It is necessary to remove contaminants, notably water, prior to the fuel being delivered to the engine. Therefore, fuel tanks are fitted with sludge valves, which are self closing. If this type of arrangement is not fitted, the sludge and water may be drained through the drain valve or plug.

6. Dump - Drain Valve or Plug

In the event of the tank rupturing or for inspection purposes, all fuel tanks which are not double bottoms must be fitted with a method of draining them into another storage tank (not the bilge).

7. & 8. Save-all and Drain

Because free standing tanks may be fitted 'high' in the engine room, it is necessary to have drip trays fitted to them so as to prevent any leakage's onto machinery below. These save-all's will also need to be drained, with the drain pipe leading to a drain tank.

9. & 10. Overflow Sight Glass & Alarm

When filling or transferring fuel there is always a danger that there may be a spillage.

Due to pollution and fire hazards associated with fuel oil, it is usual for tanks to be fitted with an overflow pipe which leads to either an overflow tank or to a double bottom fuel tank. These overflows are also fitted with a sight glass and audible alarm.

11. 12. 13 & 14. Sounding Pipe, Striker Plate, Weighted Cock & Screw on Cap

Some method of measuring the contents of the tanks is fitted to the tank. This can either be a dial gauge or sight glass. However, most tanks will be fitted with some method by which the contents can be measured or sounded by a sounding tape or dip stick.

The sounding pipe will extend from the top of the tank to near the bottom and fitted with a screw-on cap-plug and also can have a self closing cock..

At the bottom of the sounding pipe a striker plate is welded to the tank. to prevent a hole being 'punched' in the tank by the measuring device.

15. Manhole

For tanks which have a capacity of more than 800 litres, a manhole or hand hole for cleaning and inspection purposes will be provided either on the top or on the sides of the tank.

Areas such as the top or bottom of tank where water and condensate accumulate, are prone to corrosion. These areas will need a close inspection.

The bottom of the sounding pipe is another important area since if this corrodes out, the sounding device may become jammed in the pipe.

If the tank is fitted with a sight glass, this must have self closing cocks at the top and bottom. Under no circumstances must these cocks be wired open - as they will prevent a spill should the glass break

18. Baffles

Baffles spaced not more than 1 m apart are fitted to reduce the free surface effect.

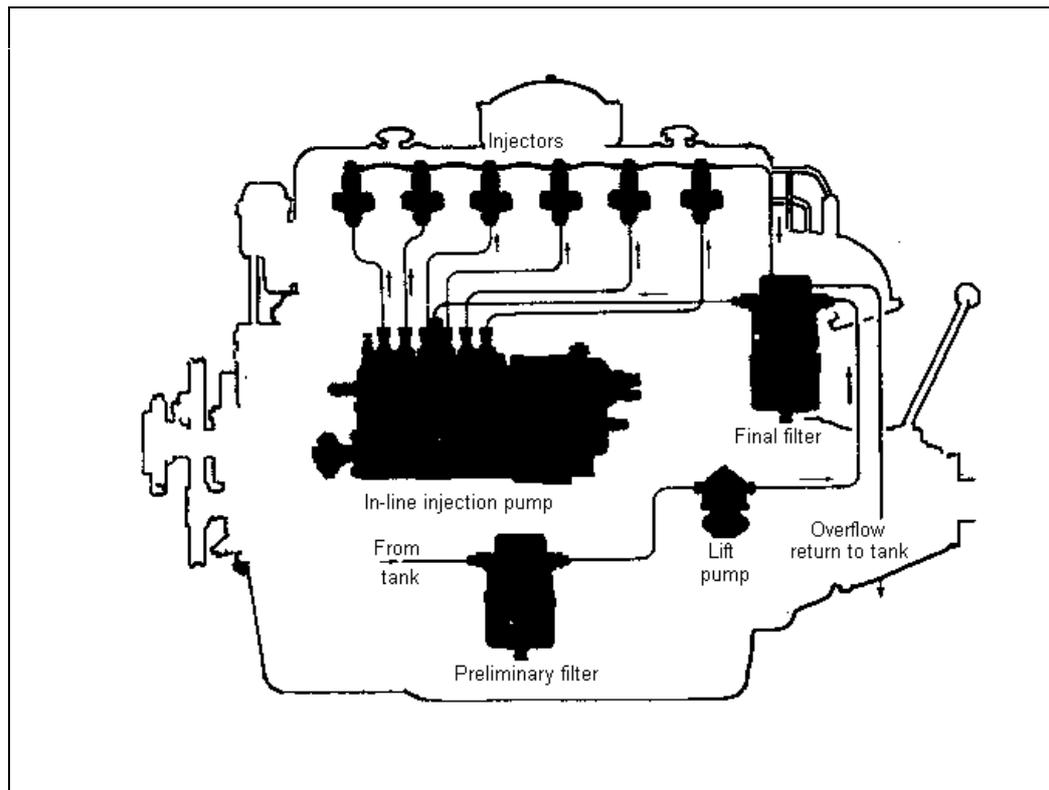


Fig 1.4.1

Figure 1.4.1 shows a typical engine built on fuel system with primary and secondary fuel filters.

Note: Where the engine can be run from more than one tank care must be taken to ensure the fuel suction and return lines a open to the same tank.

1.5 Cooling Systems

Diesel engines become hot during operation and are cooled by fresh water circulating throughout the engine. The heated fresh water is then cooled in the heat exchanger by salt water. The two most common heat exchanger systems are:

- Heat Exchanger
- Keel cooler

Fresh water circulation through the engine is common to both systems. When the engine is cold, a thermostat circulates the fresh water by passing the tube nest cooler and keel cooler. When the engine heats up the thermostat, allows the fresh water to circulate through the tube nest or keel cooling system.

Tube Heat Exchanger

Two pumps are used and both are powered by the main engine. The first pump circulates fresh water through the engine water jackets and through the tube cooler when the engine is hot. The second pump circulates sea water.

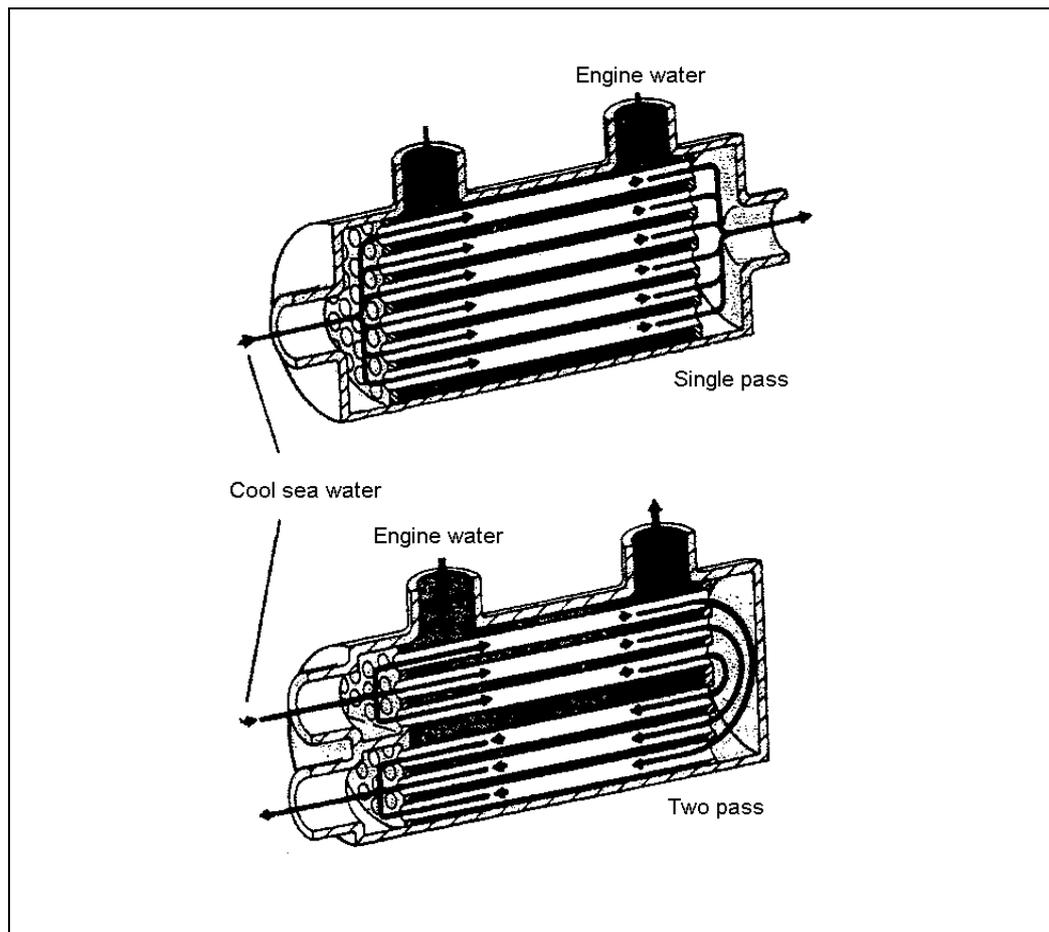


Fig 1.5.1

The second pump draws sea water through a grid on the vessel's hull to prevent large pieces of foreign matter entering or blocking the flow. A sea cock or valve is attached directly inside of the hull so that the sea water can be shut off during maintenance whilst the vessel remains in the water.

A strainer is fitted into the pipe work on the suction side of the pump, to capture small foreign matter before they can enter the system. The strainer may be fitted with a sight bowl and must be easily accessible for frequent cleaning and inspection.

The sea water then flows through the tubes in the cooler and then overboard. The cooler is located after the sea water pump.

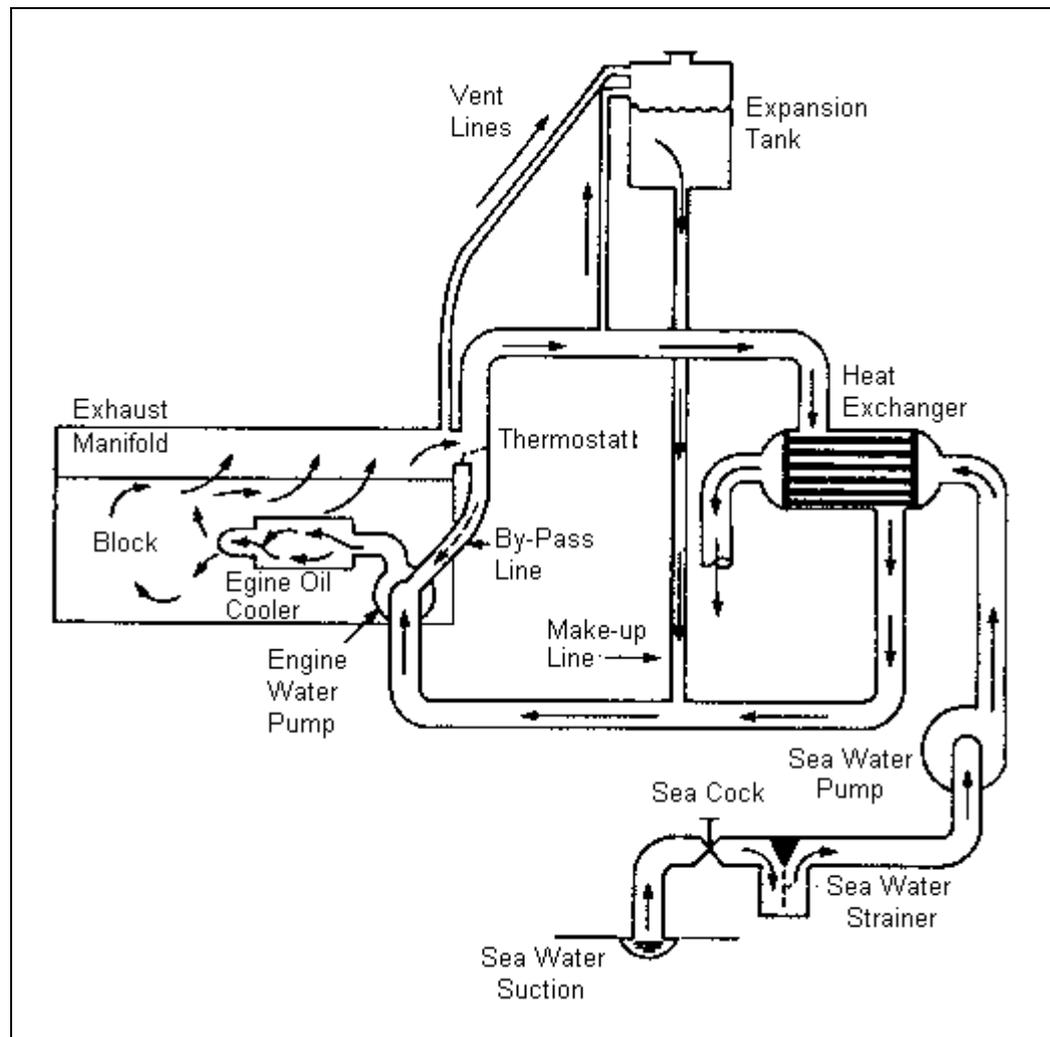


Fig 1.5.2

Section 2

Engine Operation

SECTION 2 ENGINE OPERATION

Introduction

In this section you will learn to operate diesel engines and recognise their major components. The checks and procedures for starting an engine will be identified as will the common problems that occur such as failure to start or the causes of overheating.

The purpose of the above knowledge is to enable you to safely and effectively operate diesel engines and carry out basic troubleshooting and regular user maintenance.

Section Contents

- 2.1 Checks and procedures before starting engine.
- 2.2 If an engine fails to start.
- 2.3 Engine gauge readings
- 2.4 Warm up and cool down periods.
- 2.5 Engine overheating symptoms
- 2.6 Slowing whilst underway
- 2.7 Identifying low oil pressure.

2.1 Checks and Procedures Before Starting Engines

The checks and procedures to be carried out before starting an engine depend on :

- whether the engine has just been repaired or overhauled and,
- whether you were the last person to run the engine.

The person with the Certificate of Competency to operate the machinery of the vessel is the one who takes full responsibility and cannot transfer the blame if something goes wrong. To cover yourself you must carry out pre departure checks and checks whilst the vessel is under way.

The following checks cover the engine:

- Make sure that all work carried out on the engine has been completed and that there are no tools, materials or parts lying on the engine.
- Ensure that there are no rags on the engine, especially the exhaust area. Check the whole engine is free from fuel and lubricating oil.
- Gear box is in neutral.
- Sea water strainer is clean and open the sea connection valve and, if fitted, the overboard discharge valve. Ensure there are no sea water leaks.
- **If the vessel has been on the slip, it may be necessary to bleed off any air at the sea water pump.**
- Water level in the fresh water header tank and ensure there are no fresh water leaks.
- Condition of all hoses.
- Sufficient fuel in the fuel tank for the intended voyage plus a reserve amount of fuel.
- Open the fuel tank drain valve and drain off any sediment and/or water.
- Open the fuel tank outlet valve.
- **If repairs have been carried out to the fuel system on the engine, it may be necessary to prime the fuel system and bleed off any air**
- If a water separator is fitted, drain off any accumulated water. Check the movement of the hand throttle.
- Check the oil level in the sump shows full. In some engines a hand-priming pump is fitted so the system may be primed and prevent the major wear that takes place on starting an engine.
- If the fuel injection pump has its own sump, check that the level in the sight glass is at the upper line.
- If a turbo charger is fitted and has its own lubricating system, check that the level in the sight glass is at the upper line.
- Check that the batteries are clean, charged, the electrolyte level is above the plates and the terminals are clean and tight.

If it is possible, bar the engine over at least one complete revolution This is carried out to ensure there is no fresh water in a cylinder which could hydraulic the engine. It is also to ensure the engine can turn over freely and nothing has been left in any of the cylinders and all parts are back and are in proper working order.

- Switch on power to the starter motor. Give the engine some throttle. Engage the starter motor. The engine should rotate and fire.
- Immediately check the oil pressure.
- Listen for any unusual noises, especially hard metallic knocks.
- Check for fresh water, sea water, lubricating oil, fuel oil and exhaust gas leaks. Ensure sea water is being discharged overboard. The engine fresh water temperature will slowly rise and stabilise at its operating temperature. The lubricating oil pressure will drop from its initial starting pressure to its operating pressure.

- The revolution counter will be indicating. The throttle should be increased and decreased slightly to check its movement and that the revolution counter is functioning.
- With the engine at its operating temperature, check the colour of the exhaust gas.

- * Black smoke indicates excessive fuel for the amount of air and caused by poor or insufficient combustion or engine overload.
- * White exhaust vapour indicates water or moisture. It may be in the fuel, moisture in the air or from cold cylinder liner bores when starting the engine.
- * Blue smoke indicates lubricating oil is being burnt

2.2 If An Engine Fails To Start

This section lists some reasons for engines failing to operate correctly. There are many possibilities, so discuss these with your facilitator.

Engine will not start or is difficult to start

If the engine does not start, the causes are mainly in the supply of fuel and/or air.

Remember:

1. A full charge of air needs to enter the cylinder.
2. This air must not escape as it is being compressed otherwise insufficient heat is obtained to ignite the fuel.
3. Fuel must be injected in an atomised form into the cylinder at a precise moment.
4. In addition, there must be no restriction in the flow of exhaust gases.

An engine may that fails to start or is hard to start and on starting be irregular in its firing, may have one or a combination of the above factors causing the problems.

Engine is not turning over quickly when the starter motor is engaged

Battery capacity low	<ul style="list-style-type: none"> • Check that electrolyte level is above the plates. • Try to start the engine on the other bank of batteries. Failing this, try to start the engine on both banks of batteries. Never continue to use a battery if the starter motor is sluggish because high discharge rates will buckle the battery plates. • Take the specific gravity of each cell of the battery. A fully charged battery would have a specific gravity reading in each cell of 1.26 where as a flat battery would give a reading of 1.10. The specific gravity reading should not vary more than 0.030 between cells. A lower reading on one cell usually indicates the battery needs replacing
Battery connections dirty	<ul style="list-style-type: none"> • Check that the connections to and on the battery is clean and tight. A dirty or loose connection can be identified by the heat it generates.
Bad electrical connection to starter motor	<p>The starter motor draws the most load on the battery especially on diesel engines because of their high compression ratios. The electrical connections must therefore be tight and clean.</p>
Faulty starter motor	<ul style="list-style-type: none"> • The starter motor could be burnt out or the pinion is not engaging with the ring gear on the flywheel.
Incorrect grade of lubricating oil	<ul style="list-style-type: none"> • If the oil is too thick, the engine will not attain sufficient speed on the starter motor to generate the amount of heat required on the compression stroke to ignite the fuel.
Engine has been overhauled and is tight	<ul style="list-style-type: none"> • The parts of an overhauled engine are brought back to their correct clearances. In these clearances there will be a number of high spots and they will be worn away as the engine is run in. When the engine is run in, it will turn easily. The engine will not attain sufficient speed on the starter motor to generate the amount of heat to ignite the fuel.
Air cleaner restriction	<ul style="list-style-type: none"> • The air cleaner is choked, blocking or restricting the air required for the engine.
Exhaust gas restriction	<ul style="list-style-type: none"> • Could be caused by a bucket left on the outlet of a vertical exhaust pipe to prevent rain water entering the engine or by the automatic flap valve fitted for this purpose and is stuck in the closed position. • Occasionally a baffle could come loose in a silencer and block the passage of exhaust gas. • The air must be compressed to a high enough temperature to ignite the fuel. This is usually due to low or poor compression. Compression pressure can be checked by replacing each fuel injector in turn with a compression gauge.

Fuel issues

Fuel tank empty	<ul style="list-style-type: none"> Fuel piping could develop a leak emptying the contents of the fuel tank into the bilges.
Blocked fuel feed line	<ul style="list-style-type: none"> The suction valve on the fuel tank could have vibrated closed or someone could have closed the emergency fuel shut off valve.
Faulty fuel lift pump	<ul style="list-style-type: none"> Fuel is not being delivered from the fuel tank to the engine. If it is of the diaphragm type, the diaphragm could be perished or damaged. The drive to the pump could be damaged.
Choked fuel filter	<ul style="list-style-type: none"> The fuel filter has choked up with foreign matter as to prevent the full flow of fuel. The filter may not have been changed at its recommended period. A bad batch of fuel may have been received. The filter may require changing at more frequent intervals until the system is clean.
Air in fuel system	<ul style="list-style-type: none"> Air is compressible where fuel is not. Air in a fuel system will cause the engine to malfunction or not start. Air usually enters the fuel system when repairs are carried out or where there is a fuel leak. This air must be bled off until a bubble free fuel is obtained. Some fuel systems have a manual priming handle on the fuel lift pump or on the fuel injection pump. In addition, there are bleed valves throughout the system, such as on filters or water separators.
Faulty fuel injection pump	<ul style="list-style-type: none"> The fuel pump is not delivering fuel to the injector
Faulty fuel injectors	<ul style="list-style-type: none"> The valve pintle may be seized shut in its nozzle and no fuel is delivered to the cylinder. The holes or orifices in the nozzle may be blocked. The valve pintle may not be sealing on its seat causing misfiring and irregular speed, particularly on light loads.
Incorrect fuel pump timing	<ul style="list-style-type: none"> The fuel is not being delivered to the fuel injector at the precise moment in the cycle. The engine could have been overhauled and the timing of the fuel pump was incorrectly carried out. It is possible for the timing to alter whilst the engine is running due to insufficient tension on the fuel pump coupling bolts.

2.3 Engine Gauge Readings

Engine oil pressure

When started, the oil pressure in a cold engine can rise to 150% of its normal operating pressure. As the engine reaches its normal operating temperature, the oil thins out and the relief valve on the oil pump closes. The oil will then drop to its normal operating pressure. Oil pressures will differ between types and makes of engines. As an example on one type of engine, normal oil pressures may be as follows.

Engine RPM	Pressure (kPa)	Minimum Pressure
2100 RPM	276 to 414 kPa	207 kPa
1200 RPM	207 to 414 kPa	124 kPa

As can be seen, a lower minimum oil pressure is acceptable at a lower speed compared to the minimum at a higher speed. This is due to the loading, on the bottom end bearings whilst on the power stroke, varying with speed.

Fresh water temperature

The fresh water cooling system is designed to operate between specified temperatures which will vary slightly between types and makes of engines. One example is 85° C to 90° C (185° F to 195° F) and with the 103 kPa (15 psi) pressure cap in place on the header tank, the engine can operate intermittently up to 96° C (205° F). The cooling water high temperature alarm is set at 96° C (205° F).

Depending upon the condition and efficiency of the fresh water cooler. A high sea water temperature could cause the fresh water temperature to rise. If it rises towards its maximum, the engine load must be reduced.

High cooling water temperatures increase the internal temperatures in the engine and affect the lubrication of the engine. Excessive high cooling water temperature causes overheating and subsequent seizure of the piston in the cylinder liner.

Low cooling water temperatures tend to cool the cylinders too much and retard the combustion process. This in turn will cause a smoky exhaust and reduce the power output of the engine.

2.4 Warm Up and Cool Down Periods

Warm up and cool down periods are essential for assisting efficient engine operation and maintenance. All metals in marine engines expand when heated, and contract when cooled. Different metals will expand by different amounts. Thin metals will expand quicker than thicker metals of the same type when the same amount of heat is applied.

An engine consists of different types of metals and different thickness of the same metal. Castings, such as the block, cylinder head and cylinder liner must be uniformly heated up. If the heat is localised, this section will expand at a much greater rate than the remainder of the part and will most likely crack.

On starting an engine, it is necessary for it to remain at idle speed until the temperature normalises. The engine speed and load can then be gradually increased. The fresh water cooling and the lubricating oil help normalise the temperature of the engine. This is done by taking the heat away from the hottest part of the engine to heat cooler parts of the engine.

The majority of wear takes place in an engine when it is started cold. One of the purposes of lubricating oil is to put a thin film of oil between two moving metallic parts. This separates the parts and reduces friction and therefore wear. The power stroke places a load on the bottom end bearing. The lower the revolutions of the engine, the lower the loading on the bottom end bearing and the combustion temperature. On starting, the engine should not be excessively revved

The thermostat in the fresh water cooling system ensures that the engine reaches its operating temperature quickly. This is done by distributing the combustion heat to the cold parts of the engine, thereby minimising unequal expansion

If an engine is on full load and stopped quickly, the cooling water temperature will rise. This is due to the non-circulation of cooling fresh water and the heat retained in the metallic parts of the engine. The unequal conduction of these metallic parts has the same result as expansion and could cause cracking.

2.5 Engine Overheating Symptoms

In determining the cause of an engine overheating, consideration should be given as to whether it is a gradual process or is a sudden rise in fresh water temperature.

An engine overheating can be identified by:

- the fresh water cooling temperature gauge,
- the exhaust temperature and,
- by the operators sense of touch.

When tracing a fault it is helpful to follow the circuit or flow of the sea water cooling and the fresh water cooling systems, and think what may be wrong with each component that may cause overheating.

Here are some possibilities:

- A gradual rise is where the temperature rises over a period of time caused by wear; by a gradual build up of scale on the cooling water surfaces or a sea water strainer gradually becoming clogged.
- A sudden rise in temperature could be caused by the thermostat stuck in the closed position, a pump impeller revolving on its shaft or the engine overloaded.

When the engine is hot and the fresh water level in the header tank is low, cold water should be introduced very slowly whilst the engine is running. The cold water will then be heated sufficiently before it circulates around the combustion space. Cold water suddenly coming into contact with the hot cylinder liner and cylinder head may crack them.

Sea water temperature too high

An engine with poor compression usually results in the engine receiving more fuel to get the required power. This results in overheating and a high sea water temperature will increase the problem. The engine speed should be reduced to bring the temperature back to its normal operating temperature

Sea water intake grid	<ul style="list-style-type: none"> • Could become clogged over a period of time so there would be a gradual increase in the fresh water cooling temperature. Reduce the engine speed until the normal operating temperature is obtained, or take steps to remove the obstruction.
Clogged sea water strainer	<ul style="list-style-type: none"> • Could become clogged over a period of time so there would be a gradual increase in the fresh water cooling temperature. Reduce the engine speed gradually and stop the engine. Clean out the strainer. Start the engine and let it idle until temperature stabilises. • Alternately the vessel may have voyaged through matter which quickly clogged the strainer. Take the above action.
Thermostat not opening fully	<ul style="list-style-type: none"> • When the engine is cold the thermostat is in the closed position. Water is circulated through the engine only. As the engine reaches its operating temperature, the thermostat opens and allows the water circulating through the engine to pass through the fresh water cooler or the keel cooling pipes. • Should the thermostat stay in its closed position or not open fully, the engine will overheat. Feel the pipe from the thermostat housing to the fresh water cooler. This will indicate whether or not water is flowing through it. Reduce the engine speed gradually and stop the engine. When the engine has cooled down, replace the thermostat. Should you be at sea and have no replacement thermostat, the engine can be run with the a thermostat removed.
Faulty impeller in sea water pump	<ul style="list-style-type: none"> • A faulty impeller in the sea water pump (such as the rubber one in a Jabsco pump) could be damaged. Damage usually occurs when the pump is run dry. The discharge pipe would be warm and not at the same temperature as the sea water. Also, there would be no (or reduced) sea water discharge overboard. Reduce the engine speed gradually and stop the engine. Replace the impeller.

	<ul style="list-style-type: none"> Should you be at sea and have no replacement impeller, it may be possible to reach port at reduced speed, if the impeller is only partially damaged and can still pump some water. Alternately, a sea water hose from the fire pump or the wash deck hose could be connected up to the system at the discharge side of the sea water pump to get the vessel back to port.
Keel cooling pipes not effective due to marine growth	<ul style="list-style-type: none"> This causes a gradual increase in the fresh water temperature. Reduce the engine speed gradually until the normal operating speed is obtained. The vessel will have to be slipped to clean the keel cooling pipes.
Air in sea water cooling system	<ul style="list-style-type: none"> On a lot of vessels, air is trapped in the sea water cooling system when the vessel re-enters the water after slipping. With the engine stopped, the air can be bled off by slackening off the backing plate on a jabsco pump or loosening a join in the seawater cooling pipe on the suction side of the pump that is below the water line. If it is a jabsco pump and it is run dry until the engine overheats, the rubber impeller will be severely damaged.
Insufficient speed of sea water pump	<ul style="list-style-type: none"> On some vessels the sea water pump is belt driven from the engine. The adjustment of the belt may cause it to slip. Reduce the engine speed gradually and stop the engine. Adjust the belt tension..
Faulty impeller in fresh water cooling pump	<ul style="list-style-type: none"> A faulty impeller in the fresh water pump could be damaged. Reduce the engine speed gradually and stop the engine. Replace the impeller. Should you be at sea and have no replacement impeller, it may be possible to reach port at reduced speed if the impeller is only partially damaged and can still pump some water.
Build up of scale on cylinder water jackets, etc.	<ul style="list-style-type: none"> Fresh water contains impurities. They come out of solution at high temperatures and will adhere to hot surfaces. The scale will stop the transfer of heat from the combustion process to the fresh water cooling and, in the case of passages, will restrict the flow. This will be a gradual process. Reduce the engine speed until normal operating temperature is attained.
Engine parts may be too tight causing friction	<ul style="list-style-type: none"> A new or overhauled engine normally runs hotter because it is tight. As the engine is run in, the high spots disappear. The engine turns easily, thereby reducing the operating temperature. Reduce the engine speed so that it runs at its normal operating temperature.
Fresh water cooling level is too low	<ul style="list-style-type: none"> A leak has developed in the fresh water system causing a loss of water in the header tank. It could be a leak in the piping, seal in the pump or a blown cylinder head gasket. Reduce the engine speed gradually and if the fresh water system is the unpressurised type, very slowly top up the header tank to its correct level. If the fresh water system is of the pressurised type, reduce the engine speed gradually and stop the engine. Let the engine cool down. Start the engine and very slowly top up the header tank to its correct level. If there is very little water in the header tank, it is advisable to stop the engine and let the engine cool right down before adding fresh water. If possible, the leak should be repaired
Blown cylinder head gasket	<ul style="list-style-type: none"> A cylinder head gasket leaking will be indicated by bubbles in the header tank. The extent of the leak will determine the amount of

	bubbles. However, when the engine is stopped, there is no pressure in the cylinder. The header tank is above the cylinder thereby putting pressure (a head) on the water. The water would then flow through the leak in the cylinder head gasket into the cylinder.
Engine overloaded	<p>An engine that is overloaded will overheat. An engine can be overloaded by:</p> <ul style="list-style-type: none"> • a dirty hull • a rope around the propeller • a bent propeller blade • too large a pitch propeller. <p>The engine speed should be reduced until the normal operating temperature is attained. To stop overheating, it would be necessary to clean the hull of marine growth, or repair any damage to the prop.</p>
Dirty or fouled fresh water cooler	<ul style="list-style-type: none"> • The sea water discharged overboard would be restricted. It is unusual for the cooler to be completely blocked. Reduce engine speed until normal operating temperature is attained. Stop engine and clean the cooler or return to port under reduced speed.

2.6 Slowing Whilst Under Way

The engine slowing down and stopping is of concern to the Master as the safety of the vessel may be in danger.

This may be caused by:

- lack of maintenance
- pre-departure and under way checks not being carried out or
- not responding to early indications that something is wrong.

Once again, when considering the principles upon which a diesel engine operates, it is very evident that if a fresh charge of air is drawn into the cylinder and then compressed to the proper pressure, and fuel is injected into this highly compressed air, combustion must follow. If the engine has been running satisfactory and then slows down and stops, the causes are mainly in the supply of fuel.

Fuel tank empty	<ul style="list-style-type: none"> • Isolate empty fuel tank and use another fuel tank.
Fuel tank outlet pipe split or corroded and losing all the fuel in the tank	<ul style="list-style-type: none"> • Carry out temporary repair to pipe by placing a piece of rubber around it, then a thin bit of metal to give the rubber some support and attach them with hose clips. Isolate empty fuel tank and use another fuel tank.
Fuel tank outlet valve has vibrated shut	<ul style="list-style-type: none"> • Open valve and tighten gland packing to stop valve vibrating shut.
Water in the fuel	<ul style="list-style-type: none"> • Drain off the water at the fuel tank and, if fitted, at the water separator.
Clogged fuel filter	<ul style="list-style-type: none"> • Depending on the type of filter, clean the filter or replace the disposable element.

Faulty fuel lift	<ul style="list-style-type: none"> • Repair or replace the pump
-------------------------	--

Note: Most mechanical failures do not stop the engine unless it has to do with the valve timing for all cylinders. A broken timing chain is an example. Mechanical failures result in noise, probably a knocking sound which will continue until the engine is stopped.

2.7 Identifying Low Oil Pressure

The reduction in the normal operating pressure of lubricating oil can be a gradual process or happen instantly. The loss of oil pressure will cause those parts under the most load to fail first. This would be the bottom end bearings, due to the load placed on them on the power stroke. By reducing the engine speed, the load on the bearings is reduced. If there is still some oil pressure there, the reduction in load may be sufficient to save them.

Should the oil pressure drop instantly, the engine must be stopped immediately.

A vessel does not have to be fitted with a low oil pressure audible alarm unless it is over a specific length as determined by the relevant statutory body. However most vessels under this length are fitted with some sort of alarm. No mechanical, electrical or electronic piece of equipment is fully reliable, especially in a marine environment. A low pressure oil alarm may develop a fault and not indicate. The engineer therefore must rely on his or her senses to monitor the engine condition.

Insufficient level of oil in the sump	<ul style="list-style-type: none"> • May cause a fluctuation of the oil pressure as the vessel rolls, the pump could lose suction and air enters it. Reduce speed and top up the sump to the correct level.
Lubricating oil pump strainer clogged	<ul style="list-style-type: none"> • Not much of a problem these days as the additives in the oil keep the foreign matter and sludge in suspension for the filter to remove. Signs of a dirty filter would usually be a gradual drop in pressure. If possible, clean the strainer.
Faulty lubricating oil pump	<ul style="list-style-type: none"> • If the drive to the pump has sheared, there would be no oil pressure at all. The engine must be stopped immediately otherwise severe damage will occur. Should the gears or rotors of the pump be worn or too much clearance between them and the backing plate, there will be a gradual drop in oil pressure. If the lower oil pressure is sufficient, voyage at reduced speed back to port.

Faulty relief valve	<ul style="list-style-type: none"> • The pressure relief valve may be stuck in the open position or its spring may have broken. A cold engine when started, will have a high oil pressure which will cause the relief valve to open. The engine's oil pressure drops as the engine reaches its normal operating temperature and the oil thins out. This results in the relief valve closing. Should the relief valve stick in the open position or the spring break, the oil pressure will drop below normal. Free up the sticking relief valve or replace the relief valve spring.
Filter partially blocked	<ul style="list-style-type: none"> • With the filter being partially blocked, the flow of oil will gradually be restricted. Lower oil pressure will occur and be indicated on the pressure gauge until the filter by-pass valve opens. Replace the filter element or clean the filter (centrifugal type).
Oil temperature too high	<ul style="list-style-type: none"> • A high oil temperature will thin the oil out causing it to run more easily with a resulting drop in oil pressure. This could be caused by a worn engine which would have fresh water overheating as well. Alternately, it could be caused by a dirty oil cooler on the sea water side. Run the engine at a slower speed until the normal operating oil pressure is obtained and voyage home. Alternately, clean the tubes in the oil cooler.
Faulty oil pressure gauge	<ul style="list-style-type: none"> • A faulty oil pressure gauge could indicate a low oil pressure where in fact the actual pressure is correct. If the oil pressure gauge is suspected, try another one.
Fractured lubricating oil pipes	<ul style="list-style-type: none"> • Will result in a gradual or sudden drop in pressure if the pipe splits. if it is possible, repair the leak. If the lower oil pressure is sufficient, steam at reduced speed back to port.
Water in the oil	<ul style="list-style-type: none"> • Water mixing with oil will result in emulsified oil. It is grey/white or sometimes described as milky in colour. Emulsified oil loses its lubricating properties. When a certain amount of emulsification takes place, the oil pressure will drop below normal. Stop the water leak and change the lubricating oil.
Fuel in the oil	<ul style="list-style-type: none"> • Fuel contamination will thin out the oil and it will run easily off the dip stick. There will be a rise in the level in the sump. The dip stick will also have a fuel smell. Fuel contaminated oil loses its lubricating properties and the oil pressure will drop below normal. Stop the fuel leak and change the lubricating oil.

Section 3

Routine maintenance practises

SECTION 3. ROUTINE MAINTENANCE PRACTISES

Introduction

In this section you will learn the routine tasks which are needed to maintain the engine, the deck and engineroom machinery and the maintenance which will be carried out while the vessel is on the slip. You will also be introduced to the spare parts and tools necessary to undertake these routine tasks , also to the importance of maintaining an engineroom logbook or checklist to ensure the tasks are completed on schedule.

Section Contents

- 3.1 Engine routine maintenance
- 3.2 Deck and engineroom routine maintenance
- 3.3 Spare parts and tools
- 3.4 Maintaining the drive train
- 3.5 Maintenance when on the slip.

3.1 Engine Routine Maintenance

The performance and life of an engine will, to a large extent, depend on how well it is looked after. The maker's instruction manual will give details of all maintenance schedules and it is essential these be followed. Keeping an engine logbook or an engine maintenance checklist will help ensure the routine maintenance tasks are not forgotten and are done at the required times. Some tasks will be done each day and some will be done with engine use, as indicated on the engine tachometer (ie engine running hours at a fixed revolution per minute).

The frequency of checks may vary depending on engine use, conditions of use, quality of oil used and the methods of operating the engine. What follows is an "average" procedure for a small diesel engine.

Daily checks:

- Check lube oil level in engine and gearbox
- Check FW levels.
- Check fuel level
- Drain water trap (or tank).
- Visual check of all V belts for wear and tension.
- Check engine and hoses for water/oil leaks, listen for knocks or rattles.
- Check gauges
- Grease any grease nipples on pumps
- Check battery

Every 50 Hours:

- Clean fuel filters and remove condensation.

Every 250 hours:

- Replace fuel filter
- Change lube and gearbox oil
- Replace lube oil filter
- Clean thermostat
- Check and adjust governor linkage
- Clean air filter
- Check and adjust valve clearance
- Re-tighten major bolts
- Clean air filters and replace if necessary

Every 500 hours:

- Replace zincs in engine
- Check rubber impellers
- Check fuel pump
- Check injectors (spray pattern, injection pressure, clean)

Every Year:

- Valve grind
- Check rocker arms and valve guides
- Overhaul, clean and check piston rings
- Check Con rod (bearings, bolts and torque)
- Check crank arm deflection.333

Every two years:

- Main Berringa
- Crank shaft
- Clutch/gearbox

3.2 Deck/Engineroom Routine Maintenance

As well as listing the routine maintenance task for the engine itself, the check list will include those which will be done around the engine room and deck:

These will include:

- Daily or weekly greasing of all bearings including pumps, lay shafts, steering gear components
- Battery maintenance
- Cleaning bilge strums (weekly)

3.3 Spare parts and tools

All vessels should carry those spare parts that affect the every day running of the vessel and the replacement of which, is within the capabilities of the engine operator. No need to carry those parts that will only be used at time of major overhaul or are beyond the capabilities of the engine operator.

Depending on the engine type and configuration a spare parts list might include the following:

- A spare vee belt for each size in use
- Spare hoses and clips
- Gland packing
- Materials for making gaskets
- Rubber pump impellers
- Oil, fuel and air filters
- Lube oil and grease
- Spare bulbs and fuses
- Wire
- Tape

- Epoxy putty

The tools that are carried need only be those needed to do the routine tasks listed above, or those for emergencies around deck or engine room. These might include:

- Hammer
- Cold chisel
- Ring spanner set
- Socket set
- Screwdriver set
- Adjustable spanners
- Pipe wrench
- Vice grips
- Pliers
- Grease gun
- Hydrometer
- Torch
- Knife

3.4 Maintaining the drive chain

Stern Assembly

Figure 4.5 shows a typical water cooled shaft/stern tube assembly. It is sealed by a traditional packed gland.

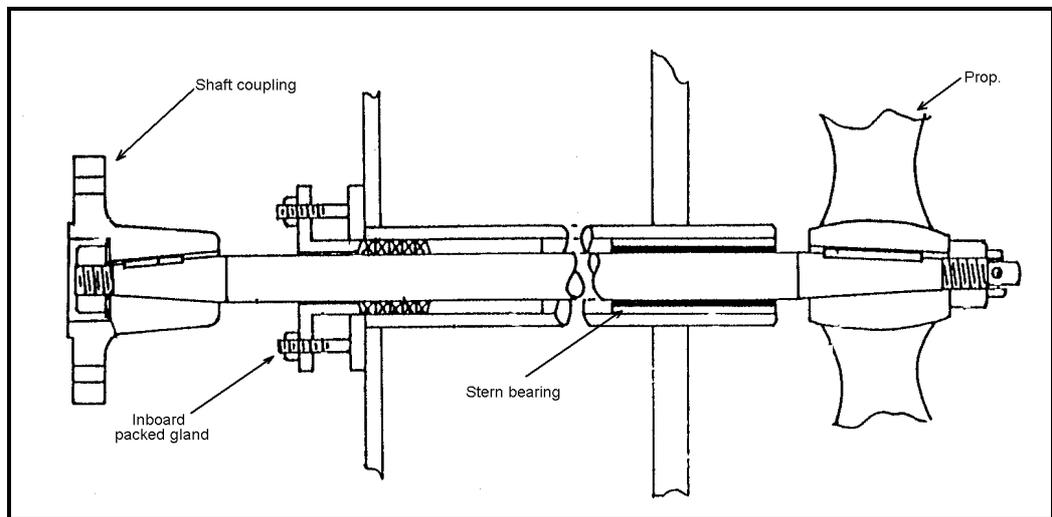


Fig 3.4.1

Shaft

The propeller shaft is generally machined from 316 stainless steel as it has good wearing properties and excellent resistance to corrosion with the propeller attached by a matching taper on the shaft and in the propeller, a keyway is used to prevent the propeller turning on the shaft, and a nut used to hold the prop on

the taper.

The inboard end is generally machined the same as the propeller end for the shaft coupling which will allow the shaft to be “end for ended” if excessive wear occurs on the shaft in the packing area.

Stern Tube

The stern tube consists of a thick walled pipe passing through the stern post and the engine room bulkhead, with a shaft bearing on the outboard end and a bearing (neckbush) and sealing arrangement on the inboard end.

The stern tube will be securely attached to the stern post and bulkhead and should be checked at each slipping for movement and the security of the fittings. Some installations use a flushing system which supplies sea water into the inboard end of the stern tube to assist in circulation of water through the tube. This system helps improve the lubrication and cooling of the bearings and flushes out sand and grit when operating in shallow conditions

The most common sealing arrangement used is a stuffing box, packed with either greasy hemp or a teflon based material, when re packing glands leave 2.5 - 3 mm gap between the ends of the turns of packing per 25mm of shaft diameter. The gland should be only tight enough to allow a small drip through to ensure effective lubrication of the gland.

After repacking, the gland should be allowed to leak and be gradually tightened to give the new packing time to “settle in”. If a stern gland is found to be overheating the following steps should be taken:

The outboard bush is made from a water lubricated material, and the neck bush generally from brass or whitemetal, some small diameter shafts won't have a neck bush and will support the shaft in the gland packing.

- Reduce speed or stop if possible
- Allow the gland to cool down gradually
- When cool loosen the gland or repack if necessary
- Steam at reduced speed for a period and readjust the gland
- Monitor the temperature and readjust for minimum leakage if required

3.5 Maintenance when on the slip

When the vessel is on the slip, there are jobs that which cannot be done at other times. On vessels that are under a survey or safe ship management regime, some of these jobs will be done as part of the survey. However, if the vessel is not covered by such a scheme the following jobs should be done regardless:

- Clean, inspect for damage, repair and paint hull
- Check and replace zinc anodes, each year
- Check radio earth plate, each year
- Clean all gratings, each year
- Check rudder, rudderstock and gland, each year
- Check stuffing box, tighten or repack
- Clean propeller and check for damage
- If there is an external log, inspect fittings
- Check stern tube and stern shaft for ware each year, pull shaft each 3 years
- Dismantle through-hull valves and check for electrolyses, every 2 or three years

Section 4

Steering Systems

SECTION 4 STEERING SYSTEMS

Introduction

In this section you will learn about the statutory requirements for steering systems and details of the various systems which can be fitted on small boats.

Contents

- 4.1 Steering Systems
- 4.2 Basic Maintenance to Steering Systems

Learning Outcome

Operate and maintain steering systems on vessels in accordance with safe practice and statutory requirements.

Most vessels are steered with the aid of a rudder, which is rotated to the required angle by a steering mechanism. The type and size of steering mechanism depends on the size and design of vessel.

4.1 Requirements for Steering Gears

Steering Gears are surveyed during a vessel's annual and periodic surveys. The requirements the requirements are determined by the relevant statutory body, an example of some of these are summarised below.

- All vessels except twin screw vessels and vessels where the normal means of steering is a hand tiller shall be fitted with two independent means of steering.
- The steering gear shall be of adequate strength to steer the vessel at maximum speed both ahead and astern.
- Rudder movement should be 35 degrees port and starboard.
- In vessels 12.5m and over the steering gear shall be capable of putting the rudder from 35 degrees on one side to 30 degrees on the other in 30 seconds at maximum speed.
- The steering gear shall be so designed and constructed to prevent violent recoil of the steering wheel.
- In hydraulic systems, changing over from primary to secondary systems should be able to be carried out easily and quickly.
- Power driven hydraulic systems shall be fitted with a relief valve to prevent mechanical damage.
- The rudder indicator shall move in the same direction and give a true indication of the rudder angle.
- If the emergency steering is remote from the steering/navigation position an adequate form of communication between these two positions shall be installed.
- Where necessary the steering gear will be fenced and have adequate guards to avoid injury to personnel.

As stated above if the tiller and hence the rudder is rotated by hand as in small vessels it is not required to have a back up or emergency system. However, in most modern vessels a mechanical means is employed to move the tiller, thus requiring an emergency back up. This may take the form of a hand tiller, which can be quickly and easily fitted to the top of the rudder stock. This emergency tiller must be kept in a place close to the steering flat and stock.

Rudders

The relevant statutory body may specify the sizes and materials used for the construction of rudders. Two methods of mounting the rudder are shown in figure 4.1.1

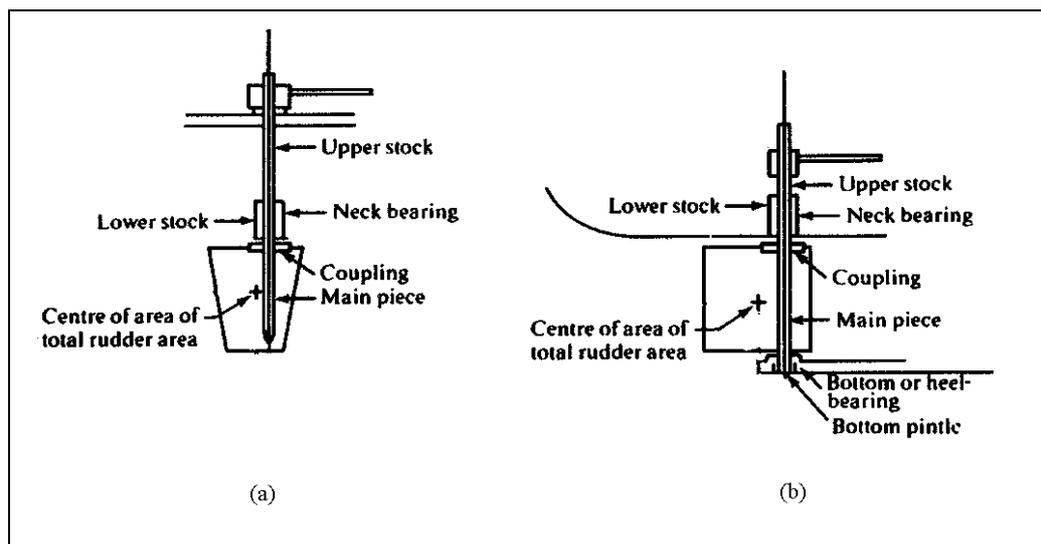


Fig 4.1.1

Drawing (a) shows a mounting arrangement where the forces on, and the weight of the rudder are carried by the rudder stock. This means that the stock and bearings should be of adequate size and strength to withstand stresses under any weather condition.

Drawing (b) shows a pintle type rudder arrangement. The rudder is hung on pintles and has a further pintle in the extension to the keel.

The rudders are secured to the stock by flanged couplings and these need to be carefully checked whenever the vessel is out of the water.

There is usually a gland around the rudder stock to prevent water entry into the hull. This needs to be checked regularly and possibly the packing or seals renewed when the vessel is in a safe situation (usually out of the water).

Next lets consider the mechanisms used to rotate the rudder, ie the steering gear. These can range from a simple wire and pulley system to a more complex electro-hydraulic one.

Wire and Pulley

A wire and pulley arrangement is shown in figure 4.1.2, which consists of a wire wound around a drum fitted to the wheel. The wire passes through a series of pulleys on the two sides which connect to the tiller or quadrant of the rudder mechanism. To avoid excessive strain and bending of the wire the pulley blocks should be as big as possible and positioned to avoid an excessive angle or be easily fouled. Buffer springs are provided on both port and starboard to prevent violent recoil of the steering wheel. All components should be inspected and greased or oiled as appropriate.

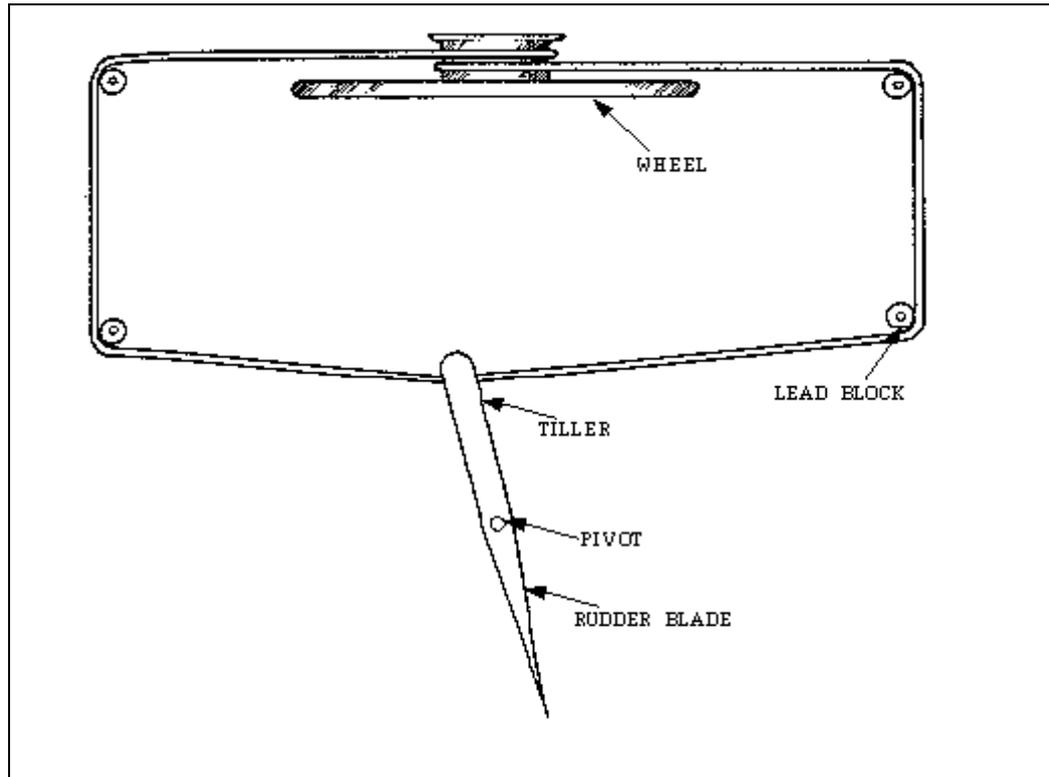


Fig 4.1.2

Chain and Box

A wide variety of chain and box installations make use of automotive parts such as shafts, universal joints and truck steering boxes. These systems require periodic inspection and lubrication. The chain is liable to stretch and should be checked regularly. For this reason the chain length is usually adjustable.

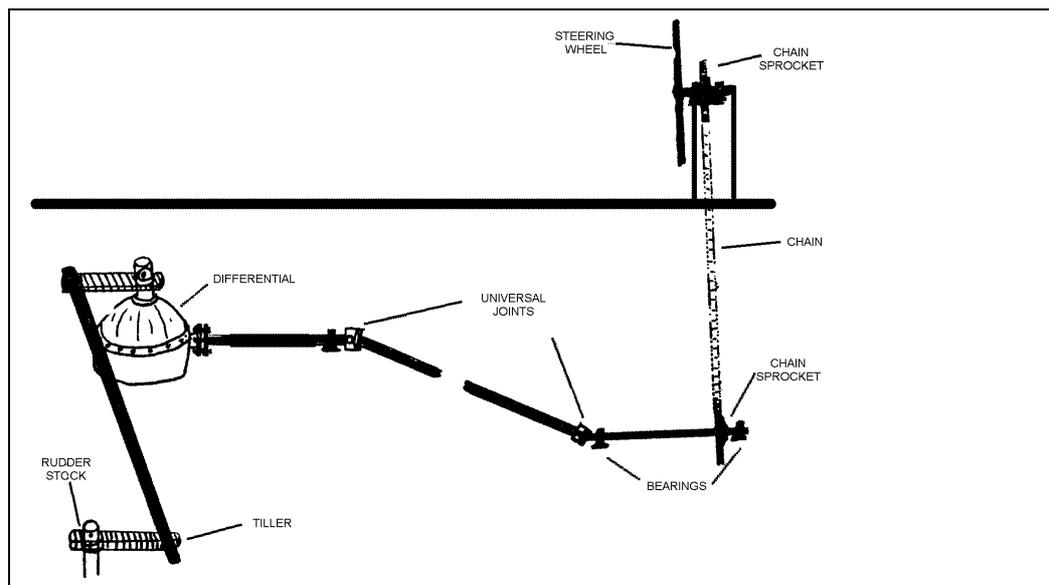


Fig 4.1.3

Push-Pull Cable

A push-pull cable type steering arrangement is shown in figure 4.1.4 This arrangement is similar to that used on outboard motors. The length of the cable should not be too long or short as this can affect the tiller response. If the push-pull cable or rod seizes, there must be provision for releasing the push-pull rod from the tiller to operate the emergency steering.

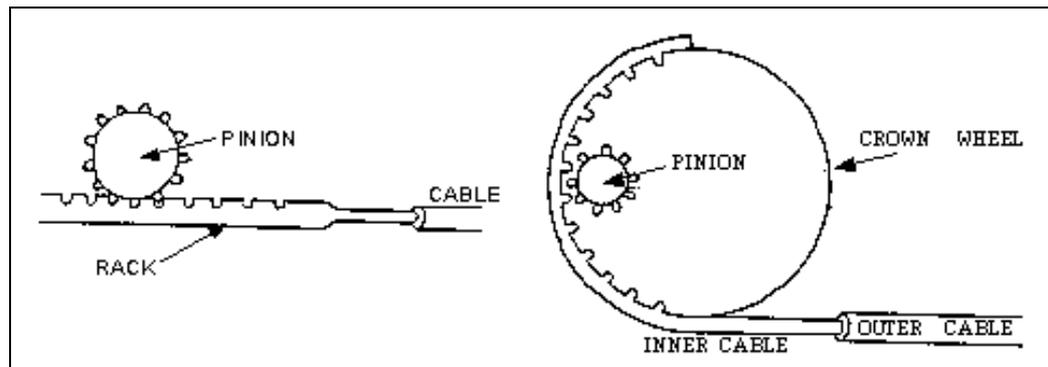


Fig 4.1.4

Basic Hydraulic Systems

Hydraulic systems are common in vessels of 20 metres or more in length. These systems range from simple manual systems to electro-hydraulic. Figure 8 shows a simple manual system with a single steering station. The system operates utilising the flow of hydraulic fluid under pressure to control the movement and position of the rudder.

The system consists of a two way hydraulic pump, (usually a gear pump), connected to the wheel. Two pipes lead from the pump to the hydraulic cylinder and ram, which in turn is connected to the tiller.

Let us say the wheel is rotated to Port (see arrows in Figure 4.1.5). This will operate the hydraulic pump, which will pump oil to the left side of the system. The oil will flow along the left pipe to the left side of the double acting ram.

The resulting hydraulic oil pressure will push the ram to the right side, which will rotate the rudder stock clockwise. This will result in the rudder turning to port as requested by the helm. The oil in the left side of the ram will return back to the pump via the other side of the system. The arrows in the diagram shows the oil flow and the resulting motion.

To turn the rudder to starboard, the process is reversed.

Due to the waves acting on the rudder, shock loading may occur, resulting in excessive pressure that could damage the system. In order to relieve this excess pressure, relief valves are located within the system. These spill oil from the side under excess pressure to the other side. These valves are called "Rudder Shock Valves".

If the hydraulic system fails, it is possible to carry out emergency steering by manually operating the tiller. This requires the by-pass valve between the two sides of the system to be opened, thus preventing hydraulic lock within the ram.

Usually, some form of local control will be available to turn the tiller manually.

A major problem associated with any hydraulic system is air in the system. Therefore, most systems are built to be self purging of air.

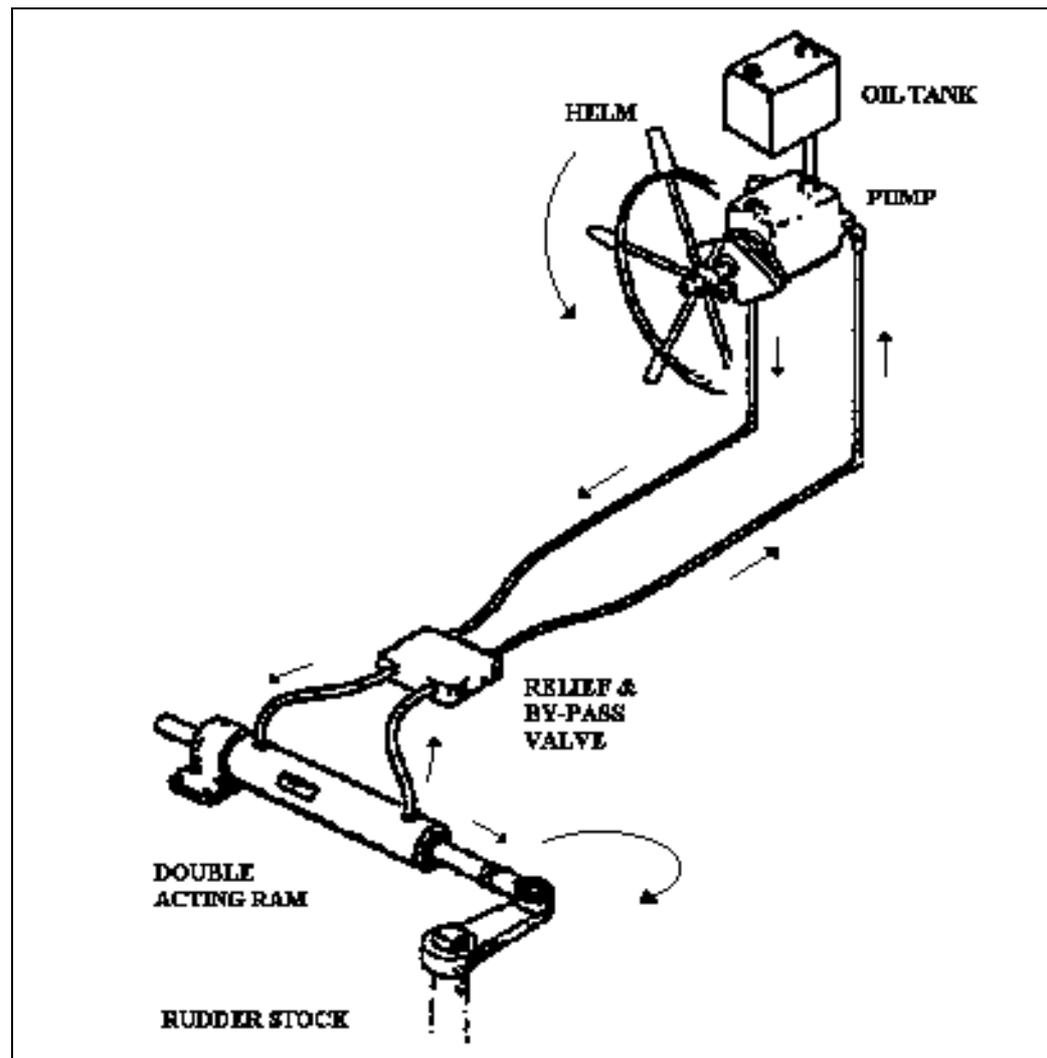


Fig 4.1.5

Section 5

Bilge Systems

SECTION 5 BILGE SYSTEMS

Introduction

In this section you will learn to operate pumping systems and recognise their major components. The checks and procedures for pumping will be identified as will the common problems that occur.

The purpose of the above knowledge is to enable you to safely and effectively operate bilge systems and carry out basic troubleshooting and regular user maintenance.

Contents

- 5.1 Statutory requirements.
- 5.2. Typical bilge systems and trouble shooting these systems
- 5.3 Backflooding

5.1 Statutory Requirements

Legislation for the fitting of bilge systems will differ from country to country, here is what may typically be required. Other than in vessels less than 7.5 metres in length, all vessels must have two bilge pumps, which in vessels of up to 20 metres may be a combination of both power and hand driven. Figure 6.2 shows a typical hand operated bilge pump.

A further requirement is that power driven pumps must be self priming or be provided with a suitable priming device.

All bilge suction's are required to be fitted with strainer to prevent solids from entering and either blocking or damaging the system.

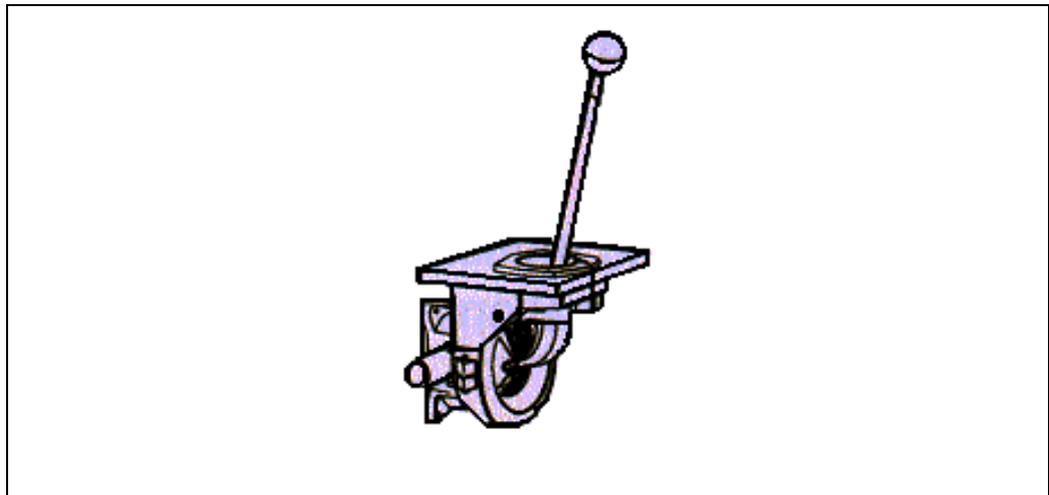


Fig 5.1.1 Hand Pump

5.2. Typical bilge systems and trouble shooting these systems

Components of a bilge pumping system

A bilge pumping system is designed to pump out any bilge water collecting in any compartment in the vessel. Bilge water can come from any leaks in the cooling system, stern gland or leaks in the hull.

In addition, if the vessel is bilged and suffers flooding the bilge pumping system must be capable of keeping the compartments dry.

The components of a bilge pumping system will depend on the size of the vessel. The common components are listed below:

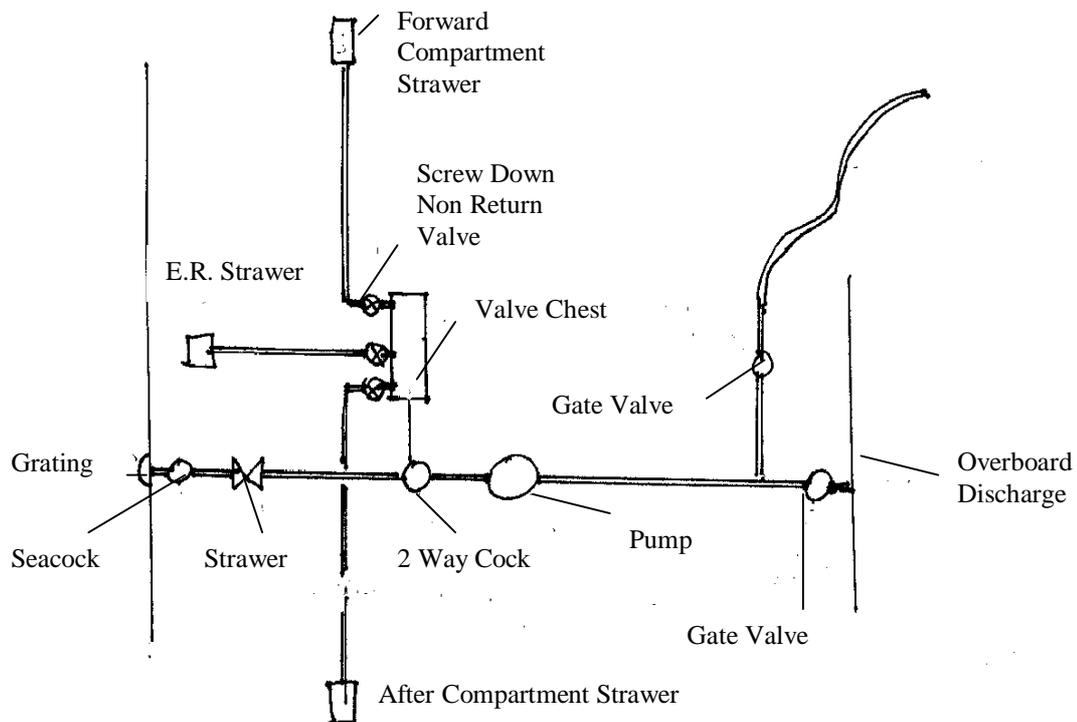
Part	Function
1. Pump	The bilge pump must be the self-priming type. The pump uses suction to draw water from the bilge and forces it out to sea.

2. Piping	Piping should be of a material suitable for the purpose and should not be effected by the foreign materials which often reach the bilge, such as fuel and oil.
3. Strainers	Strainers are used to prevent foreign materials entering the pump.
4. Bilge level alarm	These are set at predetermined levels to set off an alarm if the bilge water exceeds the set level.
5. Discharge with non-return valve	Outlet through which bilge water is pumped out to sea. There must be a non-return valve in the outlet to prevent backflooding
6. Suction non return valves	Non return valves are fitted to prevent backflooding from the sea back into the bilge and from one watertight compartment to another watertight compartment.

Typical Arrangement

Figure 5.2.1 shows a bilge system as fitted on a vessel of 10 to 20 metres in length. Smaller boats may have much simpler systems, including a simple hand pump or small electric centrifugal pump operated from the boat's 12 volt battery.

Fig 5.2.1 Typical Small Boat Bilge System



Trouble shooting the system

Mechanical Failure of Pump

- Pump not turning - check power source.
- If the pump is driven from an engine it is possible that the clutch is slipping or not engaging properly.

Flexible impeller pumps shed their vanes either through old age or having been run dry. If this is the case then the impeller will need to be replaced according to manufacturers instructions.

Air Leaks

This is a common problem and may be caused by:

- leaking glands on pump drive shafts
- leaking glands on valves or cocks
- holes in the pipework caused by mechanical damage or corrosion
- empty compartment valves being opened or leaking

Blocked Bilge Strainers

This is a common problem and may be caused by:

- leaking glands on pump drive shafts
- leaking glands on valves or cocks
- holes in the pipework caused by mechanical damage or corrosion
- empty compartment valves being opened or leaking

Therefore it is important to keep the bilges clean at all times.

High bilge levels can lead to dangerous situations including:

- Free surface effect on stability
- Fire hazard due to oil in the bilges
- Dangerous and explosive gases from bilges
- Slippery and dangerous surfaces to work on
- Corrosion
- Oil and water getting on machinery situated lower down
- Effect on trim, heel and draft of the ship
- Cleanliness
- Impaired visibility of lower spaces covered by bilges

Pollution Prevention

Oily bilges must only be discharged into a proper mobile or shore based facility. It is an offense under State and Commonwealth law to pump oil into the water.

If the vessel does not have sludge holding facilities on board then the oil bilge can be pumped into drums and stored for removal when alongside.

Regular User Maintenance

Cleanliness is the primary requirement for ensuring a bilge system is ready for operation.

A regular maintenance program should be implemented. The time interval will depend on the type and usage of the vessel.

A typical maintenance program would be to:

- keep bilges clean from rags and other foreign matter
- clean strainers
- put some water in each bilge well and pump out each in turn to confirm satisfactory operation.
- open up all bilge suction non-return valves in the system. Check the fit of the valve to the seat to ensure it seals when closed.
- operating all parts of the system regularly will ensure its reliability.

5.3 Back Flooding

Back Flooding, where sea water from the sea suction floods back through the system into a bilge space or water from one bilge space floods through the system into another, is not a desirable situation and may lead to the sinking of the vessel.

Back flooding can also occur via the deck hose being left trailing over the side when the pump has stopped. Sea water can siphon back through the hose and pump into any compartments where a valve was left open. Even where non return valves are fitted, back flooding can occur where a little debris is stuck under the valve leaving it open.

Back Flooding must be prevented at all times and is achieved by never leaving the deckhose over the side and by having non return valves in each of the bilge lines which reduce the chance of back flow into the compartments.

Section 6

DC Battery Systems

SECTION 6 DC BATTERY SYSTEMS

Introduction

In this section you will learn to manage a low voltage DC battery system to enable you to safely and effectively manage a DC battery system by being able to carry out basic troubleshooting, regular user maintenance and recharging

Contents

- 6.1 Fitting and care of the battery.
- 6.2 Assessing the condition of a battery.
- 6.3 Safety precautions with batteries.

6.1 Fitting and care of the battery

The battery is a vital component of the boats equipment both for providing light and for starting the engine. In larger boats there will be separate batteries for each function but in smaller boats one battery will do both. To prolong the life of the battery, to get maximum efficiency and for safety purposes the battery must be fitted properly and looked after carefully. The following advice should be followed.

Fitting the Battery

- Fit in a battery box in a dry place, with good ventilation. Ventilation to the fresh air is needed as the gas released when charging (hydrogen) is highly inflammable.
- Use only DC wire (to prevent volt drop) and place as close to the engine as possible.
- The battery box must have a lid to prevent anything dropping on it and causing short circuits or sparks.
- The battery box should be lined with lead or fiberglass as the liquid (electrolite) is acid and burns.
- If possible the battery box should be above the waterline.

Care of the battery

- All terminals (at the battery and the starter motor) must be kept clean and tight at all times. They should be covered in Vaseline to prevent oxidization.
- The battery should be kept fully charged and not allowed to stand in the discharged state, this causes sulphating in the battery which reduces life and efficiency.
- Each cell of the battery should be kept topped up above the plates on the battery with distilled water, or good clean rain water.
- The top of the battery should be kept clean and dry.

6.2 Assessing the condition of a battery

Batteries are used to store DC electricity, you will need to test the condition of a battery using a hydrometer. A hydrometer measures electrolytes in the battery acid. As a battery discharges, the electrolyte becomes less dense, and the indicator in the hydrometer will sink.

Firstly observe the normal safety precautions:

- Before removing the caps situated over each cell ensure you have sufficient ventilation
- Ensure there are no naked flames in the vicinity.

Using the hydrometer, insert it into each cell squeezing the sember bulb drawing liquid into the chamber. Reading the scale at eye level will tell you the condition of the battery.

- If the reading is 1.260 (green) then the battery is fully charged.

- At 1.233, the battery is 75% charged.
- At 1.198, the battery is 50% (white) charged.
- At 1.163, the battery is 25% charged.
- If the reading is 1.100 (red) then the battery is fully discharged.

Do not try and test your battery immediately after topping the battery with distilled water or after removing the battery from the charger. Wait for at least 30 minutes. This will allow for cooling and settling to gain a more accurate reading.

6.3. Safety precautions with batteries

A battery's electrolyte is a solution of sulphuric acid which can eat through clothing, cause severe burns, melt metal and give off a deadly chlorine gas when mixed with seawater.

Follow these safety tips when handling batteries:

- Ensure you have sufficient ventilation around your batteries.
- Install batteries away from the motor. Heat given off by your motor may weaken or damage the battery housing. Therefore battery acids can leak and cause corrosion to other components. A faulty connection in your starter motor could cause a spark to jump and ignite gases escaping from battery cells.
- Ensure your battery is secure when installed.
- Have an appropriate Amp meter and Volt meter installed for the purposes of monitoring the condition of your battery.
- Fit "Isolators" or circuit breakers to your wiring system.
- Ensure that the correct fuses are used when wiring additional electrical equipment to your vessel.
- Always remove jewellery especially watches with metal bands.
- Be careful when placing your tools.
- Wear some sort of eye protection.
- If battery fluid spills on your clothing or skin, wash immediately with cold water.
- Install your battery in a well-built acid proof box with a secure vented lid.

First aid with acid burns

The dilute sulphuric acid, from lead/acid batteries, does not seriously harm the skin if treatment is immediately.

Emergency Treatment

Remove contaminated clothing and shoes immediately. Wash off the chemical immediately with large amounts of clean water for at least 10 minutes. Continue for another 10 minutes if there is any evidence of chemical still on the skin. After washing cover the burn with a Vaseline gauze dressing, overlapping the burn by 50 to 100 mm. Then apply a covering of sterilised gauze, covered by a layer of cotton wool which is held in place by a suitable bandage.

Seek Medical Advice

If your eyes get splashed, immediately rinse the eyes with large amounts of clean fresh water or if available, flushing with a saline solution (2 teaspoons of house hold salt in 1 litre of water). This must be done for at least 10 minutes, timed by a clock.

If there is any doubt whether the chemical has been completely removed, repeat the eyewash for a further 10 minutes.

Seek Medical Advice

Section 7

Fire Fighting and Safety Systems

SECTION 7 FIRE FIGHTING AND SAFETY SYSTEMS

Introduction

In this section you will learn to operate the fire fighting and safety equipment.

The purpose of the above knowledge is to enable you to safely and effectively operate the fire fighting equipment aboard vessels and carry out basic troubleshooting and regular user maintenance.

Note. The principles of fire are covered in more depth in the Restricted G6 deck learner's guide.

Contents

- 7.1 The causes of fire in an engine room
- 7.2 Action on finding fire
- 7.3 Portable Fire Extinguishers in the E.R
- 7.4 Precautions with LP Gas Leaks

7.1 The causes of fire in an engine room

Fire onboard of a small boat can have devastating effects. There is always the potential for fire around the engine due to the presence of fuel (diesel) and heat (from the engine itself).

Specific causes of fire can include:

- Defective exhaust piping causing the escape of hot gas onto combustible surfaces.
- poor lagging of the exhaust system giving hot areas.
- oil soaked lagging which, despite being asbestos, may catch fire.
- fuel spraying onto hot areas due to leaks or broken piping
- cloths or rags draped over hot parts of the engine.
- electric faults and short circuits.
- bad housekeeping, such as oily rags, no drip trays, oil and grease collecting in areas where combustion may occur.

7.2 Action on finding fire

Fire is a major safety issue aboard vessels given the presence of flammable materials such as diesel, fuel and gas and indeed the material the vessel is constructed of in some cases, like fibreglass. Fire has no place on a vessel and should be extinguished immediately.

If a fire is found or suspected, follow these steps if the fire is small:

Step	Action
1	Sound the muster alarm even if you are able to extinguish the fire by yourself
2	Stop the engines and shut off any fuel supply to the area.
3	One crew member should tackle the fire with fire appliances available in the engine spaces. Ensure the correct appliance is used.
4	The second crew member should return to the fire muster station to report and summon assistance.

Follow these steps if the fire is large:

Step	Action
1	Sound the alarm and evacuate the machinery space.
2	Account for all personnel.
3	Stop the following equipment <ul style="list-style-type: none"> • machinery space ventilation fans, • machinery driving forced and induced draught fans, • fuel and lubricating oil, hydraulic oil pumps and oil separators
4	Close all skylights, doorways, ventilators, annular spaces around funnels and other openings to the machinery space.
5	If the vessel has a fixed fire installation, operate the system and carry out the procedure to discharge extinguishing media to the engine space.
6	Start emergency fire pump for possible use in cooling machinery space bulkheads or decks.
7	Look for signs that the fire has been extinguished (eg. no smoke)

	issuing from the skylight). Allow sufficient time to let the space cool down.
8	Slightly open a door to the space where the fire occurred. Close the door quickly if re-ignition occurs.
9	When satisfied that the fire is out, thoroughly ventilate the area and then enter to assess the damage.
10	Send distress calls if appropriate.
11	Prepare to abandon vessel if fire cannot be controlled.

7.3 Portable Fire Extinguishers in the E.R

Fire extinguishers are usually the first line of defence if a fire breaks out.

Caution: It is important to be aware that fire extinguishers use different materials such as water, foam, dry and wet chemicals and gases.

Each of these materials is used to extinguish fires that are fed by specific fuels, such as wood, liquids, electrical or gas. It is *dangerous* to use the wrong fire extinguisher on a particular type of fire. For example: you may suffer an electric shock (or worse) if you use a water fire extinguisher on an electrical fire.

Use the correct fire extinguishers for the correct purpose

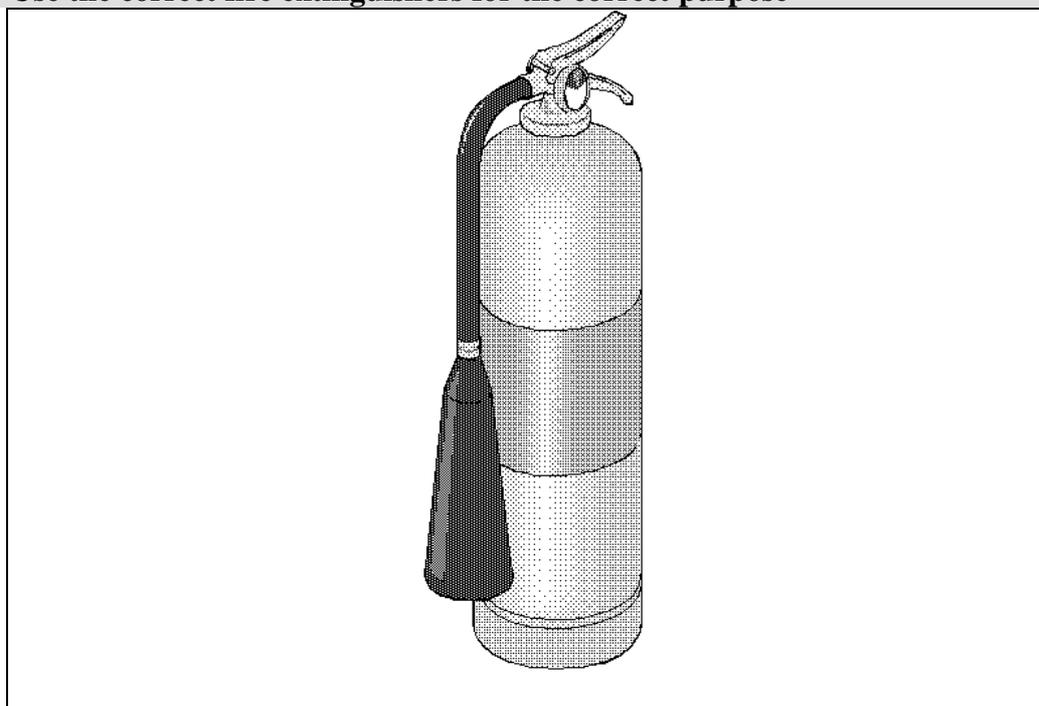


Fig 7.3.1

Fire extinguishers are colour coded to indicate type of extinguishing material used. Refer to the table on the next page to see which fire extinguisher is used on particular types of fires.

Diagram showing extinguisher types against fire type

 Portable Fire Extinguisher Guide							CLASSIFICATION Extinguishers shall be classified by letter(s) designating the general class or classes of fire for which the extinguisher has been found to be effective. For the purpose of classification, the following letters apply: Class A - Fire in which ordinary combustible materials such as wood, cloth, paper rubber and many plastics. Class B & Class F - Fire in flammable and combustible liquids and greases. Class C - Fire in flammable gases. Class D - Fire involving combustible metals. Use special purpose extinguishers only. Where an extinguishant has shown to be electrically non-conductive as discharged from an extinguisher, the extinguisher shall be identified with the marking (E).
Fire Protection Association Australia	WATER	WET CHEMICAL	FOAM	DRY CHEMICAL POWDER AB(E) B (E)	CARBON DIOXIDE (CO ₂)	VAPORISING LIQUID	
In All Cases, Call The Fire Brigade							
A Ordinary Combustibles (Wood, Paper, Plastics, etc)	YES <small>Most Suitable</small>	YES	YES	YES <small>AB(E)</small> NO <small>B(E)</small>	NO	YES	
B Flammable & Combustible Liquids	NO	NO	YES	YES	YES	YES	
C Flammable Gases	NO	NO	NO	YES	NO	NO	
(E) Fire Involving Energized Electrical Equipment	NO	NO	NO	YES	YES	YES	
F Fire Involving Cooking Oils & Fats	NO	YES	YES	NO <small>AB(E)</small> YES <small>B(E)</small>	YES <small>Limited Effectiveness</small>	NO	
<ul style="list-style-type: none"> • Fire Ratings: Fire Extinguishers are rated by the Standards Association of Australia to AS1850 • • When choosing a portable equipment company, make sure that they are a member of FPA Australia • <p>Members of Fire Protection Association Australia include companies that are able to supply and maintain portable fire extinguishers in accordance with the relevant Australian Standards.</p>							

Checking fire extinguishers

Fire extinguishers need to be checked regularly, at least every six months.

They should be serviced after **any** use no matter how small or short the usage was.

When to recharge fire extinguishers

All fire extinguishers, other than the carbon dioxide gas type, will have a gauge showing the pressure charge in the tank. If the gauge is not in the green section, the fire extinguisher needs to be recharged.

Note: During inspection, all dry chemical extinguishers need to be shaken to loosen the powder inside.

The carbon dioxide gas extinguisher needs to be weighed to determine whether it requires recharging. If there has been a drop from the original weight (marked on the body of the extinguisher) of 10% or more, then the extinguisher needs to be recharged.

In addition fire extinguishers also have a security seal on the trigger. If this seal is broken, then the extinguisher should be recharged.

Check the service date on the cylinder to determine whether it needs servicing. The relevant statutory body will determine the service period on your extinguishers.

Fire extinguishers can only be recharged or serviced by authorised suppliers. The date of any service should be stamped on the extinguisher body or an attached metal tag.

7.4 Precautions with LP Gas Leaks

LP gas use on small vessels is generally confined to cooking stoves, refrigerators and space heaters.

The relevant statutory body will determine rules for the approval, installation, testing and repair of all LP gas appliances installed on a vessel.

For example:

- **Cylinder/s shall not be installed or stored (even temporarily) inside a deckhouse or below decks.**
- **The exceptions are for cylinders which are a part of a portable appliance set and the gas storage capacity of the set does not exceed 4.5 kg**

Cylinders, their valves, the high pressure stage and regulating equipment shall be:

- secured in a position on the open deck, or deckhouse top
- outside of enclosures
- at least one metre measured horizontally from any opening leading below decks
- protected from climatic extremes
- vented to the open air at the top and bottom (if housed)

Sealing plugs are to be fitted to spare cylinders not connected to the system (whether full or empty). Spaces containing gas consuming appliances shall be provided with ventilation openings both top and bottom that cannot be readily closed.

Note: In searching for leaks on a system it should be remembered that LP gas is heavier than air and will sink to the lowest level.

Precautions for dealing with petrol and LP gas leaks:

- Advise the vessel's master and all personnel
- Turn off all engines and other appliances on the vessel
- Turn off the fuel supply
- Have the appropriate fire extinguisher available for either flammable liquids or gases. Note that a dry chemical extinguisher can be used on both petrol and LP gas
- Note that petrol and LP gas are both more flammable than diesel fuel
- Ensure the area is well ventilated, preferably using air flow to disburse any fumes
- If possible, remove gas cylinders to open deck space
- Locate and if safe, fix the leak
- Test the leak before starting any engines or switching on any appliances