Section 1: Marine Diesel Engines

Learning Outcome 1

On completion of this section you should be able to describe the operating principles of marine diesel engines not exceeding 500 kW, recognise major components and explain their function.

The areas you will cover in this section:

1.1 Principles of diesel engines

1.2 Diesel engine parts and functions

1.3 Lubrication systems

1.4 The fuel injection pump

1.5 The fuel injector

1.6 The turbo charger

1.7 The engine water cooling system

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. The *advantages* that diesel engines have 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.

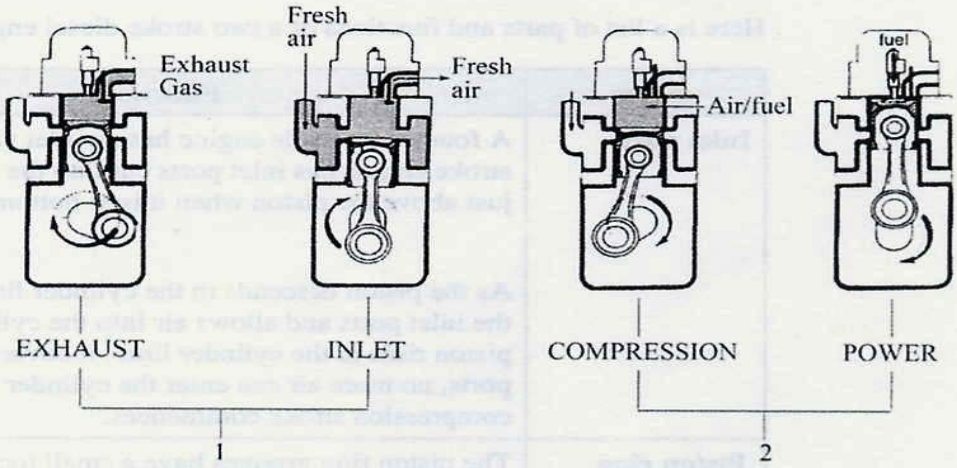
The basic principle driving diesel engines is the conversion of up and down motion to rotary motion. This is achieved by the compression ignition cycle of the pistons which are converted to a rotary movement through the crankshaft.

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 Detroit engine. The working cycle of that engine is:

1. Exhaust and Inlet
2. Compression and Power



Cycles of a Two Stroke Engine
(Courtesy: Detroit)

Stroke	Description
1. Exhaust and inlet	As the piston approaches the bottom of its stroke (BDC - bottom dead centre) exhaust valves are opened and the exhaust gases are released. 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.

Stroke	Description
2. Compression and Power	As the piston passes the BDC position, exhaust valves and inlet ports are sealed with the cylinder full of fresh air. 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.

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

Parts	Function
Inlet ports	A four stroke cycle engine has an inlet valve. A two stroke engine has inlet ports cut into the cylinder liner just above the piston when it is at bottom dead centre. 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, no more air can enter the cylinder and the compression stroke commences.
Piston ring locating pin	The piston ring grooves have a small locating pin in them. The piston rings have a small slot in the back of them at the gap. 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 piston ring gap was allowed to pass over an inlet port, it could cause the piston ring to fracture.
Exhaust ports or exhaust valves	While exhaust ports can be cut into the cylinder liner in the same fashion as the inlet ports (with the piston opening and closing the ports as it uncovers and covers them) it is more common in marine engines for exhaust valve/s to be fitted and operated in the same manner as that of the four stroke cycle engine. If exhaust ports are fitted, no camshaft, cam followers, push rods or rocker arms and shaft are required. If exhaust valves are fitted, the camshaft is chain or gear driven from the crankshaft by a 1:1 ratio so the camshaft does one revolution for every revolution of the crankshaft.

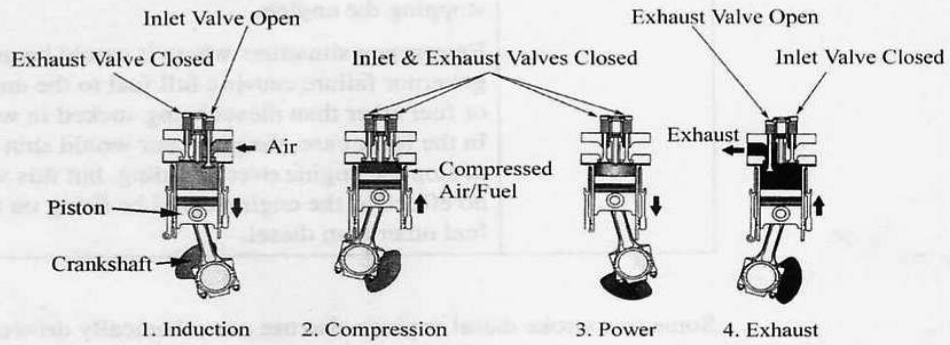
Parts	Function
Scavenge blower	In a two stroke cycle engine, air has to be forced into the cylinder. A scavenge blower consists of two rotors which revolve with every five clearances in a housing. The rotor lobes are constructed with a helical or spiral form to provide continuous and uniform displacement of air. One rotor is chain or gear driven from the engine and in turn rotates the other.
Emergency air shut off	This device can be fitted to any two or four stroke cycle engines. Typically it is fitted to the M.T.U. make of engines. It shuts off the air to the engine thereby stopping the engine. Emergency situations where it would be used would be governor failure causing full fuel to the engine or a gas or fuel other than diesel being sucked in with the air. In the latter case, the governor would shut the fuel off to stop the engine over speeding, but this would have no effect, as the engine could be firing on the gas or fuel other than diesel.

Some two stroke diesel engines also use a mechanically driven supercharger to force air into the cylinder, improving combustion and power.

Four Stroke Diesel Engine

The simple principles of a few stroke diesel engine are:

1. induction
2. compression
3. power
4. exhaust



Cycles of a Four Stroke Engine
(Courtesy: Caterpillar)

Stroke	Description
1. Induction	The exhaust valve is closed, and the inlet valve is opened. The first downward movement of the piston sucks fresh air into the cylinder.
2. Compression	Both inlet and exhaust valves are closed. On the first upward movement of the piston, the air is compressed. This heats the air. The fuel is injected just before the piston reaches Top Dead Centre (TDC).
3. Power	Both the inlet and exhaust valves remain closed. The piston is forced down when the fuel ignites in the cylinder.
4. Exhaust	The inlet valve is shut and the exhaust valve is open. The final stroke occurs when the piston expels the exhaust gases out of the cylinder.

4 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.

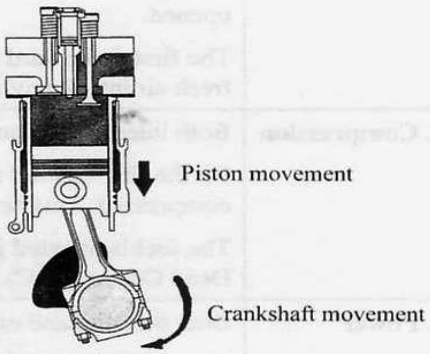
On the power stroke, both inlet and exhaust valves remain closed.

On the exhaust stroke, the exhaust valve is open, the inlet valve is closed.

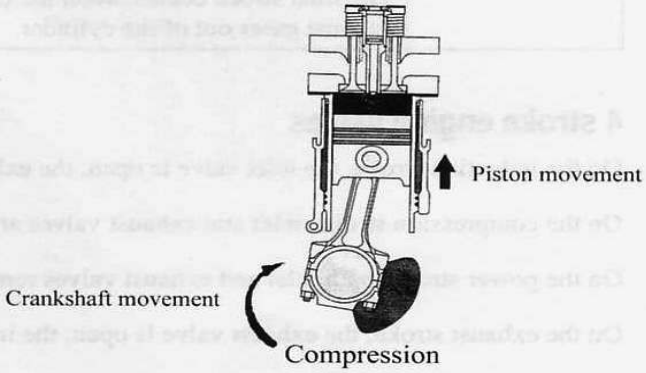
Each engine has different timing of valve opening and closing.

In the following diagrams it can be seen that the piston travels:

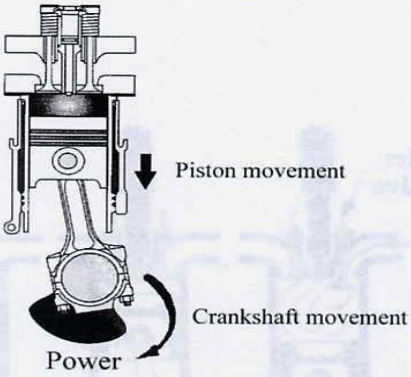
- down on the **induction** stroke



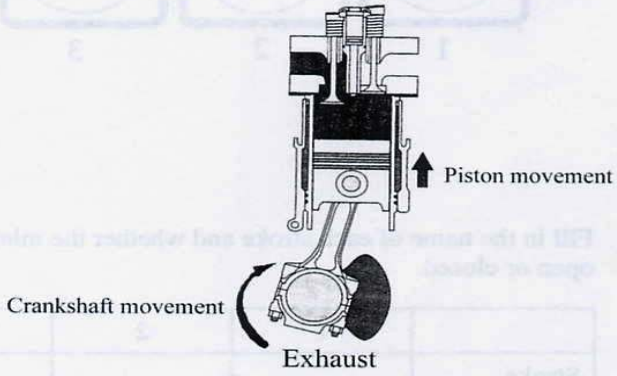
- up on the **compression** stoke



- down again on the **power** stroke



- up again on the **exhaust** stroke



(Diagrams courtesy: Caterpillar)

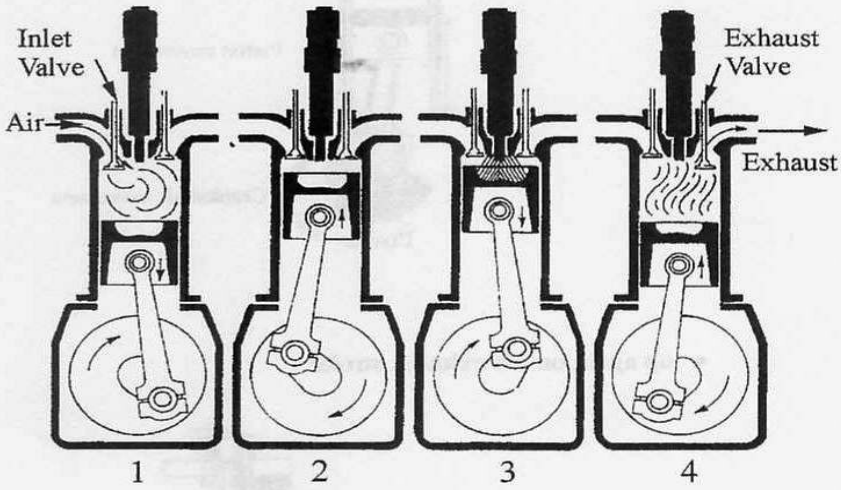
Therefore, there is one power stroke for every two revolutions of the crankshaft.

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.

A single cylinder engine has a heavy flywheel. The power stroke causes inertia to be stored up in the flywheel and turns the engine during these three strokes until the next power stroke. In two revolutions of the crankshaft, one power stroke would take place.

The more cylinders an engine has, the lighter the flywheel can be.

Written Activity 1



Fill in the name of each stroke and whether the inlet and exhaust valves are open or closed.

	1	2	3	4
Stroke				
Intake Valve				
Exhaust Valve				

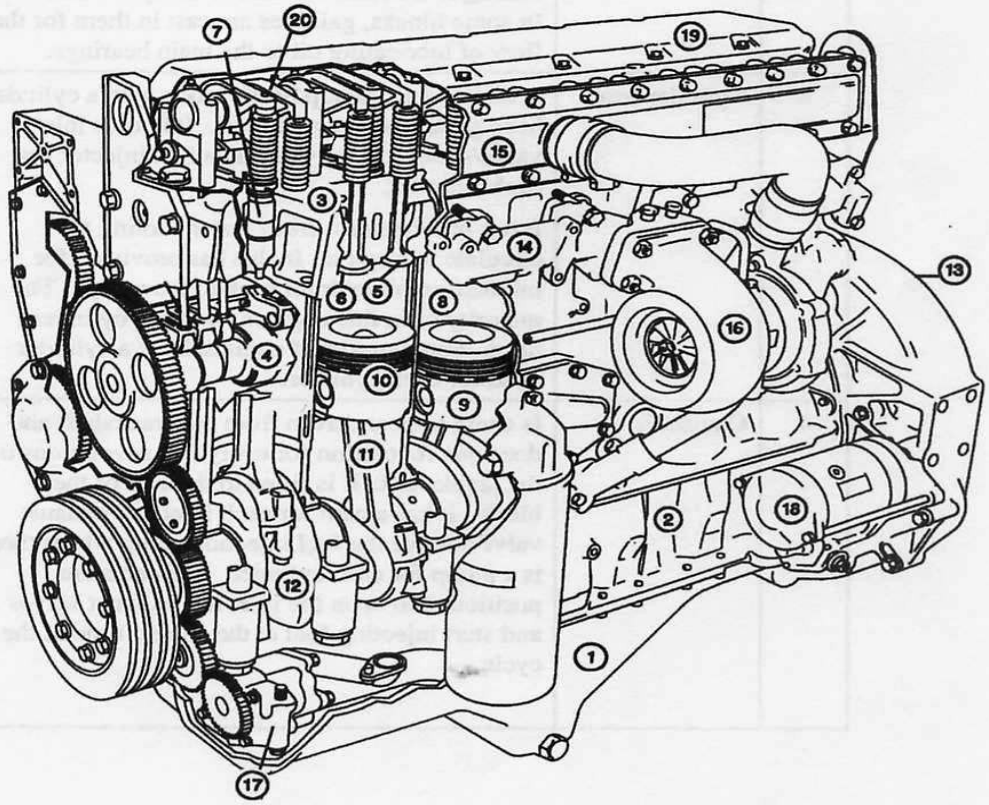
Check your answers at the end of this section.

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.



Diesel engine showing some of the major components

Note: Not all components appear on the diagram.

Diag Ref.	Part Name	Function
1	Sump	Is a reservoir to store the lubricating oil and is attached to the bottom of the block.
2	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. The casting is also machined for the cylinder liners so they accurately line up with the bottom end journals of the crankshaft. The top of the casting is machined to attach the cylinder head. In some blocks, galleries are cast in them for the flow of lubricating oil to the main bearings.
3	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. It has provision for fresh water cooling to circulate through it. It also has provision for lubricating oil to drain back to the sump. The majority of in line engines have one cylinder head. Some makes of engines have a cylinder head for each cylinder.
4	Camshaft	Is chain or gear driven from the crankshaft and does one revolution for every two revolutions of the crankshaft. It is fitted to the side of the block. It has a cam for each inlet and exhaust valve and for the fuel injection pump where there is a pump for each cylinder. The cams are positioned to open the inlet and exhaust valves and start injecting fuel at the correct time in the cycle.

Diag Ref.	Part Name	Function
5	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. It moves up and down in a valve guide. It is kept closed with a spring. A valve spring cap is fitted over the end of the spring and a collet secures it to the valve stem. A collet is split, externally tapered and has a raised 'internal section' which fits into a groove on the valve stem to retain the tensioned valve spring.
6	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 when it opens on the exhaust stroke. It moves up and down in a valve guide. It is kept closed with a spring. A valve spring cap is fitted over the end of the spring and a collet secures it to the valve stem.
7	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.

Diag Ref.	Part Name	Function
–	Heater plugs	Sometimes called glow plugs. One is fitted to each cylinder. They are fitted to assist in the ignition of fuel to start the engine when the engine is cold. Electrically operated heater plugs provide this extra heat. To start the engine, there is a delay whilst the heater plugs are activated and heat supplied to the cylinder before the starter motor is engaged.
8	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.
9	Piston	Moves up and down in the cylinder liner and is sealed to it by piston rings. It is connected to the connecting rod by a gudgeon pin.
10	Piston rings	Are fitted to grooves machined in the piston. The number of rings can vary but comprise compression rings at the top and usually one oil or oil scraper ring underneath. In the majority of engines, all rings are fitted above the gudgeon pin. The rings are fitted with a gap to allow for expansion due to temperature. The gap also allows the ring to expand outwards against the cylinder liner wall to form a seal.
11	Connecting rods	Sometimes referred to as con rods. Fitted between each bottom end journal where a bearing is attached and the gudgeon pin housed in the piston. They have a hole drilled through their centre to allow the passage of oil from the bottom end journal to the gudgeon pin.
12	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. There is a main journal beside each throw or bottom end journal. Holes are drilled through the crankshaft to lubricate the bearings.

Diag Ref.	Part Name	Function
13	Flywheel	Is attached to one end of the crankshaft. The more cylinders an engine has the lighter the flywheel. The ring gear is attached to the flywheel. It allows the starter motor pinion to engage it and turn the engine for starting purposes.
14	Exhaust manifold	Is attached to one side of the cylinder head and allows for the passage of gas from all cylinders to the silencer. In some engines, it is water jacketed to stop heat radiating into the engine room.
15	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. If a turbo charger is fitted, the air cleaner is fitted to it.
16	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. The incoming air passes over the tubes in the inter cooler while the cooling medium passes through the tubes. The cooling medium can be fresh or sea water. The cooler the air, the denser it will be and more fuel can be burnt giving more power.
17	Lubricating oil pump	Is driven off the engine, usually the camshaft and supplies oil to all parts of the engine requiring lubrication. The oil forms a film between moving parts thereby reducing wear and friction. The oil has a cooling effect.

Diag Ref.	Part Name	Function
–	Fresh water cooling pump	Is driven off the engine and is fitted to circulate cooling water throughout the engine. It removes heat caused by combustion and friction by passing it through a cooler and helps maintain the engine at a constant working temperature.
–	Thermostat	Is fitted in the cooling water system so the cooling water, on starting the engine, is only circulated through the engine until the working temperature is obtained. It is then circulated through the engine and cooler.
–	Fresh water cooler and header tank	Fresh water is circulated around the outside of the tubes in the cooler (also called a heat exchanger) while sea water is circulated through the tubes in the opposite direction. The fresh water cooler is fitted to maintain the engine at a constant temperature. The header tank usually forms part of the cooler and is situated above it. It allows for topping up the fresh water cooling system expansion of the cooling water and the venting of air and combustion gases.
–	Sea water pump	Is driven off the engine and is fitted to pump sea water through the fresh water cooler to maintain the fresh water at a pre-determined constant temperature. In a wet exhaust system, it is sprayed into the exhaust gases.
18	Starter Motor	Is driven by batteries. Its pinion engages in the ring gear attached to the flywheel and turns the engine which will fire when fuel is admitted. As the engine fires, the pinion will be disengaged due to centrifugal force.
19	Rocker cover	Fits over the top of the rocker gear to contain the oil that is splashed around.
20	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. This causes the other side of the rocker arm to open the valve. The spring on the valve causes the valves to close when the back of the cam is in line with the cam follower.

Diag Ref.	Part Name	Function
_	Alternator	Is driven off the engine, supplies electrical power to the circuitry and charge the batteries.

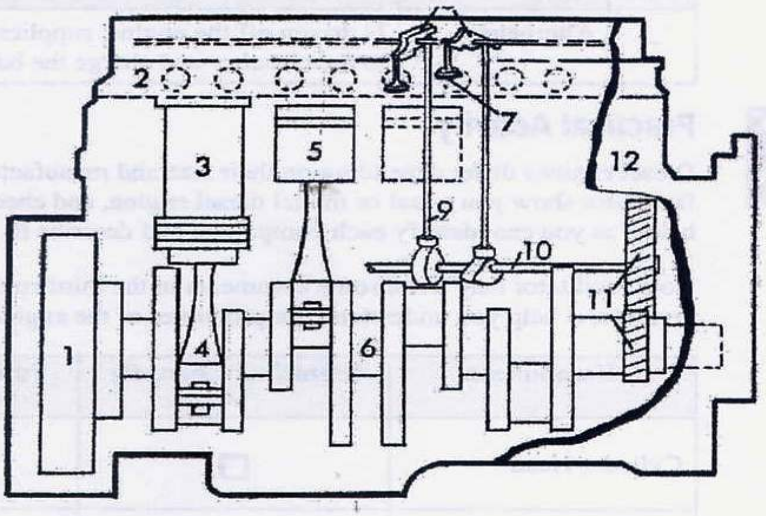
Practical Activity

Diesel engines differ depending on their size and manufacturer. Have your facilitator show you a real or model diesel engine, and check off the list below as you can identify each component and describe its function.

Your facilitator may write some comments in the third column to assist your review and help you understand the principles of the engines.

Component	Identified Correctly ✓	Function described correctly
Cylinder Head	❒	
Fuel Injector	❒	
Piston	❒	
Crankshaft	❒	
Sump	❒	
Exhaust Valve	❒	
Inlet Valve	❒	
Other components	❒	
	❒	
	❒	

Written Activity 2



Place the number of the part next to its corresponding name below:

_____ Piston	_____ Crankshaft
_____ Cylinder head	_____ Block
_____ Connecting rod	_____ Cylinder
_____ Valve	_____ Rocker arms
_____ Flywheel	_____ Camshaft

Check your answers at the end of this section.

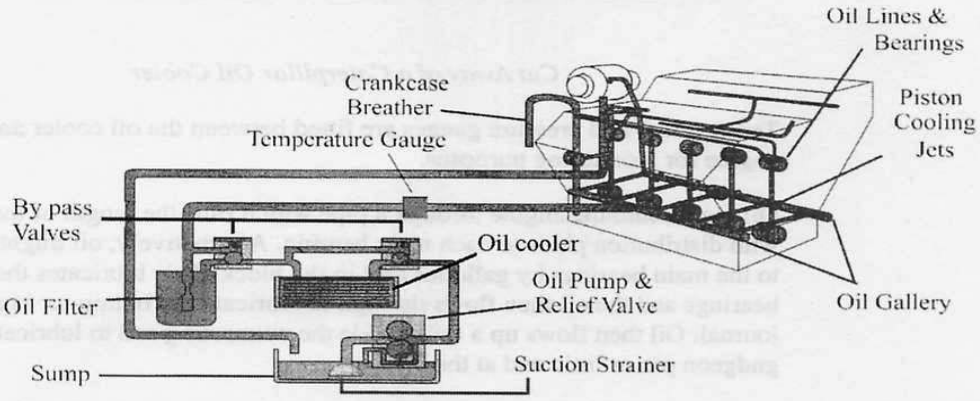
1.3 Lubrication systems

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:

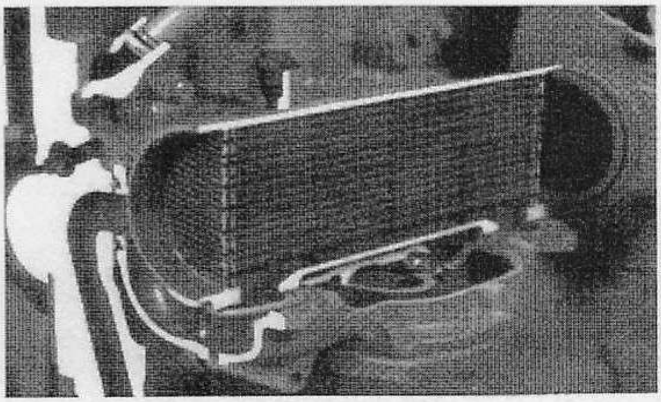
- oil pump
- sump
- suction strainer
- dipstick
- filter
- cooler
- temperature gauge
- pressure gauge
- relief valves



Lubrication System
(Courtesy: Caterpillar)

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 at the recommended pressure is pumped to the cooler which maintains a constant temperature by using sea water to draw out heat. 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.



Cut Away of a Caterpillar Oil Cooler

Temperature and pressure gauges are fitted between the oil cooler and the engine for monitoring purposes.

Oil moves 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 ie. 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.

Practical Activity

Have your facilitator show you a real or model lubrication system.

Get them to check off the list as you can identify each component of the system and can describe its function.

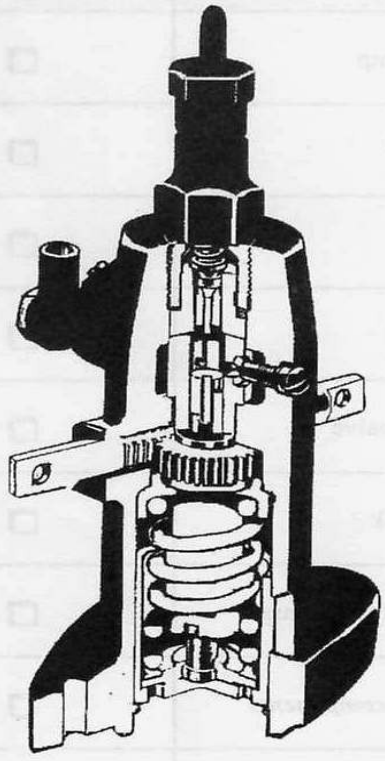
Component	Identified Correctly ✓	Function described correctly
oil pump	❒	
sump	❒	
filter	❒	
cooler	❒	
relief valve	❒	
dipstick	❒	
temperature gauge	❒	
Other components	❒	
	❒	
	❒	

1.4 The fuel injection pump

The fuel injection pump is a crucial component of the fuel system and complex in its construction. It is also an expensive part. For these reasons only experienced technicians should be employed to work on these pumps. The fuel injection pump is located on the side of the engine, connected directly to the fuel injectors by an injection pipe.

There are a lot of variations in the way in which fuel is injected into the cylinder. However, the principle is that the pump accurately meters the fuel and delivers it under high pressure at a precise moment to the spray nozzle of the fuel injector where it is injected into the cylinder.

Jerk type fuel pumps



Single Element Jerk Type Fuel Pump

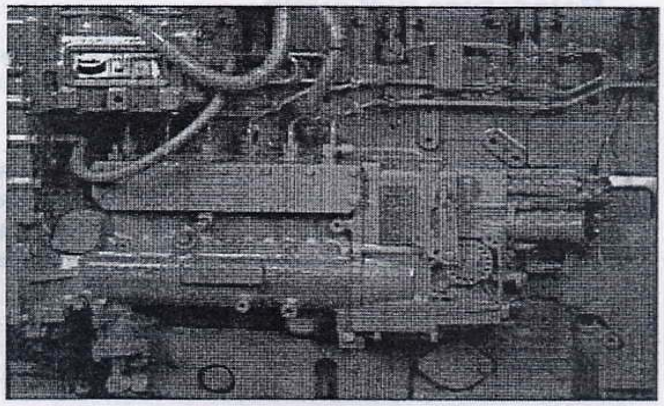
A jerk type fuel injection pump can be a separate unit for each cylinder. In a six cylinder engine, there would be six jerk type fuel pumps.

All these fuel pumps would be operated off the camshaft and would have their own cams in order that the period of injection is correct.

There would be a fuel line running the length of the engine with a branch line to each pump. The fuel lift pump would supply oil from the fuel tanks to the fuel line.

The internals of the pump meter the amount of fuel required and also provide the high pressure required to pump it to the rejector.

Multi-element jerk type fuel pumps



Multi element jerk type fuel pump
(Courtesy: Caterpillar)

The multi element jerk type fuel pump is a number of single element jerk fuel pumps contained in the one housing. For a six cylinder engine, there would be one fuel pump but it would contain six elements.

With this type of pump, it is necessary to adjust each element to ensure injection starts at the correct angle and all pump the same amount of fuel.

The multi element pump has its own camshaft which is in the main engine drive. Lubrication of the camshaft and its associated parts is via the engine lubricating oil pump or its own oil reservoir.

The fuel lift pump required to get the fuel from the tanks to the fuel pump is often mounted on and actuated by a cam of the fuel pump.

The amount of fuel injected into the cylinder is determined by the movement of the fuel rack on the fuel pump, which is attached to each injector. As the fuel rack is rotated, more or less fuel is pumped into the cylinder.

The fuel rack is also attached to the governor. The governor reacts to changes in engine speed and moves the fuel rack to compensate the flow of fuel. For example, if the propeller comes out of the water, the engine will speed up, the governor will move the fuel rack to reduce the fuel flow and slow down the engine. The fuel rack is also used to close off the fuel supply and as a result, will stop the engine.

The pump can incorporate a governor to maintain a set speed with fluctuations in load by metering the amount of fuel.

Rotary type fuel pump

The rotary type pump is also referred to as a distributor type of pump. It operates on a principle entirely different from that of the jerk pump. It is comparatively simpler, compact and of lower cost.

It incorporates a single pumping element. This element contains ports, the number of which will correspond to the number of cylinders. It has an automatic metering device so it is unnecessary to calibrate and balance a number of pumping elements as in the case of the jerk pump.

Practical Activity

As in previous sections, it is important you can identify parts and components on a working or model fuel injection pump.

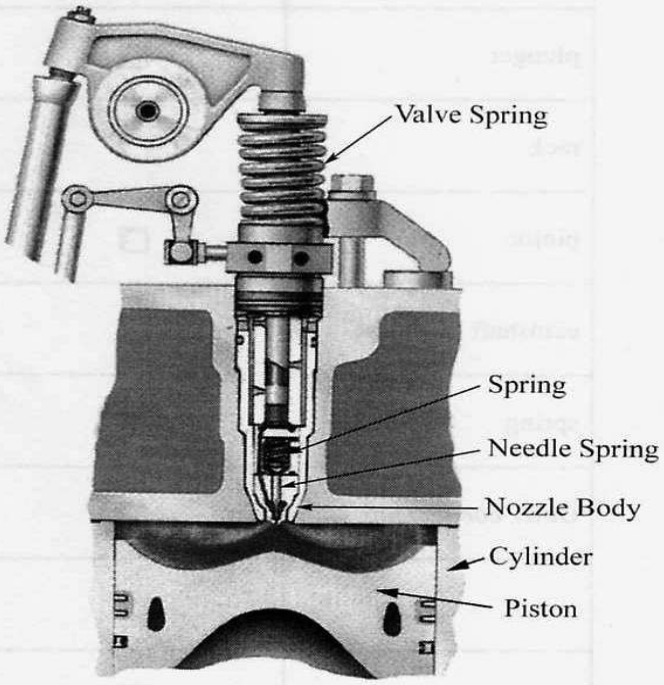
With your facilitator, identify the part and describe how it works within the system:

Component	Identified Correctly ✓	Function described correctly
barrel	❒	
delivery valve	❒	
plunger	❒	
rack	❒	
pinion	❒	
camshaft	❒	
spring	❒	
Other components	❒	
	❒	
	❒	
	❒	

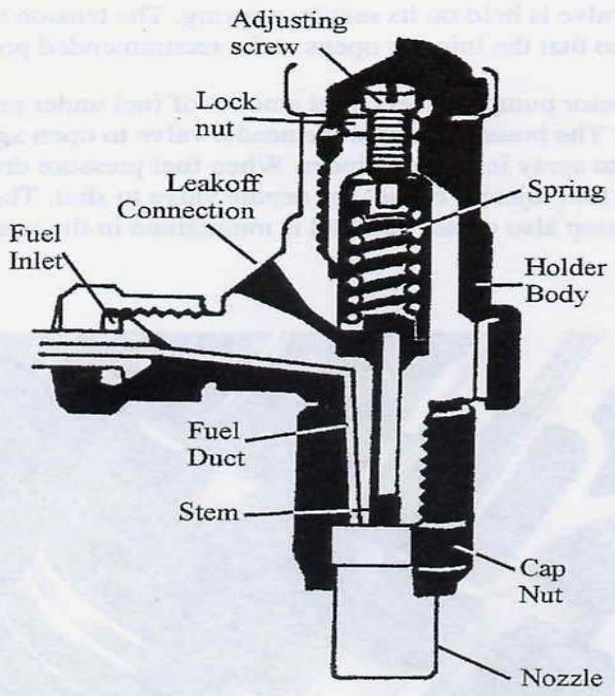
1.5 The fuel injector

A fuel injector is a spring controlled valve located in the engine cylinder head. It allows the fuel, which is under pressure from the fuel pump, to enter the cylinder. The fuel enters the cylinder in an atomised form so it will mix completely with the hot compressed air and ignition can take place with efficient combustion.

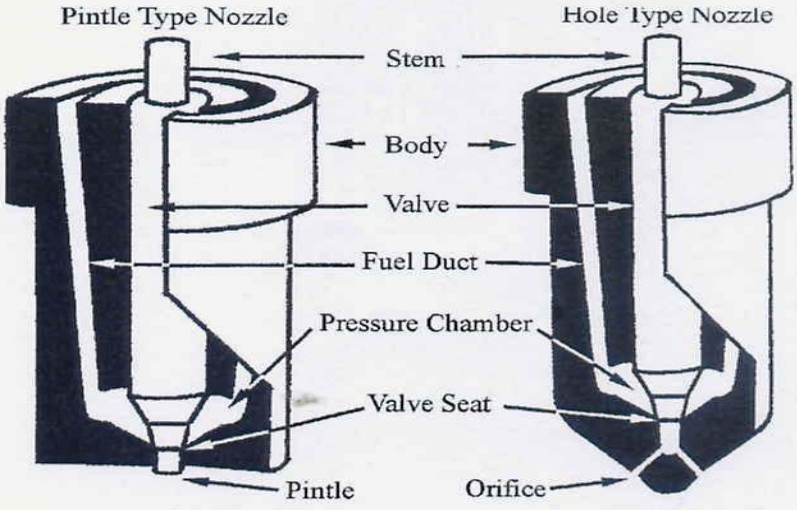
The fuel injector consists of a nozzle which incorporates a needle valve and seat and holes in it to atomise the fuel. The needle valve must seal effectively on the valve seat to allow for a clean cut off of fuel to the cylinder. A leaking valve causes misfiring and irregular speed, particularly on light loads.



Location of fuel injector in relation to cylinder
(Courtesy: Caterpillar)



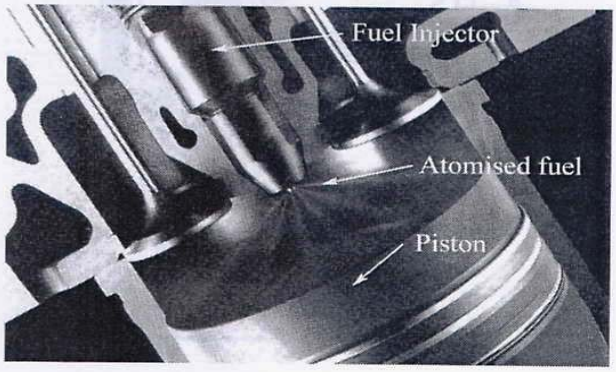
Fuel injector



Nozzle assembly

The needle valve is held on its seat by a spring. The tension of the spring can be adjusted so that the injector opens at the recommended pressure.

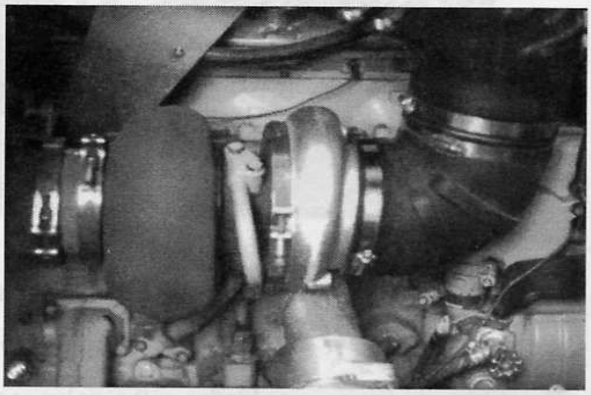
The fuel injector pump delivers a set amount of fuel under pressure to the fuel injector. The pressure causes the needle valve to open against the spring and the fuel to spray into the cylinder. When fuel pressure drops quickly, the spring in the fuel injector causes the needle valve to shut. The delivery valve in the fuel pump also closes and fuel is maintained in the injector pipe.



Fuel Injection
(Courtesy: Caterpillar)

1.6 The turbo charger

When fitted to the engine, the turbo charger significantly increases the power of the engine through greater combustion.



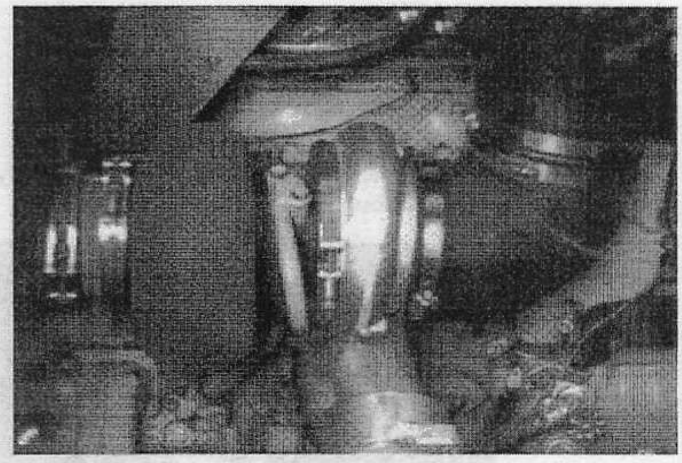
The turbo charger
(Courtesy: Caterpillar)

A turbo charger (sometimes called a turbo blower) has a shaft which has:

- exhaust gas turbine blades on one end and
- rotary air compressor blades on the other end.

The shaft rotates in bearings which can be lubricated from the engine driven oil pump. Alternatively, the bearings may have their own reservoir which forms part of the turbo charger. These reservoirs usually have round oil level sight glasses with two horizontal lines marked to indicate the high and low levels.

Exhaust gases flow from each cylinder into the exhaust manifold and then past the turbine blades of the turbo charger. With the engine running at full speed, the turbo charger can obtain a speed in excess of 100,000 revolutions per minute (rpm).



Internal View of Turbo Charger

(Courtesy: Caterpillar)

The rotary air compressor blades will revolve at the same speed. Air is drawn through the air cleaner and forced under pressure into the intake manifold. When the inlet valve opens on the induction stroke with the piston descending in its cylinder, air is forced into the cylinder.

The turbo charger causes a larger mass of air into the cylinder to that of a same cubic capacity, normally-aspirated engine. This allows for a proportional increase in the amount of fuel that can be injected and burnt in the cylinder thereby providing an increase in the power output of the engine.

Care should be taken to allow the turbo charger time to cool down before stopping the engine. The engine should be idled for a period of 2-3 minutes to allow the high temperatures that are generated to dissipate. The idle down period is also important if the turbo charger is lubricated by oil from the engine. The oil flow will stop immediately after the engine stops.

Practical Activity

Inspect a model or working fuel injector and turbo charger.

Ensure you are familiar with components and how they function.

You will be asked to explain their function as part of your assessment.

Keep any notes here that will assist you remember and understand these components.

1.7 The engine water cooling system

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.

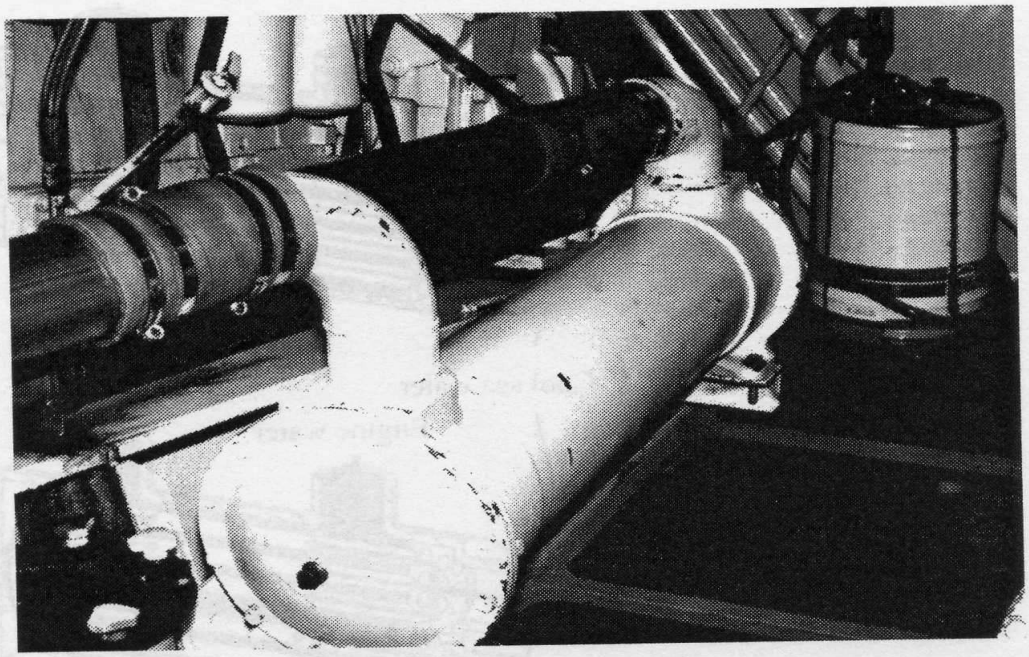
The two most common heat exchanger systems are:

1. A tube nest cooler
2. A keel cooler

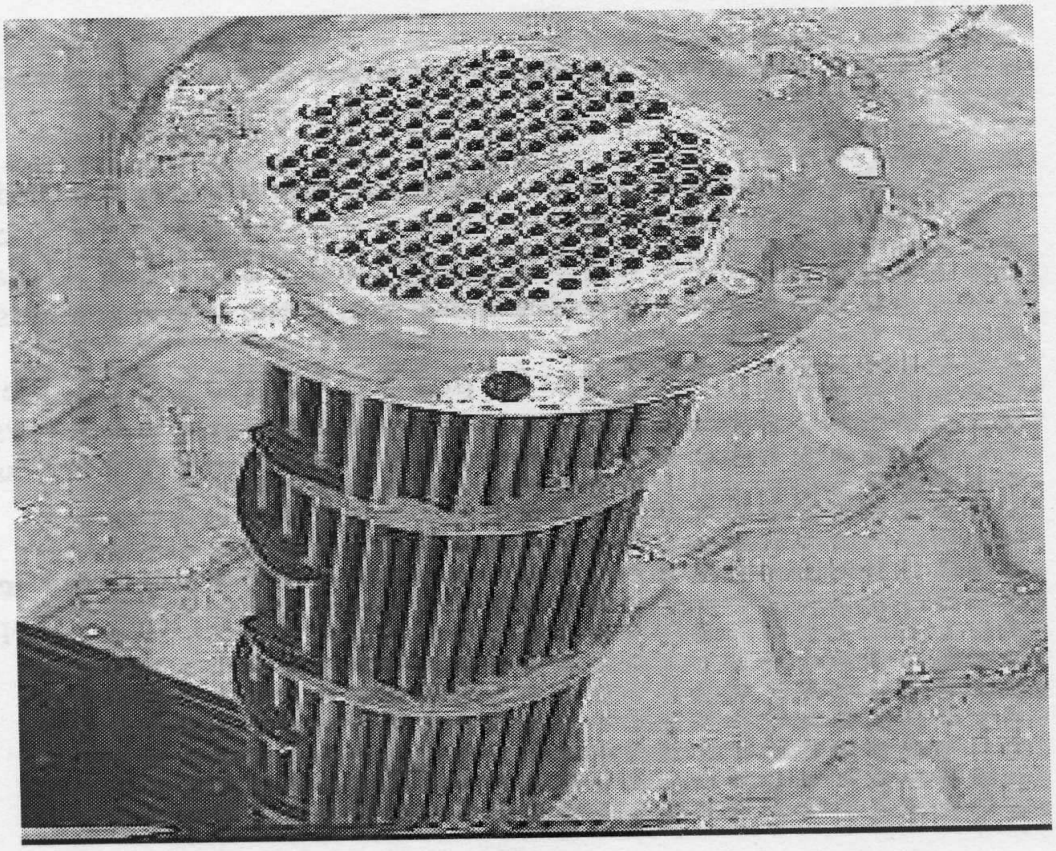
Fresh water circulation through the engine is common to both systems. When the engine is cold, a thermostat circulates the fresh water by passing the tube nest cooler and keel cooler. When the engine heats up the thermostat, allows the fresh water to circulate through the tube nest or keel cooling system.

Tube nest cooling system

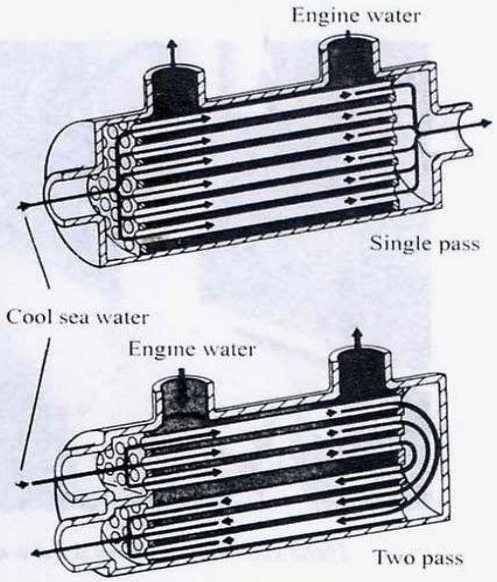
Two pumps are used and both are powered by the main engine. The first pump circulates fresh water through the engine water jackets and through the tube nest cooler when the engine is hot. The second pump circulates sea water.



Heat Exchanger from a tube nest cooling system.



Internals of a heat exchanger from a tube nest cooling system.



Internals of a heat exchanger from a tube nest cooling system.
(Courtesy: Caterpillar)

The second pump draws sea water through a rose or 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.

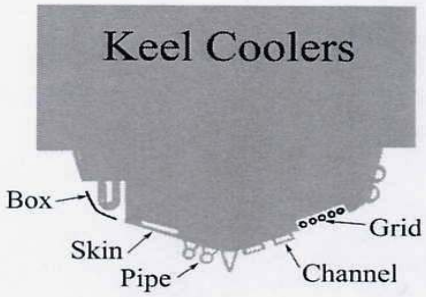
The sea water then flows through the tubes in the tube nest cooler and then overboard. The cooler is located after the sea water pump.

Keel cooling system

In this system, fresh water is circulated through the engine. When hot, the thermostat directs water flow through a pipe mounted externally on the hull below the waterline. The sea water on the outside of the keel cooling pipes cools the fresh water on the inside. The sea water pump is eliminated, however a pump is required to circulate the fresh water within the system.

As the fresh water remains in the system, keel cooling has the advantage that there is no possibility of the system becoming clogged by foreign matter which could enter the sea water cooling system.

The disadvantage is that marine growth on the external pipe will impair the transfer of heat. The vessel would have to be slipped to clean the keel cooling pipe.



Types of external piping mounted on the hull in a keel cooling system

Practical Activity

The system detailed above is a simple arrangement.

Have your facilitator show you a complete cooling system on a vessel which will cover all other types of coolers (eg oil coolers) and any other components found in typical cooling systems.

Practical Activity

Ask your facilitator to show and explain a simple water cooling system.

Practise your understanding by explaining back to them what you have learnt.

Write any key points to study and learn here:

Check Your Progress

1. Name two reasons why lubrication is necessary for diesel engines:

2. Explain how a typical fresh water cooling system works. How does it remove the heat from the engine?

3. Where are fuel injectors located? Explain how fuel is forced into the cylinder and why:

4. Explain how combustion occurs in the engine and how this is converted to power (energy):

Check your answers on the next page.

Answers to Written Activity 1

	1	2	3	4
Stroke	Induction	Compression	Power	Exhaust
Inlet Valve	Open	Closed	Closed	Closed
Exhaust Valve	Closed	Closed	Closed	Open

Answers to Written Activity 2

5	Piston	6	Crankshaft
2	Cylinder head	12	Block
4	Connecting rod	3	Cylinder
7	Valve	8	Rocker arms
1	Flywheel	10	Camshaft

Answers to Check Your Progress

1. Lubrication is to

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

Check all other answers in the text and with your facilitator.

Assessment Criteria

Can you now:

- ❑ describe the principles of operation of two stroke and four stroke cycle marine engines
- ❑ explain the basic construction of a marine diesel engine
- ❑ describe the lubrication system of an inboard engine
- ❑ identify the fuel injection pump and the injector and explain their functions
- ❑ identify the turbo charger and explain its function
- ❑ identify the cooling water heat exchanger and components and explain their functions
- ❑ explain the operation of a simple sea water cooling system and identify the components
- ❑ explain the function of basic engine components such as the piston, the connecting rod and the valves.