Alpha Series Workshop Manual

LPA, LPW, LPWT, LPWS and LPWG

P027-08240

Manual Contents

page

Introduction

The purpose of this manual is to give information, operating, maintenance and repair procedures for the 'Alpha' series of industrial, marine and gas fuelled engines.

The manual is designed primarily for use by qualified technicians with electrical and mechanical experience.

This work can only be carried out if the necessary hand and service tools are available. When the user has insufficient tools, experience or ability to carry out adjustments, maintenance and repairs then this work should not be attempted.

Where accurate measurements, or torque values, are required they can only be made using calibrated instruments.

Under no circumstances should makeshift tools or equipment be used, as their use may adversely affect safe working procedures and engine operation.

The specification details given apply to a range of engines and not to any one particular engine. In cases of difficulty the user should consult the local Lister Petter Distributor or Dealer for further advice and technical assistance.

The information, specifications, illustrations, instructions and statements contained within this publication are given with our best intentions and are believed to be correct at the time of going to press. Our policy is one of continued development and we reserve the right to amend any technical information with or without prior notice.

Whilst every effort is made to ensure the accuracy of the particulars contained within this publication, neither the Manufacturer, Distributor or Dealer shall in any circumstances be held liable for any inaccuracy or the consequences thereof.

The information given is subject to the Company's current Conditions of Tender and Sale, is for the assistance of users and is based upon results obtained from tests carried out at the place of manufacture. This Company does not guarantee that the same results will be obtained elsewhere under different conditions.

Parts that have not been approved by the Lister Petter organisation cannot be relied upon for correct material, dimensions or finish. This Company cannot therefore, be responsible for any damage arising from the use of such parts and the guarantee will be invalidated.

When purchasing parts or giving instructions for repairs users should, in their own interests, always specify Genuine Lister Petter Parts and quote the Description of the Part and the Engine Serial Number.

Associated Publications

LPA, LPW, LPWT, LPWS Operators Handbook
- English P027-08182
- German P027-08182/ger
- Italian P027-08182/ita
- French P027-08182/fre
- Spanish P027-08182/spa
- Portuguese P027-08196
- Russian/English P027-09126

LPWG Operators Handbook P027-08197
Alpha Marine Operators Handbook P027-08181
LPA Master Parts Manual P027-08040
LPW/LPWS Master Parts Manual P027-08041
LPWG Master Parts Manual P027-08044
Technical Handbook P027-08247

Various technical/sales leaflets are available; please contact your Lister Petter Distributor or Dealer for details.

Training

Comprehensive training in the correct operation, service and overhaul procedures of engines is available at the Lister Petter International Product Training Centre.

Please contact Lister Petter for details.

If Problems Occur

If problems occur with your engine, or any of the Lister Petter approved accessories fitted to it, your local Lister Petter Distributor should be consulted.

There are Lister Petter Distributors in most countries of the world and details for these can be obtained from any one of the companies listed on the back cover.

Using this Workshop Manual

Each section title is given at the top of the relevant pages and a full cross reference 'Index' appears at the back of the manual.

It is recommended the individual steps contained in the various maintenance or repair operations are followed in the sequence in which they appear.

At times it may be necessary to refer to other parts of the section, or to a different section, for more specific or detailed information.

Caution and Warning Symbols

When an engine is operating or being overhauled there are a number of associated practices which may lead to personal injury or product damage.

The symbols are shown and described on the next page.

⚠ WARNING

Unauthorised adjustments to the emission compliant fuel injection pump may invalidate warranty claims.
In the USA, unauthorised adjustment of emission critical components is prohibited by Federal Law, incurring civil penalty.

Section 01. General Information

01.1 SAFETY PRECAUTIONS AND SAFE WORKING PRACTICES

At all times follow the recommended precautions and safe operating and working practices.

The following are of a general nature and more specific information appears where it is relevant.

Caution and Warning Symbols

⚠ CAUTION

This caution symbol draws attention to special instructions or procedures which, if not correctly followed, may result in damage to, or destruction of, equipment.

⚠ WARNING

This warning symbol draws attention to special instructions or procedures which, if not strictly observed, may result in personal injury.

⚠ WARNING

A WARNING SYMBOL WITH THIS TYPE OF TEXT DRAWS ATTENTION TO SPECIAL INSTRUCTIONS OR PROCEDURES WHICH, IF NOT STRICTLY OBSERVED, MAY RESULT IN SEVERE PERSONAL INJURY, OR LOSS OF LIFE.

Follow All Safety Instructions

a. Carefully read all safety messages in this manual and the safety and informative symbols on your engine and plant.
b. Starting any diesel engine can be dangerous in the hands of inexperienced people. Engine operators must be instructed in the correct procedures before attempting to start any engine.
c. Do not make any unauthorised modifications as these may affect the safe operation of the engine and put the operator at risk.
d. Ensure all starting devices are removed, or isolated, before commencing any work on the engine or plant.

Emergency Considerations

a. Be prepared with suitable equipment, and knowledge, in case a fire starts.
b. Know where to make calls to the emergency services from.
c. Ensure a third party knows where you are working and when you leave the working area.

Handling Fluids Safely

a. When working with fuel or batteries do not smoke or work near to heaters or other fire hazards.
b. Store flammable liquids away from fire hazards.
c. Do not expose pressurised containers to heat and do not incinerate or puncture them.
d. Handle fuel with care and always stop the engine before refuelling. Do not overfill the fuel tank.
e. Thoroughly clean any lubricating or fuel oil from the skin as soon as possible.
f. Rectify all fuel, coolant and oil leaks as soon as practicable and clean any spills when they occur.
g. Remove any build-up of grease, oil or debris.
h. Batteries contain sulphuric acid - if the acid has been splashed on the skin, eyes or clothes flush it away with copious amounts of fresh water and seek medical aid.

Personal Safety

a. Tie long hair close to your head.
b. Do not wear a necktie, scarf, loose clothing or necklace when working close to a running engine.
c. It is advisable to remove rings and other jewellery to prevent possible entanglement in moving parts. These items could also cause an electric short circuit if any part of the electrical system is being worked on.
d. Ensure any lifting equipment to be used has the correct capacity to lift the engine.
e. Lifting equipment must be designed to give two vertical lifts from directly above the engine lifting eyes.
f. The engine lifting eyes fitted to the engine are suitable for lifting the engine and accessory assemblies originally fitted by Lister Petter. They must not be used to lift the complete plant.
g. Do not work under any plant that is only held by overhead lifting equipment.

Protective Clothing and Equipment

a. Wear close fitting clothing and personal protective clothing and safety equipment appropriate to the work being done.
b. Wear suitable ear protection to protect against objectionable or uncomfortable loud noise.

   Prolonged exposure to loud noise can cause impairment, or loss of hearing.
c. The use of music or radio headphones could cause a loss of concentration.

Handling Chemical Products Safely

a. Direct exposure to hazardous chemicals can cause serious injury.

b. Potentially hazardous chemicals include such items as lubricants, fuel, coolant concentrate, battery acid, paint and adhesives.

c. Manufacturers Safety Data Sheets will provide specific details of the physical and health hazards, safety and emergency procedures and any necessary personal protection equipment required while working with hazardous materials.

Rotating Machinery

a. Entanglement with any rotating equipment can cause serious injury or death.

b. If unprotected skin comes into contact with rotating equipment severe burns can result.

Safe Maintenance Considerations

a. Understand the service procedures before commencing any work.

b. Ensure the work area is clean, dry, well ventilated and has adequate lighting.

c. Isolate the engine starting system before commencing any work on the plant.

d. All persons using equipment or processes in connection with the maintenance of plant and machinery must have received adequate and suitable training.

High Pressure Fluids

a. Never allow any part of the body to come into contact with high pressure hydraulic oil, compressed air or fuel oil, for example when testing fuel injection equipment.

b. Both digested and injested fluids can lead to serious injury, possibly with fatal results in a very short period of time.

Electrical System Considerations

a. Ensure that the battery is of sufficient capacity to start the engine down to its minimum operating temperature taking into account any drag that may be imposed on the engine by the type of transmission that is attached to it.

b. Ensure the battery and all engine wiring cables are of sufficient size to carry the currents required.

c. Check that the engine mounted alternator is of sufficient output to cope with the total electrical load required by the machine to which it is fitted.

d. Ensure engine wiring cables are:

Bound together in a loom and adequately supported.

Routed to avoid any hot surfaces, particularly the exhaust system.

Not in contact with any rough surfaces or sharp corners so as to avoid any possibility of chaffing taking place

Alternator Precautions

a. Never remove any electrical cable while the battery is connected in the circuit.

b. Only disconnect the battery with the engine stopped and all switches in the OFF position.

c. Ensure cables are fitted to their correct terminals. A short circuit or reversal of polarity will ruin diodes and transistors. Never connect a battery into the system without checking that the voltage and polarity are correct.

d. Never flash any connection to check the current flow or experiment with any adjustments or repairs to the system.

e. The battery and alternator must be disconnected before commencing any electric welding when a pole strap is directly or indirectly connected to the engine.

Starter Battery Precautions

⚠ WARNING

Sulphuric acid in battery electrolyte is poisonous, is strong enough to burn skin, eat holes in clothing and cause blindness if splashed into the eyes.

a. Do not smoke near the batteries and keep sparks and flames away from them.

b. Batteries contain sulphuric acid - if the acid has been splashed on the skin, eyes or clothes flush it away with copious amounts of fresh water and seek immediate medical aid.

c. Keep the top of the battery well ventilated during charging. Switch off the battery charger before connecting or disconnecting the charger leads.

d. Disconnect the battery negative (earth) lead first and reconnect last.

e. Never 'flash' connections to check current flow.

f. A damaged or unserviceable battery must never be used.

g. Do not attempt to charge a frozen battery; it may explode; warm the battery to 16°C (60°F).

Waste Contamination

a. Extreme care must be taken to ensure that waste oil, fuel, filter elements, coolant concentrate, battery electrolyte, solvents or other toxic wastes are disposed of in accordance with local regulations to prevent contamination.

b. Drains and water courses must not be used to dispose of contaminated, or waste fluids.

Oil Seals Containing Viton

Some engines may be fitted with seals or 'O' rings manufactured from 'Viton' or a similar material.

When exposed to abnormally high temperatures, in excess of 400°C (752°F), an extremely corrosive acid is produced which cannot be removed from the skin.

If signs of decomposition are evident, or if in doubt, always wear disposable heavy duty gloves.

Fuel System Precautions

a. When priming or checking the fuel injection pump timing, care must be taken to wipe spilled fuel from the outside of the engine.

b. Always fit a new joint when a union has been disturbed.

c. Special care must be taken to see that there is no leakage from the joints of the fuel pipe connection to the pump.

d. When tightening or loosening the fuel injection pump delivery connections, use two spanners to prevent the un-sealing of the fuel pump delivery valve holders.

e. When refitting the fuel pipe from the pump to injector, the connection to the injector must be tightened before the connection to the fuel pump.

   This procedure will ensure that there is no leakage from these joints.

f. It is most important that all fuel joints are tight and leak proof.

g. Always fill the fuel tank through a fine strainer, preferably at the end of the engine work period.

   If any sediment is stirred up during the process this has time to settle before the engine is used again, this will minimise the risk of condensation contaminating the fuel.

   If cans are used, avoid tipping out the last few drops.

h. Funnels are very difficult to keep clean in dusty conditions.

   Wash them before and after use and wrap them up when not required, or fill the tank direct from a small mouthed screw capped fuel can.

i. The fuel injection equipment is manufactured to very accurate limits and the smallest particle of dirt will destroy its efficiency.

   Fuel free from water and contaminants is of the utmost importance.

Precautions for Oil, Filters and Elements

a. Used liquid filters and elements contain some of the filtered liquid and should be handled and disposed of with care.

b. After handling new or used elements the users hands should be thoroughly washed, particularly before eating.

c. Fuel and new or used lubricating oil may cause skin irritation.

   Contact with used lubricating oil can cause cancer, birth defects or other reproductive harm.

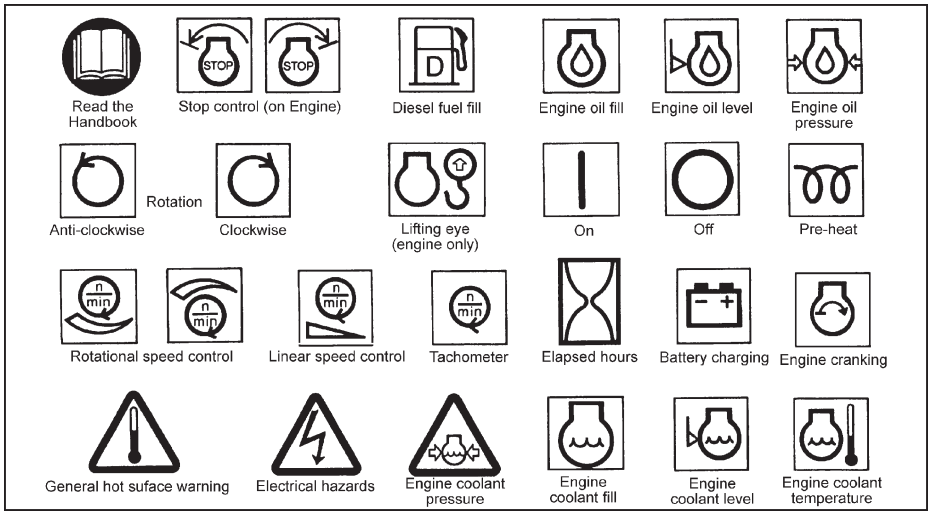
d. The materials used in the manufacture and treatment of some filters and elements may cause irritation or discomfort if they come into contact with the eyes or mouth and they may give off toxic gasses if they are burnt.

e. Extreme care must be taken to ensure that waste oil, filter elements, solvents or other toxic wastes are disposed of in accordance with local regulations to prevent contamination.

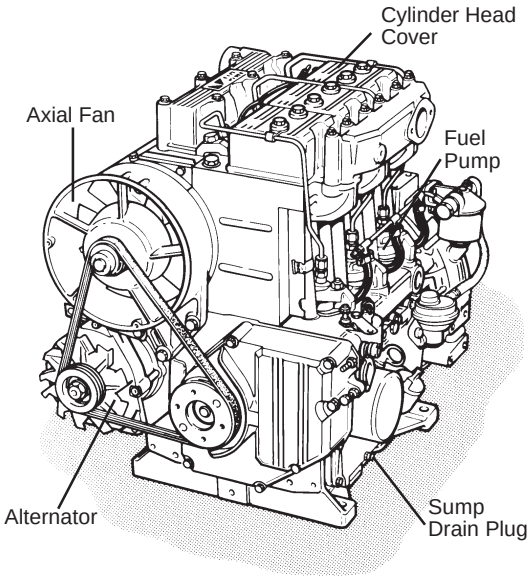
f. As a direct result of combustion the lubricating oil may contain harmful acids and therefore it should not be left in the sump if it is known that the engine will not be used for extended periods.

01.2 SAFETY SYMBOLS

This section identifies the ISO 8999 symbols currently used by Lister Petter

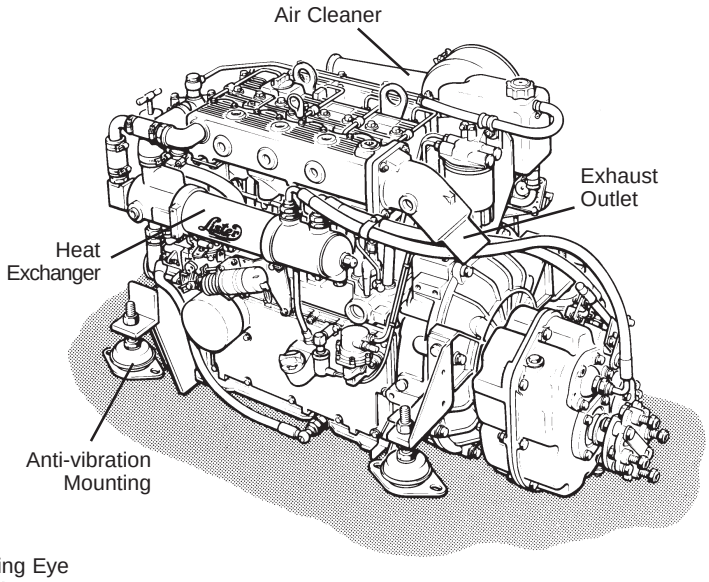


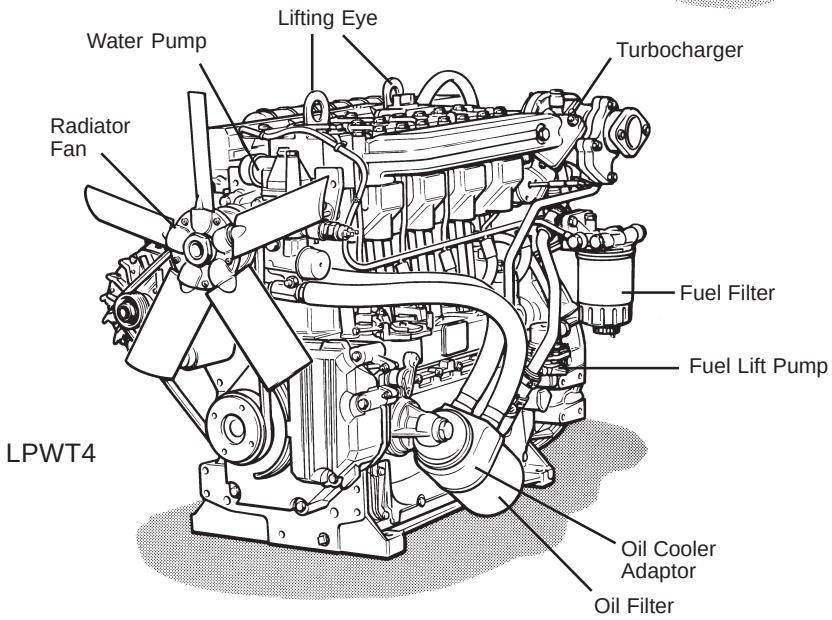
01.3 ENGINE FEATURES



LPA3

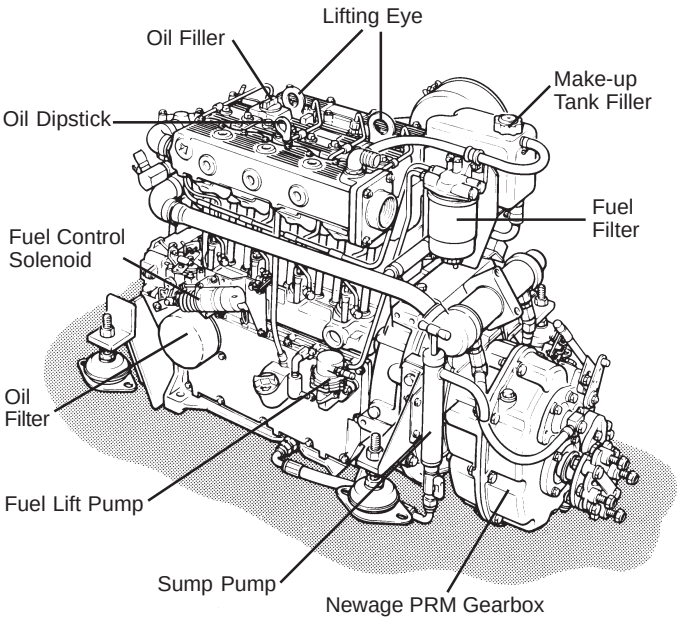
LPWS4 Marine Sail/Work Boat

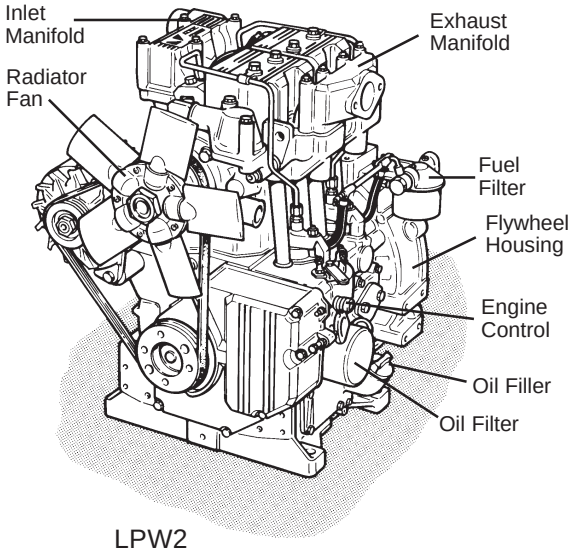




LPWT4

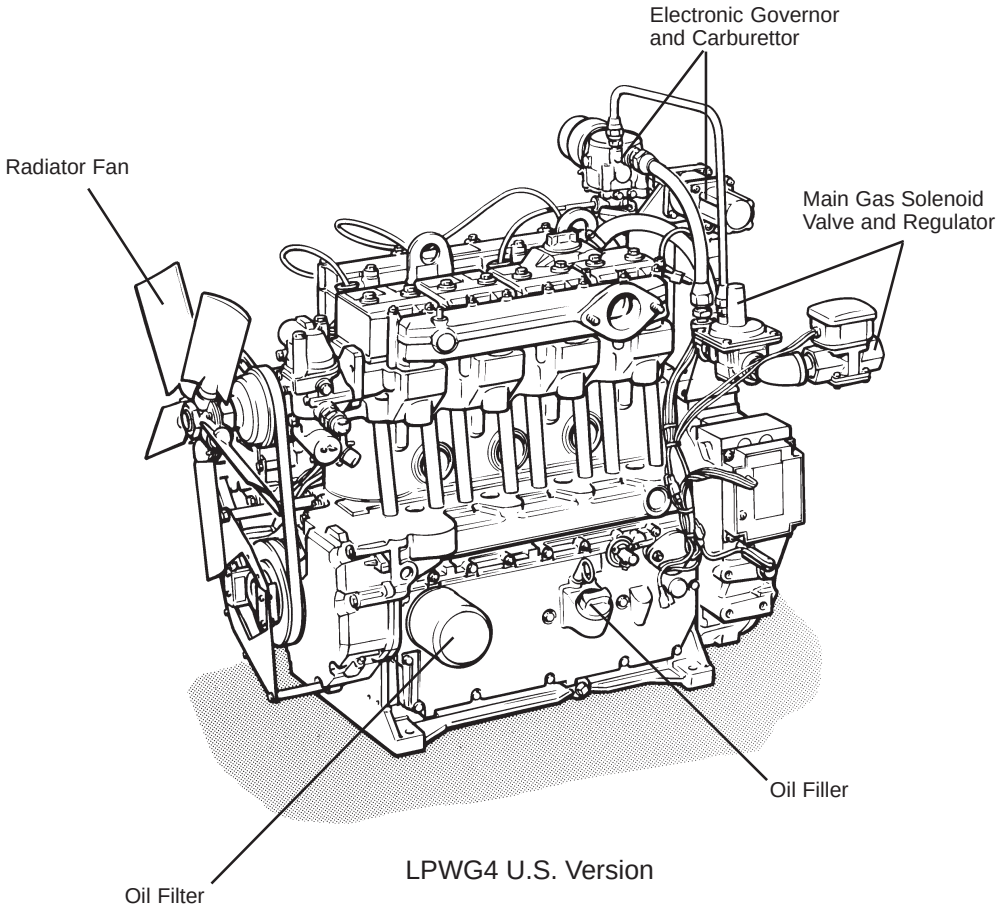
LPWS4 Marine Canal Star



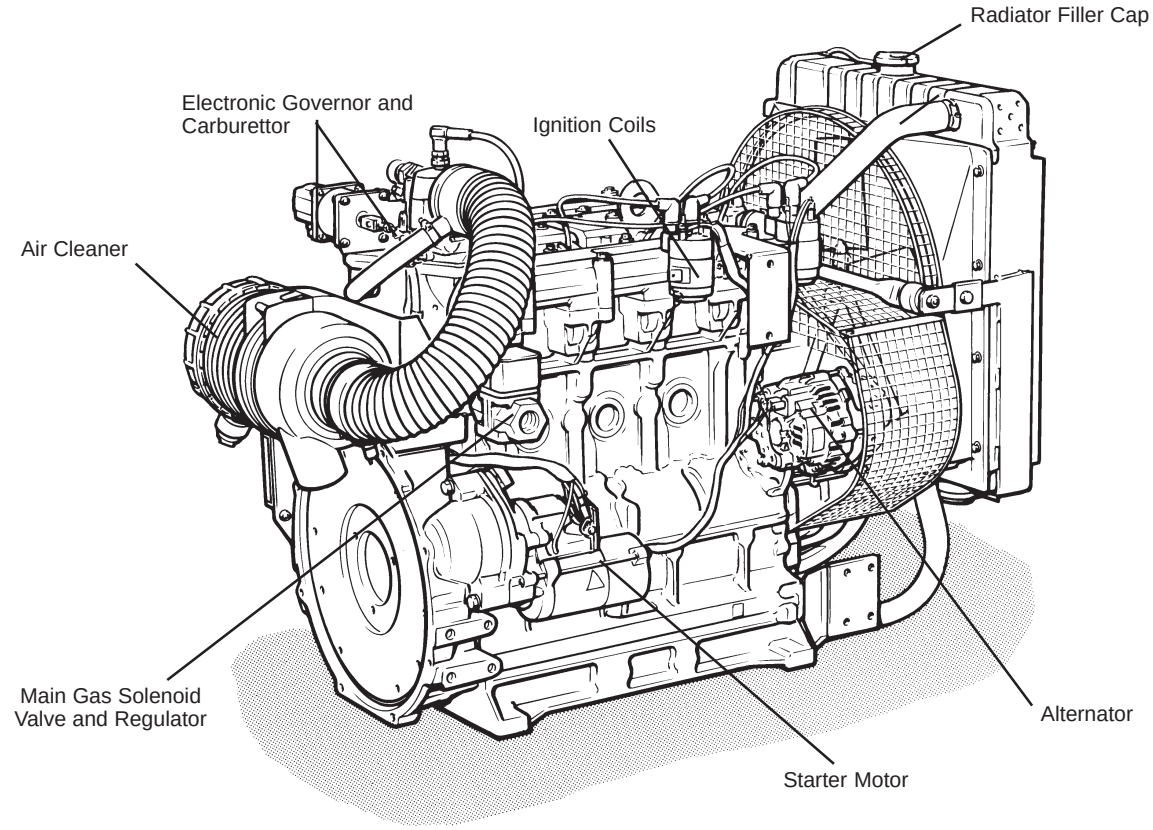


LPW2

01.3.1 ENGINE FEATURES - LPWG



LPWG4 U.S. Version



LPWG4 European Version

01.4 ENGINE IDENTIFICATION

01.4.1 Nomenclature

LPA2 and 3 - two and three cylinder, direct injection, naturally aspirated axial fan cooled diesel engines.

LPW2, 3 and 4 - two, three and four cylinder, direct injection, naturally aspirated water cooled diesel engines.

LPWT4 - four cylinder, direct injection, turbocharged water cooled diesel engine.

LPWG2, 3 and 4 - two, three and four cylinder, gas fuelled, naturally aspirated water cooled diesel engines.

LPWS2, 3 and 4 - two, three and four cylinder, indirect injection, naturally aspirated water cooled diesel engines.

01.4.2 Build Information

The engines within each range have been assembled to predetermined configurations and where the build number is preceded by a '9' this indicates that the engine is either of a non-standard configuration, or contains non-standard parts or accessories.

When new parts are required for such a build it is suggested that reference be made to Lister Petter to determine the exact engine specification and which parts are non-standard.

Where the engine serial number contains a 'G', for example GLPW3, this denotes the engine was built into a generating set by Lister Petter.

A full list of builds is given in "Section 13 - The Engine Builds".

01.4.3 Marine Builds

Marine engines are designated Builds 40, 41, 42, 43, 44, 45, 46, 47, 48 and 49.

In general 'Alpha' marine propulsion engines are designed for the following applications.

LPA - leisure and commercial craft.

LPW - workboats and commercial craft.

LPWT - workboats and commercial craft.

LPWS - canal boats.

01.4.3 Engine Serial Number

The engine serial number is stamped on a plate attached to the engine.

It is necessary to identify the type and build of each engine to enable the correct maintenance procedures, as described later in this publication, to be carried out.

An example number is shown below.

03 00123 LPW3 A 01

03 ..... Year of manufacture code (03 = 2003)
00123 ..... Consecutive number of engine
LPW3 ..... Model
(T = turbocharger, S = indirect injection)
G = gas fuelled)
A ..... Anticlockwise rotation
01 ..... Build of engine

01.5 BATTERY DETAILS

⚠ WARNING

Battery posts, terminals and related accessories contain lead and lead compounds, chemicals known to the State of California to cause cancer and reproductive harm. Wash hands after handling.

⚠ WARNING

Sulphuric acid in battery electrolyte is poisonous, is strong enough to burn skin, eat holes in clothing and cause blindness if splashed into the eyes.

01.5.1 Battery Polarity

The electrical system for all engines is 12 or 24 volt negative earth.

01.5.2 Recommended Battery Type

Heavy Duty Batteries to BS3911:982 or IEC95-1 are recommended for all engine applications.

For temperatures below -18°C (0°F), high discharge, low resistance Arctic or Alkaline batteries must be used.

Lister Petter recommend that a battery should provide a minimum cranking period of 60 seconds from a 70% charged 12 volt battery, with a minimum voltage at the end of the cranking period of 8.4 volts (16.8 volts on a 24 volt system).

01.5.3 Preparing a Battery for Use

The following procedure should be used to prepare a battery with factory sealed charge.

1. Where necessary remove the flash seal in each vent plug hole.
2. Fill with battery grade sulphuric acid of specific gravity 1.260 (1.200 for tropical climates - see Note). The temperature of this acid should not be above 30°C (90°F) before filling. The correct level is 6mm (0.25in) above the separator guards.
3. Stand the filled battery for one hour and adjust the acid to the correct level by adding more acid where necessary.
4. Charge the battery at 6-12 amps for a minimum period of 4 hours.
5. At the end of this charge period the specific gravity of the acid in any cell should not be less than 1.260 (1.200 for tropical climates).

   If the specific gravity readings are uneven or the specific gravity low, continue charging until two consecutive half hourly readings of specific gravity and charge voltage are approximately the same.

   Discontinue charging and allow the battery to cool if the temperature rises above 40°C (110°F).

Note:
Tropical climates apply to those countries or areas where the average temperature of any month of the year exceeds 27°C (80°F).

01.5.4 Connecting Batteries

It is most important to ensure that the starter battery, or batteries, are properly connected and all connections are tight.

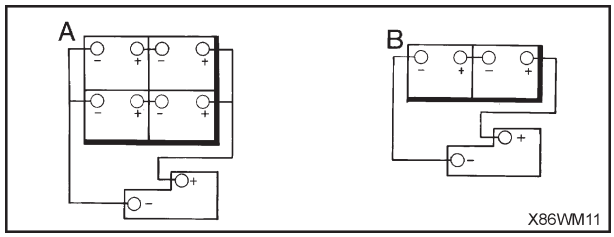


Figure 1.5.1 Battery Connections
A - 12 volt system using four 6 volt batteries connected in series-parallel.
B - 12 volt system using two 6 volt batteries connected in series.

01.5.5 Connecting a Slave Battery

A slave, or booster battery can be connected in parallel with the existing battery to aid starting in cold weather conditions.

⚠ WARNING

Heavy duty jumper leads must always be used and no attempt must be made to use any others.

⚠ WARNING

Do not allow the jumper lead free ends to directly, or indirectly touch the engine at any time.

1. Connect one end of the jumper lead to the positive (+) post of the slave battery.
2. Connect the other end of the jumper lead to the positive (+) post of the battery connected to the starter motor.
3. Connect one end of the jumper lead to the negative (-) post of the slave battery.
4. Make the final connection of the negative (-) cable to a good earth on the engine frame and away from all the batteries.

01.5.6 Disconnecting a Slave Battery

1. Start the engine.
2. Disconnect the slave battery negative (-) jumper lead first.
3. Disconnect the remaining jumper leads.

01.5.7 Servicing a Battery

In freezing weather conditions, run the engine for at least 30 minutes to ensure thorough mixing after adding distilled water to the battery.

The battery electrolyte level should be checked every 500 hours and distilled water added, if necessary, to bring the level to the bottom of each filler neck.

Keep the battery clean by wiping it with a damp cloth. If the terminals or battery posts are corroded wash them with a solution of 1 part baking soda to 4 parts of water.

To help reduce corrosion, coat the battery terminals or posts with petroleum jelly and baking soda.

01.5.8 Cold Cranking Battery Requirement

The cold cranking battery requirement table below is to BS3911 and IEC95-1.

The table below defines the recommended minimum cold cranking performance required from lead acid batteries, when tested at an ambient temperature of -18°C (0°F).

The recommendations made assume that the engine is filled with the recommended type and grade of lubricating oil and is not required to start against high inertia loads such as concrete mixers, tar boilers, hydraulic pumps, screw pumps and similar. In these applications, wherever possible, means should be provided to overcome such loads by the inclusion of clutches and unloading valves, etc.

	System Volts	Ambient Temperature Range °C (°F)			
		Above 27° (80°)	26° to 1° (79° to 34°)	0° to -8° (32° to -18°)	-9° to -18° (16° to 0°)
LPA2	12V	100A	135A	190A	315A
LPA3	12V	110A	135A	200A	355A
	24V	65A	90A	140A	245A
LPW2, LPWS2	12V	115A	150A	210A	350A
	24V	75A	90A	140A	215A
LPW3, LPWS3	12V	175A	225A	345A	600A
	24V	90A	105A	160A	285A
LPW4, LPWT4, LPWS4	12V	190A	255A	380A	670A
	24V	75A	105A	160A	300A

01.5.9 Recommended Battery Type

Heavy Duty Batteries to BS3911:982 or IEC95-1 are recommended for all applications.

For temperatures below -18°C (0°F), high discharge, low resistance Arctic or Alkaline batteries must be used.

Lister-Petter recommend that a battery should provide a minimum cranking period of 60 seconds from a 70% charged 12 volt battery, with a minimum voltage at the end of the cranking period of 8.4 volts (16.8 volts on a 24 volt system).

01.5.10 Cold Starting Performance

The figures given in the table below are for bare engines only.

	Ambient Temperature Range °C (°F)				
	30° to 5° (86° to 41°)	4° to -15° (39° to 5°)	-16° to -25° (3° to -13°)	-26° to -32 (-15° to -26°)	Below -32° (-26°)
LPA, LPW, LPWS	A - D	B - D - F	C - D - I	C - D - I - G	C - D - I - G - H
LPWT4		B - D - F - I			

1.15.7.1 Table Code

A. 15W/40 Lubricating oil in the sump.
B. 10W/30 Lubricating oil in the sump.
C. 5W/20 Lubricating oil in the sump.
D. 12 volt starting.
E. Air inlet manifold heater energised while cranking.
F. High discharge, low resistance artic type or alkaline batteries.
G. Heating of the engine and batteries in a housing or engine room.
H. Air inlet manifold heater energised for pre-heat and while cranking.

Section 02. Engine Servicing and Adjustments

02.1 PRELIMINARY INSTRUCTIONS

⚠ WARNING

Maintenance must be performed by qualified persons who are conversant with the hazards of fuels, electricity and machinery.
Before commencing any work on the engine read the "Safety Precautions and Safe Working Practices" at the front of this manual.

Dismantling and Rebuilding

When the engine is being dismantled all items must be identified and retained in their respective cylinder orientation and all related components must be treated similarly.

The instructions given deal with individual components and it may be necessary to remove others before the relevant instructions can be carried out.

a. Disconnect or isolate any non-electric starting systems.
b. Disconnect and remove the battery.
c. Drain the diesel fuel and lubricating oil.
d. Drain the coolant.
e. Disconnect all services.
f. Remove any accessories or components that may be susceptible to damage when the engine is turned out of its normal plane.

⚠ WARNING

Do not attempt to remove the fuel injection pumps without referring to the relevant instructions.

⚠ WARNING

These engines are fitted with hydraulic tappets therefore it is important to follow the procedures given.

Because of the various engine configurations, and installations in which the engine can be fitted, it is not possible to give detailed instruction for each one.

Tightening torques are included in the text as necessary and in table format in "07.5 Spanner Torques". Sealing compounds and mating face instructions are given in "Section 07.4".

When assembling the engine, use the same type of lubricating oil as used in the engine to spray all moving parts during assembly. All bearings and bushes must be well lubricated during assembly.

Renew all joints, gaskets, connecting rod nuts and bolts and the cylinder head bolts.

02.2 THE AIR CLEANER

Plastic air cleaners have been available since March 2000 and these complement the existing sheet metal types.

Care must be taken to ensure that the air cleaner draws air in at a temperature not exceeding:-

a. 12°C (54°F) above outside ambient in temperate climates.
b. 6°C (43°F) above outside ambient in tropical climates.

02.2.1 The Light Duty Air Cleaner

The industrial type has a replaceable paper element, and the marine type a serviceable foam element.

The snout is normally fitted lying horizontal and pointing towards the gear end although the cleaner itself can be rotated through 360°.

1. Release the three cover clips (A).
2. Lift off the cover (B).
3. Lift out the element (C).
4. Industrial Engines:
   a. Fit a new paper element.

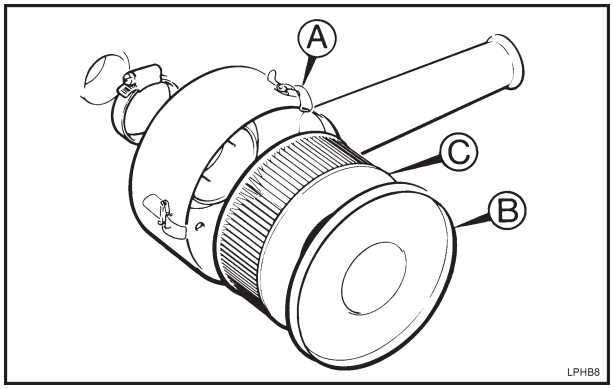


Figure 2.2.1 Light Duty Air Cleaner

Marine Engines:
   b. Wash the foam element in petrol or fuel oil.
   c. Soak the element in clean engine lubricating oil and squeeze it out to remove the excess oil.
   d. Refit the inner and outer perforated support tubes, ensure there is equal protrusion of the element at both ends.
   e. Replace the element.
5. Replace the cover and clips.

02.2.2 The Cyclonic Air Cleaner

A cyclonic air cleaner can be remote or engine mounted over the flywheel housing, both are connected to the engine by a moulded rubber hose secured by jubilee clips.

Regularly remove the dust cap (A) and empty all the dust.

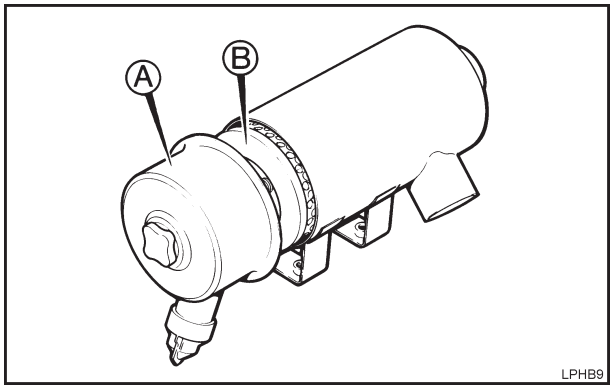


Figure 2.2.2 Cyclonic Type Air Cleaner

1. Access to the paper element (B) is gained by undoing the wing nut in the centre of the main body of the filter.
2. Remove the element.
3. The element can be cleaned by directing a low pressure compressed air nozzle up and down the pleats from inside the element.
4. Inspect the element for damage by placing a suitable light source inside it. If the element is found to have any holes it must be replaced.
5. Replace the element and dust cap.

02.2.3 Intake Restriction

The maximum intake restriction figures at full load are 254mm WG (10.0in WG).

02.3 THE MANIFOLDS

Various inlet and exhaust manifolds are available for industrial and marine engines for which full details can be found in the relevant Master Parts Manual.

The inlet manifold is secured by bolts and the exhaust by studs. There are two studs or bolts to each cylinder and these must be torqued to 9.0Nm (6.5lbf ft).

Whenever the manifolds are replaced all traces of the old exhaust gaskets and joints must be removed and new ones fitted. Current LPA engines are fitted with a joint between the top air cowl and each cylinder head inlet port.

⚠ WARNING

EXHAUST GASSES CONTAIN CARBON MONOXIDE WHICH IS A COLOURLESS, ODOURLESS AND POISONOUS GAS THAT CAN CAUSE UNCONSCIOUSNESS AND DEATH.

02.3.1 The Inlet Manifold Restrictor

Some inlet manifolds, as shown in the table below, are fitted with a restrictor. The restrictor is secured in position with Hylosil 303.

	Builds
LPA2	08 58 79 81
LPA3	07 08 57 74 79 81 113
LPW2	18 27 28 41 57 58 74 79 81 177
LPW3	18 27 28 41 74 79 81 113 177
LPW4	18 27 28 41 57 74 79 81
LPWS2	18
LPWS3	07 18 41 57
LPWS4	18 57

2.3.2 Inlet Manifold Cold Start Aid

To provide additional heating of the combustion air during starting a 345W heater plug may be fitted to the inlet manifold on LPA and LPW engines. A 696W plug is fitted on LPWT4 engines.

LPWS engines are fitted with a 12V glow plug for each cylinder as standard.

Cold start aids are not fitted to LPWG engines.

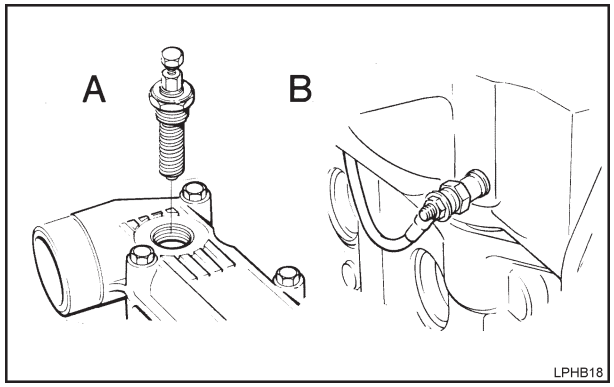


Figure 2.3.1 Heater Plugs
A - Manifold Heater Plug
B - LPWS Glow Plug

02.4 THE EXHAUST SILENCER

Various silencers and adaptors are available for industrial and marine engines for which full details can be found in the relevant Master Parts Manual.

⚠ CAUTION

Detrimental damage to the engine, or loss of performance, may be caused if exhaust gasses are sucked in by the air cleaner, the axial or radiator fan.

02.4.1 Exhaust Backpressure

The maximum permissible backpressure figures are 762mm WG (30.0in WG) except the LPWT4 which are 508mm WG (20.0in WG).

02.5 THE TURBOCHARGER - LPWT4

The turbocharger bearing is fed by a pressurised oil feed from the crankcase oil gallery to the top of the turbocharger.

A non-pressurised return to the crankcase door allows the oil to drain back to the sump.

⚠ CAUTION

Serious damage to the turbocharger bearing can result if or any reason the turbocharger housing is not full of oil. It is recommended that these engines run on 'no load' after starting for 30 seconds, to ensure an adequate oil supply to the turbocharger, and 30 seconds before stopping to allow the heat from the bearing to dissipate.

02.5.1 Removing the Turbocharger

1. Disconnect and remove the turbocharger oil feed pipe (A) and oil return pipe (B).
2. Remove the air cleaner, exhaust silencer and associated parts.
3. Support the turbocharger and remove the three mounting stud nuts (C).
4. The turbocharger can be dismantled by removing the four nuts (D).

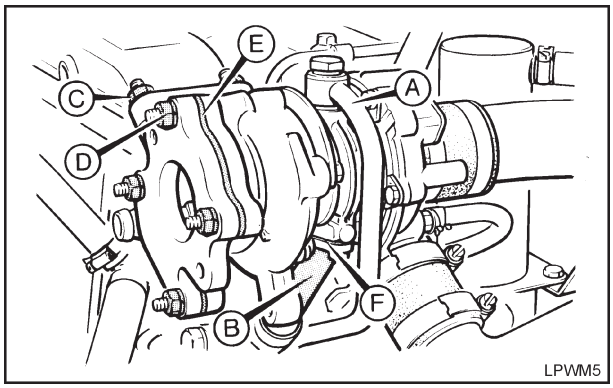


Figure 2.5.1 The Turbocharger

02.5.2 Refitting the Turbocharger

1 If the turbocharger was dismantled fit a new joint (E) and assemble the unit.

It may be an advantage to replace the three nuts and studs to aid removal at a later date.

2. Fit a new joint (F) and replace the oil feed and return pipes.
3. Before attempting to start the engine for the first time read the 'Caution' in "02.5 The Turbocharger - LPWT4".

02.6 THE CRANKCASE BREATHER

The breather canister and hoses should be checked periodically, and cleaned if there is evidence of frothy, emulsified oil blocking the passageways.

This should be done at least every 500 hours; more often in cold climates, or if the engine is started and stopped frequently without being allowed to reach normal operating temperature.

Blow-by vapours are routed to the canister through a hose connected to the cylinder head cover. Any entrained lubricating oil mist is separated in the canister and allowed to drain back to the sump through a fitting on the crankcase door.

The remaining vapours are then routed from the canister to the air inlet. This results in the blow-by vapours being re-burned in the combustion chamber, thus preventing their escape to the atmosphere.

A small amount of oil may collect in the transition sleeve and/or the carburettor air horn; this is normal.

02.6.1 LPWT4 Engines

The combined oil separator and crankcase breather is fitted above the flywheel housing and attached to the air inlet and No.4 cylinder head cover on industrial engines, No.2 on marine engines, by flexible pipes.

A restrictor (A) is fitted in the outlet hose on some builds and It is important to ensure it is replaced and pushed into the centre of the outlet hose.

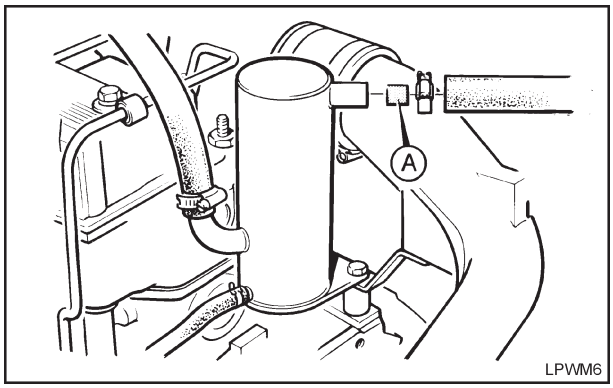


Figure 2.6.1 LPWT4 Oil Separator and Breather

02.6.2 LPWG Engines

LPWG engines feature a closed crankcase breathing system.

The combined oil separator and breather is the same as that fitted to the LPWT4. It is fitted above the flywheel housing and attached to the air inlet and the flywheel end cylinder head cover.

02.7 THE STARTER MOTOR

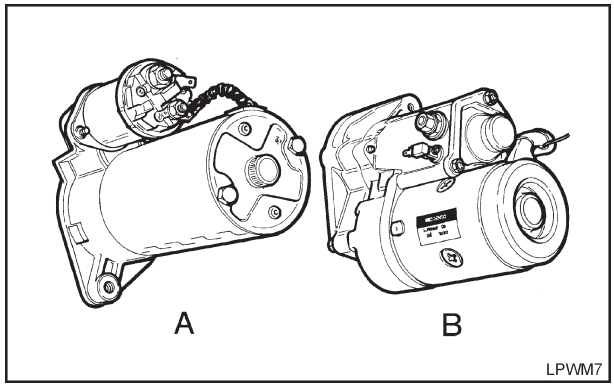


Figure 2.7.1 Starter Motors
A - Lucas
B - Denso

02.7.1 Removing the Starter Motor

1. Isolate the battery.
2. Disconnect the electrical wiring loom from the starter.
3. Support the starter motor and remove the mounting bolts.

   On 24 volt starter motors (approved applications only) the bolts pass through the starter and screw into the flywheel housing.

2.7.2 Replacing the Starter Motor

1. Isolate the battery.
2. Support the starter motor and fit the mounting bolts finger tight.
3. Torque the bolts to 41.0Nm (30.0lbf ft).
4. Replace the cable loom connections in the positions as shown in 'Figure 2.7.2'.
5. Torque the connections to the values given in "02.7.3 Starter Motor Terminal Torques".

02.7.3 Starter Motor Terminal Torques

Starter Motor		Battery +Terminal 1	Link Terminal 2
Lucas/Magnetti Marrelli	Nm	4.0-4.2	3.1-3.2
	lbf ft	2.95-3.01	2.3-2.4
Denso Starter	Nm	5.89-11.77	5.89-11.77
	lbf ft	4.34-8.68	4.34-8.68

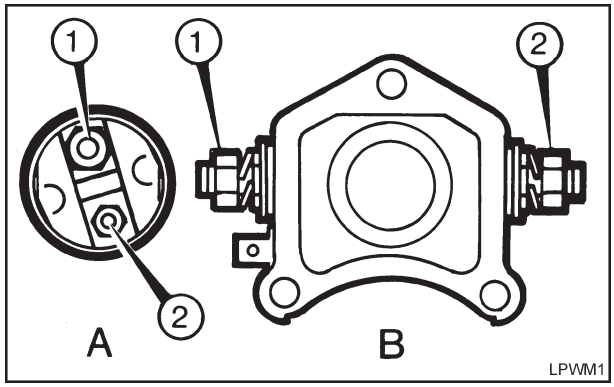


Figure 2.7.2 Starter Motor Terminals
A - Lucas
B - Denso

02.8 THE ALTERNATOR

From March 1999 a Mitsubishi 50 amp alternator has been fitted which replaced the Magnetti Marelli (Lucas) type. The alternator accessory kit codes remain the same but new parts and wiring looms have been introduced.

If an alternator is not required a jockey pulley is fitted in its place.

The alternator is belt driven at the gearcase end by a V-ribbed belt and the alternator to engine speed ratio and output is constant for all engines.

An additional 100A earth return, or 55A insulated return, alternator to power on board equipment is available as an option for some marine builds.

Industrial - 12 volt negative earth with an engine mounted 45A or 50A battery charging alternator.

Marine Canal Star - 12 volt negative earth with an engine mounted 45A or 50A battery charging alternator.

Marine Sail/Workboat - 12 volt insulated return with an engine mounted 55A charging alternator.

⚠ CAUTION

When running the engine for battery charging purposes the engine speed should be set to a minimum of 1200r/min.

02.8.1 Terminal Identification

Terminal	Mitsubishi	Magnetti Marrelli
Battery +	B	+
Warning light	L	IND
Phase tap	P	W
Regulator reference	R	not available

⚠ WARNING

The Mitsubishi 'R' terminal is for the alternator reference circuit and must be wired into the circuit.

02.8.2 Removing the Alternator

These instructions are specific to a Marelli Magnetti alternator but also apply in general to the Mitsubishi type.

1. Isolate the battery.
2. Remove the cable loom plug from the alternator
3. Slacken the alternator lower pivot bolt and nut (A).
4. Slacken the two adjuster arm retaining bolts (B).
5. Place the palm of the hand under the alternator and lift it upwards until the alternator moves towards the crankcase sufficiently to remove the drive belt.
6. Support the alternator and remove the bolt from the slotted section of the adjusting arm.
7. Support the alternator and remove the lower pivot bolt and nut.
8. Lift the alternator clear.

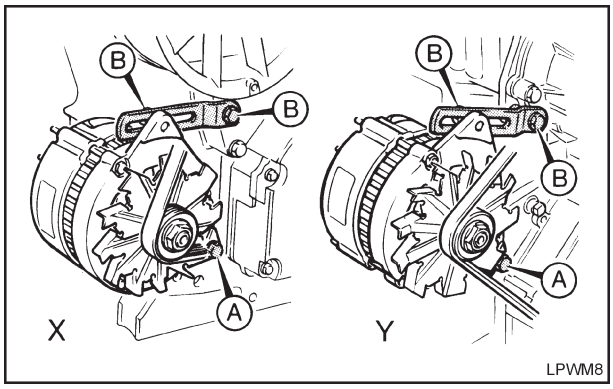


Figure 2.8.1 Magnetti Marelli Alternator Adjustment Arm
X - LPA
Y - LPW/LPWS

02.8.3 Replacing the Alternator

1. Hold the alternator in position and replace the lower pivot bolt and nut.
2. Replace the alternator adjusting arm bolts finger tight.
3. Ensure the adjusting arm is fitted with the offset the correct way round for the type of engine as shown in 'Figure 2.8.1'
4. Place the palm of the hand under the alternator and lift it upwards until the alternator moves towards the crankcase sufficiently to replace the drive belt by hand.
5. Move the alternator outwards as far as possible by hand and tighten the pivot and adjusting arm bolts.
6. Tension the drive belt as described in "02.9 Drive Belt".

02.9 THE DRIVE BELT

It is important that the tension of the drive belt is checked after the first 50 hours, after an overhaul, after a new belt has been fitted and as specified in "07.3 Routine Maintenance - Schedule Hours".

The belt is manufactured from specific materials and construction. No other belt than that specified must be used.

The crankshaft and driven pulleys must have a smooth finish to the grooves, and be aligned within 1.6mm (0.061in), measured at the centre of the grooves.

⚠ CAUTION

The belt must be slackened and fitted to the pulleys by hand, under no circumstances must it be levered or wound on. The belt must be replaced every 2000 hours, irrespective of its condition.

02.9.1 Tensioning the Drive Belt

When a new belt is correctly fitted and tensioned a force (F) of 31.0-33.5N (7.0-7.5lbf) is required to deflect it a distance (d) of 3.5mm (0.14in).

On subsequent checking and adjustment a force (F) of 22.0-24.0N (5.0-5.4lbf) is required to deflect it a distance (d) of 3.5mm (0.14in).

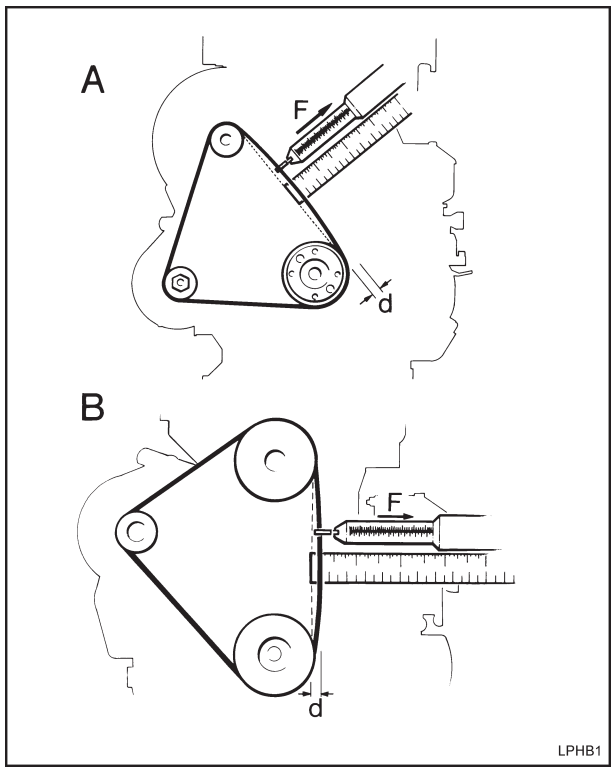


Figure 2.9.1 Checking Belt Tension
A - LPA
B - LPW, LPWS

⚠ CAUTION

To ensure the correct measurement is obtained the tensioning measurement must only be taken on the longest length between pulley centres.

02.10 THE FUEL TANK

A 12.0 litre (2.5 gal; 3.0 US gal) polypropylene tank, with a screw-on filler cap is available as an optional accessory. The tank is secured by two nylon webbing straps tensioned at the base.

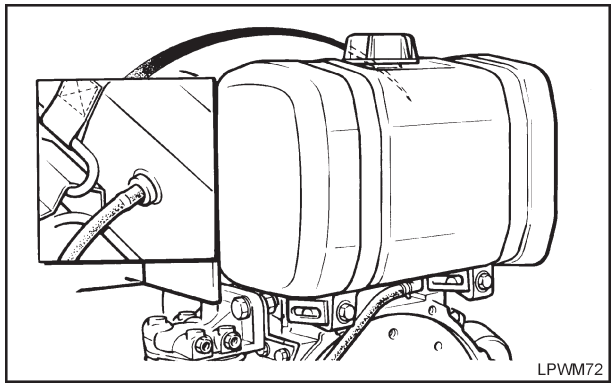


Figure 2.10.1 The Fuel Tank

02.10.1 Removing the Fuel Tank

1. Drain the fuel tank into a clean receptacle.
2. Either, remove the fuel pipe at the filter inlet or, use a pair of pliers to squeeze the tails of the fuel pipe clip at the tank outlet end together sufficiently. Move the clip sideways along the pipe and pull the pipe off.
3. Disconnect the leak-off pipe from back of the tank.
4. Slacken, or remove, the two setscrews securing the straps to the mounting bracket base.
5. Remove the tank.

02.10.2 Maintenance of the Fuel Tank

Remove any sediment from the tank and, if necessary, flush the tank with clean kerosene and allow it to drain.

02.10.3 Replacing the Fuel Tank

1. Support the tank and replace it on the mounting bracket.
2. Replace the two setscrews securing the straps and tighten them until the tank is secured.
3. Replace the fuel pipe to either the filter or fuel tank.
4. Push the leak-off pipe onto the tank.
5. Refill the fuel tank.

02.11 THE FUEL LIFT PUMP

A fuel lift pump is fitted to all engines, except Builds 71 and 72, and is operated from the camshaft by a push rod.

The pump has a maximum lift of approximately 3m (10ft) and a maximum head of 600mm (2ft).

Note:
It is recommended that the fuel lift pump diaphragm is inspected at frequent intervals if it is known the fuel is contaminated. It should also be inspected at regular intervals on engines in low duty cycle applications; for example, stand-by generating sets.

On engines not fitted with a lift pump a blanking plate is in its place. The plate is secured by two nuts torqued to 13.5Nm (10.0lbf ft). A lift pump push rod will not be fitted.

The current industrial Pienne and Corona types of lift pump are not interchangeable with the earlier AC Delco pump or the marine type. Full details can be found in the relevant Master Parts Manual.

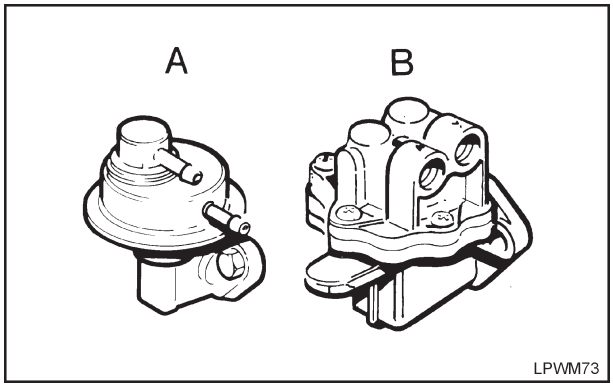


Figure 2.11.1 Fuel Lift Pumps
A - AC Delco Pump
B - Pienne/Corona Pump

02.11.1 The Marine Fuel Lift Pump

The current marine lift pump is not interchangeable with the industrial type.

The pump has a primary gauze filter fitted under the pump cap and it is important to ensure this gauze is periodically cleaned.

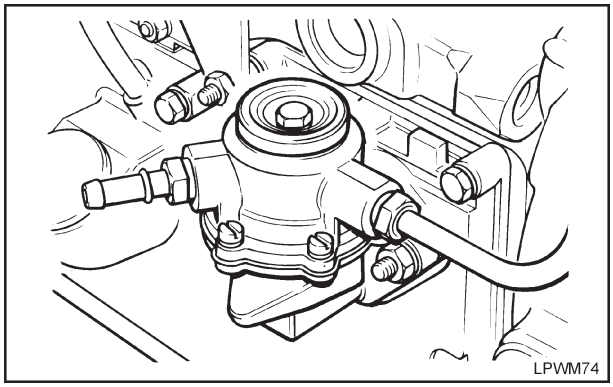


Figure 2.11.2 Marine Fuel Lift Pump

02.11.2 Replacing the Fuel Lift Pump

The fuel lift pump is operated by a push rod from the camshaft and the distance from the camshaft to the pump tappet is not adjustable.

Care must be taken to ensure that only one paper joint is fitted between the pump and crankcase.

Current pumps are fitted with plain and spring washers under the mounting stud nuts. It is recommended that plain washers are fitted to earlier pumps if this has not yet been done.

1. Remove the fuel inlet and outlet pipes from the pump.
2. Remove the two stud nuts, spring washers and plain washers.
3. Lift off the pump.
4. Remove all traces of the old joint.
5. Ensure the pump and crankcase mating surfaces are clean and dry before fitting a new paper joint.
6. Refit the pump, plain and spring washers and nuts. Torque the two nuts to 21.0Nm (15.5lbf ft).
7. Replace the inlet and outlet fuel pipes.

02.12 THE FILTER AND AGGLOMERATOR

The fuel filter is an essential part of the engine and it must never be run without a filter. The element should be renewed every 500 hours, or more frequently if for any reason the fuel is known to be dirty.

One of two types of fuel agglomerator may be fitted in place of the standard fuel filter. One type has an aluminium or clear bowl and replaceable element but the other is only replaceable as a total unit.

02.12.1 Changing the Cartridge Agglomerator

Water is drained from the agglomerator by unscrewing the drain tap (C) sufficiently to allow the water to drain.

1. Using a suitable strap wrench unscrew the cartridge (A) from the head (B).
2. Screw a new cartridge onto the head and hand tighten it.

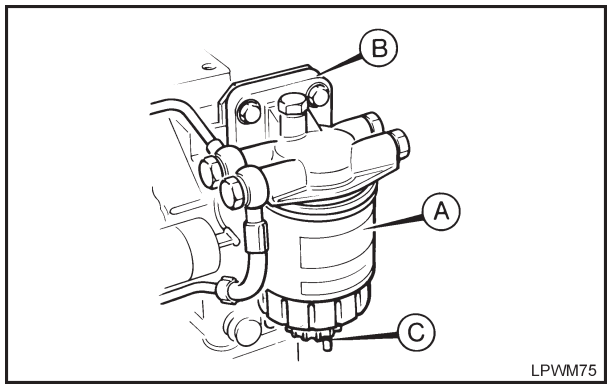


Figure 2.12.1 Cartridge Agglomerator

3. Fill the fuel tank and prime the system.
4. Run the engine and check to see that no fuel is leaking from the agglomerator.

02.12.2 Changing the Agglomerator Element

Water is drained from the agglomerator by unscrewing the drain tap (D) sufficiently to allow the water to drain.

1. Isolate the fuel supply or drain the fuel tank.
2. Unscrew the securing bolt (A) and remove the filter bowl (E) and the element (B).

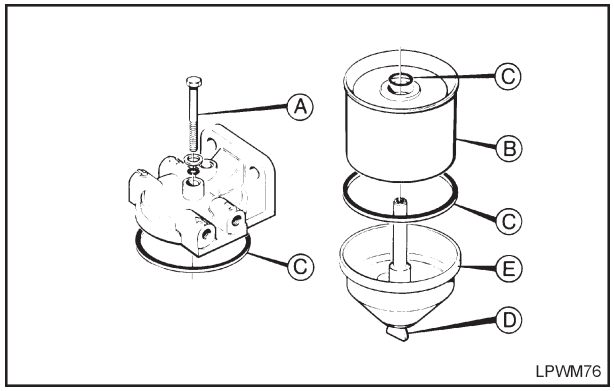


Figure 2.12.2 Fuel Filter/Agglomerator

3. Discard the element and the upper and lower sealing rings (C).
4. Wash out the bowl with clean fuel oil; do not use a cloth.
5. Fit new sealing rings to the filter head and bowl.
6. Assemble the element and filter bowl to the filter head.
7. Replace and tighten the securing bolts.
8. Fill the fuel tank and prime the system.
9. Run the engine and check to see that no fuel is leaking from the filter.

02.12.3 Changing the Fuel Filter Element

The element should be renewed every 500 hours, or more frequently if for any reason the fuel is known to be dirty.

1. Isolate the fuel supply or drain the tank.
2. Unscrew the centre bolt (A) of the filter assembly.
3. Discard the old element (B) and sealing rings (C).
4. Fit a replacement element with new sealing rings.

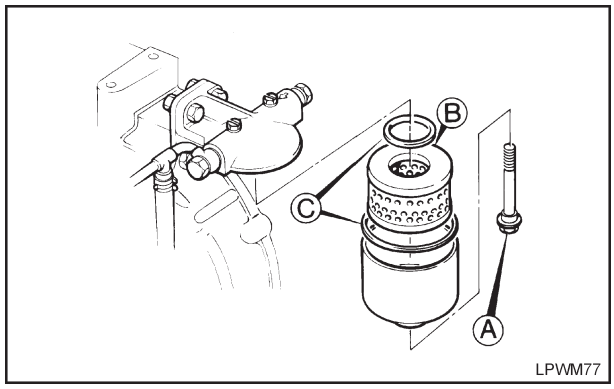


Figure 2.12.3 Fuel Filter

5. Fill the fuel tank and prime the system.
6. Run the engine and check to see that no fuel is leaking from the filter.

02.12.4 Priming the Fuel System

1. Ensure there is sufficient fuel.
2. Release the bleed screws (A) on the filter and re-tighten when no further air bubbles are expelled.

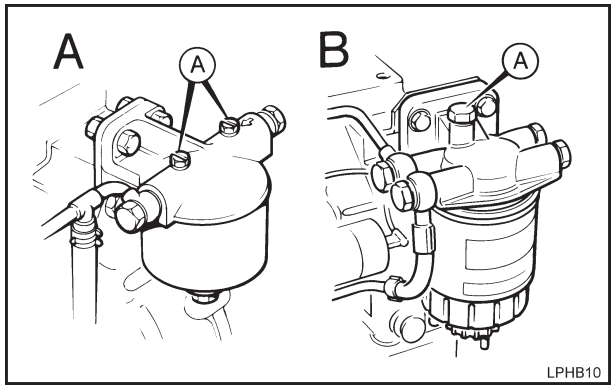


Figure 2.12.4 Priming the Fuel Filter

3. On variable speed engines, move the speed control to the fast position
4. Move the engine stop/run control from the stop, to the run position.
5. Operate the fuel lift pump by hand.
6. Tighten (A) after all air bubbles are expelled.

02.13 THE FUEL INJECTION PUMP

The individual fuel pumps are located at the side of the engine, between the push rods. They are secured to the top of the crankcase by a clamp and nut.

Each fuel pump is timed individually, using the appropriate flywheel timing degree mark. When an existing or new fuel pump is refitted, it is only necessary to refit the existing shim pack, or a new pack of the same thickness as the original.

02.13.1 Removing a Fuel Pump

To retain the governor setting leave one fuel pump in position.

1. Isolate the fuel supply.
2. Using a pair of pliers, squeeze the tails of the flexible fuel pipe clip (A) at the pump end together sufficiently to enable the clip to be moved sideways along the pipe.

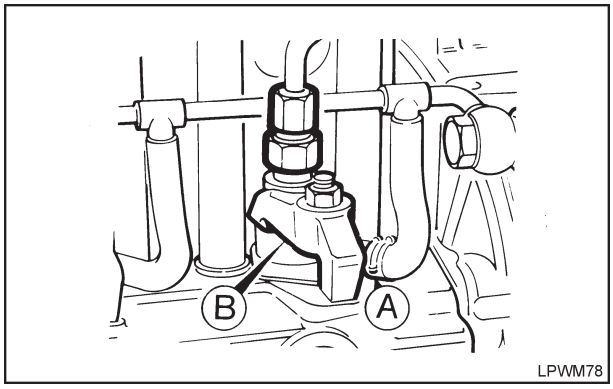


Figure 2.13.1 Fuel Pump

3. Pull the pipe off of the fuel pump.
4. Turn the engine control anticlockwise to the stop position.
5. Remove the fuel pump clamp (B).
6. Lift out the fuel pump.

⚠ CAUTION

If more than one fuel pump is being removed extreme care must be taken to ensure that the shim pack is kept with the relevant pump and cylinder.

⚠ WARNING

Under no circumstances must any attempt be made to remove the fuel pump tappet stud from the crankcase. The shims fitted between the steel plate and the fuel pump flange must not be removed or added to.

02.13.2 Servicing the Fuel Pump

No attempt to dismantle the fuel pump, other than to replace the delivery valve, must be made.

Whenever the delivery valve holder is removed a new joint must be fitted before it is reassembled and the holder torqued to 47.0Nm (35.0lbf ft).

02.13.3 Refitting a Fuel Pump

Before refitting a fuel pump, the governor must be correctly adjusted. If it has been removed or is known to be out of adjustment, refer to "02.59 Setting the Governor"

If the fuel pump tappet has been removed it must be replaced with the longer slot (A) facing outwards. This will ensure it is correctly located over the end of stud (B) which is fitted inside the crankcase.

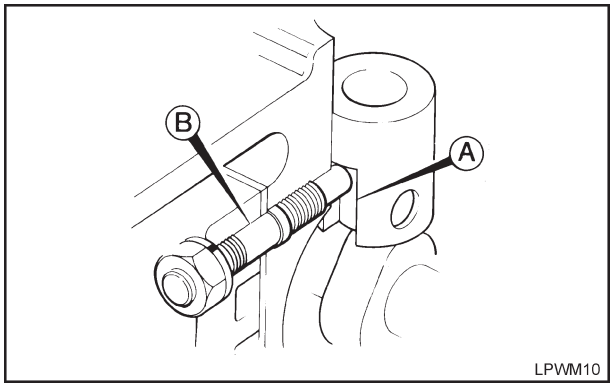


Figure 2.13.2 Fuel Pump Tappet and Stud

The tappet can be placed into the crankcase with the aid of long-nosed pliers held open against the top inside edge of the tappet recess.

1. Hold the engine control in the stop position.
2. Press down on the top of the fuel pump tappet, and slowly turn the crankshaft until the fuel pump tappet is felt to be at its lowest position.
3. Using the fuel pump rack setting gauge, 317-50114, clamp the pump rack (C) with the end protruding 55.5mm (2.18in) from the crankcase end face (D)

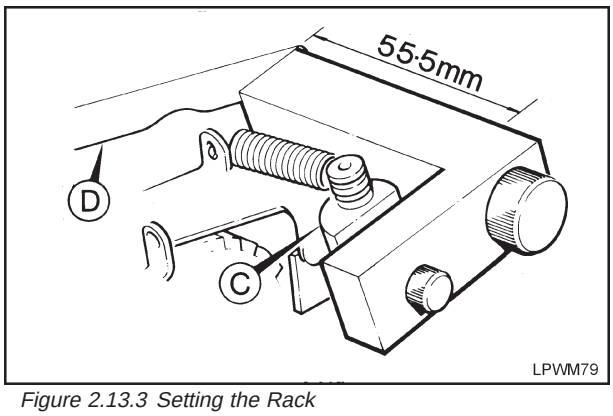


Figure 2.13.3 Setting the Rack

4. Replace the correct original shim pack to the fuel pump.
5. Gently insert the fuel pump, and shims into the crankcase taking care to ensure that the fuel pump rack engages with the slot in the governor rack.
6. Carefully turn the fuel pump anticlockwise until the pump rack is felt against the stop.

   Hold the pump in this position, and replace the fuel pump clamp with the bevelled face of the nut towards the clamp finger tight. Take care to ensure the pump does not move.

⚠ CAUTION

It is possible that the engine will not stop when required if

the pump is not turned anticlockwise before tightening down or it moves before, or while, being tightened.

7. Torque the nut to 34.0Nm (25.0lbf ft).
8. Replace the fuel pipes.
9. To ensure the control lever is positively stopped by the control lever stop screw and not the fuel pump stops refer to "02.61 Setting the Stop/Run Lever".

02.13.4 Fuel Pump Shims

The shims fitted by the pump manufacturer between the pump flange and the steel plate must not be removed or added to.

02.13.5 Fuel Pump Shim Packs

Extreme care must be taken to ensure that the individual shim packs that are fitted between each fuel pump plate and the crankcase are retained with their original respective cylinder.

The colour coded shims are available in three sizes:

Green ..... 0.075mm (0.003in).
Slate blue .. 0.125mm (0.005in).
Black ..... 0.250mm (0.010in).

02.14 FUEL PUMP TIMING

It will only be necessary to carry out pump timing if the original shims have been lost or mixed with those of another pump.

The following shim combinations are used to vary the timing.

Change	Shim Combination
1°	1 Green
2°	1 Green and 1slate blue
3°	1 Green and 1 black
4°	2 Green and 1 black

To advance the timing - remove shims.
To retard the timing - add shims.

02.14.1 Piston Displacement Method

The following sequence of operations must be repeated for each pump as necessary, using the appropriate firing degree mark on the flywheel.

1. Rotate the piston to TDC on the firing stroke.
2. Use a suitable probe resting on top of the piston, on the gudgeon pin axis, to accurately determine TDC.
3. Rotate the flywheel clockwise to beyond the specified piston displacement, as given in "02.15 Fuel Pump Timing Values", from TDC.

   The correct figure for the type and build of engine must be used.
4. Carefully rotate the flywheel anticlockwise until the correct piston displacement figure is reached.
5. Use a probe to measure dimension 'X' which is from the top face of the crankcase, to the top of the fuel pump tappet cap.
6. Subtract dimension 'X' from dimension 'B' to give the required thickness of shim pack to be fitted between the fuel pump plate and the crankcase.

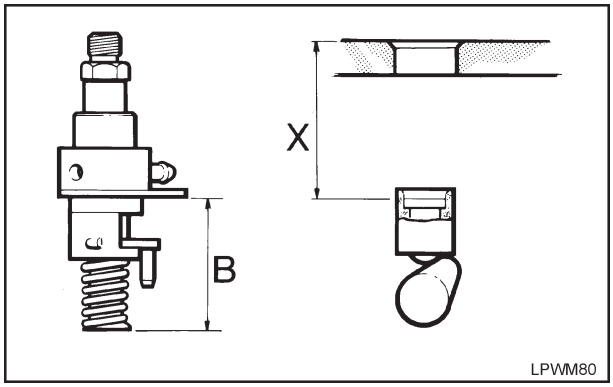


Figure 2.14.1 Fuel Pump Timing Dimension
B = 51.2mm (2.012in) at Port Closure

2.14.2 Timing Gauge Method

1. Assemble the pipe (A) to the gauge ensuring that the pipe nuts are tight.
2. Remove the fuel pipe from the pump to the injector.
3. Connect the gauge and pipe to the fuel pump delivery union for the cylinder being timed.

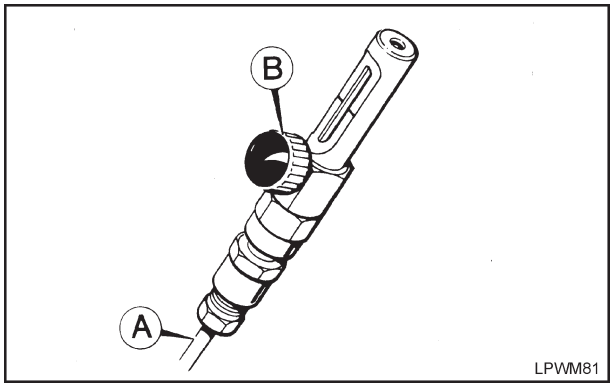


Figure 2.14.2 Fuel Pump Timing Gauge - 317-50518

4. Bleed the fuel filter and pump.
5. Ensure the fuel pump rack is in the run position.
6. Turn the flywheel in the direction of rotation to prime the gauge.
7. Turn the flywheel until the relevant timing figure is visible on the compression stroke.
8. Turn the flywheel against rotation for 50mm (2.0in).
9. Slowly release the gauge knob (B) until the fuel level is in line with the calibration mark on the gauge sight glass.
10. Turn the engine in the direction of rotation extremely slowly, until the fuel in the sight glass ***just moves.***
11. Check that the correct flywheel timing figure, as given in "02.15 Fuel Pump Timing Values", is visible.
12. Remove the gauge and replace the pump to injector pipe.

02.15 FUEL PUMP TIMING VALUES

LPA, LPW and LPWS

Build	Speed Setting	Engine	°BTDC	Piston Displacement from TDC (mm)
01, 02, 03, 04, 12, 13, 14, 16, 40, 42, 46, 48, 49, 51, 52, 70, 75, 86, 102	Variable - up to 3000r/min	LPA, LPW	20°	3.097
		LPWS3, 4		
01, 02, 03, 13, 42, 46, 48, 49, 51, 52	Variable - up to 3000r/min	LPWS2	22°	3.735
07, 57, LPWS2 41	Fixed - 1500r/min	LPA, LPW	20°	3.097
07, 57		LPWS	18°	2.519
58, 79, 113, LPWS 18	Fixed - 1800r/min	LPA, LPW	20°	3.097
58, 79, 113		LPWS	18°	2.519
11, 76, 108	Variable - up to 3000r/min	LPWS	18°	2.519
27, 28, 74, 81, LPW 41	Dual - 1500/1800r/min	LPA, LPW	20°	3.097
45, 47	Variable - up to 2800r/min	LPW	20°	3.097
		LPWS	22°	3.735
71, 72	Fixed - 1800 or 2000r/min	LPW	18°	2.519
84	Variable - 850/2500r/min	LPW	20°	3.097
10, 83	Fixed - 3600r/min	LPA, LPW	24°	4.428
104	Variable - up to 3600			
18, 173, 174	Fixed - 1800 or 2000r/min	LPW	16°	
177	Dual 1500/1800r/min	LPW	16°	
70	Variable - up to 3000r/min set at 2800r/min	LPW3	20°	3.097
		LPWS4	22°	3.735
71	Fixed - 2000r/min	LPW2, 4	18°	2.519
72	Fixed - 1800r/min	LPW2, 4	18°	2.519
73	Variable - up to 2500r/min	LPWS4	18°	2.519
75	Variable - up to 3000r/min	LPA	20°	3.097
76	Variable - up to 3000r/min	LPWS2	22°	3.735
	Variable - up to 2800r/min	LPWS3, 4	18°	2.519
79	Fixed - 1800r/min	LPA, LPW	20°	3.097
80	Fixed - 1800r/min	LPWS	18°	2.519
		LPW2	20°	3.097
81	Fixed - 1800r/min	LPA2	20°	3.097
	Fixed dual - 1500 or 1800r/min	LPA3		
		LPW		
82	Fixed - 3000r/min	LPA, LPW	20°	3.097
83	Fixed - 3600r/min	LPA, LPW	24°	4.428
84	Variable - 950 to 2500r/min	LPW4	20°	3.097
85	Fixed - 1800r/min	LPA	20°	3.097
86	Variable - up to 3000r/min	LPA2	20°	3.097

LPWT4

01, 02, 03, 04, 07, 08, 41, 42, 46, 48, 51, 57, 58, 74, 78, 79, 81, 84, 89		LPWT4	20°	3.097
01, 02, 84 Also refer to Accessory Code ZF		LPWT4	18°	2.519
09, 59, 82		LPWT4	24°	4.428

02.16 THE FUEL INJECTOR

LPA and LPW engines are direct injection and LPWS are indirect. There are differences in the fuel pipes and injector sealing washers therefore they are not interchangeable.

It is important to maintain the fuel injection equipment, all pipes and unions between the fuel supply outlet filter and the injector absolutely clean. A minute particle of dirt can easily block an injector nozzle hole and this will give rise to a dirty exhaust, difficult starting and running problems.

02.16.1 Fuel Injector Settings

	Builds	bar	atmos	lbf/in^2
LPA	All	240	237	3481
LPW	All	240	237	3481
LPWT4	07, 08, 57, 58, 81	245	242	3553
	All others	240	237	3481
LPWS	All	123-131	121-129	1784-1900

Note:
Early LPW injectors were set at the following figures but all can now be set as given above.
New ..... 205-225bar (202-222atmos).
Used ..... 200bar (197atmos).

02.16.2 Cleaning and Servicing the Injector

To ascertain if the injector is in good condition, it is removed from the engine and connected to a fuel injector test rig.

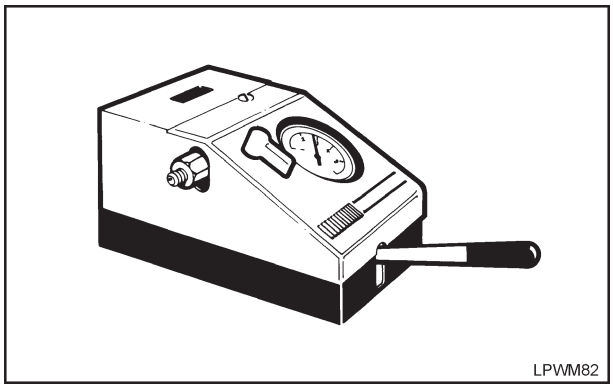


Figure 2.16.1 Typical Injector Tester

If a test rig is not available, it becomes necessary to replace the complete injector by a new or a serviced one. A serviced injector must have a clean nozzle and be set to the correct pressure. The complete faulty injector should then be sent to an accredited service depot for reconditioning.

All sprays on LPA/LPW injectors should have the same appearance, and the same length of penetration in the air. If one spray is shorter or weaker than the others this indicates that the corresponding hole is partially blocked and best engine performance results will not be obtained. If one hole is totally blocked or the nozzle dribbles it must be replaced.

If the nozzle only is replaced, the injector spring pressure must be reset and this cannot be done without the test rig.

After testing and resetting the injector top plug must be torqued to

LPA, LPW ..... 47.0Nm (35.0lbf ft).

LPWS ..... 81.0Nm (65.0lbf ft).

02.16.3 LPA and LPW Injector Back Leakage

The leak-off rate is 10-40 seconds between 152-101bars (150-100atmos) on an injector tester using Calibration C fluid, at a temperature of 15.5°C (60°F).

02.16.4 Replacing an Injector

1. Pull off the injector leak-off pipe from the injector body stub pipe.
2. Remove the cylinder head cover nut retaining the fuel pump to injector pipe clip and release the clip.
3. Hold the fuel pump delivery valve holder (B) with a spanner and slacken the pump to injector pipe nuts.

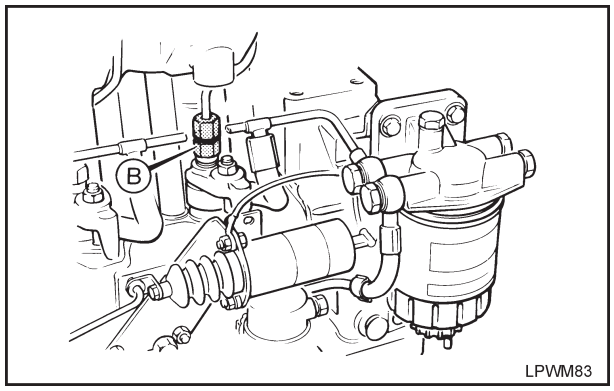


Figure 2.16.2 Delivery Valve Holder

4. Slacken the LPA or LPW injector clamp bolt.
5. Remove the pump to injector pipe.
6. LPA and LPW:
   Remove the injector clamp and lift out the injector.
   LPWS:
   Use the injector removal tool, 317-50112, to remove the injector by unscrewing it anticlockwise.
7. Remove the injector sealing washer from the cylinder head taking care not to damage the seating area.
8. Ensure the seating in the cylinder head is clean and smooth.
9. Lightly smear a very small amount of high melting point grease to one side of a new injector sealing washer and place it over the injector nozzle, greased side first.

⚠ CAUTION

If the injector sealing washer has been used more than once it may become compressed causing a leak or damage to the injector seat.

10. LPA and LPW:
    Replace the injector and clamp. Hand tighten the clamp bolt.
    LPWS:
    Screw in the injector and torque it to 68.0Nm (50.0lbf ft).
11. Replace the pump to injector pipe hand tightening the nuts.
12. Fit new rubber ‘O’ rings into the recesses on the cylinder head cover.
13. Replace the pipe clip and torque the nut to 9.0Nm (6.5lbf ft).
14. Torque the LPA or LPW injector clamp bolt to 21.0Nm (15.5lbf ft).
15. Hold the fuel pump delivery valve holder with a spanner and torque the fuel pipe nuts to 29.0Nm (21.0lbf ft).
16. Replace the injector leak-off pipe.

02.17 THE OIL SYSTEM

The lubricating oil sump forms an integral part of the cast iron crankcase and has two drain plugs; one at the gear end and the other on the filter side of the crankcase.

The oil filler and dipstick are both located on the crankcase door or cylinder head.

The oil pump, shown in "Figure 2.24.3", is gear driven from the camshaft and is fitted with a removable strainer and oil relief valve; the relief valve setting is pre-set.

Oil in the sump is drawn into the pump through the oil strainer and is then delivered by the pump through a drilling in the crankcase to the hole nearest the outside of the cartridge type oil filter base.

Filtered pressure oil passes through the centre of the filter into the oil gallery in the crankcase door and from the oil gallery it is delivered to the crankshaft and bearings.

The connecting rod big end bearings are pressure fed through internal drillings in the crankshaft from the supply to the main bearings.

Splash oil lubricates the gears, governor, camshaft and the underside of the pistons. On some engines oil jets supply oil under pressure to the pistons and governor gears.

An internal crankcase drilling provides an oil feed to the hydraulic tappets.

⚠ WARNING

New lubricating oil may cause skin irritation.
Contact with used lubricating oil can cause cancer, birth defects or other reproductive harm.

⚠ WARNING

The materials used in the manufacture and treatment of some filters and elements may cause irritation or discomfort if they come into contact with the eyes or mouth and they may give off toxic gasses if they are burnt.

⚠ WARNING

Extreme care must be taken to ensure that waste oil, filter elements, solvents or other toxic wastes are disposed of in accordance with local regulations to prevent contamination.

⚠ CAUTION

As a direct result of combustion the lubricating oil may contain harmful acids and therefore it should not be left in the sump if it is known that the engine will not be used for extended periods.

02.18 LUBRICATING OIL PRESSURE

		bar	lbf in^2
LPA	Idling	0.7	10.2
	3000r/min	2.0	29.0
LPW	Idling	1.0	14.5
	3000r/min	2.0	29.0
LPWT	Idling	1.0	14.5
	3000r/min	2.5	36.3
LPWS	Idling	1.0	14.5
	3000r/min	2.0	29.0
LPWG	1800r/min	2.0	29.0

Note:
The figures given are with the oil at 110°C (230°F) and for idling speed they are the minimum pressures.

02.19 THE OIL DIPSTICK

Extreme care must be taken to ensure the correct dipstick is returned to the engine.

Illustrations of the various dipsticks can be found in the relevant Master Parts Manual:

LPA, ... P027-08040
LPW, LPWT, LPWS P027-08041
LPWG P027-08044

02.20 OIL AND FILTER CHANGE PERIODS

Before attempting to change the lubricating oil it is essential to identify the type and build of engine and ensure the new oil meets the correct specification

To help assist engine running-in, all engines are despatched with an initial fill lubricating oil which must be changed, with the filter, after 100 hours. All subsequent oil changes must be as specified in "07.2 Oil and Filter Change Periods"

02.21 DRAINING THE OIL SUMP

Oil drain plugs are located on the oil filter side and at the gear end of the crankcase.

If the engine has been run immediately before draining the warm oil will drain quicker.

Before draining the oil sump read the precautions on the previous page.

02.21.1 Draining the Oil Sump - Marine

1. Run the engine to warm the oil.
2. Place a suitably sized container under the pump outlet (A).
3. Operate the pump handle (B) until the sump has been emptied.

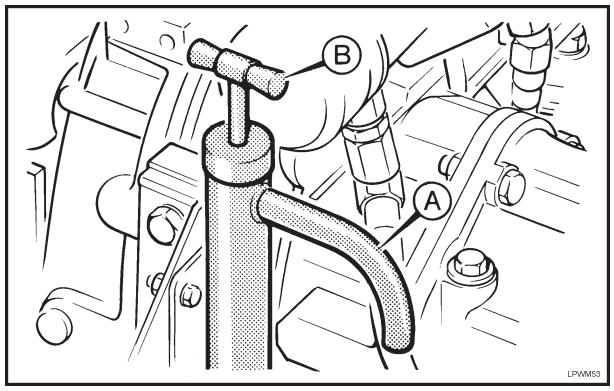


Figure 2.22.1 Oil Sump Pump - Marine

⚠ CAUTION

The pump should not be utilised to pump other liquids as these may damage the pumps non-metal components.

02.22.2 Draining the Oil Sump - Industrial

1. Run the engine to warm the oil.
2. Remove the oil filler cap.
3. Remove the oil sump drain plug and allow the oil to run into a suitably sized container..
4. Clean the drain plug threads and coat them with Hylomar PL32/M, Loctite 572 or Hylogrip 760.
5. Replace the plug and tighten it.

2.22.3 Refilling the Oil Sump

Before refilling the oil sump ensure the new oil meets the specification and viscosity as given in "Section 03. Engine Fluids".

Before filling the oil sump read the precautions on the previous page.

⚠ CAUTION

Do not overfill with oil. If a cylinder head oil filler is fitted the oil must only be poured into the filler at a rate which enables it to drain into the crankcase. If the oil is poured in too quick it can flood the crankcase breather holes and escape into the inlet manifold and cylinders.

1. Fill the sump through the crankcase or cylinder head filler (A) to the upper mark on the dipstick.
2. Start the engine, run it for a few minutes and check the drain plug does not leak.
3. Stop the engine and allow time for the oil to drain down and check the level on the dipstick.
4. Add more oil if necessary.

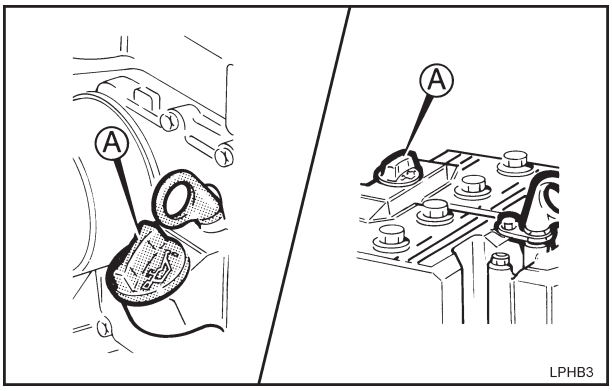


Figure 2.22.2 Oil Filler

2.22.4 The Oil Sump Capacity - less filter

⚠ CAUTION

Do not overfill with lubricating oil as this may have a detrimental effect on engine performance.

All Builds except 28, 51, 52, 57, 58, 59

	LPA/LPW/ LPWS2	LPA/LPW/ LPWS3	LPW/LPWT/ LPWS4
litres	3.00	3.75	5.50
pints	5.28	6.60	9.68
US quarts	3.17	3.96	5.81

Builds 28, 51, 52, 57, 58, 59

	LPA/ LPW/ LPWS2	LPA/ LPW/ LPWS3	LPW/LPWT/ LPWS4
litres	5.85	8.25	11.5
pints	10.29	14.52	20.23
US quarts	6.18	8.72	12.12

3.8.2 Capacity Between Dipstick Marks

All Builds except 28, 51, 52, 57, 58, 59

	LPA/LPW/ LPWS2	LPA/LPW/ LPWS23	LPW/LPWT/ LPWS4
litres	0.9	0.95	1.2
pints	1.58	1.67	2.11
US quarts	0.95	1.00	1.27

Builds 28, 51, 52, 57, 58, 59

	LPA/LPW/ LPWS2	LPA/LPW/ LPWS3	LPW/LPWT/ LPWS4
litres	1.50	1.75	2.20
pints	2.64	3.08	3.87
US quarts	1.59	1.85	2.32

02.23 THE OIL FILTER

The standard full flow oil filter is a spin-on cartridge type usually located on the crankcase door. In some applications with limited space a remote filter arrangement may be fitted.

Care must be taken to ensure the correct filter is fitted; refer to 'Figure 2.23.1'.

Only filters approved by Lister Petter should be used as these have the correct by-pass valve pressure to match the oil pump relief valve, high temperature joints, adequate filter paper characteristics and a rigid case. The fact that a proprietary filter may have the same external dimensions and thread as the genuine one is no guarantee that it will not fail in service.

02.23.1 Oil Filter Identification

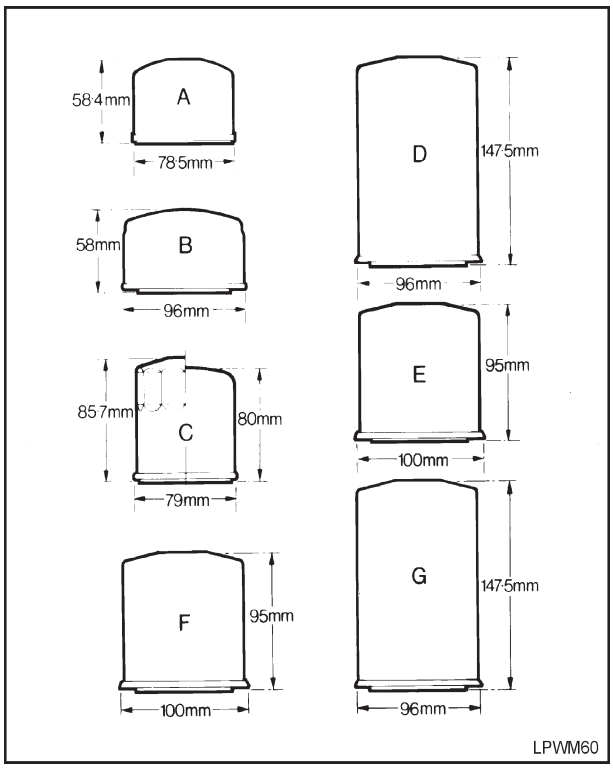


Figure 2.23.1 Oil Filter Identification and Part Numbers
A - 751-12870
B - 751-10620
C - 201-55370
D - 328-11500
E - 328-21600
F - 751-43850
G - 751-43860

02.23.2 Oil Filter Capacity

Illustration Code	litre	pint	US pint
A	0.14	0.25	0.30
B	0.23	0.40	0.49
C	0.32	0.56	0.68
D, G	0.90	1.6	1.90
E, F	0.40	0.70	0.85

02.23.3 Oil Filter Application

Illustration Code	Application
A	LPA2 Builds 01, 02, 03, 09, 10, 75, 79, 81, 83, 85, 86, 104, 105
	LPW2 Builds 01, 02, 03, 09, 10, 18, 27, 41, 42, 46, 47, 79, 81, 82, 83, 89, 102
	LPWS2 Builds 01, 02, 03, 13, 18, 42, 44, 45, 47
B	LPA3 Builds 01, 02, 03, 04, 09, 10, 75, 79, 81, 82, 83, 85, 113
	LPW3 Builds 01, 02, 09, 10, 14, 16, 18, 27, 40, 41, 42, 44, 46, 47, 48, 79, 81, 82, 83, 89, 113
	LPWS3 Builds 01, 02, 03, 07, 09, 11, 12, 13, 18, 41, 42, 47, 79
	LPW4 Builds 01, 02, 09, 10, 14, 16, 18, 27, 40, 41, 42, 44, 46, 47, 48, 79, 81, 82, 83, 84, 89
	LPWS4 Builds 01, 02, 03, 11, 13, 18, 42, 44, 46, 47, 49, 73, 79
	LPWT4 Build 84
C	LPA3 Build 74
	LPW2 Builds 72, 74, 173, 174,177
	LPW3 Build 74
	LPW4 Builds 71, 72, 74, 173, 174
D	LPW4 Builds 28, 51, 52, 57, 58, 59
	LPWS4 Builds 28, 51, 52, 57, 58, 59, 108
	LPWT4 Builds 51, 52, 57, 58, 59
E	LPA2 Builds 51, 52, 58, 59
	LPW2 Builds 28, 51, 52, 57, 58, 59
	LPA3 Builds 57, 59
	LPW3 Builds 28, 51, 59
	LPWS3 Build 57
	LPWT4 Builds 01, 02, 03, 04, 07, 08, 09, 41, 42, 46, 48, 74, 81, 82, 89
F	LPWS3 Build 76
G	LPWS4 Build 76
	LPWT4 Build 76

02.23.4 Changing the Oil Filter

Before changing the filter read the precautions in "02.17 The Oil System".

It is important to ensure the filter is correctly fitted for the build of engine.

1. Use a band type gripping tool to remove the filter from the crankcase or filter mounting bracket.
2. Lightly grease or oil the face of the rubber joint on the new filter.
3. Screw the new filter onto the filter adaptor or mounting bracket, until the rubber joint just makes contact with the crankcase or filter mounting bracket facing.
4. Screw the filter on a further quarter to half of a turn.
5. Start the engine and run it for a few minutes to circulate the oil.
6. Stop the engine and allow time for the oil to drain down and check the level on the dipstick.
7. Add more oil if necessary.

02.23.5 Filter Mounting Bracket

Care must be taken to ensure the instructions relevant to the engine and build are followed.

LPA2 Builds 51, 52, 58, 59
LPW2 Builds 28, 51, 52, 57, 58. 59

1. Tighten the bolt (A) ensuring the filter canister allows access to the oil filler.

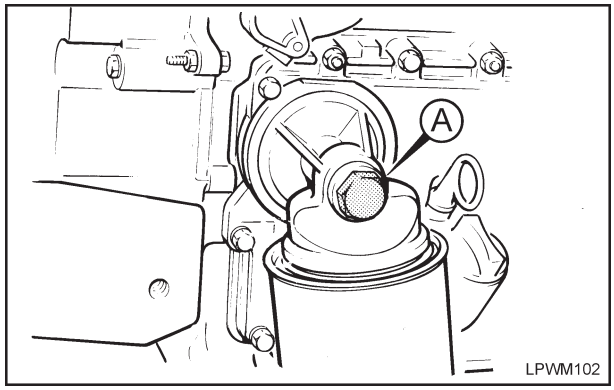


Figure 2.23.2 Oil Filter Location

LPA3 Builds 57, 59
LPW3 Builds 28, 51, 59
LPWS3 Build 51, 57

1. Tighten the bolt (A) to 9.0Nm (6.6lbf ft).
2. Tighten the bolt further to line up the bolt head 'flats' with the bracket 'horns' (B).

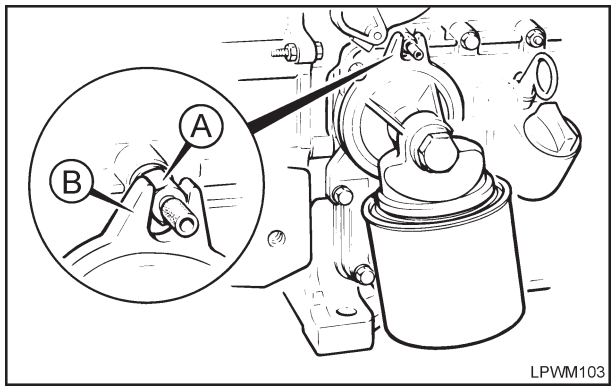


Figure 2.23.3 Oil Filter Location

LPW/LPWS4 Builds 28, 51, 52, 57, 58, 59

1. Tighten the bolt (A) to 9.0Nm (6.6lbf ft).
2. Tighten the bolt further to line up the bolt head 'flats' with the bracket 'horns' (B)

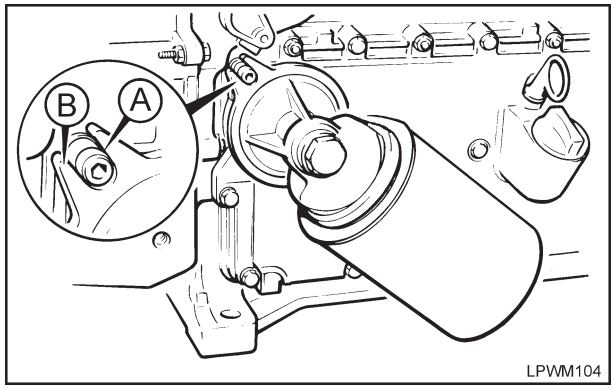


Figure 2.23.4 Oil Filter Location

02.24 THE OIL COOLER - LPWT4

The oil cooler is fitted between the filter canister and the filter adaptor and is connected to the water pump by flexible hoses.

On marine builds the oil cooler is mounted directly onto the crankcase.

Builds 07, 81 and 84 are not fitted with an oil cooler.

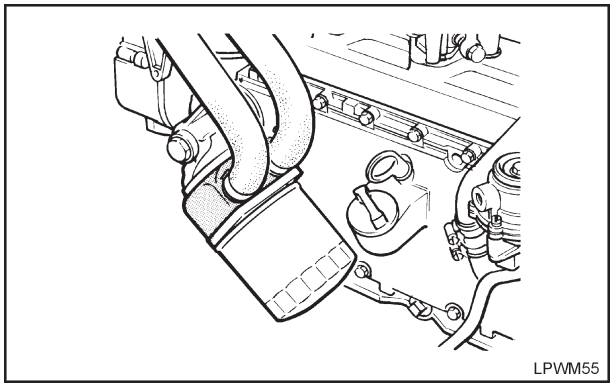


Figure 2.24.1 Industrial Oil Cooler

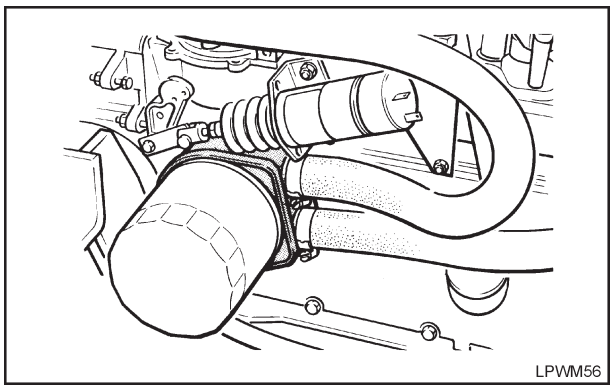


Figure 2.24.2 Marine Oil Cooler

(C) from inside the crankcase.

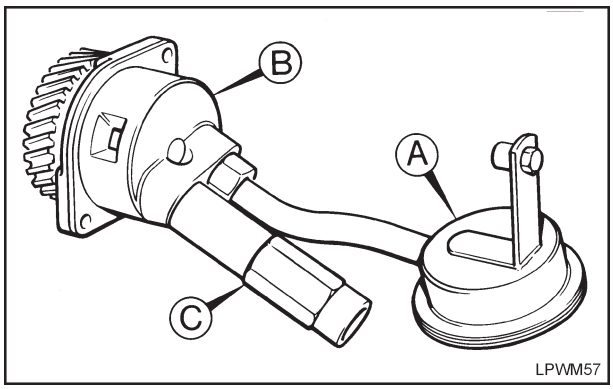


Figure.2.24.3 Oil Strainer and Pump
A - Strainer
B - Pump
C - Relief Valve

4. Remove the two pump retaining bolts.
5. Ease the pump (B) out of the crankcase.

⚠ CAUTION

To avoid possible damage to the pump flanges do not use a screwdriver or other tool to lever the pump out.

6. On early engines remove the copper washer from the pump inlet port.

02.25 THE AIR COWLING AND AXIAL FAN

LPA2 and 3 engines are cooled by an axial fan fitted at the gear end and driven by a single 'V' ribbed belt. This enables the engine to operate continuously on full load at temperatures up to 52°C (126°F).

Three sides of the engine are encased in an air cowl and two side shields, which together with the air baffles between the cylinders direct cooling air from the axial fan around the cylinders.

It is important to ensure the engine is installed where a generous supply of fresh air is assured which is not re-circulated or restricted.

Before attempting to remove the air cooling baffles or shields particular notice must be taken of their respective positions. Before or during removal it is recommended they are marked to ensure correct positioning on re-assembly.

02.25.1 Removing the Air Cowling

1. Remove the cylinder head cover nuts that are retaining the fuel pump to injector pipe clips.
2. Release the clips and replace the cover nuts.
3. Slacken the pump to injector pipe unions at both ends.
4. Slacken the injector clamps sufficient to clear the top cowling (D), if necessary.

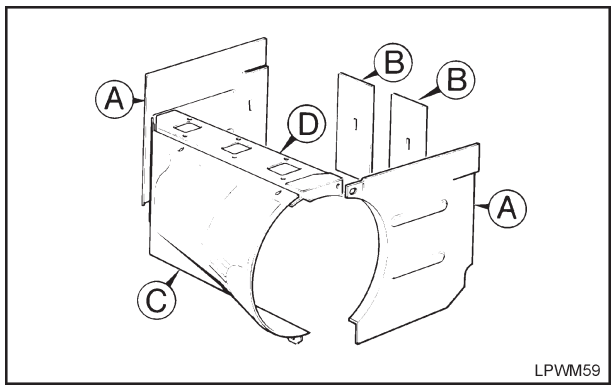


Figure 2.25.1 Air Cowling, Shields and Baffles
A - Side Shields
B - Cylinder Centre Baffles
C - Axial Fan Cowling
D - Top Cowling

5. Remove the inlet manifold and joints.
6. Detach the axial fan cowling (C) from the top cowling (D) and the bottom cowling and remove it.
7. Remove the spring clips from the push rod tubes at the gear and flywheel ends and remove the two side shields (A).
8. Remove the top cowling (D).

02.25.2 Refitting the Air Cowling

1. Replace the centre baffles (B) and fit new split pins; the baffle and split pin are fitted to the fuel pump side of the engine.
2. Fit the bottom cowling section to the crankcase.
3. Fit the top cowling section to the cylinder heads.

   An inlet manifold joint must be fitted each side of the cowling.
4. Replace the remaining air cowling and shields and tighten the retaining bolts.
5. Fit new rubber 'O' rings into the recesses on the cylinder head covers.
6. Replace the fuel pump to injector pipe securing clips and torque the nuts to 9.0Nm (6.5lbf ft).
7. Torque the injector clamp bolts to 21.0Nm (15.5lbf ft).
8. Torque the fuel pipe unions to 29.0Nm (21.0lbf ft).
9. Replace the inlet manifold and joints and torque the manifold bolts to 9.0Nm (6.5lbf ft).

02.25.3 The Air Baffles

After the axial fan cowling section has been removed the air baffles, (B) in 'Figure 2.25.1' which are fitted between the cylinder barrels, can be removed for cylinder fin cleaning by removing the split pin from the fuel pump side; note that a spring clip retains the tie in position.

⚠ CAUTION

To prevent possible injury, care must be taken to prevent the spring clip, on the axial fan side, ejecting the tie when the split pin is removed from the fuel pump side.

02.25.4 The Axial Fan

The fan blades should be checked for damage every 2000 hours, or more frequently if the application demands.

Care must be taken to ensure the air flow is unobstructed and is not being re-circulated from the driven equipment.

02.25.5 Removing and Replacing the Fan

1. Slacken the jockey pulley or alternator pivot bolt and nut.
2. Slacken the bolts at both ends of the adjuster arm (A).

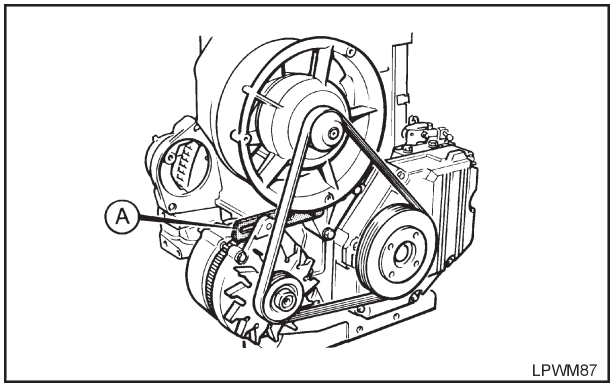


Figure 2.25.2 Removing the Axial Fan

3. Place the palm of the hand under the jockey pulley or alternator and lift it upwards towards the crankcase sufficiently to remove the drive belt.
4. Remove the bolt at the crankcase end of the jockey pulley or alternator adjusting arm.
5. Move the jockey pulley or alternator outwards.
6. Slacken or remove the axial fan side air cowling.
7. Support the fan and remove the two remaining bolts from the mounting bracket.
8. Hold the fan in position and replace the two mounting bracket bolts nearest to the crankshaft finger tight.
9. Replace the drive belt by hand.
10. Torque the first two fan mounting bolts to 21.0Nm (15.5lbf ft).
11. Tighten the remaining bolts to 21.0Nm (15.5lbf ft).
12. Replace or tighten the axial fan side air cowling.
13. Move the jockey pulley or alternator outwards as far as possible by hand and tighten the pivot bolt and adjusting arm bolts.
14. Tension the drive belt as described in "02.9 The Drive Belt".

02.26 THE CYLINDER HEAD

The individual light alloy cylinder head covers are attached to the top of the cylinder heads with two nuts and a rubber sealing ‘O’ ring under each nut.

The cover is removed to give access to the crankcase breather pipe and the valve rockers.

On LPWT4 and marine engines an oil filler is fitted into one of the covers. This arrangement is also available as an accessory.

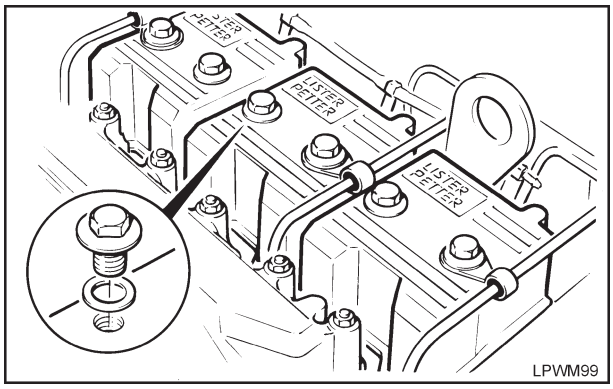


Figure 2.26.1 LPA Cylinder Head Cover

When a cylinder head cover is replaced a new joint should be fitted and the cover nuts torqued to 9.0Nm (6.5lbf ft).

All LPA engines have individual cylinder heads and gaskets, LPW and LPWS engines have monobloc heads and gaskets.

LPW4 and LPWT4 cylinder heads are not interchangeable.

LPWG cylinder heads are a modification of the direct-injection diesel head. The casting has been made slightly thicker around the injector bores to allow machining for the spark plugs. The spark plug is located on the injector centre line and the flame face of the head is flat.

LPWG2 engines are fitted with valve rockers that do not have an oil feed hole. This is due to the unique crankcase breathing characteristics of the even-fire twin, which breaths much like a single-cylinder engine. As a result the valve gear receives adequate lubrication without a direct feed.

LPWG3 and 4 engines have rocker arms with an oil feed hole in the pushrod socket.

⚠ WARNING

The two types of LPWG valve rockers are not interchangeable.

02.26.1. Removing a Cylinder Head

Detailed instructions for removing the LPA air cowling and baffles between the cylinders are given in "02.25 The Air Cowling and Axial Fan".

⚠ CAUTION

It is advisable to remove the water pump from the cylinder head as difficulty may be experienced when replacing the head with the pump still in position. Refer to "02.52 The Water Circulating Pump".

1. Remove the inlet and exhaust manifolds.
2. Slacken the fuel pump to injector pipe unions at both ends and then remove the pipe.

On LPWG engines remove the high tension leads from the spark plugs.

3. On LPA and LPW engines remove the injector clamp and lift out the injectors.

. On LPWS engines unscrew and remove the injectors.

On LPWG engines unscrew and remove the spark plugs.

4. Remove the injector copper sealing washers from the cylinder head taking care not to damage the seating area. The washer should be captive on the spark plugs.
5. On LPWT4 engines remove the breather flexible pipe from the cylinder head cover.
6. Remove the lifting eye.
7. Remove the cylinder head covers and gaskets.
8. Remove the valve rocker retaining nuts (A).
9. Remove the valve rockers (B).

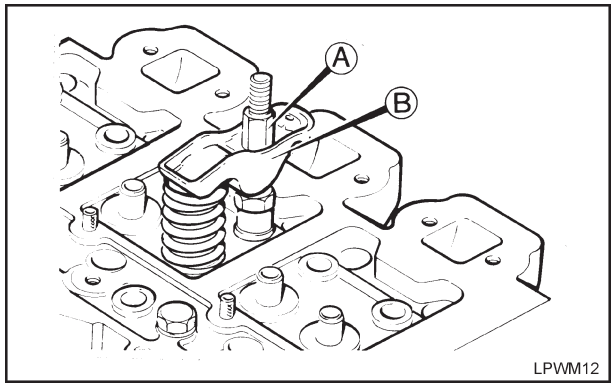


Figure 2.26.2 Valve Rocker Removal

10. Lift out the push rods, if necessary.
11. Make a note of the position of the cylinder head retaining bolts and studs.
12. Slacken the cylinder head retaining bolts; to prevent possible damage to the exhaust manifold studs a long socket should be used.
13. Lift off the cylinder head.
14. Remove the cylinder head gasket.

02.26.2 Refitting a Cylinder Head

The cylinder head clearance is 0.7-0.9mm (0.027-0.035in) and is maintained by a single gasket under the head; refer to "02.28 Cylinder Head Clearance".

When an LPA cylinder head is replaced a new gasket of the same thickness as the original must be fitted. The gasket sizes are given in "02.28.2 Cylinder Head Gaskets".

It is strongly recommended that the cylinder head bolts and the push rod seals in the crankcase and cylinder head are replaced every time the head is being refitted, except when checking the cylinder head clearance.

The push rod seals are not interchangeable and they are identified in 'Figure 2.26.3'.

If a new LPA cylinder head is being fitted it will not normally be necessary to re-check the cylinder head clearance. However, if the clearance is checked and it is found that a different size gasket from the original is necessary the remaining cylinder head clearances must be checked and the mean measurement of them all is used to determine which gasket is used. It is important to ensure that all heads have the same thickness of gasket fitted.

1. Fit the hydraulic tappets into the crankcase; refer to "02.27 The Hydraulic Tappets".
2. Lightly coat the bore of new push rod seals with grease or Hellerine Rubber Lubricant.
3. Fit the seals to the crankcase and cylinder head ensuring that the washers (C) which are fitted underneath the crankcase seals are in position.

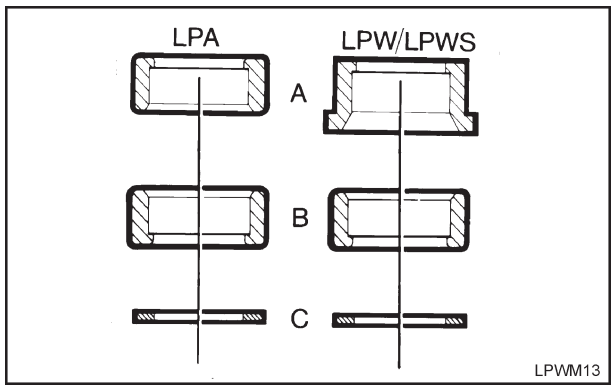


Figure 2.26.3 Push Rod Tube Seals
A - Cylinder Head Seal
B - Crankcase Seal
C - Crankcase Seal Washer

4. Place a new cylinder head gasket onto the crankcase taking care to ensure the holes in the gasket coincide with those in the crankcase.

   On LPA engines the gaskets are fitted with the raised corrugations against the crankcase.
5. Replace the push rod tubes into the crankcase, taking extreme care to ensure they are centralised and fully fitted in the seals; misalignment of the tubes can cause serious damage to the seals.
6. Very carefully lower the cylinder head into position checking that the push rod tubes engage in the tube seals. Care must be taken to ensure the push rod seals are not damaged.
7. Refer to the relevant 'Head Bolt Locations' illustration and fit new cylinder head bolts, finger tight only, with spacers (X) and washers (Y) where these were originally fitted.

   The 'A', 'B' and 'C' annotations relate to the bolt type and location.

   On LPA engines coat both sides of the spacer (X) between the cylinder head and nut section of the valve rocker stud with Wellseal Jointing Compound.

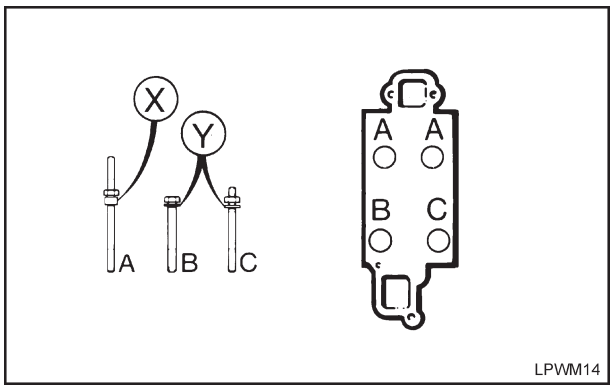


Figure 2.26.4 Head Bolt Locations - LPA

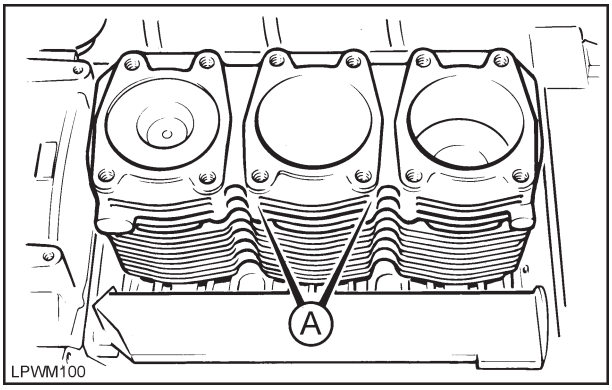


Figure 2.26.7 LPA Cylinder Barrel Bosses

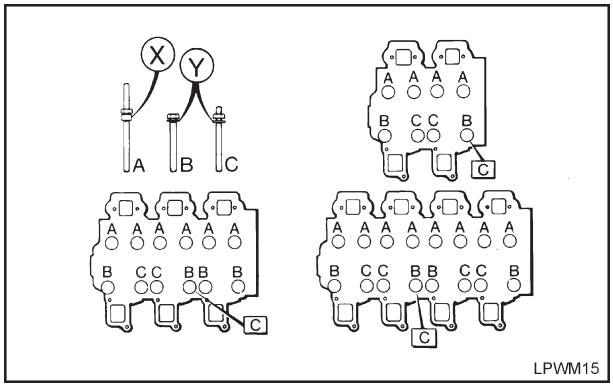


Figure 2.26.5 Head Bolt Locations - LPW /LPWS

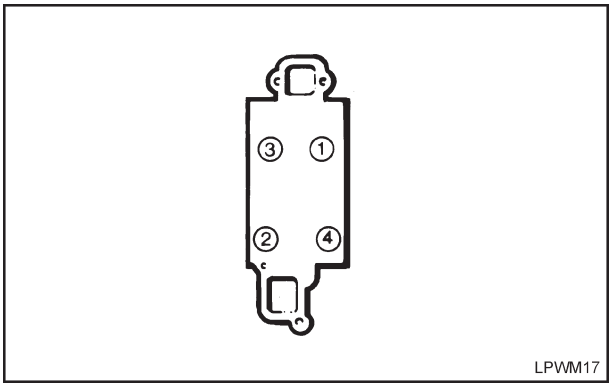


Figure 2.26.8 Head Bolt Torque Sequence - LPA

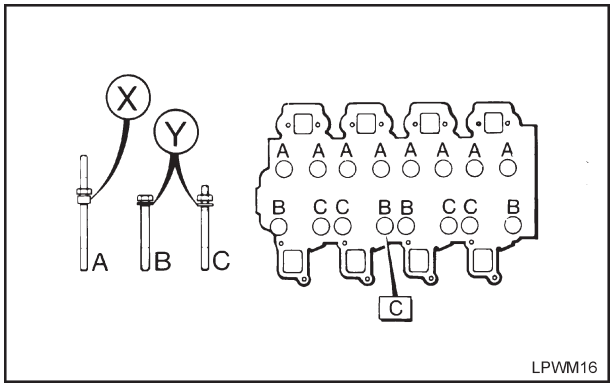


Figure 2.26.6 Head Bolt Locations - LPWT4

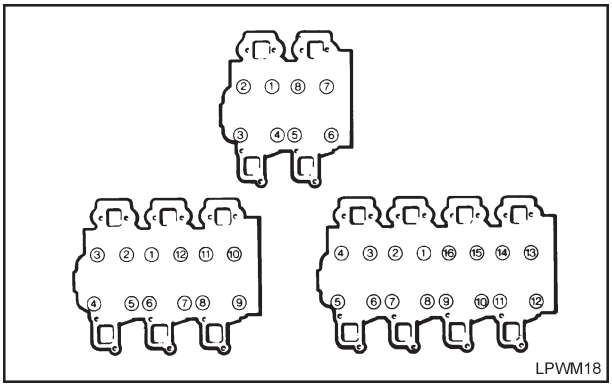


Figure 2.26.9 Head Bolt Torque Sequence - LPW /LPWS

8. On LPA engines check that all the manifold flanges are aligned by using a straight edge; any gap along the straight edge must not exceed 0.2mm (0.008in).

   Alternatively fit one manifold, without gaskets, before tightening down the cylinder head.

9. Refer to the relevant 'Head Bolt Torque Sequence' illustration and tighten down the cylinder head bolts evenly, in the sequence shown, to the final torque:

   Stage 1 - 8.0Nm (6.0lbf ft).

   Stage 2 - 48.0Nm (35.0lbf ft). See Note below.

   61.0Nm (45.0lbf ft). See Note below.

   Stage 3 - 88.0Nm (65.0lbf ft). (LPW, LPWT and LPWS only).

Notes:

The lower torque figure is used on earlier engines and the higher figure for later 'High Boss' cylinder barrels
On earlier barrels the bosses and threads are below the top fin. On the 'High Boss' arrangement the bosses and threads (A) are at the top of the barrel.

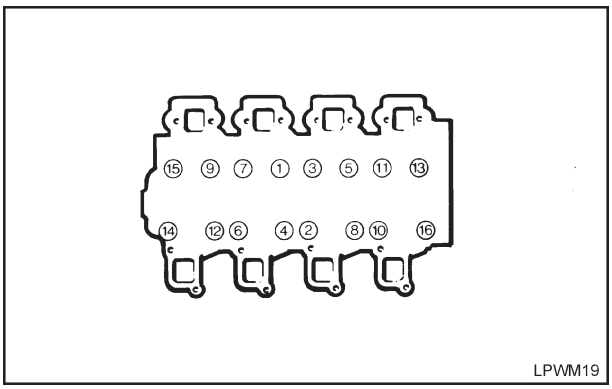


Figure 2.26.10 Head Bolt Torque Sequence - LPWT4

10. Lightly oil the pushrods and replace them.
11. Press down on the top of the push rods while very slowly turning the crankshaft until they are at their lowest point of travel.

12. Replace the valve rocker (B), pivot and nut (A).

Note:
On LPW2 Builds 71, 72 and 80 rocker lever part number 751-10412 is fitted.

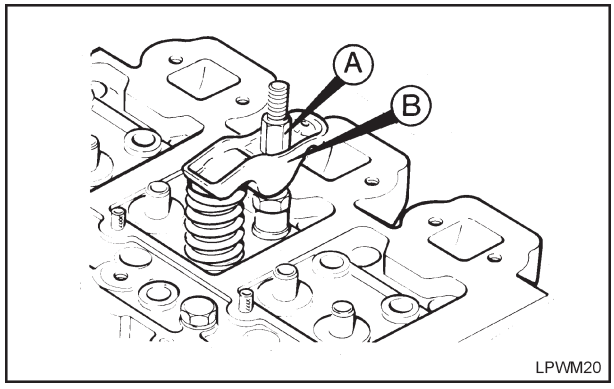


Figure 2.26.11 Valve Rocker

13. Depress the push rod end of the rocker arm, using the tappet compressing tool 317-50107 and torque the rocker lever nut to 34.0Nm (25.0lbf ft).

    Alternatively torque the rocker lever nut to 34.0Nm (25.0lbf ft) and wait for the lubricating oil to 'bleed down':

    Up to 90 seconds on a new tappet.
    Up to 45 minutes on a used tappet.

⚠ CAUTION

During the waiting period the crankshaft must not be turned.

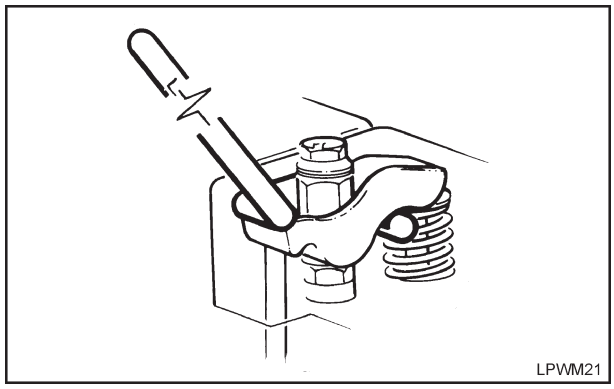


Figure 2.26.12 Valve Tappet Compressing Tool 317-50107

14. Replace the cylinder head covers and torque the nuts to 9.0Nm (6.5lbf ft).

    Extreme care must be taken to ensure the joint is carefully aligned with the valve rocker cover, especially where a dual cover incorporating an oil filler is fitted.

    It is suggested that Hylomar is applied to the cover before fitting the joint to it.

15. Replace the lifting eye, fuel pipes and the manifolds.

16. On LPWT4 engines replace the breather flexible pipe to the cylinder head cover.

02.27 THE HYDRAULIC TAPPETS

All engines are fitted with one of two types of hydraulic tappets and both types are interchangeable.

No adjustment is necessary or possible and removal of any part of the valve gear will allow the hydraulic tappet to extend and hydraulically lock.

When new hydraulic tappets have been fitted the engine must be cranked for at least 15 seconds before attempting to start it.

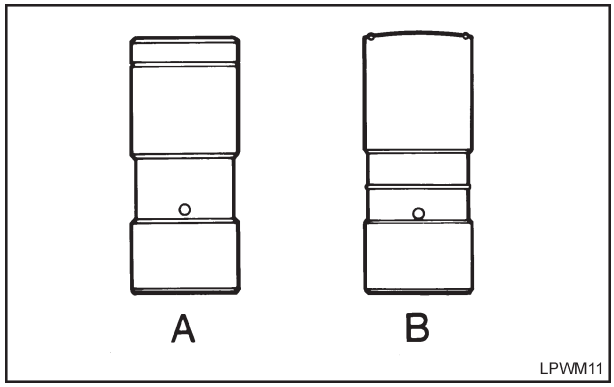


Figure 2.27.1 Hydraulic Tappets
A - 751-11730
B - 751-16720

When fitting the cylinder head, valve to piston contact can be avoided when tightening the valve rocker lever nut by depressing the push rod end of the rocker lever using the tappet compressing tool 317-50107.

⚠ CAUTION

Extreme care must be taken not to bend the push rod by using excessive force.

If the tappet compressing tool is not available torque the rocker lever nut to 34.0Nm (25.0lbf ft) to open the valve and wait for up to 45 minutes for the lubricating oil in the tappet to 'bleed down', and so allow the valve to seat in the head.

⚠ CAUTION

No piston must be at TDC when the head is replaced and during the 'bleed down' waiting period the crankshaft must not be turned.

02.28 CYLINDER HEAD CLEARANCE

02.28.1 Checking the Clearance

It is not necessary to check the cylinder head clearance on LPWG engines if the cylinder head has been removed.

All LPWG engines are fitted with the middle thickness (1.47mm) cylinder head gasket.

⚠ WARNING

Do not attempt to re-use an old head gasket.

1. Remove the cylinder head and push rods.
2. Place the gasket onto the crankcase taking care to ensure the holes in the gasket coincide with those in the crankcase.

   On LPA engines the gaskets are fitted with the raised corrugations against the crankcase.
3. Using two pieces of lead wire 1.6mm (0.06in) diameter and 50mm (1.9in) long form two 'U'

⚠ CAUTION

To ensure accurate measurements are made multicore solder must not be used.

4. Twist the open tails of the loops together to form four or five coils.
5. Refer to 'Figure 2.16.1' and using a very small amount of high melting point grease place the two pieces of wire (A) onto the piston crown (B) at either side of the gudgeon pin axis and 90° to the centre line.

   The two wires should just touch the cylinder bore and care should be taken to ensure they are not placed over any markings on the piston crown.

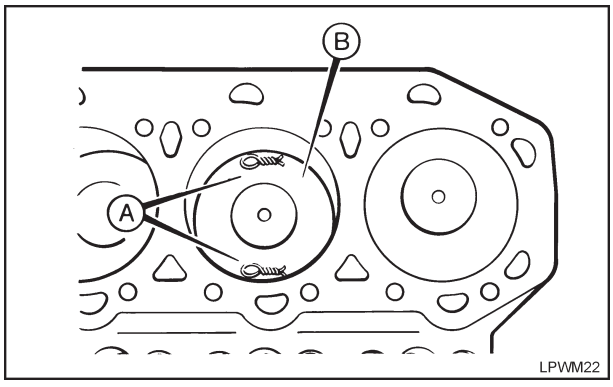


Figure 2.28.1 Checking Cylinder Head Clearance with Wire (An LPW head is shown)

6. Replace the cylinder head and torque the bolts in stages:

   Stage 1 - 8.0Nm (6.0lbf ft).

   Stage 2 - 48.0Nm (35.0lbf ft).

   Stage 3 (LPW, LPWT and LPWS only) - 88.0Nm (65.0lbf ft).
7. Rotate the engine by hand for two complete revolutions.
8. Remove the cylinder head and measure the thickness of the lead; this should be 0.7-0.9mm (0.027-0.035in).

   If the clearance is not correct it can be adjusted by changing to a different thickness of gasket.

   Only one gasket must be fitted and the available sizes are given in "02.28.2 Cylinder Head Gaskets".
9. Replace the push rods and cylinder heads after referring to "02.26.2 Refitting a Cylinder Head".

02.28.2 Cylinder Head Gaskets

Air Cooled Gasket Part Numbers

Three sizes of gasket are available.

0.25mm 751-10771

0.38mm 751-10770

0.51mm 751-10772

Water Cooled Gasket Part Numbers

Only the 1.47mm gasket is currently offered for spares use and these can be identified by the blue screen printed sealing compound and the two identification holes.

LPW2, LPWS2 752-40751

LPW3, LPWS3 753-40891

LPW4, LPWT4, LPWS4 754-40891

LPWG Gasket Part Numbers

All LPWG engines are fitted with the 1.47mm gasket and these can be identified by the blue screen printed sealing compound and the two identification holes.

LPWG2 752-40751

LPWG3 753-40891

LPWG4 754-40891

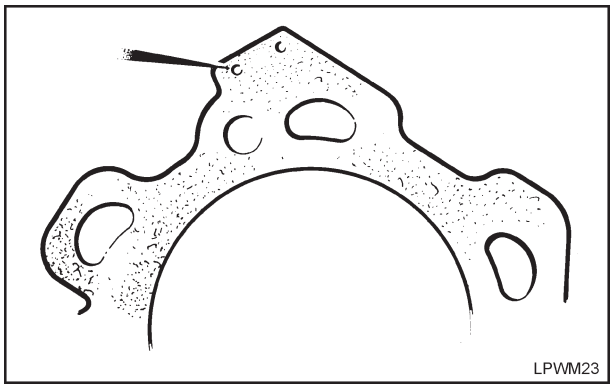


Figure 2.28.2 Gasket Identification Marks

02.29 THE VALVES

The valves are pre-finished and therefore no lapping or further processing is required and they are sunk below the combustion surface of the head to the figures given in "02.29.3 The Valve Seats".

Care must be taken to ensure that all valve associated items are retained in their respective cylinder orientation.

02.29.1 Removing a Valve

1. Lay the head upright on a bench and place a suitable circular block of wood under the head of the valve.
2. Fit the adaptor (A) onto the valve spring carrier with the two indentations facing outwards.
3. Fit the tool (B) into the two plate indentations.

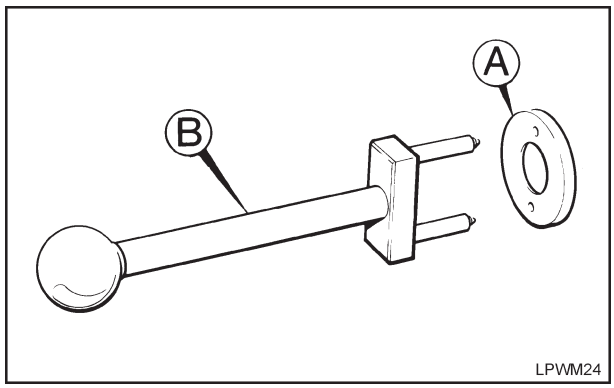


Figure 2.29.1 Valve Spring Compressor - 393155

4. Push down on the tool to compress the valve spring until the collets can be removed.
5. Gently release the tool and remove the carrier, valve spring, valve stem sealing ring and the valve spring plate.
6. Turn the cylinder head over and remove the valve.

02.29.2 Refitting a Valve

It is recommended that all valves and springs are replaced during a major overhaul.

A valve stem sealing ring is fitted to the top of the valve guides and it is recommended that a new seal is fitted whenever the valves are being refitted or renewed.

LPWG engines use umbrella type valve stem seals fitted to the inlet valves only, These seals are the early Alpha diesel engine type; see (C_1) in "Figure 2.29.2 Valve Assembly".

For all diesel fuelled engines new valve guides and valve stem seals have been introduced; see "02.29 The Valve Guides" and 'Figure 2.29.3'.

If more than one valve was removed ensure they are replaced in their respective positions.

1. Replace the valve if it is pitted or damaged.
2. Lightly lubricate the valve stem and insert the valve.
3. Lay the head upright on the bench and place a circular block of wood under the head of the valve being replaced.
4. Place the valve spring plate (B) in position.

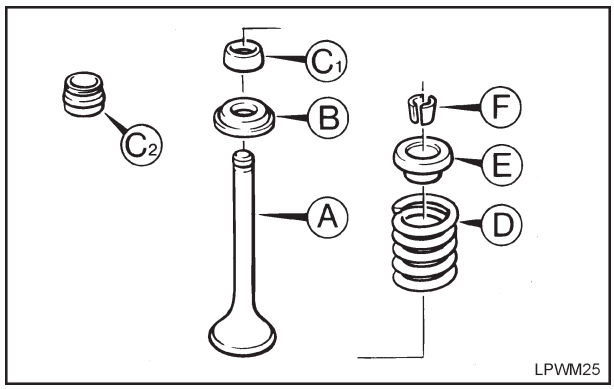


Figure 2.29.2 Valve Assembly
A - Valve
B - Valve Spring Plate
C1 - Early Valve Stem Seal and LPWG engines
C2 - Later Valve Stem Seal
D - Valve Spring
E - Valve Spring Plate
F - Collets

5. Fit a new valve stem seal (C), see "02.30 The Valve Guides", to the valve guide taking care to ensure it is correctly located over the guide and is not distorted.

   The later valve guide seals are fitted to both valve guides and must be pressed on until the shoulder is 12mm (0.47in) above the machined face of the cylinder head as shown in 'Figure 2.29.3'. LPWG valve stem seals are fitted to the inlet valves only.

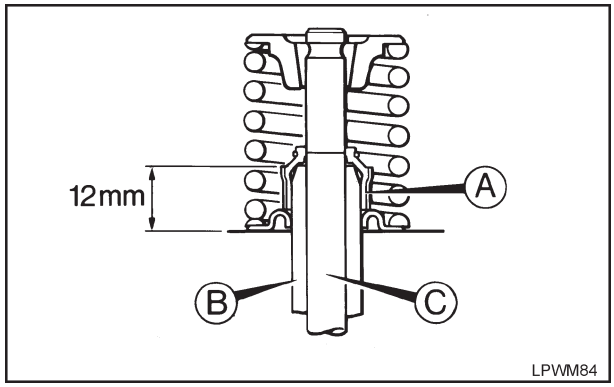


Figure 2.29.3 Later Valve Guide Seal Location
A - Valve Guide Seal
B - Valve Guide
C - Valve Stem

6. Replace the valve spring (D) and spring carrier (E).
7. Fit the adaptor (A), see 'Figure 2.29.1', over the valve spring carrier with the two indentations facing outwards.
8. Push down on the tool lever until the collets (F) can be replaced in position with their tops slightly sunk in the valve spring carrier.
9. Gently release the tool and check that the collets are correctly located.

02.29.3 The Valve Seats

Valve seat inserts are only fitted to LPA, LPWG and LPWT4 engines.

On LPWG valve seats the finished depth of the valve face below the cylinder head face is not nearly as critical as for the diesel engines.

The valve seats must be precision ground so that the valves are sunk below the combustion surface of the head as shown.

The seats are cut at a 45° angle and a 1° interference angle between the face and the seat provides a high-contact-pressure seal. The main consideration is that the installed valve spring tension will be reduced if valve recession is excessive. Good automotive machine shop practice should be followed in all cases, using spring shims if required to restore correct installed height.

		Valve Seat Depth	
		Inlet Seat	Exhaust Seat
LPA	mm	0.95-1.26	
	in	0.0374-0.0496	
LPW	mm	0.95-1.26	1.33-1.64
	in	0.0374-0.0496	0.0524-0.0646
LPWT4	mm	1.54-1.86	
	in	0.0606-0.0732	
LPWS	mm	0.95-1.26	1.33-1.64
	in	0.0374-0.0496	0.0524-0.0646
LPWG	mm	0.95-1.26	1.33-1.64
	in	0.0374-0.0496	0.0524-0.0646

02.29.4 Valve Seat and Recess Cutting

Specialized equipment is required to re-finish the valve seats which are cut at a 45° angle.

1. Fit the correct adjustable mandrel (A) into the valve guide and turn the adjuster until the flutes just bind onto the guide.

⚠ CAUTION

The valve guide will be damaged if the mandrel is adjusted too much when it is located in the guide and care must be taken to ensure an even, gentle downward pressure is applied when using the cutter to prevent the removal of too much metal.

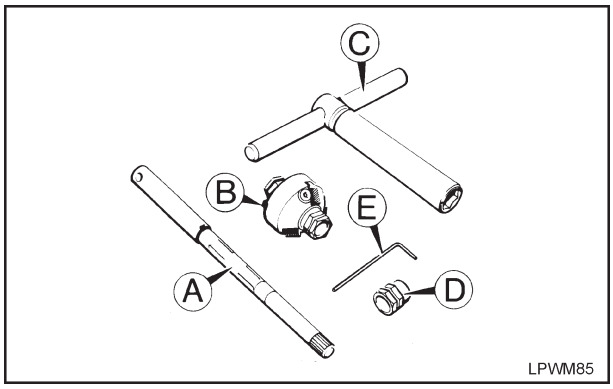


Figure 2.29.4 Valve Seat Kit - 317-50042
A - Adjustable Mandrel
B - Cutting Tool
C - 'T' Handle
D - Adaptor
E - Allen Key

2. Select the necessary cutting tool (B) and assemble it to the handle (C).
3. Place the cutter over the mandrel and adjust the three individual blades, using the Allen Key, if necessary.
4. Rotate the tool in a clockwise direction until the valve seat or recess finish is satisfactory

02.30 THE VALVE GUIDES

The guides are a press fit into the cylinder head and must protrude by 11.75-12.25mm (0.462-0.482in) above the top machined face of the cylinder head. This dimension will be achieved when the depth stop, 317-50108, is used with the guide removal and replacement tool, 317-50033.

New valve guides and oil seals were first fitted on the engines shown and all LPWT4. The seals now grip on the valve guides instead of the valve stem, early seals are compatible with the current valve guides but the current seals cannot be fitted to early valve guides.

42 00987 LPA2
42 00763 LPA3
42 00396 LPW3
42 00850 LPW3
42 00687 LPW4
42 00770 LPWS4

02.30.1 Valve Guide and Seal Part Numbers

	Early Type	Later Type
Guide	751-10901	751-10903
Seal	751-13570	751-41701

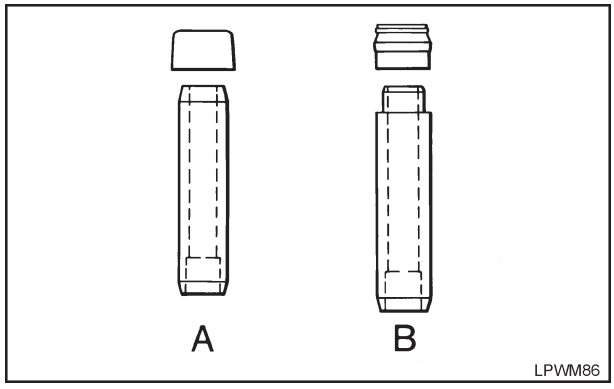


Figure 2.30.1 Valve Guides and Seals
A - Early Type
B - Later Type

02.30.2 Removing a Valve Guide

1. Remove the cylinder head.
2. Remove the valve.
3. Remove the valve stem oil seal from the guide.
4. Preferably place the cylinder head on its side in a soft jawed vice.
5. Screw the correct mandrel (A) into the tool (B).

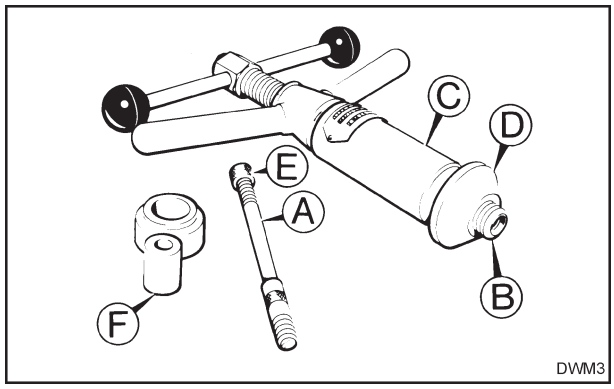


Figure 2.30.2 Valve Guide Tool and Depth Stop

6. Place the sleeve (C) onto the tool.
7. Fit the bevelled adaptor (D) into the sleeve (C) and locate the bevel into the valve seat.
8. Locate the mandrel through the guide from the valve seat side.
9. Screw the small threaded sleeve (E) onto the mandrel at the valve rocker side.
10. Holding the sliding handle firmly to prevent rotation, turn the double handled lever clockwise until the guide is withdrawn through the head.

    If it is found difficult to start moving the guides a sharp tap with a copper hammer should break the seal.

02.30.3 Refitting a Valve Guide

1. Fit the correct mandrel into the valve guide hole from the valve rocker end.
2. Place the valve guide over the mandrel with the counterbored end of the guide facing towards the valve seats.
3. Place the depth stop (F) over the mandrel and screw on the threaded sleeve (E).
4. Fit the tool complete with the bevelled adaptor onto the mandrel at the valve seat side.
5. Hold the sliding handle firmly, to prevent it rotating, and turn the double handled lever clockwise until the depth stop prevents any further movement. At this point the guide will protrude the correct distance above the cylinder head.
6. Fit a new valve stem oil seal.

02.31 THE CRANKCASE DOOR

The door is secured to the crankcase by studs, nuts and setscrews. The door carries the fuel lift pump, oil dipstick, oil filler and the oil filter.

To gain access to the sump the door must be removed.

⚠ CAUTION

The LPW4 and LPWT4 crankcase doors are not interchangeable.

02.31.1 Removing the Crankcase Door

1. Remove the two fuel pipes from the lift pump.
2. Remove the LPWT4 turbocharger oil feed and return pipes.
3. Pull out the oil dipstick.

   If an extended dipstick is fitted it will be necessary to disconnect the securing bracket at the cylinder head end.
4. Remove the door and joint. To avoid possible damage do not use a screwdriver on the door or crankcase mating faces.

02.31.2 Replacing the Crankcase Door

1. Clean and dry the crankcase and door mating surfaces.
2. Replace the crankcase door with a new joint, which must be fitted dry, and torque the bolts to 11.0Nm (8.0lbf ft) in the sequence shown below.

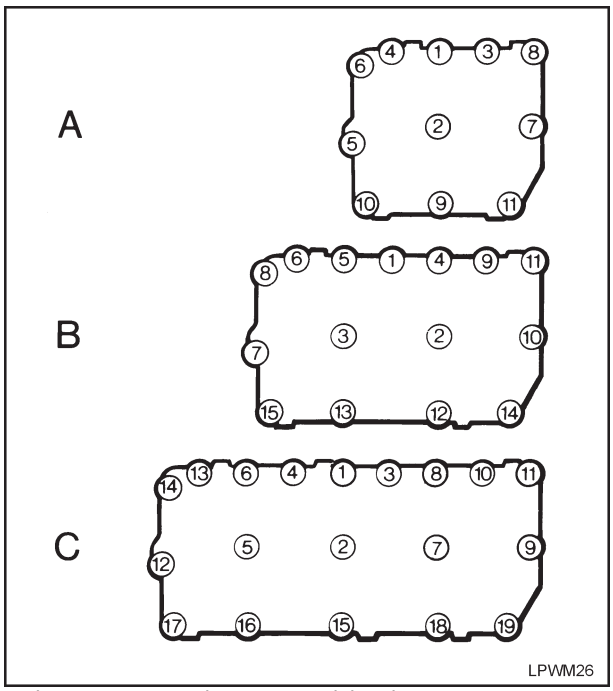


Figure 2.31.1 Crankcase Door Tightening Sequences
A - 2 Cylinder Engines
B - 3 Cylinder Engines
C - 4 Cylinder Engines

3. Replace the two turbocharger oil pipes, the fuel lift pump pipes and the dipstick.

02.32 THE GEAR END COVER

The light alloy, standard and hydraulic pump build, end cover is located on two dowels and secured to the crankcase on seven studs or bolts.

If the two dowels are being replaced care must be taken to ensure the flat end enters the crankcase fully; the taper end provides engagement with the end cover.

The crankshaft oil seal is of the lip type and a joint is fitted between the end cover and the crankcase face.

The oil seal tool, 317-50103, is used to protect the oil seal when the end cover is either removed or replaced and is also used to remove and replace the seal in the end cover.

02.32.1 Removing the End Cover

1. Fit the flywheel locking tool, 317-50057, into the flywheel gear ring by screwing it into the tapped hole in the flywheel housing

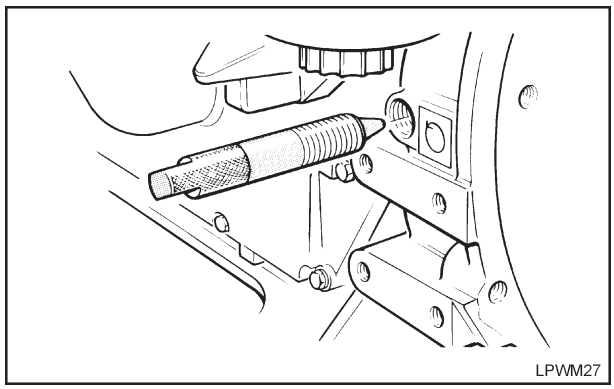


Figure 2.32.1 Fitting the Flywheel Locking Tool

2. Ensure the locking tool is fully engaged into a flywheel ring gear tooth by attempting to turn the flywheel.

   If the locking tool is not available wedge the crankshaft with a suitable piece of hardwood to prevent it turning.
3. Slacken the alternator, or belt tensioner, and move it towards the crankcase sufficiently to allow removal of the fan drive belt.
4. **On Early Engines:**

   Bolt the pulley tool, 317-50105, to the pulley and fit a suitable wrench to the tool and unscrew the left hand thread pulley.

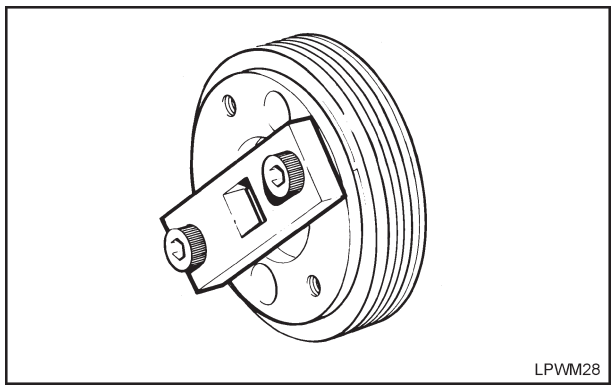


Figure 2.32.2 Pulley Tool

5. **On Later Engines:**

   Use a suitable socket and wrench and unscrew the left hand thread crankshaft pulley bolt and remove the pulley.
6. **On All Engines:**

   Remove the flywheel locking tool, or wood wedge.
7. To protect the oil seal insert the seal tool, 317-50103, into the end cover.
8. Remove the end cover retaining nuts, spring washers, cup and rubber washers or bolts.
9. Remove the end cover.

   To avoid possible damage do not use a screwdriver on the cover or crankcase mating faces.
10. Clean all traces of the old joint from the crankcase and cover.
11. If necessary push out the oil seal from the end cover using the service tool or a suitable plug press.

2.32.2 Fitting a New End Cover Oil Seal

Lip type oil seals are fitted to the gear end cover and are fitted without any jointing compound being applied.

The lip seals used must be the approved type as supplied by Lister Petter; ordinary rubber seals may quickly harden in use, rapidly wear the shaft, or not even seal on fitting and therefore must not be used.

A lip type seal will not seal if the shaft is scratched or bruised within 5mm either side of the path of the lip of the seal.

A finely and accurately ground shaft without chatter marks and with a surface finish of 0.4-0.6 microns Ra is required. Emery cloth of any grade must not be used on the shaft in the area of the lip.

1. Lightly grease the sealing lip of the new seal.
2. Place a new seal into the outside neck of the end cover, lip side first, and position it squarely on the shoulder of the seal boss.
3. Using the seal tool, 317-50103, drive the seal into position in the end cover.

   In an emergency, if the tool is not available a suitable plug, preferably hard wood, can be used.

02.32.3 Fitting the End Cover

A solid mounted end cover has replaced the earlier type that was secured with studs and cup washers which also had a thicker joint. The two types of cover and joint are not interchangeable.

Full details for all end covers is given in the relevant Master Parts Manual.

⚠ CAUTION

Under no circumstances must the later thinner joint be used with the earlier end cover as adequate clearance for the internal governor components would be lost.

1. Clean all traces of the old joint from the crankcase and cover.
2. Fit a new joint, which must be fitted dry, over the two dowels and onto the crankcase.
3. Fit the oil seal tool, 317-50103, into the outside face of the oil seal.
4. Replace the end cover, taking care to ensure the new joint is not damaged and the cover is correctly located over the dowels.
5. Replace the early rubber washers, cup washers, spring washers and the nuts or the later bolts finger tight.

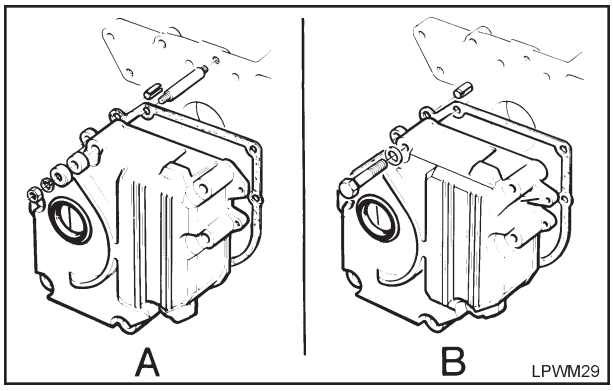


Figure 2.32.3 Gear End Cover
A - Early Type Fixing
B - Later Type Fixing

6. Following the sequence shown torque the nuts or bolts to 9.0Nm (6.5lbf ft).

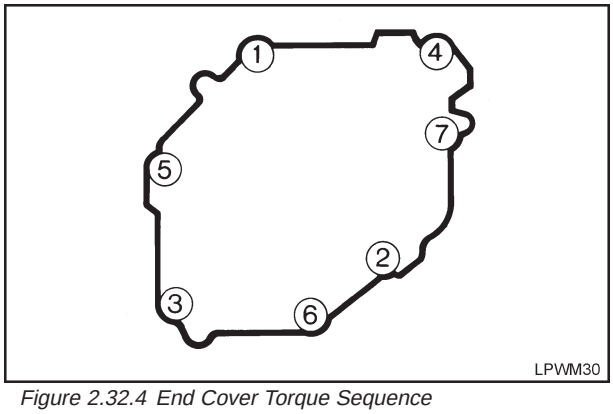


Figure 2.32.4 End Cover Torque Sequence

02.33 THE CAMSHAFT

The steel camshaft is carried in a bearing bush at the gear end and carries the governor weights and a thrust plate fitted behind the gear.

Cams on the camshaft operate the hydraulic tappets, fuel pumps and the fuel lift pump.

LPWG camshafts do not have fuel pump lobes, therefore they are not interchangeable.

⚠ CAUTION

No attempt must be made to remove the gear from the camshaft.

02.33.1 Removing the Camshaft

1. Remove the gear end cover, cylinder head, push rods, push rod tubes and fuel pumps.
2. Remove the fuel lift pump, push rods and the fuel injection pumps.
3. Lift out the fuel pump tappets.
4. Lift out the hydraulic tappets with a suitable magnet.
5. Unhook the thrust plate to engine control spring (A).

   The thrust plate is fitted between the rear face of the camshaft gear and the crankcase face.

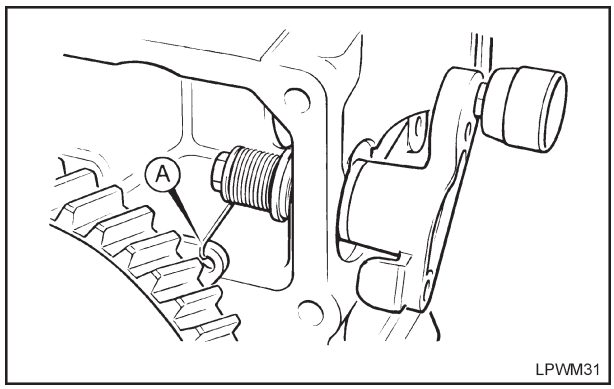


Figure 2.33.1 Thrust Plate Spring

6. Unhook the speeder spring (A) from the governor lever assembly (B) and the speed control lever (C) and remove the spring.

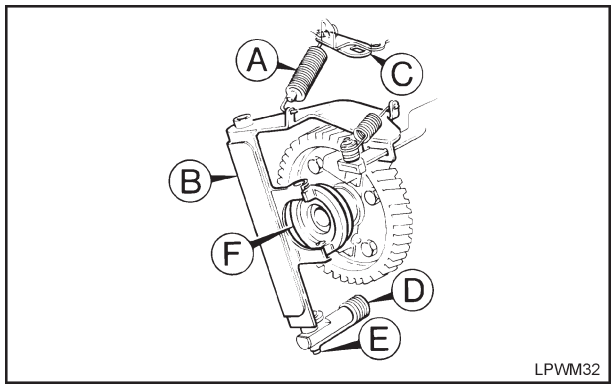


Figure 2.33.2 Removing the Governor

7. Unhook the small spring (D) from the lower end of the governor lever assembly retaining pin (E).
8. Remove the pins from the top and bottom of the governor lever assembly taking care to retain any end float shims that are fitted.
9. Gently remove the governor lever assembly from the crankcase.
10. Remove the governor weights.
11. Remove the governor sleeve (F) and the thrust washer.
12. Turn the camshaft until the large holes in the camshaft gear coincide with the two thrust plate bolts.
13. Use a suitable socket and remove the two thrust plate bolts.
14. Gently ease the camshaft out of the crankcase keeping it square at all times.

02.33.2 Inspection of the Camshaft

a. Examine the camshaft bush for scars or wear.
b. Check the camshaft gearwheel and crankshaft pinion teeth for wear.
c. Ensure the cams are not chipped or damaged.
d. Check the tappets for scars or damage to the contact face.

02.33.3 Replacing the Camshaft

1. Carefully replace the camshaft into the crankcase keeping it square at all times and taking care to line up the 'O' and '●' timing marks on the crankshaft and camshaft gears exactly.

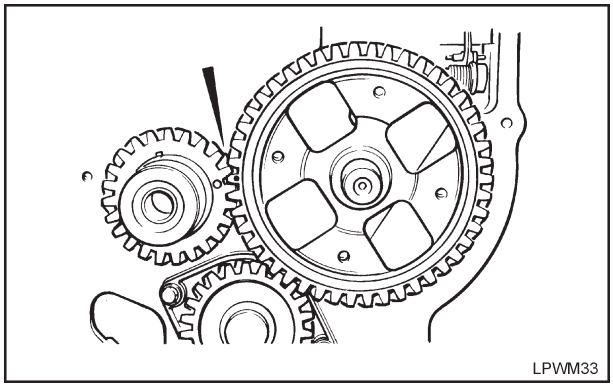


Figure 2.33.3 Camshaft Timing Marks

2. Turn the camshaft until the large holes in the gear, the two thrust plate bolt holes and the two threaded holes in the crankcase all coincide.
3. Replace the two thrust plate bolts through the camshaft gear and thrust plate.

   Torque the two bolts to 9.0Nm (6.5lbf ft).
4. Fit the tail of the engine control spring (A) onto the thrust plate.

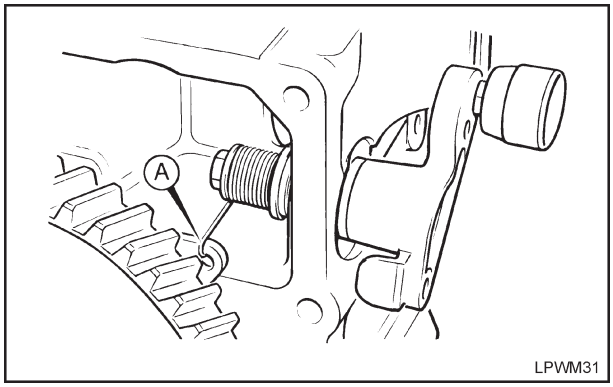


Figure 2.33.4 Thrust Plate Spring

5. Replace the governor weights and torque the bolts to 9.0Nm (6.5lbf ft).
6. Replace the governor sleeve (F) and the governor lever and rack assembly.

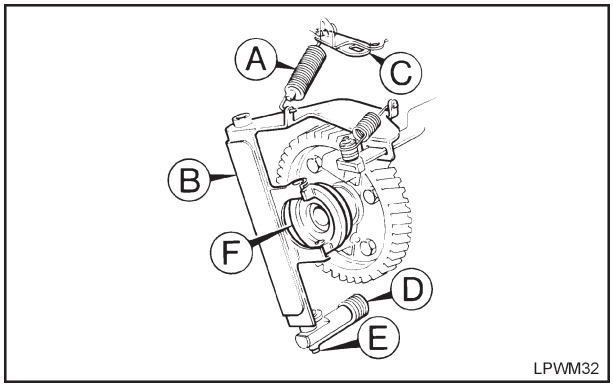


Figure 2.33.5 Thrust Plate Spring

7. Fit the speeder spring (A) to the governor lever assembly (B) and the speed control lever assembly (C) with the fixed spring tail onto the speed control.
8. Replace the end cover and torque the bolts to 9.0Nm (6.5lbf ft) in the sequence shown.

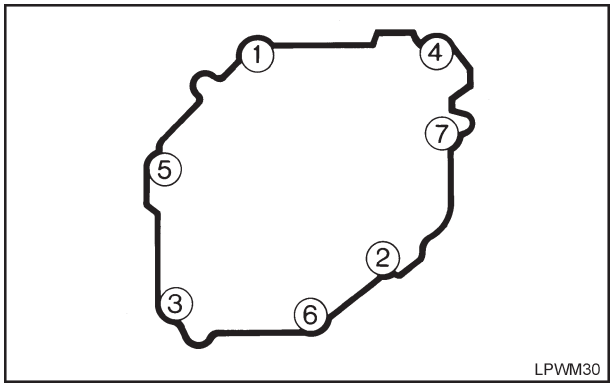


Figure 2.33.6 End Cover Torque Sequence:

9. Replace the dipstick, fuel lift pump and fuel pumps.
10. Refer to "02.26.2 Refitting a Cylinder Head" and replace the cylinder head.

02.33.4 Camshaft Endfloat

The camshaft endfloat is factory set at 0.07-0.20mm (0.004-0.008in) and cannot be adjusted.

If the endfloat is greater than that given the camshaft must be replaced.

02.33.5 Checking the Endfloat

1. Remove the gear end cover.
2. Push the camshaft towards the flywheel end.
3. Fix a clock gauge in position against the camshaft gear wheel.

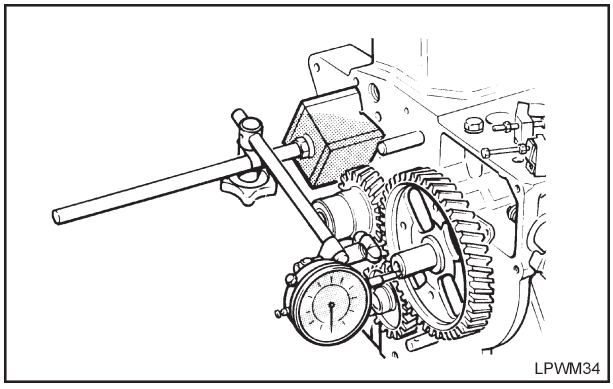


Figure 2.33.7 Checking Camshaft End float

4. Zero the gauge.
5. Move the camshaft as far as it will go towards the gear end.

   The movement recorded on the gauge is the endfloat.

2.24 THE CAMSHAFT BUSH

2.24.1 Removing the Bush

1. Fit the guide (A) into the bush from inside the crankcase.
2. Fit the slide hammer (B) onto the guide threads.
3. Use the slide hammer to remove the bush.

⚠ WARNING

Care must be taken to ensure that any part of the hand is not likely to become trapped between the two parts of the slide hammer while it is being used.

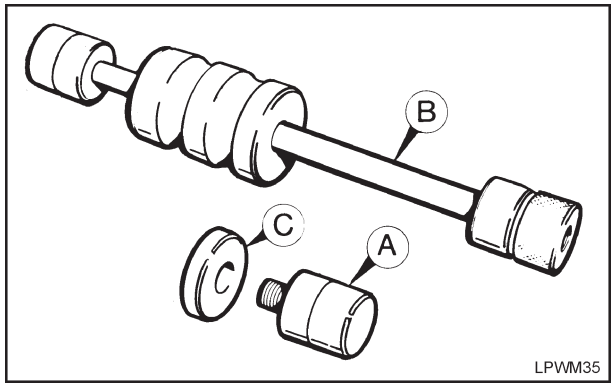


Figure 2.24.1 Camshaft Bush Tool

2.24.2 Fitting a New Bush

Before fitting a new camshaft bush the outside diameter must be lightly oiled with engine lubricating oil before assembly.

When the bush is replaced the split in it must be positioned at the top of the bush bore.

1. Fit the new bush over the guide threads.
2. Screw on the depth plate (C); see the above illustration.
3. Fit the slide hammer onto the guide threads.
4. Place the assembly squarely into the crankcase bush bore from the outside of the crankcase.
5. Use the slide hammer to replace the bush.

⚠ WARNING

Care must be taken to ensure that any part of the hand is not likely to become trapped between the two parts of the slide hammer while it is being used.

02.35 THE PISTON

The piston is made of low expansion alloy with a recessed combustion chamber in the crown and is fitted with three rings. LPWG pistons are 'dished' to give a compression ratio of 9.5:1, which allows operation on either natural gas or propane fuel.

The piston crown is stamped ‘Camshaft Side’ to ensure the piston is correctly assembled to the engine and with the part number.

The gudgeon pin is a clearance fit in the piston and is retained by two circlips. The gudgeon pin runs in a bush in the small end of the connecting rod.

⚠ CAUTION

The LPWT4 piston and connecting rod assemblies are not interchangeable with any other.

02.35.1 The Piston Rings

Piston rings are only available as sets and it is recommended that they are only fitted as a set.

Firing Ring

A barrel lapped chrome ring is situated at the top of the piston, one surface is marked ‘TOP’ and the ring must be fitted the correct way up.

Compression Ring

The compression ring has a tapered face in contact with the barrel, one surface is marked ‘TOP’ and the ring must be fitted the correct way up.

Oil Control Ring

A conformable type, with a spring expander, is fitted above the gudgeon pin.

02.35.2 Piston Assemblies

LPWT4 Engines:

LPWT4 engines have only been fitted with controlled expansion piston assemblies and these are not interchangeable with any other.

All Other Engines, except LPWG:

Mono-metal piston assemblies were fitted on early engines but from the engines given below controlled expansion piston assemblies have been fitted. Either type of piston, with the correct rings, can be used but the two piston types must not be mixed within an engine.

LPA and LPW engines before those shown below were fitted with injector seal washers 361296, later engines are fitted with seal washer 201-45070.

41 00885 LPA2	42 00014 LPWS2
41 00443 LPA3	42 00041 LPWS3
	42 00685 LPWS4
41 00324 LPW2	
41 00001 LPW3	
41 00570 LPW4	

⚠ CAUTION

If expansion controlled pistons are being fitted to replace the early mono-metal type the higher output oil pump assembly 750-12020 and oil cooling jets must also be fitted.

02.35.3 Controlled Expansion Pistons

⚠ CAUTION

Controlled expansion piston assemblies are cooled by oil jets in the main bearing housings.
If controlled expansion pistons are being fitted to engines not originally fitted with oil jets it will be necessary to fit them; refer to "02.36 Piston Oil Jets".

02.35.4 Removing a Piston

1. Isolate the fuel supply and remove the inlet and outlet pipes from the fuel lift pump.
2. On LPWT4 engines remove the turbocharger oil feed and return pipes.
3. Remove the crankcase door.
4. Remove the cylinder head.
5. If Number 1 piston is being removed it will be necessary to unscrew and remove the oil pressure relief valve and oil strainer.
6. Rotate the crankshaft sufficiently to give access to the connecting rod bearing cap bolts.
7. Remove the two bearing cap bolts and the bearing cap.

⚠ CAUTION

To avoid possible injury, due to the sharp edges of the machined crankcase face, use a drive socket and not a spanner.

8. Carefully scrape any build up of carbon from the top of the cylinder bore.
9. Rotate the crankshaft until the piston is at TDC.
10. Screw the piston removal tool into the nearest connecting rod bearing cap bolt hole.

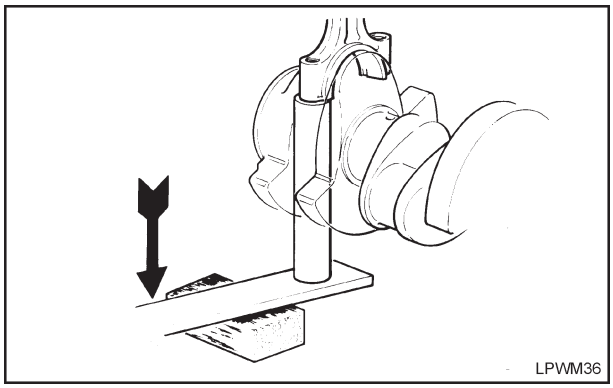


Figure 2.35.1 Piston Lifting Tool 317-50113

11. Using a suitable lever against the crankcase and the bottom end of the tool press down on the end of the lever until the piston rings are clear of the cylinder bore.
12. Lift out the piston and connecting rod.
13. Replace the bearing cap onto the connecting rod.
14. By using a standard ring expander the piston rings can be removed.
15. The gudgeon pin may be removed by releasing the circlip from one end and pushing out the pin.

02.35.5 Inspecting and Servicing the Piston

1. Thoroughly clean the cylinder barrel and check for scoring and wear.
2. Clean the piston, removing all traces of carbon from both the upper and underside of the crown and the ring grooves.
3. With the piston rings in an unworn section of the cylinder barrel check for the correct gap clearance; refer to "2.39 Dimensions of Wearing Parts".
4. Clean the connecting rod.
5. Examine the small end bush for wear.
6. If the big end has been dismantled because of metal failure, the oil passages in the crankshaft must also be examined for obstruction and fragments of metal.

02.35.6 Fitting a Piston

The pistons with rings and connecting rods assembled, must be submerged in oil just before fitting into the cylinder. After submersion drain both ways so that no oil is left in the combustion chamber or inside the piston.

1. Fit the piston to the connecting rod with the wording 'Camshaft Side' on the piston to the same side as the identification marks on the connecting rod big end and cap.

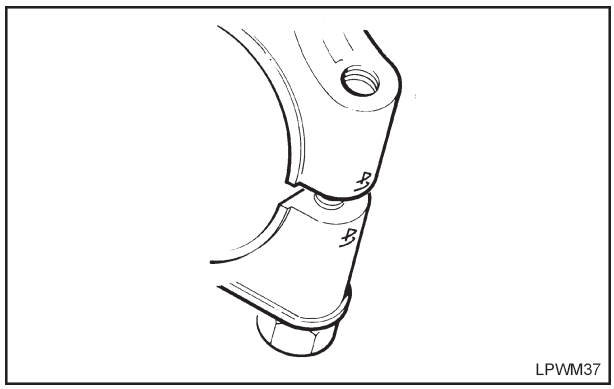


Figure 2.35.2 Connecting Rod and Cap Identification Marks

2. Place the connecting rod into the piston and Insert the gudgeon pin and circlips into the piston. Special care must be taken to ensure the circlips are correctly and securely located.

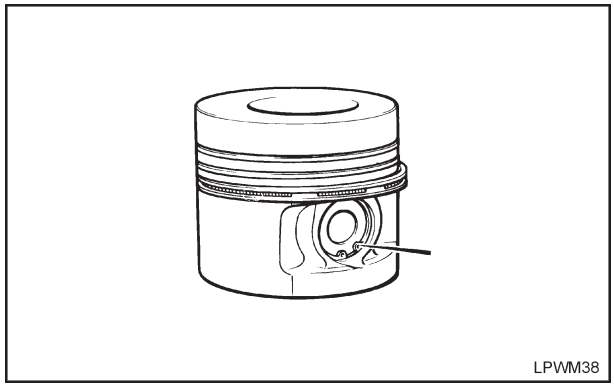


Figure 2.35.3 Gudgeon Pin Circlip

3. Fit the piston rings, using a piston ring expander, taking care to ensure they are fitted in the correct order.

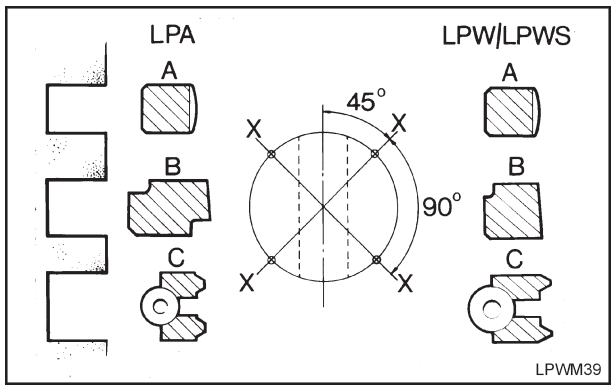


Figure 2.35.4 Piston Ring and Gap Positions
A - Firing Ring
B - Compression Ring
C - Oil control Ring
X - Piston Ring Gap Positions

4. Turn the crankshaft journal to TDC.

   If necessary, fit new connecting rod big end bearing shells ensuring they are correctly located in both the connecting rod and cap.
5. Stagger the piston ring gaps as shown at 'X' in the above illustration.

   Each ring gap must be set at 90° to the adjacent rings and 45° from the gudgeon pin axis.
6. Fit the piston and connecting rod into the cylinder while compressing the piston rings using a suitable piston ring compressor.

   Ensure the identification marks on the connecting rod will be facing towards the crankcase door on final assembly.
7. Push down on the piston crown and turn the crankshaft anti-clockwise until the big end is almost at BDC.
8. Ensure the identification marks on the connecting rod cap and rod are identical and replace the cap. Fit two new bolts and nuts and torque them to 35.0Nm (26.0lbf ft).

   It is recommended that the bolts are replaced at every major overhaul.

02.36 PISTON OIL JETS

⚠ CAUTION

If expansion controlled pistons are being fitted to replace the early mono-metal type the higher output oil pump assembly 750-12020 and oil cooling jets must also be fitted.

⚠ CAUTION

Do not attempt to drill out the plugs or increase the oil jet hole diameter.

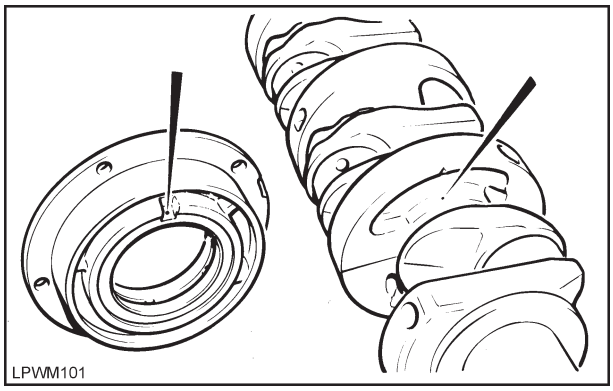


Figure 2.26.1 Oil Jet

02.36.1 Fitting Piston Oil Jets

1. Fit new gear end, centre and flywheel end main bearing housing assemblies or remove the crankshaft from the engine.
2. Remove the centre main bearing housing assembly from the crankshaft.
3. Remove the bearing shells from the gear end, centre and flywheel end main bearing housing assemblies.
4. Use a suitable, small diameter punch to drift out the blanking plugs from the bearing housings.
5. Fit new main bearing shells to the bearing housings and refit the crankshaft.
6. Lightly grease the steel back of the crankshaft thrust washers and position them in the housing with the copper face towards the crankshaft.

   Ensure the tab is correctly located at the bottom of the recess.

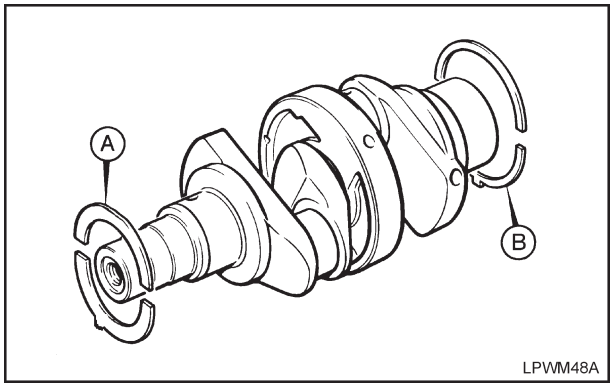


Figure 2.36.2 Crankshaft Thrust Washers
A - Gear End
B - Flywheel End Bearing Housing

02.37 THE CONNECTING ROD

The connecting rod is connected to the crankpin by a big end bearing cap held in position by two bolts torqued to 35.0Nm (26.0lbf ft).

The big end bearing shells are steel backed copper lead, or aluminium tin and should not be scraped or touched up in any way.

⚠ WARNING

Copper lead and aluminium tin big end connecting rod bearing shells must not be mixed in an engine.

The bearing shells are plain and without circumferential grooves.

The connecting rod must be assembled to the piston so that when it is in the engine 'Camshaft Side' on the piston crown is correctly positioned and the rod and cap identification numbers will be facing towards the crankcase door; refer to "02.35.6 Fitting a Piston".

02.37.1 Checking Bearing Clearance

1. Place a piece of the correct size 'Plastigauge' approximately 6.35mm (0.25in) off-centre across the full width of one bearing shell.

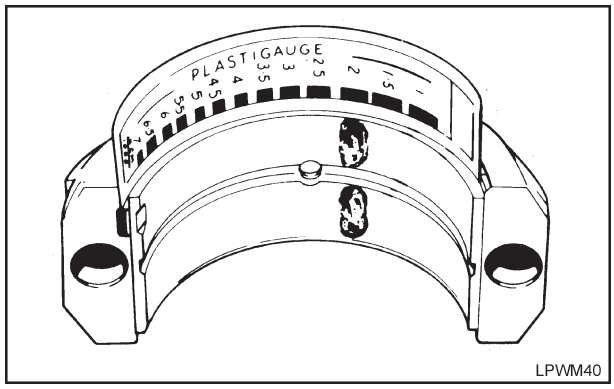


Figure 2.37.1 Checking Bearing Clearance

2. Replace the bearing and torque the bolts to 35.0Nm (26.0lbf ft).

⚠ CAUTION

Care must be taken to ensure the crankshaft is not turned when the 'Plastigauge' is in place, and all traces of it must be removed before final assembly of the bearing.

3. Remove the bearing shell and use the scale to check the width of the flattened 'Plastigauge'; the width at the widest point establishes the minimum clearance and at the narrowest point the maximum clearance.

   The difference between the two readings is the journal to bearing clearance and is compared with the figures given in "2.39 Dimensions of Wearing Parts".

02.38 THE FLYWHEEL

The flywheel rotates within the flywheel housing aperture and the type fitted depends on the engine and build. All flywheels are fitted with a ring gear for electric starting and have tapped holes for attaching couplings, clutches, shaft extensions or pulleys.

The flywheel is located with a dowel and held in position with five bolts (6 bolts on the LPWT4) and the tolerance for spigot and mounting face run-out must be within 0.25mm (0.010in) T.I.R.

Marks showing the timing degrees for each cylinder can be viewed through an aperture in the rear of the housing.

⚠ CAUTION

It is strongly recommended that the available flywheel tools, shown in 'Figure 2.38', and suitable lifting equipment are used when removing, handling or replacing the flywheel.

02.38.1 Removing the Flywheel

1. Disconnect the driven equipment and the battery.
2. Fit the flywheel locking tool (B) through the flywheel housing into the flywheel gear ring, ensuring that it locates by attempting to turn the flywheel.

   If the locking tool is not available wedge the crankshaft with a suitable piece of wood to prevent it turning.

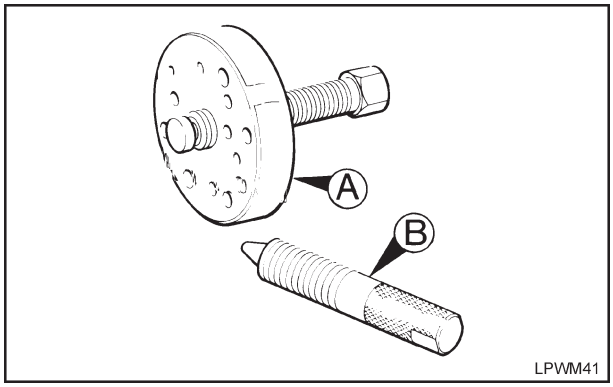


Figure 2.38.1 Flywheel Tools
A - Puller 317-50100
B - Locking Tool 317-50057

3. Slacken the flywheel retaining bolts two turns.
4. Remove the locking tool.
5. Turn the flywheel until the locating dowel is at the top.
6. Bolt the puller plate (A) to the flywheel and turn the tool centre bolt clockwise sufficiently to loosen the flywheel.

   If the puller plate is not available use a suitable brass drift or piece of hardwood through the starter motor aperture to slacken the flywheel.
7. Remove the service tool and the flywheel bolts.
8. Support the flywheel at all times and, keeping it square lift it off of the crankshaft and out of the housing.

02.38.2 Refitting the Flywheel

1. Turn the crankshaft until the flywheel locating dowel is at the top.
2. Position the flywheel with the locating dowel hole at the top.
3. Lift the flywheel, supporting and keeping it square at all times, into the flywheel housing and onto the crankshaft.
4. Replace the retaining bolts finger tight.
5. Push the flywheel fully into position.
6. Fit the flywheel locking tool.
7. Torque the retaining bolts to 68.0Nm (50.0lbf ft).
8. Remove the flywheel locking tool.

02.39 THE FLYWHEEL HOUSING

The flywheel housing locates on the flange of the main bearing housing and is not dowelled to the crankcase therefore, before attempting to remove it scribe a line on its rear face and the crankcase to ensure it is replaced in its original orientation.

Build 70 engines are fitted with a backplate in place of a flywheel housing.

02.39.1 Removing the Flywheel Housing

1. Remove the flywheel.
2. Remove the four housing retaining bolts.
3. Lift off the housing.

02.39.2 Fitting the Flywheel Housing

1. Lift the housing into position; also refer to "02.39.3 Marine Flywheel Housing".
2. Replace the bolts finger tight.
3. Align the previously scribed marks.
4. Torque the retaining bolts to 68.0Nm (50.0lbf ft).

02.39.3 The Marine Flywheel Housing

Following removal of a marine flywheel housing all traces of jointing compound must be removed from the housing and crankcase mating faces.

Before refitting the housing the following jointing compounds must be used:

At (A) timing hole plug - Hylosil 300 Silicon RTV Compound.

At (B) the housing - a bead of Loctite 573 or 574 must be applied immediately before fitting the housing to the crankcase.

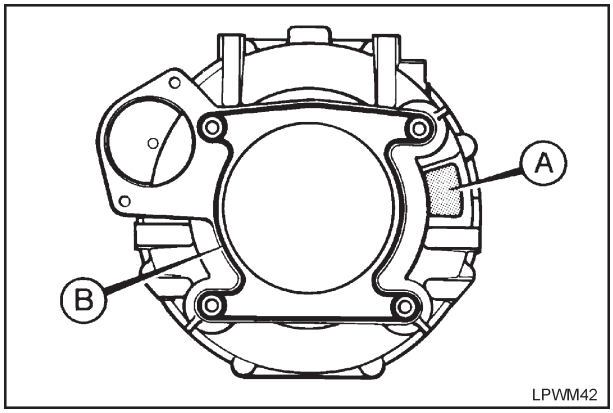


Figure 2.39.1 Marine Flywheel Housing
A - Timing Hole Plug
B - Position of Jointing Compound

02.40 REAR MAIN BEARING HOUSING

The two halves of the main bearing are steel backed copper lead and should not be scraped or touched up in any way. The bearing shells are plain and without circumferential grooves.

The bearing housing is secured to the crankcase at the flywheel end and has an oil drain which must be located at the bottom of the housing when it is refitted.

A single shim fitted between the housing and the crankcase maintains the crankshaft end float.

An oil seal is fitted to the centre bore of the housing and the bearing oil feed enters a drilling in the side of the bearing housing which aligns with a similar one in the crankcase.

02.40.1 Removing the Bearing Housing

⚠ CAUTION

Failure to remove a centre bearing dowel may result in distorting it, if the bearing housing is levered off, making it difficult to remove at a later stage.

1. Remove each centre bearing locating dowel securing screw from the fuel pump side of the engine. On some engines the dowel is held in position by the crankcase door.
2. To prevent possible distortion of the centre bearing dowel when the bearing housing is removed:

   Screw a suitable new or clean M6, or inlet manifold, bolt (A) into the dowel.

   Pull the bolt and dowel out of the crankcase and leave the bolt in the dowel until it is refitted to ensure the dowel is refitted the correct way round.

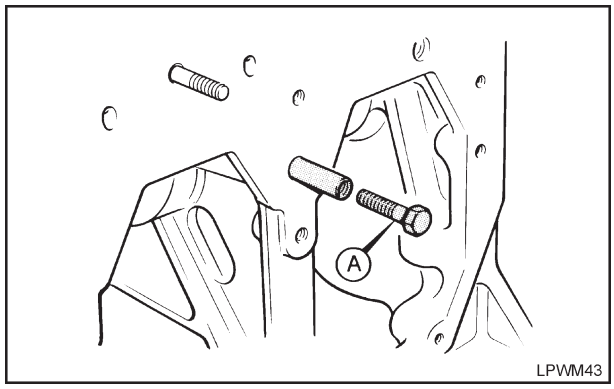


Figure 2.40.1 Removing the Centre Bearing Dowel

3. Remove the bolts securing the main bearing housing.
4. Remove the bearing housing.

   If the housing is tight, lever it off with a suitable screwdriver using the recesses in the '3 o-clock' and '9 o-clock' positions.
5. Clean all traces of the old shim and jointing compound from the housing and crankcase.
6. Drift out the oil seal taking care not to damage the bearings.

02.40.2 Refitting the Main Bearing Housing

If the bearing shells have been replaced before refitting the housing check that the oil supply holes in the bearing shells and the housing align.

The main bearing shells are steel backed copper lead, or aluminium tin and should not be scraped or touched up in any way.

⚠ WARNING

Copper lead and aluminium tin main bearing shells must not be mixed in an engine.

⚠ CAUTION

Striking the crankshaft may displace the thrustwashers and damage the bearing locating dowel if it has not been removed.

1. Lightly grease the steel back of the thrust washers and position them in the housing; ensure the tab is correctly located at the bottom of the recess and the copper face will be towards the crankshaft.
2. Coat both sides of a new main bearing housing shim with Wellseal and fit it to the housing with the flat side towards the crankcase.

   Ensure the notches and holes in the shim match those in the housing.
3. With the oil seal removed refit the housing ensuring the metal shim remains in position and the oil drain will be located towards the bottom of the crankcase on final assembly.
4. Torque the housing bolts to 27.0Nm (20.0lbf ft) in the sequence shown.

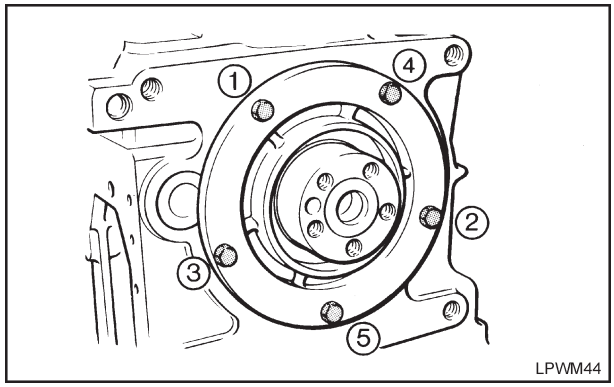


Figure 2.40.2 Bearing Housing Tightening Sequence

5. Check the crankshaft endfloat as described in "02.36 Crankshaft Endfloat".
6. Replace the oil lip seal as described in "02.32 The Main Bearing Oil Seal".
7. Replace each centre bearing locating dowel with the tapped end facing outwards.

   Before fitting the dowel ensure the bore is clean.
8. Replace the locating dowel securing screw.

   On some engines the dowel is held in position by the crankcase door.

02.41 MAIN BEARING HOUSING OIL SEAL

Lip type oil seals are fitted to the flywheel end main bearing housing and are fitted without any jointing compound being applied.

The lip seals used must be the approved type as supplied by Lister Petter; ordinary rubber seals may quickly harden in use, rapidly wear the shaft, or not even seal on fitting and therefore must not be used.

A lip type seal will not seal if the shaft is scratched or bruised within 5mm either side of the path of the lip of the seal.

A finely and accurately ground shaft without chatter marks and with a surface finish of 0.4-0.6 microns Ra is required. Emery cloth of any grade must not be used on the shaft in the area of the lip.

02.41.1 Fitting the Oil Seal

1. Place the new seal (A) squarely into the housing (B); do not use any jointing compound.

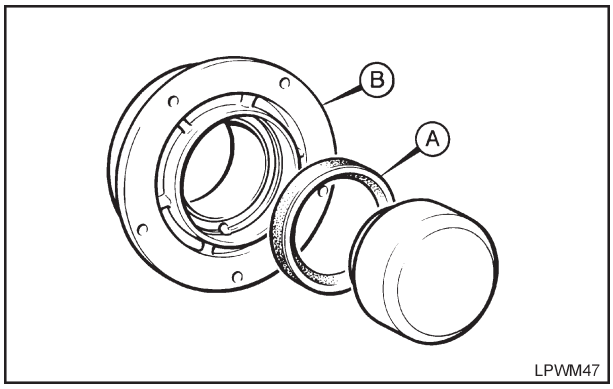


Figure 2.41.1 Oil Seal Tool, 317-50104

2. Hold the oil seal tool, 317-50104, firmly onto the outside face of the seal and drive the seal into the bearing housing until it is flush with the outside face of the housing.

02.42 THE CRANKSHAFT PULLEY

The crankshaft and driven pulleys must have a smooth finish to the grooves, and be aligned within 1.6mm (0.061in), measured at the centre of the grooves.

Early Engines

On early engines the crankshaft pulley was fitted to a ***left hand thread*** stud. The stud is torqued to 7.0Nm (5.0lbf ft) and the pulley then fitted to the stud and torqued to 300Nm (221lbf ft).

Later Engines

On later engines the pulley is retained by a ***left hand thread*** bolt torqued to 300Nm (221lbf ft).

02.43 THE CRANKSHAFT

The crankshaft is carried in steel backed copper lead faced main bearings which are located in the crankcase at the gear end, the flywheel end main bearing housing and the centre main bearing housings.

The two halves of the flywheel end main bearing shells are plain with no circumferential grooves but both halves have an oil feed hole. Two grooved half bearing shells are fitted in the crankcase at the gear end and the centre bearing housings.

An interference fit gear is keyed onto the gear end of the crankshaft and engages with the camshaft gear.

The balance weights are an integral part of the shaft and the centre bearing housing is in two halves secured by two capscrews.

End thrust is taken on steel backed copper faced split thrust washers fitted at the gear end of the crankcase and in the flywheel end main bearing housing.

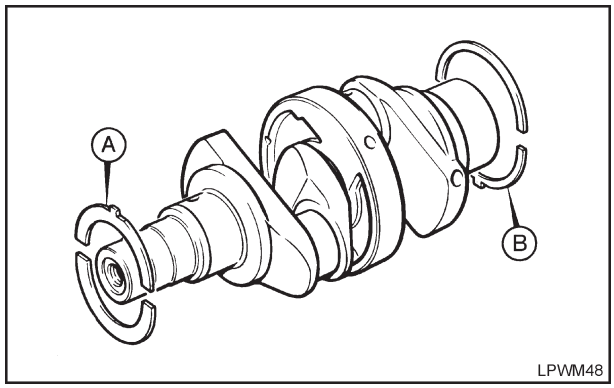


Figure 2.43.1 Thrust Washers
A - Gear End
B - Flywheel End Bearing Housing

02.43.1 Removing the Crankshaft

1. Remove the gear end cover.
2. Remove the pistons and connecting rods.
3. Remove the flywheel, flywheel housing and main bearing housing.
4. Remove the camshaft.
5. Screw a suitable new or clean M6, or inlet manifold, bolt (A) into the dowel.

   Pull the bolt and dowel out of the crankcase and leave the bolt in the dowel until it is refitted to ensure the dowel is refitted the correct way round.

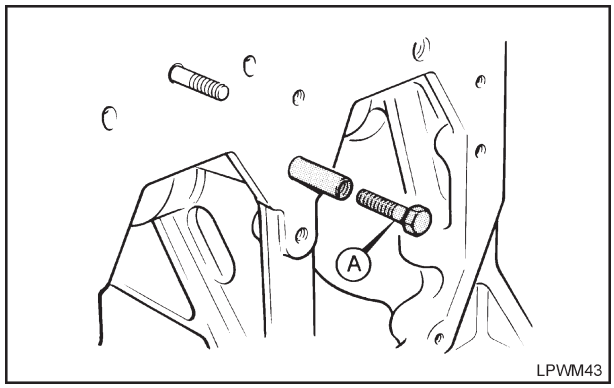


Figure 2.43.2 Removing the Centre Bearing Dowel

6. Use a suitable three legged puller to remove the crankshaft pinion.
7. Gently withdraw the crankshaft through the flywheel end of the crankcase.
8. Remove the two socket screws and dismantle the centre bearing housing/s.
9. Remove the thrust washers from the gear end of the crankcase and the flywheel end main bearing housing.

02.43.2 Inspecting the Crankshaft

a. Inspect the main bearings for scoring or wear.
b. If the connecting rod big end has been dismantled because of failure of the bearing, the oil passages in the crankshaft must also be examined for obstruction and fragments of metal.
c. Check the clearance between the crankshaft and journals, the main bearings and crankpins and also the connecting rod bearings.
d. Examine all bearing surfaces for scoring and wear.
e. Examine the thrust washers for damage and wear.

02.43.3 Refitting the Crankshaft

1. If necessary, fit new bearing shells to the main bearing housing, centre bearing housing/s and the gear end crankcase main bearing.
2. Re-assemble the centre main bearing housing/s around the crankshaft and torque the capscrews to 21.0Nm (15.5lbf ft). Ensure 'Flywheel End', stamped on the two housing halves, will be facing towards the flywheel after assembly.
3. Smear a small amount of grease to the steel side of the thrust washers and place them in the gear end of the crankcase; ensure the tab is correctly located in the recess and the copper face will be towards the crankshaft.
4. Fit the crankshaft into the crankcase from the flywheel end taking care to ensure the centre bearing dowel hole is in alignment with the hole in the crankcase on final assembly.

⚠ CAUTION

Take special care when passing the crankshaft through the gear end bearing as it is quite easy to score the bearing shell with the crankshaft.

5. With a suitable 6mm bolt or an inlet manifold bolt inserted in the centre bearing dowel, insert the dowel through the crankcase wall and into the centre bearing housing.

⚠ CAUTION

Ensure the dowel is fully seated and not in the housing capscrew head recess (B).

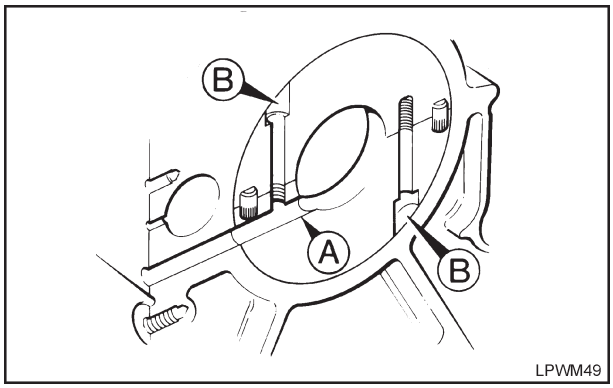


Figure 2.43.3 Dowel Hole Alignment
A - Bearing Housing Dowel Hole
B - Capscrew Head Recess

6. Remove the bolt from the dowel and repeat the procedure for the remaining cylinders.
7. Replace the rear main bearing housing and oil seal as described in "2.30.2 Refitting the Main Bearing Housing".
8. Check that the crankshaft is free to rotate.
9. Fit the Woodruff key at the gear end if it was removed.
10. Heat the crankshaft pinion to a straw yellow colour and fit it to the crankshaft without delay ensuring the 'O' mark is facing outwards.

    Insufficient heat or delay in fitting could well cause the pinion to become jammed on the crankshaft, whereas overheating may cause softening of the pinion.
11. Check the crankshaft end float as described in "02.44.1 Checking Crankshaft Endfloat".

02.44 CRANKSHAFT ENDFLOAT

The crankshaft endfloat is obtained by inserting a single aluminium shim between the flywheel end main bearing housing flange and the crankcase.

02.44.1 Checking Crankshaft Endfloat

1. Set a dial test indicator so that the actuating plunger makes contact with the flywheel end face of the crankshaft.

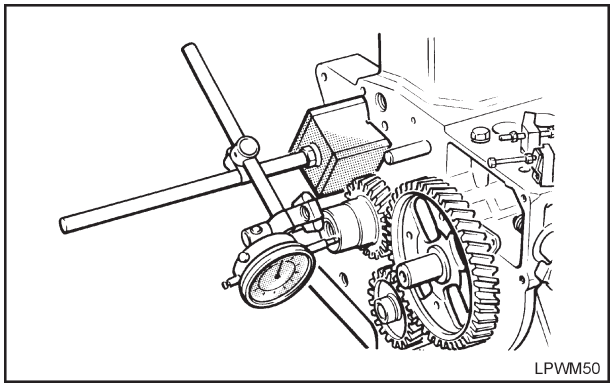


Figure 2.44.1 Checking Crankshaft Endfloat

2. Push the crankshaft firmly towards the gear end of the engine and zero the indicator.
3. Push the crankshaft firmly towards the flywheel end of the engine and check the measurement on the indicator which will be the endfloat.
4. The endfloat should be:
   0.18-0.45mm (0.007-0.018in)
   and is maintained by fitting a single 0.38mm (0.015in) or 0.55mm (0.022in) aluminium shim behind the bearing housing flange.

02.45 CRANKSHAFT MAIN BEARINGS

The procedure for removing and fitting both main bearings is identical except smaller tool components are used at the gear end.

The main bearing shells are steel backed copper lead, or aluminium tin and should not be scraped or touched up in any way.

⚠ WARNING

Copper lead and aluminium tin main bearing shells must not be mixed in an engine.

02.45.1 Removing Main Bearings

Before attempting to remove the bearings from the main bearing housing it should be firmly held in a soft-jawed vice.

1. Remove the oil seal by pushing it out from inside the bearing housing.
2. Place the bolt (A) through the plain dolly (B).

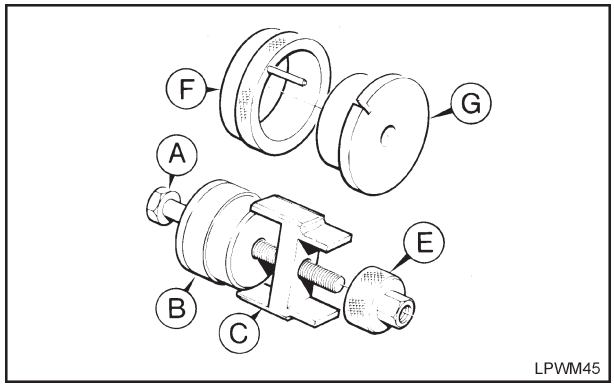


Figure 2.45.1 Main Bearing Tool

3. Fit the bolt and dolly into the bearing from the oil seal side (crankcase outside face).
4. Fit the bridge (C) over the bolt threads until the two legs are against the housing face (crankcase at the gear end)
5. Fit the nut (E) onto the bolt.
6. Using a suitable spanner tighten the nut until the bearing shells are withdrawn.

2.45.2 Fitting New Bearings

The main bearing shells are steel backed copper lead, or aluminium tin and should not be scraped or touched up in any way.

⚠ WARNING

Copper lead and aluminium tin main bearing shells must not be mixed in an engine.

Before attempting to replace the bearings in the main bearing housing it should be firmly held in a soft-jawed vice with the small oil feed hole uppermost.

1. Place the large tapered collar (F) on a bench with the spigot facing upwards.
2. Place the new bearing shells into the collar ensuring that one oil feed hole is in line with the spigot and the end of the shell is in line with the mark on the collar face.
3. Place the driver (G) onto the collar (F) with the cutout on the driver located over the collar spigot.
4. Push the driver sufficiently until the bearings come out the other side of the collar to provide a lead-in.
5. Scribe a pencil line in line with the oil hole (X) on the outside face of the housing (crankcase at the gear end).

   On early bearing housings the oil feed hole was drilled at 90° to the crankshaft.

   On current housings care must be taken to align the spigot with the inner oil hole; see (X) in 'Figure 2.31.2'.
6. Fit the assembly into the housing from the oil seal side (crankcase outside face at the gear end) with the spigot in line with the pencil line on the housing (crankcase at the gear end).

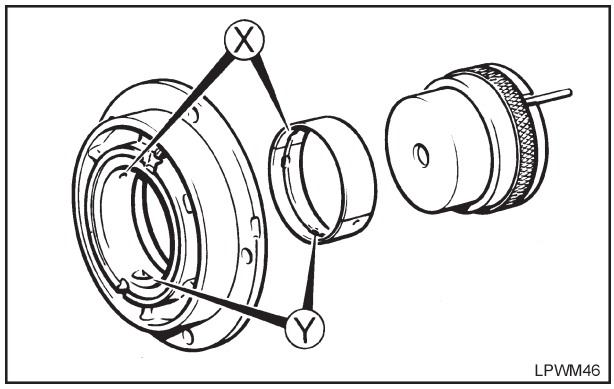


Figure 2.45.2 Main Bearing Housing Oil Hole

7. Place the bolt (A) through the assembly.
8. Fit the bridge (C) and the nut (E) onto the bolt.
9. Tighten the nut until the driver (G) is against the face of the collar (F).
10. Remove the tool.
11. Check that the elongated oil hole (X) and the small oil hole (Y) in the bearing shell is correctly aligned with the oil feed holes in the housing (crankcase).

02.45.2 Fitting Centre Main Bearings

The bearing shells both have circumferential grooves and are contained within the two halves of the housing which are dowelled and secured by two capscrews.

The housing is located by a hollow dowel fitted through the crankcase.

The bearing shells both have circumferential grooves and are contained within the two halves of the housing which are dowelled and secured by two capscrews.

The housing is located by a hollow dowel fitted through the crankcase.

1. Remove the crankshaft.
2. Remove the two retaining capscrews and lift the housing halves away.
3. Slide out the bearing shells and fit the new ones taking care to ensure the oil holes in the shells and housing align.
4. Fit the bearing housing to the crankshaft ensuring the two halves correctly align on the dowels and the words 'Flywheel End' face the correct way.
5. Replace the capscrews and torque them to 21.0Nm (15.5lbf ft).

02.46 THE OIL STRAINER AND PUMP

Access to the pump is only possible after removing the end cover. The crankcase door must be removed to gain access to the oil strainer.

A higher capacity pump, 750-12020, is fitted to engines which have controlled expansion pistons and it is interchangeable with the earlier pump for engines fitted with mono-metal pistons.

Engines are fitted with a coarse lubricating oil strainer on the suction side of the oil pump and care must be taken to ensure that rags are not used to wipe the inside of the crankcase during overhauls to prevent possible fluff clogging the strainer.

02.46.1 Removing the Pump and Strainer

No attempt must be made to dismantle the oil pump; if it is faulty it must be replaced complete.

1. Remove the camshaft and crankcase door as described.
2. Remove the oil strainer bracket bolt, spacer, washer and locknut.
3. Remove the oil strainer (A) and the relief valve (C) from inside the crankcase.

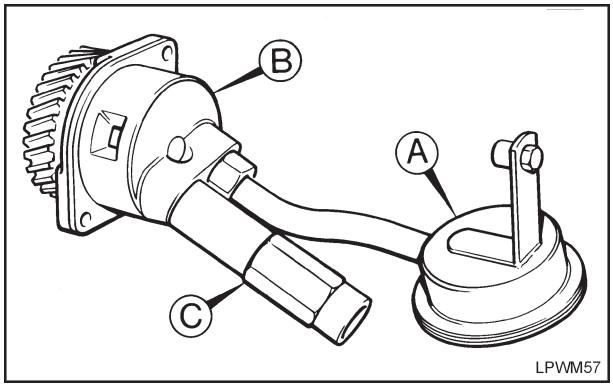


Figure 2.46.1 Oil Strainer and Pump
A - Strainer
B - Pump
C - Relief Valve

4. Remove the two pump retaining bolts.
5. Ease the pump (B) out of the crankcase.

⚠ CAUTION

To avoid possible damage to the pump flanges do not use a screwdriver or other tool to lever the pump out.

6. On early engines remove the copper washer from the pump inlet port.

⚠ CAUTION

Extreme care must be taken to ensure the copper washer fitted to early engines does not fall into the sump when the oil strainer is removed.

7. Check that the pump is working by turning the gear while holding the palm of the hand over the two ports and listen for a sucking/pumping sound.
8. Clean the strainer.

02.46.2 Refitting the Pump and Strainer

1. Refit the pump to the crankcase with the cut-out section of the pump flange (X) facing towards the top of the crankcase.

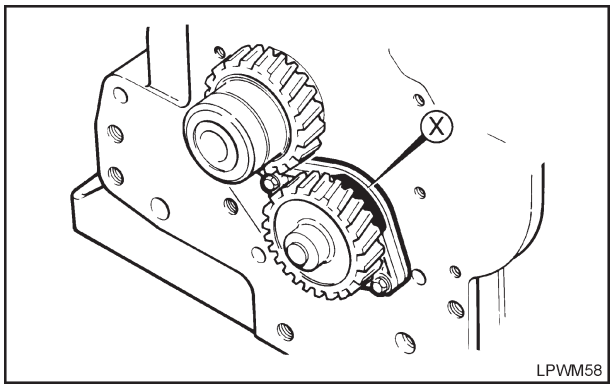


Figure 2.46.2 Oil Pump Locating Cutout

2. Replace and torque the two pump retaining bolts to 9.0Nm (6.5lbf ft).
3. On early engines only:
   Fit a new copper washer to the pump inlet port; the inlet port is on the right hand side of the pump when viewed from inside the crankcase.
4. Replace the oil strainer, strainer bracket bolt, spacer, washer and locknut.
5. Tighten the oil strainer pipe nut to 27.0Nm (20.0lbf ft); ensure the strainer gauze is parallel with the sump base.
6. Replace the relief valve to the left hand pump port and tighten the retaining nut.
7. Replace the camshaft, end cover and crankcase door.

⚠ WARNING

If controlled expansion pistons are being fitted to replace the early mono-metal type the higher output oil pump 750-12020 must be fitted. Oil jets are required as described in "2.26 The Piston Oil Jets".

02.47 THE WATER COOLING SYSTEM

The basic engine is supplied with a freshwater circulation pump but the radiator and cooling fan are specified as accessories and can be engine mounted or supplied loose depending on the engine application.

Marine engines are usually fitted with a heat exchanger and a cooling system make-up tank.

02.47.1 Radiator Cooling

Radiators can be engine or remote mounted including some which may not have been originally fitted by Lister Petter.

The radiator capacity must be determined then added to that given in "02.47.3 Engine Block Coolant Capacity".

An additional amount must also be taken into consideration for the capacity of the hoses on remote radiator applications.

02.47.2 Marine Cooling

The capacity of the heat exchanger and make-up tank must be added to that given in "02.47.3 Engine Block Coolant Capacity"

An amount must also be taken into consideration for the capacity of the hoses when a keel cooling system is installed.

02.47.3 Engine Block Coolant Capacity

It is advisable to ascertain the coolant capacity before determining the amount of coolant concentrate to be added to maintain a 40% concentration.

	litre	pint	US gal
LPW2 LPWS2	2.1	3.7	0.55
LPW3 LPWS3	2.5	4.4	0.66
LPW4 LPWT4 LPWS4	3.0	5.3	0.79

02.47.4 Draining the Cooling System

⚠ WARNING

The cooling system is pressurised and extreme care must be taken when removing the radiator or expansion tank cap if the engine is hot.

1. Place a suitable container under the radiator or heat exchanger bottom hose if the coolant is to be retained. Some heat exchangers may be fitted with a drain plug.
2. Slacken a bottom hose clip and slide the hose off.
3. Remove the radiator, heat exchanger or expansion tank filler cap and allow sufficient time for the system to drain.

02.47.5 Flushing the Cooling System

Flushing the Radiator or Heat Exchanger

With the bottom water hose removed flush the radiator, make-up tank or heat exchanger through the filler with clean fresh water, preferably using a hose pipe, until clean water emerges and then replace the filler cap and hoses.

Flushing the Engine Block

With the top and bottom hoses removed from the engine, flush the block through the top hose with clean fresh water, preferably using a hose pipe, until clean water emerges and then replace the hoses.

02.47.6 Filling the Cooling System

⚠ CAUTION

Under some circumstances an air lock could occur in the cylinder head when filling the system causing a false level indication.

1. Replace the hoses and tighten the hose clips.
2. Slacken or remove a plug to allow the air in the system to vent as the water is being added.
3. Slowly refill the system with clean fresh water and coolant concentrate to a 40% concentration through the filler cap.
4. Replace the filler cap and vent plug.
5. Run the engine for a few minutes and check the coolant level.

02.48 COOLANT CONCENTRATE

Refer to "03.3 Engine Fluids - coolant concentrate".

⚠ WARNING

Coolant concentrate must not be allowed to come into contact with the skin; adhere to the manufacturers instructions and precautions.

⚠ WARNING

Extreme care must be taken to ensure that coolant concentrate, solvents or other toxic wastes are disposed of in accordance with local regulations to prevent contamination.

02.49 THE THERMOSTAT

A common thermostat is not fitted therefore reference should be made to the Master Parts Manual for comprehensive information.

The thermostat housing cover for the various builds must be fitted as shown.

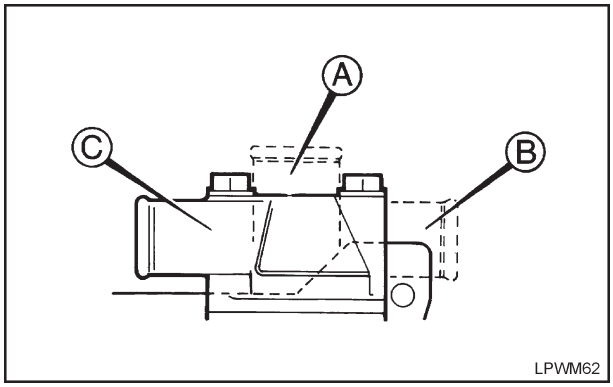


Figure 2.49.1 Thermostat Housing Cover
A - LPW3, LPWS4 Build 70
B - Builds 40,41,42,43,44,45,46,47,48,49,71, 72,173,174
C - All Other Builds

02.49.1 Thermostat Identification

Builds	Part Number
All LPWT4 except Build 89 All other engines except Builds 40, 42, 45, 47, 48, 49, 74, 84, 89, 102, 177	751-40982
LPW/LPWS2,3 Builds 40, 42, 45, 47	803-02221
LPW3, 4 Build 48	751-40983
LPW3, LPW4, LPWT4 Build 74 LPW4 Build 84 LPW, LPWT4 Build 89 LPW2 Build 102 LPW2, 3 Build 177	751-40981
LPW/LPWS4, LPWT4 Build 40, 42, 47, 49	854-01222

02.49.2 Removing the Thermostat

The early type of thermostat, shown as C_1 is not interchangeable with later types shown as C_2 which can be identified by the lower skirt profile.

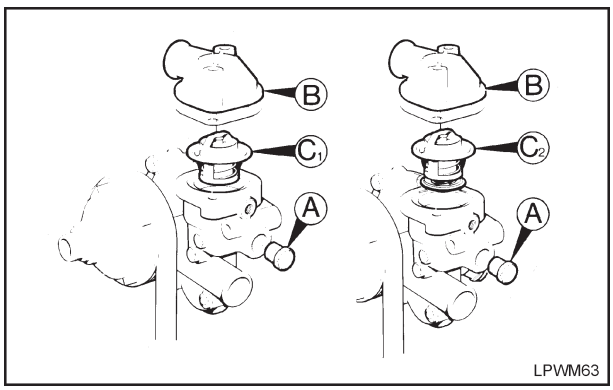


Figure 2.49.2 Removing the Thermostat
C_1 - Early Type
C_2 - Current Type

1. Remove the radiator top hose.
2. Unscrew and remove the engine temperature switch, if fitted, from the thermostat body drain plug (A).
3. Remove the two cover retaining bolts.
4. Lift off the cover (B).
5. Lift out the thermostat (C).
6. Clean any debris and the old seal from the thermostat housing.

02.49.3 Replacing the Thermostat

1. With all surfaces clean and dry, coat both gasket faces with Hylomar PL32/M and fit a new gasket.
2. Replace the thermostat into the housing taking care to ensure the jiggle pin (A) moves freely and is located as shown towards the recess. If a jiggle pin is not fitted the round hole must be in this position.
3. Replace the cover in the correct plane, see 'Figure 2.49.1'.

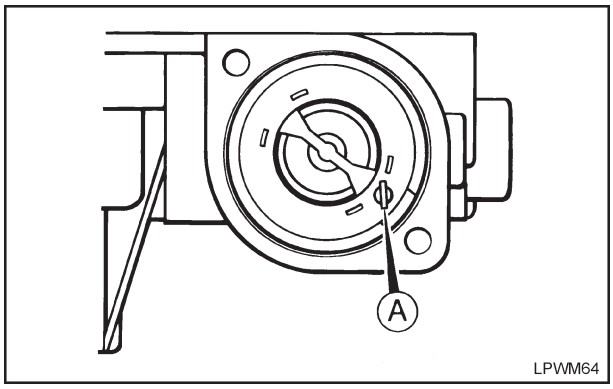


Figure 2.49.3 Replacing the Thermostat

4. Replace the engine temperature switch, if fitted.
5. Replace the radiator top hose.
6. Refill the system with clean fresh water and coolant concentrate to a 40% concentration.

2.49.4 Testing the Thermostat

1. With the thermostat removed from the engine submerge it in a suitable container of warm water.
2. Raise the water temperature and check when the thermostat begins to open and when it is fully open.
3. Compare the results with the figures given in the table and if they are outside those given the thermostat must be replaced.

	°C	°F
751-40981		
Starts to Open	72-76°	162-169°
Fully Open	85-88°	185-190°
All Others		
Start to Open	86-90°	187-194°
Fully Open	99-102°	210-216°

02.50 THE RADIATOR

Care must be taken to ensure the air flow is unobstructed and has not been re-circulated from the driven equipment.

The radiator fins should be checked for damage every 2000 hours, or more frequently if the application demands.

02.50.1 The Radiator Cap

Either a 10.0lb/in^2 or 15.0lb/in^2 cap is used on all radiators originally fitted by Lister Petter. If there is any doubt as to which is fitted Lister Petter should be consulted.

Cap Part Numbers

10.0lb/in^2 027-07834
15.0lb/in^2 027-07878

02.50.2 Radiator Coolant Capacity

There are a number of radiator options available for LPW, LPWT and LPWS engines including some which may not have been originally fitted by Lister-Petter.

For these reasons it is advisable to ascertain the radiator capacity which must then be added to that given in "5.3 Coolant Capacity" before determining the amount of coolant concentrate to be added to maintain a 40% concentration.

An additional amount must also be taken into consideration for the capacity of the hoses on remote radiator applications.

02.50.3 Removing the Radiator

1. Place a suitable container under the radiator bottom hose if the coolant is to be retained.
2. Slacken the clip at the radiator end of the bottom hose (A) and slide the hose off the radiator.
3. Remove the radiator filler cap.
4. Allow sufficient time for the radiator to drain.
5. Slacken the clip at the radiator end of the top hose (B) and slide the hose off the radiator.

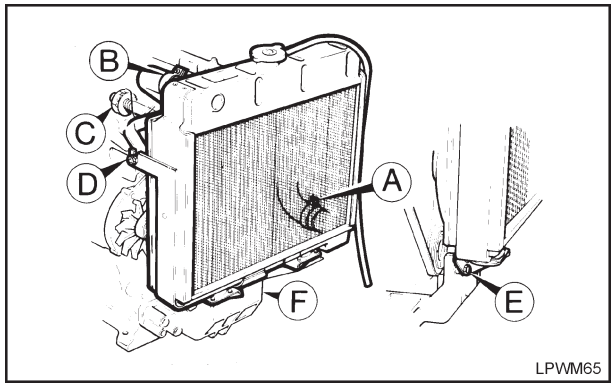


Figure 2.50.1 Radiator Mountings

6. Slacken the two radiator stay hook bolt nuts (C).
7. Slacken the outer nuts from the two top flexible mountings (D) sufficiently to remove the mountings from the radiator lug slots.
8. Support the radiator and remove the bolts from both bottom radiator support brackets (E).
9. Lift the radiator off taking care not to damage the fan or radiator core fins.

5.6.4 Replacing the Radiator

1. Support the radiator and bolt the two bottom radiator support brackets to the radiator mounting bracket (F).
2. Tighten the two top flexible mountings and stay hooks.
3. Replace the two radiator hoses.
4. Refill the system with clean fresh water and coolant concentrate to a 40% concentration.

02.51 THE RADIATOR FAN

Radiator fans are available with pusher or puller options and it is suggested that where possible pusher fans are used, especially in encapsulated installations, as this arrangement draws radiated heat from the enclosure. The drive ratio of all fans is 1:1.

The fan blades should be checked for damage every 2000 hours, or more frequently if the application demands.

To maintain adequate cooling, extreme care must be taken to ensure that the fan is correctly fitted.

Fans originally fitted, or supplied, by Lister-Petter are marked with an arrow on each blade showing the direction of rotation. When viewed from facing the gear end of the engine, the arrows should point in a clockwise direction.

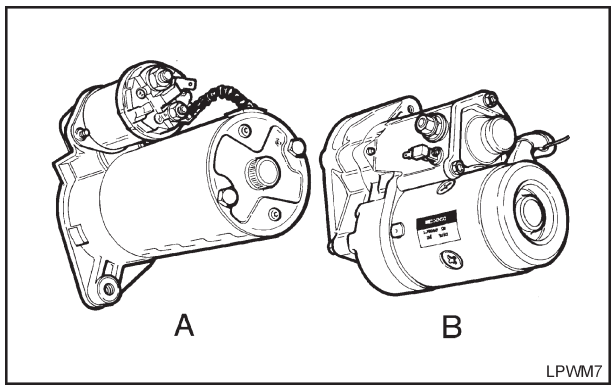


Figure 2.51.1 Fan Blade Profiles
A - Pusher
B - Puller

02.51.1 Removing and Fitting the Fan

1. Remove the radiator.
2. Remove the fan drive belt.
3. Use a 1^1/$_2$ inch AF size socket to remove the ***left hand thread*** fan securing nut.
4. Lift off the fan.
5. Replace the fan and the ***left hand thread*** fan securing nut.
6. Torque the nut to 30.0Nm (22.0lbf ft).
7. Replace the fan drive belt and tension it; refer to "02.9 The Drive Belt".
8. Replace the radiator.
9. Refill the system with clean fresh water and coolant concentrate to a 40% concentration.

02.52 THE WATER CIRCULATING PUMP

If an early type pump is being replaced with the later type it will be necessary to change the water pipes and the original thermostat; refer to the Master Parts Manual.

The water pump assembly can be removed from the engine, without the need to remove the thermostat, radiator fan or fan pulley.

02.52.1 Removing the Water Pump

1. Remove the radiator.
2. Remove the fan drive belt.
3. Remove the five stud nuts on early engines or the five bolts and two stud nuts from the pump assembly.

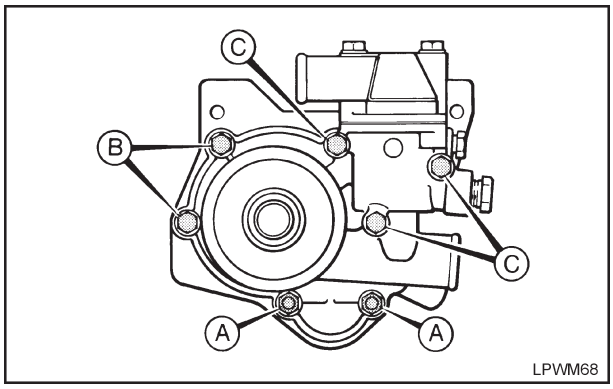


Figure 2.52.1 Water Pump Bolt Locations
A - M8 x 45mm studs (M8 x 55mm on Build 70)
B - M8 x 45mm bolts
C - M8 x 75mm bolts

4. Lift off the pump assembly.
5. Clean any debris and old seal from the pump assembly and the pump mounting face on the crankcase.

02.52.2 Fitting the Water Pump

1. With all surfaces clean and dry fit a new gasket.
2. Replace the pump assembly and torque the five bolts and two stud nuts to 21.0Nm (15.5lbf ft).

   The early water pump was secured by studs and nuts torqued to 16.0Nm (12.0lbf ft).
3. Replace the fan drive belt and tension it; refer to "02.9 The Drive Belt".
4. Replace the radiator.
5. Refill the system with clean fresh water and coolant concentrate to a 40% concentration.

02.53 THE MARINE EXPANSION TANK

The tank is manufactured from polypropylene and extreme care must be taken to ensure it is protected from possible damage.

02.53.1 Removing the Expansion Tank

1. Remove the top and bottom hoses from the tank.
2. Slacken or remove the retaining strap or the later mounting screws.
3. Remove the tank from the mounting bracket.

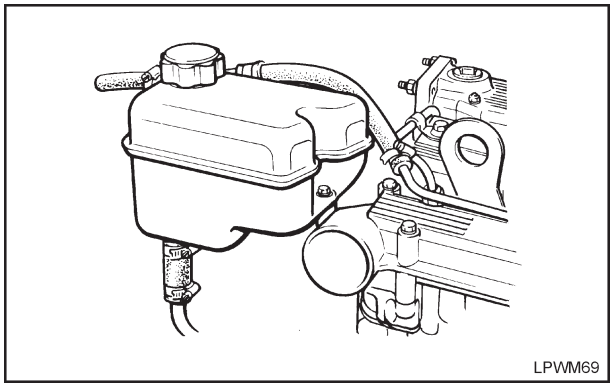


Figure 2.53.1 Expansion Tank

02.54 THE MARINE RAW WATER PUMP

The pump draws raw water in and pumps it around the heat exchanger, before discharging it back to source.

The size of pump fitted will depend on the engine and they are not interchangeable due to their output volumes and pipe layout.

The pump is located by either four setscrews, or two setscrews and clamps.

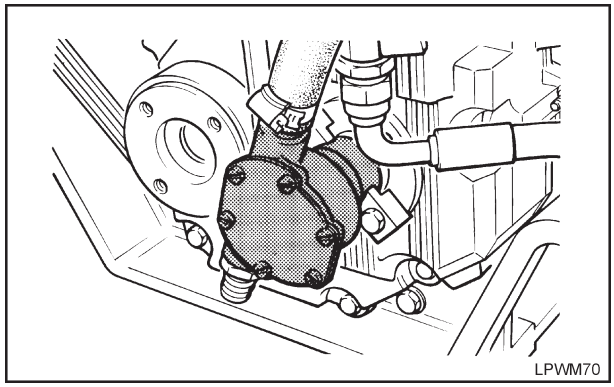


Figure 2.54.1 Raw Water Pump

02.54.1 Replacing the Water Pump

1. Remove the pump inlet and outlet pipes.
2. Remove the pump mounting setscrews and remove the pump by keeping it square as it is pulled outwards from the engine.
3. Remove the 'O' ring and fit a new one.
4. Take care to ensure the coupling assembly will be aligned with the spigot on the pump.
5. Replace the pump and mounting setscrews.

02.54.2 Replacing a Water Pump Impeller

The impeller can be replaced with the pump fitted to the engine.

1. Remove the six cover setscrews (A) and the cover (B).

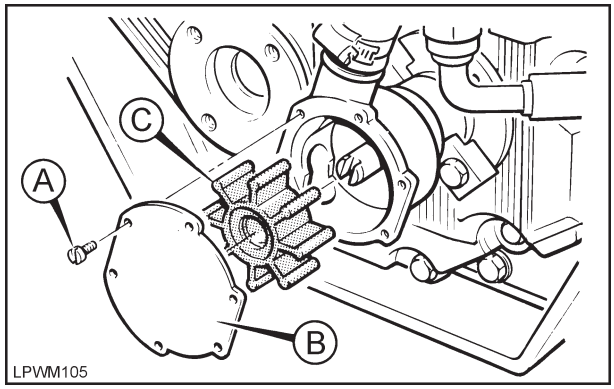


Figure 2.54.2 Water Pump Impeller

2. Pull out the old impeller (C) and fit a new one.
3. Replace the cover and setcrews.

02.55 THE MARINE HEAT EXCHANGER

The raw water pump draws water in and pumps it around the heat exchanger before discharging it back to source.

On propulsion engines fitted with a Newage gearbox the heat exchanger also cools the gearbox lubricating oil as it passes through the exchanger.

The type and size of heat exchanger fitted will depend on the engine; they are not interchangeable due to the oil pipe layout.

Water can be drained from the exchanger by removing the anode (A) in the end cover.

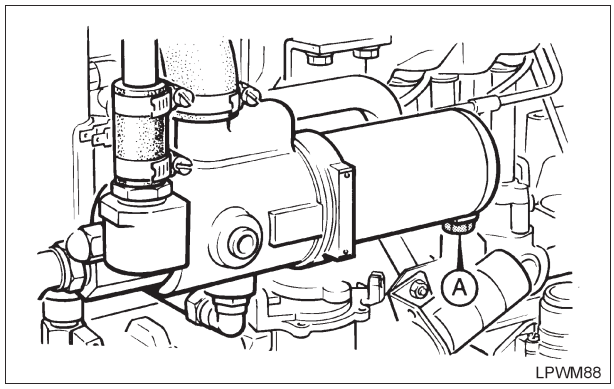


Figure 2.55.1 Heat Exchanger

02.56 THE MARINE ZINC ANODE

A sacrificial zinc anode is fitted to protect the heat exchanger internal brass plates from corrosion.

The anode is fitted in the end cap of the heat exchanger.

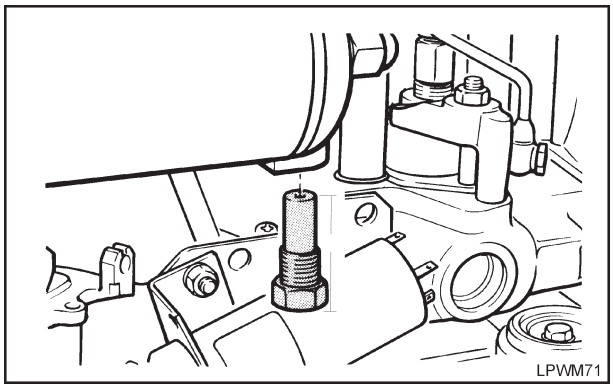


Figure 2.56.1 Zinc Anode

02.56.1 Checking the Anode

When it is new the anode is 10mm in diameter and 38mm long overall.

Lister Petter recommend it is removed and checked at regular short time intervals until a wear pattern has been determined.

Once a wear pattern has been established the anode will need checking accordingly.

⚠ CAUTION

Sea water will drastically shorten the life of the anode, as will stray electrical currents.

2.38 LAYING-UP PROCEDURE

The following routine should be carried out when it is known that the engine will not be required for some months.

If the following procedure is not carried out the engine should be run on full load for approximately 45 minutes once a month.

⚠ CAUTION

As a direct result of combustion the lubricating oil may contain harmful acids and therefore it should not be left in the sump if it is known that the engine will not be used for extended periods.

a. On diesel engines, replace the fuel in the tank with a small supply of suitable inhibition fluid.
b. Drain the lubricating oil from the sump and refill with new oil.
c. Run the engine for a period to circulate the oil through the system and to ensure the inhibition fluid is passed through the fuel pumps and injectors.
d. Stop the engine, drain the cooling system and drain the lubricating oil from the sump.

   The crankshaft should NOT be turned until the engine is again required for service.

   The inhibition fluid should be left in the fuel system.
e. Seal all openings on the engine with tape.
f. Remove the batteries and store them fully charged after coating the terminals with petroleum jelly.
g. Grease all external bright metal parts and the speed control linkage.
h. Tie labels on the engine clearly stating what steps have been taken to inhibit the engine during storage.

02.57 THE GOVERNOR

LPWG engines are fitted with an electronic governor; refer to "8.1 The Electronic Governor".

The method of governing is common for all other engines. The 'G' setting, speeder springs and weights vary with the engine type and build.

The governor must be fitted, and correctly adjusted, before the fuel pumps can be replaced.

Before dismantling the governor it is suggested that the 'G' setting is measured and recorded to ensure the original setting is maintained.

02.57.1 Removing the Governor

1. Remove the gear end cover and fuel injection pumps.
2. Unhook the speeder spring (A) from the governor lever assembly (B) and the speed control lever (C) and remove the spring.

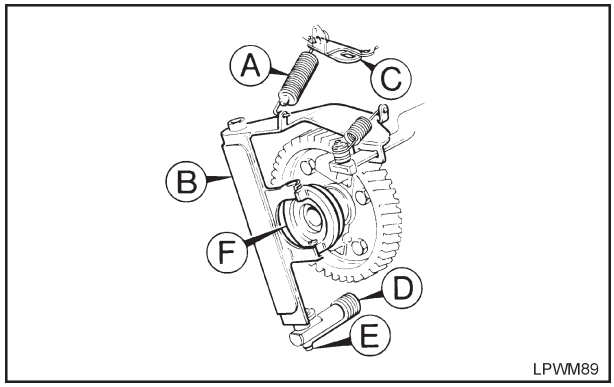


Figure 2.57.1 Removing the Governor

3. Unhook the small spring (D) from the lower end of the governor lever assembly retaining pin (E).
4. Remove the pins from the top and bottom of the governor lever assembly taking care to retain any end float shims that are fitted.
5. Gently remove the governor lever assembly from the crankcase.
6. Remove the governor sleeve (F) and the thrust washer.

02.57.2 Fitting the Governor

A damper spring is fitted to the top governor lever pivot on the following engines:

LPA/LPW3 Build 113
LPW Build 84

1. Turn the camshaft until Number 1 cylinder fuel pump tappet is in its lowest position.
2. Replace the governor sleeve and washer; refer to "6.14.3 Governor Sleeve and Washer Combinations".
3. Gently place the governor lever assembly into the crankcase taking care to ensure that the innermost end of the governor rack is located in its housing at the flywheel end.
4. Fit the lower governor assembly retaining pin and shim onto the governor lever assembly.

   On Builds 71, 72 and LPW Builds 74, 173 and 174 one 0.25mm shim must always be fitted at the lower pivot
5. Fit the retaining spring (D).
6. Replace the top retaining pin and shims.
7. Replace the speeder spring taking care to ensure that it is correctly located in the speed control lever at both ends.

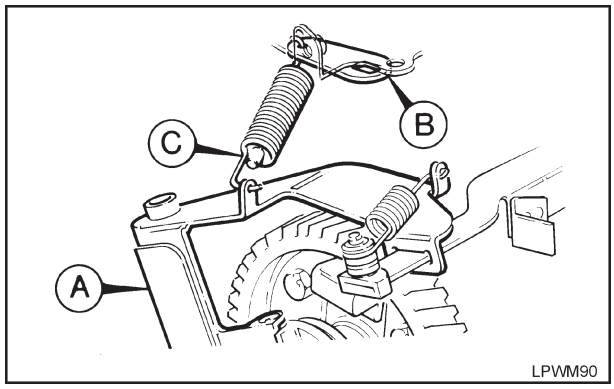


Figure 2.57.2 Speeder Spring Location
A - Governor Lever Assembly
B - Speeder Spring Lever
C - Fixed End of the Spring

8. Follow the procedures given in "6.16 Setting the Governor".

02.57.3 Governor Sleeve and Washer Combinations

Build	Part Number		
	Thrust Collar	Governor Sleeve	Steel Washer
LPA			
01, 02, 03, 04, 10, 51, 52, 75, 82, 83, 86, 104, 105	751-12823	751-10288	751-13130
07, 08, 09, 57, 58, 59, 74, 79, 81, 85, 113	751-15430	751-15441	751-13130
LPW			
01, 02, 03, 10, 14, 16, 27, 28, 40, 41, 42, 46, 4,7 48, 51, 52, 81, 82, 83, 84, 102, 107, LPW2,3 74	751-12823	751-10288	751-13130
09, 18, 44, 57, 58, 59, 79, 89, 109, 113	751-15430	751-15441	751-13130
71, 72, 173, 174. LPW4 74	Thrust Collar 751-12824 Thrust Washer 751-15950 Governor Sleeve 750-12660 Thrust Washer 751-15940		
LPWT4			
01, 02, 03, 04, 07, 08, 09, 41, 51, 57, 58, 59, 78, 79, 82, 89	751-12823	751-10288	751-13130
74	Thrust Collar 751-12824 Thrust Washer 751-15950 Governor Sleeve 750-12660 Thrust Washer 751-15940		
42, 46, 48, 81, 84	Thrust Collar 751-12823 Thrust Washer 751-15950 Governor Sleeve 750-12660 Thrust Washer 751-15940		
LPWS			
01, 02, 03, 11, 12, 13, 42, 45, 46, 47, 49, 70, 76, 108	751-12823	751-10288	751-13130
07, 09, 18, 41, 44, 57	751-15430	751-15441	751-13130

02.57.4 Governor Lubrication

On 1500/1800r/min generating set build engines an oil jet is provided to spray lubricating oil over the governor mechanism.

The jet is a drilling in the camshaft thrust plate retaining screw. On the specified builds both retaining screws incorporate an oil jet to minimise the risk of incorrect fitting.

This modification should be incorporated when converting engines for 1500/1800r/min generating set operation.

02.58 GOVERNOR WEIGHTS AND SPRINGS

02.58.1 Changing Governor Weights

The weights are held by pins which are retained by plates bolted to the camshaft gearwheel.

On Builds 10, 83 and 104 a special weight retaining plate is used and this can be identified by the letters 'HS' below the location hole.

1. Remove the governor lever assembly.
2. Remove the governor sleeve (A).

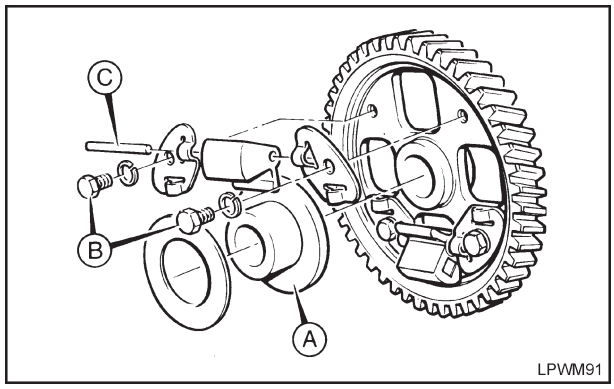


Figure 2.58.1 Changing Governor Weights

3. Turn the camshaft until the weights are horizontal.
4. Slacken the weight retaining plate bolts (B).
5. Remove the weight retaining plates.
6. Lift out the weights taking care to retain the pins with them.
7. Slide the weights off of the pins (C).
8. Lightly lubricate the pins and fit them to the new weights.
9. Refit the weights and pins with the large section of the weights facing outwards.
10. Replace the weight retaining plates leaving the bolts finger tight.

    On Build 10, 83 and 104 engines a special weight retaining plate is used and this can be identified by the letters 'HS' below the location hole.
11. Torque the retaining bolts to 9.0Nm (6.5lbf ft).
12. Check that the weights are free to move.

02.58.2 Governor Weights and Springs - LPA

Build	Part Number of Weight	Number of Weights	Part Number of Speeder Spring	Spring Colour Code
01, 02, 03, 04, 51, 52, 75, 86, 105	751-15461	4	751-15720	Green/White
57	751-12980	4	751-16611	Green
58, 74, 79, 113	751-12980	4	751-12895	Black
09, 59, 82, 85	751-15461	4	751-16613	Blue
10, 83	751-15461	4	751-17790	Red
81	751-12980	4	751-16613	Blue
104	751-11091	2	751-11663	Blue/Yellow

02.58.3 Governor Weights and Springs - LPW2, 3

Build	Part Number of Weight	Number of Weights	Part Number of Speeder Spring	Spring Colour Code
01, 02, 03, 14, 16, 40, 42, 46, 48, 51, 52, 102	751-11091	2	751-15720	Green/White
47	751-12980	2	751-15720	Green/White
57	751-12980	4	751-12894	Black/White
18, 58, 79, 113	751-12980	4	751-12895	Black
09, 44, 59, 82, 89	751-15460	4	751-16612	Yellow
10, 83	751-15460	4	751-17790	Red
27, 28, 41, 74, 81, 177	751-12983	4	751-16613	Blue
72, 173, 174	751-12684	4	751-40906	Green/Silver

02.58.4 Governor Weights and Springs - LPW4

Build	Part Number of Weight	Number of Weights	Part Number of Speeder Spring	Spring Colour Code
01, 02, 14, 16, 40, 42, 46, 48, 51, 84	751-11091	2	751-15720	Green/White
47	751-12980	2	751-12894	Black/White
57	751-12980	4	751-12894	Black/White
18, 79	751-12980	4	751-12895	Black
09, 44, 59, 82, 89, 109	751-15460	4	751-16612	Yellow
10, 83	751-15460	4	751-17790	Red
27, 28, 41, 81	751-12983	4	751-16613	Blue
71, 72, 173, 174	751-12684	4	751-40906	Green/Silver
74	750-12684	4	751-19130	Yellow/Green

02.58.5 Governor Weights and Springs - LPWT4

Build	Part Number of Weight	Number of Weights	Part Number of Speeder Spring	Spring Colour Code
01, 02, 03, 04, 51, 78	751-11091	2	751-15710	White/White
07, 41, 57	751-12983	4	751-12789	White/Yellow
08, 58, 79	751-12983	4	751-16613	Blue
09, 59, 82, 89	751-15460	4	751-12894	Black/White
42, 46, 48, 84	751-15460	4	751-15720	Green/White
74	750-12684	4	751-19130	Yellow/Green
81	751-12983	4	751-16611	Green

02.58.6 Governor Weights and Springs - LPWS2 and 3

Build	Part Number of Weight	Number of Weights	Part Number of Speeder Spring	Spring Colour Code
01, 02, 03, 11, 12, 13, 42, 48, 76	751-11091	2	751-15300	-
07, 41, 57	751-12980	4	751-16611	Green
18	751-12980	4	751-13455	Blue/Red
09, 44	751-15460	4	751-16613	Blue
45, 47	751-12980	2	751-15300	-

02.58.7 Governor Weights and Springs - LPWS4

Build	Part Number of Weight	Number of Weights	Part Number of Speeder Spring	Spring Colour Code
01, 02, 03, 11, 13, 42, 46, 70, 76, 108	751-11091	2	751-15300	-
18	751-12980	4	751-13455	Blue/Red
44	751-15460	4	751-16614	Red/White
47	751-12980	2	751-15300	-
49	751-16240	2	751-15300	-
57	750-12980	4	751-16611	Green

02.59 SETTING THE GOVERNOR

02.59.1 Governor 'E' Setting

1. Move the lever assembly until it abuts against the top pivot support and check that it falls freely under its own weight.

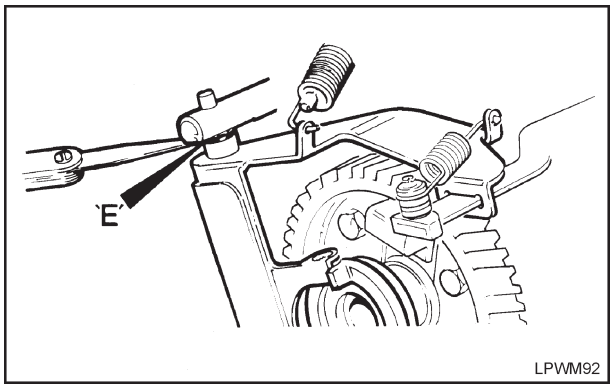


Figure 6.16.1 Governor 'E' Setting

2. Check the governor lever assembly end float (E), and add or remove 0.25mm shims at the cylinder head end pivot to obtain an endfloat of 0.1-0.3mm (0.004-0.012in).

   On Builds 71, 72 and LPW4 Builds 74, 173 and 174, one 0.25mm shim must always be fitted at the lower pivot.

02.59.2 Governor 'G' Setting

The 'G' setting is made to ensure the fuel pumps deliver the correct amount of fuel as dictated by the engine build number.

⚠ CAUTION

On some engines a tamperproof setscrew nut is fitted to prevent changes being made to the engine stop/run control settings. In these cases adjustment is not possible.

The following instructions only apply to engines not fitted with tamperproof nuts.

Any adjustment should not be made until the engine control lever has been correctly set.

1. Move the engine control (B) to the run position.

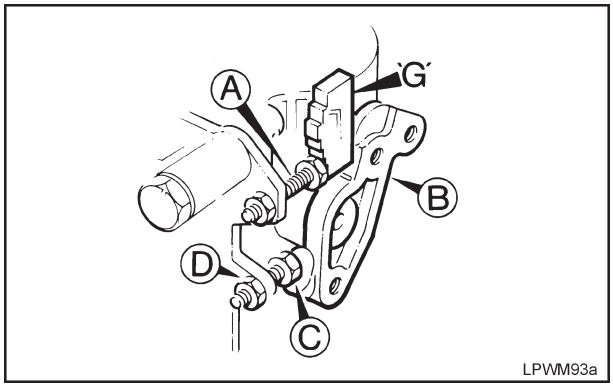


Figure 2.59.2 Governor 'G' Setting

⚠ CAUTION

The settings given below are the initial settings. Resetting may be necessary to achieve optimum running and performance.

2. Insert a gauge of the appropriate 'G' dimension between the head of the setscrew (A) and the top of the radiused part of the engine control (B).

   LPA, LPW, LPWS:
   All Builds 23mm

   LPWT4:
   Builds 01, 02, 51, 84 ..... 23mm
   All Others 27mm

3. Adjust the setscrew (C) until the engine control just touches the setting gauge.
4. Tighten the setscrew locknut (D).
5. Remove the gauge.

02.60 ADJUSTING THE ENGINE SPEED

The speed adjustments must only be made after the governor has been correctly set. The locations of the two adjusting setscrews are given in "02.60.4 Speed Adjustment Setscrews".

⚠ CAUTION

On some engines a tamperproof setscrew nut is fitted to prevent changes being made to the engine stop/run control settings. In these cases adjustment is not possible.

02.60.1 Idling Speed Adjustment

The setscrew (A) is adjusted until it makes contact with the speed control at the required speed and then locked in position with the locknut.

On marine propulsion engines check the idling speed and adjust if necessary after the first 100 hours.

Idling Speeds:

LPA:

All Builds ..... 850-900r/min.

LPW/LPWS:

LPWS3/4 Build 76 ..... 1025-1050r/min.
Builds 45, 47, 73 ..... 800-850r/min.
Build 76 ..... 900-950r/min.
LPW4 Build 84 ..... 950-1000r/min.
All other Builds ..... 850-900r/min.

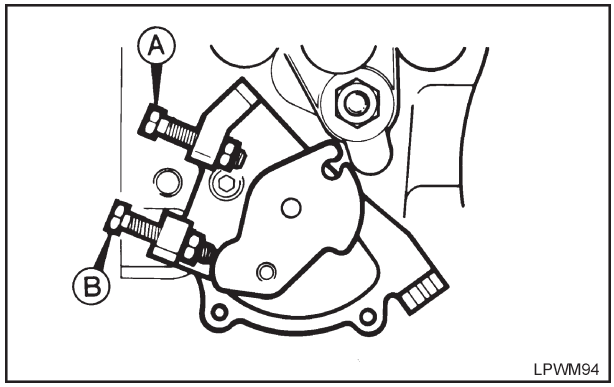


Figure 2.60.1 Idling Speed Adjustment

02.60.2 Fixed Speed Adjustment

The minimum full load speed for all engines and builds is 1500r/min.

The two setscrews (A) and (B) are adjusted until at the required speed both make contact with the speed control, both are then locked in position with the locknuts.

Rotating the setscrew (B) anticlockwise increases the engine speed.

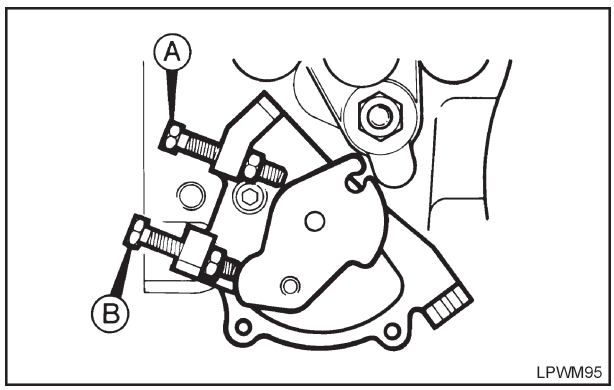


Figure 2.60.2 Fixed Speed Adjustment

02.60.3 Variable Speed Adjustment

The speed of the engine is controlled by the tension of the speeder spring. The spring is attached to the speed control, which in turn can be operated either by a cable, rod, lever or solenoid.

The setscrew (B) is adjusted until it makes contact with the speed control, at the required maximum speed, and then locked in position with the locknut.

Rotating the setscrew anticlockwise increases the engine speed.

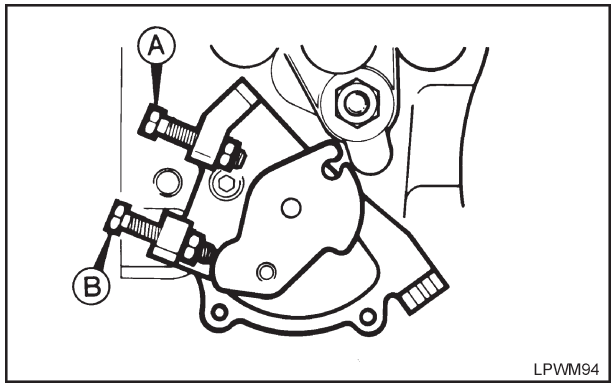


Figure 2.60.3 Variable Speed Adjustment

02.60.4 Speed Adjustment Setscrews

⚠ CAUTION

On some engines a tamperproof setscrew nut is fitted to prevent changes being made to the engine stop/run control settings. In these cases adjustment is not possible.

Illustration Code	Builds
A	01, 02, 03, 04, 11, 14, 16, 40, 42, 45, 46, 47, 48, 49, 51, 52, 75, 76, 84, 102, 105, 108
B	70
C	08, 09, 10, 18, 44, 58, 59, 71, 72, 82, 83, 85, 89, 109, 173, 174
D	57 (except LPWT4)
E	79 LPWT 09, 78, 113
F	1500r/min 27, 28, 74, 81 LPW/LPWT 41, 177
G	1800r/min 27, 28, 74, 81 LPW/LPWT 41, 177
H	104
J	86
K	07, 57 LPWS3 41
L	12, 13

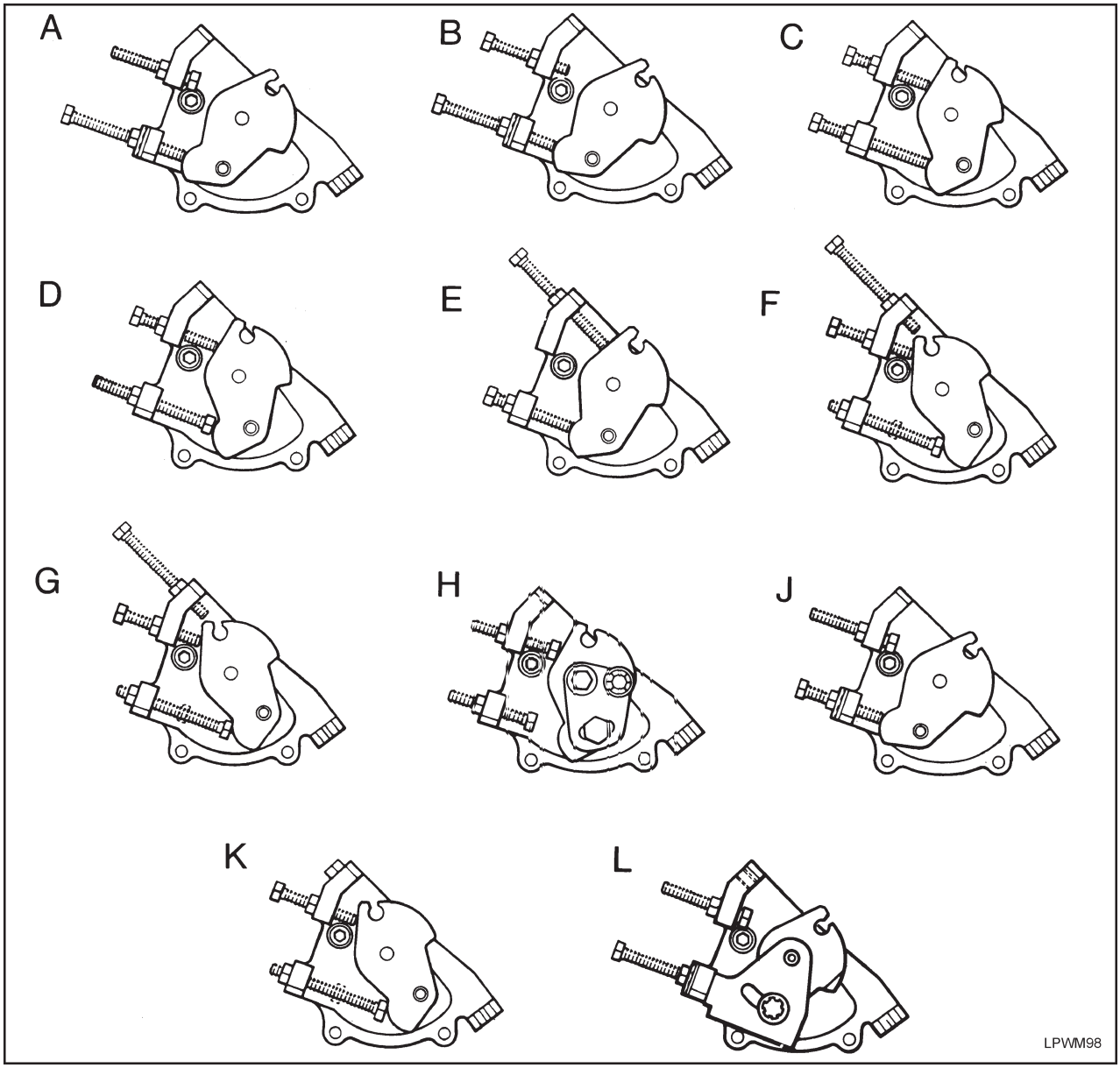


Figure 2.60.4 Speed Adjustment Setscrews

02.61 SETTING THE STOP/RUN LEVER

To ensure the control lever is positively stopped by the control lever stop screw, and not the fuel pump stops, the following sequence must be carried out with the end cover in position.

⚠ CAUTION

On some engines a tamperproof setscrew nut is fitted to prevent changes being made to the engine stop/run control settings. In these cases adjustment is not possible.

1. Turn the engine control lever (A) anticlockwise towards the 'STOP' position until the fuel pump stop is just felt with gentle finger pressure.
2. Slacken the nut (B) and adjust the setscrew (C) until it just touches the control lever (A).

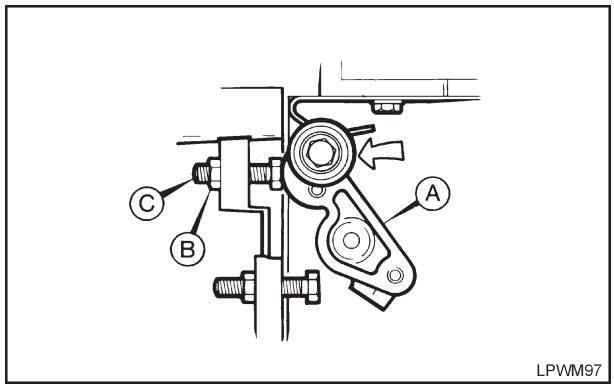


Figure 2.61.1 Setting the Control Lever

3. If an energised to stop fuel control solenoid is not fitted, screw the setscrew (C) out a further one turn and tighten the locknut.

   For engines fitted with an energised to stop fuel control solenoid:

   LPW - screw the setscrew (C) out a further 1.5 turns.

   LPWS - screw the setscrew (C) out a further 2.5 turns.

02.62 CRANKCASE VACUUM

The value depends to some extent on the type and size of air cleaner fitted to the engine.

Regardless of the type of air cleaner used, the vacuum with a clean air cleaner/element must not be less than the minimum figures given in the table below.

The vacuum is measured with a manometer at the lubricating oil dipstick hole with the engine running at any speed.

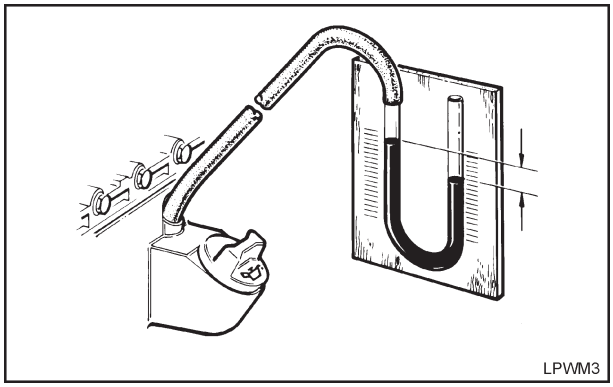


Figure 2.62.1 Manometer

In engines in good condition the vacuum increases slightly with engine speed, but not proportionally.

A fluctuating vacuum may indicate faulty oil seals, valves or piston blow-by troubles.

Crankcase pressure can cause serious oil leaks and often occurs in engines which need overhauling.

02.62.1 Engines Running up to 1800r/min

For engines running at these speeds the vacuum may be as low as 10.0mm WG (0.4in WG).

02.62.2 Engines Running above 1801r/min

	Minimum	Average
mm WG	20.0	35.0
in WG	0.79	1.37

Section 03. Engine Fluids

03.1 ENGINE FLUIDS - lubricating oil

03.1.1 The Oil Specification

To help assist engine running-in, all engines are despatched with an initial fill lubricating oil which must be changed after 100 hours.

The lubricating oil specification is given in the Operators Handbook and care must be taken to ensure the correct handbook is being referred to:

LPA, LPW, LPWT, LPWS P027-08182
LPWG P027-08197
Alpha Marine P027-08181

⚠ CAUTION

Lister Petter recommend that oils of different brands or types are not mixed together.

03.1.2 European Oil Specifications

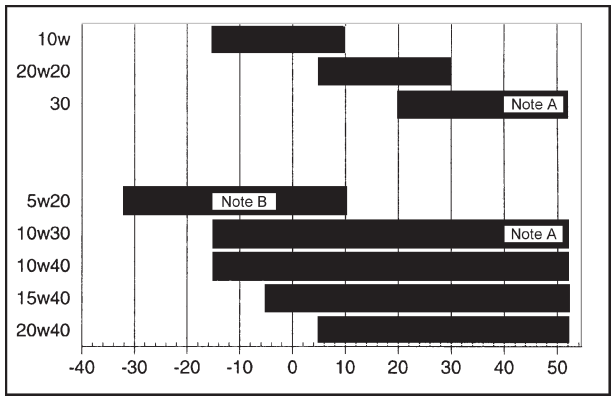
ACEA specifies the following:

Gasolene engines: A1-96, A2-96, A3-96.

Light duty diesel engine operation: B1-96, B2-96, B3-96.

Heavy duty and commercial vehicle diesel engine operation: E1-96, E2-96, E3-96.

03.1.3 Oil Viscosity



Notes:

A. Intermittent running.

B. Synthetic oils only.

°F = (1.8 x °C) + 32.

1. *SAE 5W-20 oils are recommended on the basis that they are fully synthetic, and are technically suitable for use up to 25°C (77°F). Non synthetic oils at very low temperatures will suffer from wax crystallisation.*

   Monograde SAE 5W is not normally available as a synthetic oil and therefore is not quoted.

2. *In order to maintain the cold starting characteristics of any recommended grade it is essential that oil changes are made within the Lister Petter recommendations.*

   An oil change is recommended immediately if the engine fails to reach its normal cold start cranking speed due to excessive oil viscosity.

   Fuel dilution of the lubricating oil will adversely affect cold starting and oil consumption.

3. *SAE 30 and 10W-30 oils may be used at up to 52°C (126°F) but oil consumption may be affected.*

   10W-40, 15W-40 and 20W-40 multigrades are recommended for continuous full load operation at this temperature.

4. *Monograde SAE 40 oils are not recommended.*

03.1.4 The Oil Classification System

The information contained in this section has been extracted from "Lubricant and Fuel Performance", with the permission of 'The Lubrizol Corporation'.

⚠ CAUTION

Some of the following classifications may not be available in your country. In cases of difficulty, it is suggested contact be made with a reputable oil supplier or any Lister Petter Distributor.

Note:
US 'S' grade oils are for gasolene engines and are not recommended for Lister Petter diesel engines.

Past and Current US API Grade Oils

API Service Category CA:

Service typical of diesel engines operated in mild to moderate duty with high-quality fuels; occasionally has included gasoline engines in mild service.

Oils designed for this service provide protection from bearing corrosion and ring-belt deposits in some naturally aspirated diesel engines when using fuels of such quality that they impose no unusual requirements for wear and deposit protection.

They were widely used in the 1940's and 1950's but should not be used in any engine unless specifically recommended by the equipment manufacturer.

API Service Category CB:

Service typical of diesel engines operated in mild to moderate duty, but with lower quality fuels, which necessitate more protection from wear and deposits; occasionally has included gasoline engines in mild service.

Oils designed for this service were introduced in 1949. They provide necessary protection from bearing corrosion and from high-temperature deposits in naturally aspirated diesel engines with higher sulphur fuels.

API Service Category CC:

Service typical of certain naturally aspirated diesel engines operated in moderate to severe-duty service, and certain heavy-duty gasoline engines.

Oils designed for this service provide protection from high-temperature deposits and bearing corrosion in diesel engines, and also from rust, corrosion, and low-temperature deposits in gasoline engines. These oils were introduced in 1961.

API Service Category CD:

Service typical of certain naturally aspirated, turbocharged or supercharged diesel engines where highly effective control of wear and deposits is vital, or when using fuels with a wide quality range (including high-sulphur fuels).

Oils designed for this service were introduced in 1955 and provide protection from high-temperature deposits and bearing corrosion in these diesel engines.

API Service Category CD-11:
Severe duty two-stroke

Service typical of two-stroke cycle diesel engines requiring highly effective control of wear and deposits.

Oils designed for this service meet all performance requirements of API Service Category CD.

API Service Category CE - 1983:

Service typical of certain turbocharged or supercharged heavy-duty diesel engines, manufactured since 1983 and operated under both low speed, high load and high speed, high load conditions.

Oils designated for this service may also be used when API Service Category CD is recommended for diesel engines.

API Service Category CF-4 -1990:

Service typical of high-speed, four-stroke cycle diesel engines.

API CF-4 oils exceed the requirements for the API CE category, providing improved control of oil consumption and piston deposits.

These oils should be used in place of API CE oils. They are particularly suited for on-highway, heavy-duty truck applications. When combined with the appropriate 'S' category, they can also be used in gasoline and diesel powered personal vehicles - i.e., passenger cars, light trucks, and vans - when recommended by the vehicle or engine manufacturer.

API Service Category CF:
Indirect injection

Service typical of indirect-injected diesel engines and other diesel engines that use a broad range of fuel types, including those using fuel with high sulphur content; for example, over 0.5% weight.

Effective control of piston deposits, wear and copper-containing bearing corrosion is essential for these engines, which may be naturally aspirated, turbocharged or supercharged.

Oils designated for this service have been in existence since 1994 and may be used when API Service Category CD is recommended.

API Service Category CF-2:
Severe duty, two-stroke cycle

Service typical of two-stroke cycle diesel engines requiring highly effective control over cylinder and ring-face scuffing and deposits.

Oils designed for this service have been in existence since 1994 and may also be used when API Engine Service Category CD-11 is recommended.

These oils do not necessarily meet the requirements of API CF or CF-4 unless they pass the test requirements for these categories.

API Service Category CG-4 - 1994:
Severe duty

API Service Category CG-4 describes oils for use in high-speed four-stroke-cycle diesel engines used in both heavy-duty on-highway (0.05% weight sulphur fuel) and off-highway (less than 0.5% weight sulphur fuel) applications.

CG-4 oils provide effective control over high-temperature piston deposits, wear, corrosion, foaming, oxidation stability, and soot accumulation.

These oils are especially effective in engines designed to meet 1994 exhaust emission standards and may also be used in engines requiring API Service Categories CD, CE, and CF-4. Oils designed for this service have been in existence since 1994.

03.2 ENGINE FLUIDS - fuel

03.2.1 The Fuel Specification

The engine must only be used with diesel fuel oil which conforms to one of the following:

a. BS 2869:1988 Class A2.
b. BS EN590:1995 Class A1.
c. USA Specification ASTM D-975-77 Grades No.1-D and 2-D.
d. BSMA 100 Class M1 for marine use.

The fuel must be a distillate, and not a residual oil or blend.

Vaporising oils are not suitable as fuels for Lister Petter engines.

The user is cautioned that although the engines may operate on fuels outside the above specifications, such operation may well result in excessive wear and damage.

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a. BS 2869:1988 Class A2.
b. BS EN590:1995 Class A1.
c. USA Specification ASTM D-975-77 Grades No.1-D and 2-D.
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The user is cautioned that although the engines may operate on fuels outside the above specifications, such operation may well result in excessive wear and damage.

⚠ CAUTION

The fuel injection equipment is manufactured to very accurate limits and the smallest particle of dirt will destroy its efficiency. Fuel free from water and contaminants is of the utmost importance.

03.2.2 Low Temperature Fuels

Special winter fuels are often available for use at ambient temperatures below 0°C (32°F).

These fuels have a lower viscosity and limit the formation of wax at low ambient temperatures.

⚠ CAUTION

Wax formation can rapidly reduce the flow of fuel through the fuel filter element.

03.3 ENGINE FLUIDS - coolant concentrate

Traditionally the term ‘antifreeze’ has been used to describe the concentrate which is added to the cooling system. However, this term takes into account only the frost-protective role of the product, so implying that its use is a seasonal requirement, and ignores its function as a heat exchange medium which is designed to protect the system from corrosion and damage under all operating conditions.

The term ‘engine coolant concentrate’ embraces all these requirements.

⚠ WARNING

Coolant concentrate must not be allowed to come into contact with the skin; adhere to the manufacturers instructions and precautions.

03.3.1 Concentrate Specification

The specification of the coolant concentrate should comply with one of the following:

BS6580 : 1985
MIL-A-11755D
MIL-A-46153/B

03.3.2 Concentration

A 40% concentration must be maintained under all operating conditions.

To determine the amount of coolant concentrate to be added it will be necessary to calculate the total coolant capacity by adding together that of the engine, as given in "02.47.3 Engine Block Coolant Capacity", the radiator, or heat exchanger, and associated pipe work capacities.

Section 04. The LPWG Gas and Electrical Systems

⚠ WARNING

Maintenance must be performed by qualified persons who are conversant with the hazards of fuels, electricity and machinery.
Read the Safety Precautions and observe all instructions and precautions in this publication.

04.1 GENERAL DESCRIPTION

LPWG gaseous-fuelled spark-ignition engines are designed to operate on either natural gas or vaporised propane fuel meeting the specifications given.

Fuel gases with properties falling outside of these specifications will not provide the same rated output from the engine, and in some cases may result in high exhaust gas temperatures and/or detonation, which can be detrimental to the service life of the engine.

Pipeline gas with large and varying amounts of inert gases will require a much greater quantity of fuel for a given quantity of air. In these applications the engine will need to be set up on site for the particular fuel, by an experienced technician.

Engines can operate with little loss of power on fuel gases with very low heat values, provided that a sufficient quantity of fuel can be introduced to keep the air/fuel ratio in balance. Consult Lister-Petter for further information.

⚠ WARNING

Operation on 'sour' wellhead gas has not been approved by Lister-Petter.

04.2 GAS SAFETY PRECAUTIONS

⚠ WARNING

GAS IS FLAMMABLE AND EXPLOSIVE AND CAN CAUSE SEVERE PERSONAL INJURY OR DEATH.

- Take special care to ensure all sources of ignition are well away from areas where fuel fumes are present and areas sharing ventilation.
- Gas fuel lines must be secured, free of leaks and separated, or shielded from electrical wiring.
- Take care to prevent leaks which can lead to explosive accumulations of gas.

  Natural gas is lighter than air and rises when released.

  LPG is heavier than air and sinks when released.
- Approved non-conductive flexible fuel pipes should be used for gas connections to the engine.

04.3 THE PRINCIPLE OF OPERATION

The carburettor uses a sliding air and gas valve assembly to meter the required amount of fuel for the speed and load at which the engine is running.

The air valve is held in the closed position by a metering spring, and is opened by increasing airflow through the carburettor. Airflow through the carburettor applies an increasing vacuum signal to the bottom of the air valve, opening it against spring tension and thus admitting an increased quantity of fuel to keep the air/fuel ratio in balance.

The air/fuel ratio at idle is controlled by the idle air bypass adjustment screw which is located on the side of the carburettor, below and to the right of the fuel inlet connection.

The adjustment screw bypasses a portion of the incoming air around the air valve. Turning the screw in, or clockwise, gives a richer air/fuel ratio, turning it out, or anti-clockwise gives a leaner ratio.

Wide-open throttle air/fuel ratio is controlled by the power mixture valve which is located on top of the carburettor. The limits of adjustment are marked 'R' (rich) and 'L' (lean); fully turned to the left is the maximum rich, and fully turned to the right will result in maximum lean.

The air/fuel ratio between idle and wide-open throttle is determined by the shape of the gas metering valve, which is part of the air valve assembly. This is generally shaped to produce leaner mixtures at light loads and increasingly richer mixtures at heavier loads.

04.4 THE GAS SPECIFICATION

		Type of Gas	
		Natural	Propane
Calorific value	kcal/m^3	9228	22764
	Btu/ft^3	1037	2558
Specific gravity		0.601	1.552
Methane content	min	85%	-
Propane content	min	-	90%
Propylene content	max	-	5%
Butane and heavier	max	-	2.5%

Note:
LPWG propane fuelled engines are designed for operation on HD-5 fuel (motor fuel grade propane).

04.5 THE CARBURETTOR

04.5.1 Non-emission Compliant Engines

These engines use an IMPCO Technologies model CA55-8 carburettor for both natural gas and propane fuels.

04.5.2 Emission Compliant Engines

These engines use a CT55-8 carburettor for natural gas and a CT55-10 carburettor for propane.

'CT' carburettors have tamper proof idle air bypass and power mixture adjustments. The CT55-10 has a special gas valve to give leaner air/fuel ratios with propane fuel.

Lean air/fuel ratios (excess air) are used to achieve emissions compliance without any form of after treatment.

04.5.3 Carburettor Adjustments

Impco carburettor provide two limited-range fuel mixture adjustments. These are only adjustable on non-emission compliant builds.

Before attempting to adjust the carburettor, the fuel supply pressure must be correctly set as described in "7.4.5 Regulator Pressure Adjustment".

⚠ WARNING

CARB and EPA emissions compliant engine adjustments are factory sealed. No attempt should be made to change these adjustments.

1. Turn the idle air bypass screw all the way in (clockwise) until it bottoms and then back it out 2 full turns.
2. With the engine running at full rated load, set the power mixture valve initially to about $^{3}/_{4}$ 'rich'.
3. Apply full load to the engine.

   The throttle lever will be at some relatively fixed position.
4. Gradually turn the valve towards 'lean' until the throttle lever just slightly opens from its original position at full load.

04.5.4 Carburettor Repair Kit

A carburettor repair kit is available to overhaul non-emissions compliant natural gas and propane carburettors, and CARB and EPA compliant natural gas carburettors.

A new air and gas valve assembly is included in the kit.

⚠ CAUTION

I*f a CARB or EPA compliant propane carburettor is to be repaired, the original gas valve must be re-used.*

Gas valves for natural gas fuel are swaged onto the air and gas valve assembly, and propane gas valves are secured with a screw.

04.6 SECONDARY GAS PRESSURE REGULATOR

The purpose of the secondary regulator is to provide a constant fuel supply pressure to the carburettor. This outlet pressure will remain constant despite fluctuations in the inlet pressure.

The gas pressure regulator functions to control pressure, not flow. Flow is a function of the pressure and resistance within a circuit, which in this case is the carburettor mixer.

The regulator functions by balancing outlet pressure on one side of a rubber diaphragm against spring tension on the opposite side.

⚠ CAUTION

The regulator is not a fuel shut-off device.

04.6.1 How the Regulator Operates

The secondary regulator is mounted on a bracket to the top left side of the flywheel housing.

Fuel gas is supplied to the carburettor through a flexible pipe.

The atmospheric vent port on the regulator is connected to the carburettor air horn by a flexible balance pipe. This allows the air/fuel ratio to remain constant.

A dirty air cleaner restricts the airflow into the engine; this restriction is communicated to the 'atmosphere' side of the regulator diaphragm by the balance pipe. The regulator outlet pressure is reduced slightly, thus keeping the air/fuel ratio in balance.

A 12 volt DC powered gas solenoid valve is provided immediately before the secondary regulator inlet. When the solenoid is energised, the valve opens to allow gas to pass to the secondary regulator. The valve inlet connection is a female $^{3}/_{4}$in NPT (U.S. National Taper Pipe) thread.

⚠ CAUTION

Leakage can occur if the fuel supply pipe and fittings are not aligned correctly.

04.6.2 The Regulator Inlet Pressure

Fuel gas is supplied to the secondary regulator at a positive pressure in the range of 17.8-50.8mbar (7.4-20.4 in WG).

⚠ WARNING

Do not exceed 49.3mbar (19.8in WG) as damage to the regulator diaphragm will result.

At least one additional primary regulator is usually required to drop the line pressure (natural gas) or the tank pressure (vaporised propane) to the required inlet pressure.

In some countries, natural gas line pressure may be as low as 12.0mbar (4.8in WG).

The vapour pressure of propane is 8.3bar (120lb/in^2) at 39°C (70°F).

Vapour propane installations will require two regulators in series between the tank and the secondary regulator.

04.6.3 The Regulator Outlet Pressure

Natural Gas Fuelled Engines

A Maxitrol model RV-52 regulator is used on natural gas fuelled engines.

The outlet pressure is set to 12.4mbar (5.0in WG) with the engine running at no load. This outlet pressure will then droop to approximately 10.0mbar (4.0in WG) at full load.

Propane Gas Fuelled Engines

A Maxitrol model R4OOZ zero-pressure regulator is used on propane fuelled engines.

The outlet pressure is set to -3.7mbar (-1.5in WG) with the engine running at full load. The pressure will then rise to approximately -2.5mbar (-1.0in WG) at no load.

04.6.4 Measuring the Regulator Pressure

A 'U' tube manometer is required for checking and setting the regulator outlet pressure.

To measure the regulator outlet pressure, connect one side of the manometer to the 1/8 inch NPT (U.S. National Taper Pipe) thread outlet pressure tapping on the regulator using a suitable flexible hose and fittings. Connect the other side to the balance line between the regulator vent port and the carburettor air horn, using a suitable 'T' connection fitting.

04.6.5 Regulator Pressure Adjustment

The Maxitrol regulators provide a limited range of outlet pressure adjustment on non-emission complaint builds only.

The RV-52 can be adjusted from approximately 7.5-14.9mbar (3.0-6.0in WG), and the R4OOZ from approximately -3.7 - 2.5mbar (-1.5 - 1.0in WG).

⚠ WARNING

CARB and EPA emissions compliant engine adjustments are factory sealed. No attempt should be made to change these adjustments.

1. Remove the adjustment cap on top of the regulator using a straight-blade screwdriver.

   The adjustment screw is underneath the cap.
2. To increase outlet pressure, turn the screw 'in' or to the right.
3. To decrease outlet pressure, turn the screw 'out' or to the left.
4. Replace the adjustment cap.

⚠ CAUTION

If the secondary regulator is faulty, it should be replaced and no repairs to it should be attempted.

04.7 THE ELECTRONIC GOVERNOR

LPWG engines are fitted with the Barber-Colman DYNA 2000 linear actuator electronic governor.

The electronic governor gives the fast response and precise control required of a generating set engine.

The system consists of:

a. An actuator.

b. Controller.

c. Magnetic pick-up.

The actuator mounts to a bracket that is sandwiched between the carburettor and the inlet manifold.

The actuator plunger is attached to the carburettor throttle lever by a linkage.

The actuator uses a sliding armature, the magnetic force of which is proportional to the input coil current supplied by the controller. The actuator extends to maximum throttle by application of this current, and is retracted to closed throttle by an internal spring. The actuator linkage geometry is critical for good governing. Under normal operation the linkage should require no adjustment although it will be necessary if replacement parts are fitted.

The controller is mounted on a bracket attached to the left side of the flywheel housing.

The controller circuit board is sealed in an aluminium housing and two potentiometers are provided for adjustment of speed and gain.

The magnetic pick-up is threaded into the flywheel housing immediately below the controller. The pick-up senses the flywheel gear ring teeth as the engine rotates, generating an AC voltage signal whose frequency is proportional to engine speed. This signal is the governor controllers speed reference signal.

04.8 GOVERNOR ADJUSTMENTS

04.8.1 Adjusting the Linkage

Linkage adjustment must be carried out with the engine stopped. The linkage should have a smooth and free movement throughout its travel.

1. Disconnect the linkage at the throttle arm by undoing the 10-32 x 3/4in machine screw and nut.
2. Holding the throttle arm in the closed position, back out the idle stop screw until there is a gap between the end of the screw and the roll pin set in the throttle body.
3. Turn the screw in until it just touches the roll pin, then advance a further half turn.

   At this point, the throttle arm should be vertical. If not:

   a. Loosen the throttle arm pinch bolt and move the throttle arm until it is vertical with the throttle closed (idle screw against its stop).

   b. Tighten the pinch bolt securely.
4. With the actuator at rest (closed throttle position) and the throttle closed, adjust the length of the linkage so that the rod-ends line up with the holes in the clevis and the throttle arm
5. Tighten the locknut.

   The two screws should just pass through the holes,

and the two rods should be very nearly in the same plane, to avoid binding of the linkage.

04.8.2 Speed Adjustment

To adjust the engine speed, turn the controller speed potentiometer clockwise to increase the speed, and anti-clockwise to decrease it.

04.8.3 Gain Adjustment

Before attempting to adjust the gain the engine must be run until the normal operating temperature is reached.

1. With the engine running at no load, gradually turn the gain potentiometer, which is graduated from 0-100%, clockwise until the engine speed becomes unstable.

   It may be necessary to upset the linkage by hand to induce instability.
2. Slowly turn the potentiometer anti-clockwise until stability is restored.

   This setting will give best stability and response for normal operating temperatures, but will be unstable when the engine is cold.

   For stable operation when cold, reduce this setting by 10%. Most engines will have a gain setting of 20-25%.

04.8.4 Magnetic Pick-up Adjustment

The magnetic pick-up must generate a minimum of 2.5 VAC while cranking, if the voltage is lower the controller will not energize the actuator.

If the clearance between the end of the pick-up and the flywheel teeth is too great, the voltage signal generated will be insufficient for operation of the electronic governor.

It will be necessary to adjust the magnetic pick-up whenever it is removed.

1. With the magnetic pick-up removed from the flywheel housing, align one of the flywheel gear ring teeth with the centre of the pick-up threaded hole.
2. Carefully replace the pick-up and screw it in until it just touches the ring gear tooth
3. Unscrew the pick-up a quarter turn.
4. Hold the pick-up to prevent it moving and tighten the lock nut.

04.9 THE PRIMARY IGNITION SYSTEM

The primary ignition system is battery-powered and the spark timing is fixed, with no provision for advance or retard adjustment.

The purpose of the primary ignition system is to start and stop the flow of battery current through the ignition coil's primary windings.

The ground path for the primary winding is provided through a Hall-effect module that switches on and off. The Hall-effect module performs the same function as a set of breaker points, with no moving parts.

When switched on, primary current flows and the coil windings are saturated by the magnetic field created.

When switched off, the ground path is taken away and the sudden cessation of current flow causes the magnetic field to collapse, inducing a high voltage in the coil secondary winding to fire the spark plug.

A magnet wheel is fitted to the crankshaft pulley bolt and retained by two setscrews.

⚠ WARNING

*One side of the magnet wheel is marked "Flywheel Side". On LPWG engines this side must face **away** from the flywheel, towards the radiator.*

The wheel contains a 'North' and a 'South' pole magnet.

The two magnets are separated by 117° of rotation; this is the dwell angle.

The close-fitting retaining washers align the magnet wheel concentrically with the crankshaft and maintains a nominal constant air gap of 0.76mm (0.030in) between the wheel and the module(s).

The Hall-effect modules are positioned around the circumference of the magnet wheel by an ignition plate, and are switched on and off as the magnets pass by.

The dwell period begins when the North pole is directly in line with the Hall-effect module, and ends when the South pole passes in line with the module.

Each coil requires its own Hall-effect module and each cylinder is fired once every revolution at the top of the compression stroke and at the top of the exhaust stroke. The exhaust firing is known as a "maverick" or "wasted" spark.

4.9.1 Ignition Timing Adjustment

Timing marks are stamped on the front face of the flywheel from 10° to 24° BTDC; these marks can be viewed through an aperture on the front left side of the flywheel housing, immediately to the rear of the crankcase door. The aperture also contains a pointer for alignment of the appropriate mark.

Incorrect ignition timing can cause increased exhaust emissions.

The timing is adjusted by turning the magnet wheel in relation to the crankshaft.

On non-emissions compliant engines, the timing can be adjusted using ordinary hand tools.

Emissions compliant engines require a special tool to loosen the magnet wheel setscrew; this tool is only available to authorised distributors, to prevent

unauthorized adjustment.

The timing must be reset each time the magnet wheel is removed and reinstalled.

All timing adjustments must be carried out with the engine stopped.

1. Turn the crankshaft until number 1 cylinder is on the compression stroke at the relevant timing position, plus 1°.
   Natural gas engines 21° BTDC.
   Propane gas engines 11° BTDC.
2. The Hall-effect module must be connected to its ignition coil:
   Red lead to positive (+).
   Black lead to negative (-).
3. Slacken the magnet wheel setscrew, to allow the wheel to be rotated manually.
4. Connect a jumper lead to the positive terminal of number 1 coil, and apply 12 volts to the coil primary.

⚠ WARNING

Do not leave this power connected any longer than necessary or damage to the coil and/or module may result.

5. Connect the positive (+) lead of a DC voltmeter to the negative (-) terminal of the coil, and the negative (-) lead to a chassis ground (the ignition plate is a good spot).

   The voltmeter will read less than 1 volt DC during the dwell period, and will immediately increase to battery voltage (approximately 12.6 volts DC) when the dwell period ends and the coil is to fire.
6. The magnet wheel may need to be rotated through a full revolution to initiate the dwell period.

   Always rotate the magnet wheel in the direction of engine rotation, which is clockwise looking on the front of the engine.
7. With the coil on dwell (voltmeter reading low) slowly rotate the magnet wheel until the voltage goes high, then tighten the magnet wheel setscrew.
8. Remove the voltmeter and jumper leads.
9. Verify the timing is correct while the engine is running by using an inductive timing light and the flywheel timing marks.

   Natural gas engines should have a dynamic timing of 20° BTDC, and propane engines should be 10° BTDC.

04.10 THE SECONDARY IGNITION SYSTEM

The purpose of the secondary ignition system is to develop the high voltage required to jump the spark plug gap in the coil secondary windings, and deliver this voltage to the spark plug via the high tension leads. The coil boosts the normal 12 volts battery potential to the 30000-40000 volts required to jump the spark plug gap.

Current flows through the primary windings during the dwell period and this current flow establishes a magnetic field that envelops the secondary windings.

When the dwell period ends and primary current flow ceases, the rapid collapse of this magnetic field induces a high voltage in the secondary windings. This high voltage is carried to the spark plug through a conductor known as the high-tension lead.

⚠ CAUTION

The installation of replacement ignition system components not supplied by Lister Petter may result in a reduction of available spark energy, which can cause misfiring on the compression stroke. The unburned fuel can then be ignited on the exhaust stroke by the wasted spark, causing a backfire through the inlet manifold due to valve overlap.

04.10.1 The Coils

Neither type of coil requires an external primary resistance.

LPWG2 and 4

These engines use a dual outlet coil. Each end of the secondary winding is connected to a spark plug.

The spark plugs and high tension leads must be in good condition to form a complete circuit. If one plug or lead is “open” electrically, neither plug will fire.

When one cylinder fires on its compression stroke, the other fires on its exhaust stroke.

LPWG3

These engines use a single outlet coil, one coil required for each cylinder.

One end of the secondary winding is connected to the spark plug, and the other end is connected to the positive (+) side of the primary winding, to form a complete circuit.

04.10.2 The High Tension Leads

The high-tension leads are 7mm diameter and have a suppression core and EPDM covering.

LPWG4 engines use both 305mm and 457mm (12.0 and 18.0in) leads,

LPWG2 and 3 engines use 305mm (12.0in) leads only.

Single outlet coils have a tower configuration different from the dual outlet coils, thus a different boot on the coil end of the lead is used.

04.10.3 The Spark Plugs

It is crucial to ensure that only serviceable spark plugs are fitted in gas fuelled engines. If there is any sign of misfire, or damage to them, they should be changed. A misfiring engine will not produce full rated power.

The spark plug specified for normal applications

is the Champion type RC9YC, with a gap of 0.50mm (0.020in). It is recommended that these be replaced every 500 hours for maximum reliability.

For long-run applications, where extended spark plug life is desired, the Champion type RC78PYP with a gap of 0.53mm (0.021in) can be used.

The RC78PYP has platinum centre and side electrodes and is designed as a heavy-duty industrial spark plug, whereas the RC9YC is an automotive plug.

⚠ WARNING

An oversize electrode gap may allow the spark to escape elsewhere in the ignition system and damage other high tension components.

Section 05. Operating Instructions

05.1 INDUSTRIAL OPERATING INSTRUCTIONS (not LPWG engines)

For LPWG engines refer to "05.2 LPWG Operating Instructions".

The following information is of a general nature and should be read in conjunction with, or substituted by, the equipment manufacturers instructions.

05.1.1 Preliminary Instructions

⚠ WARNING

Starting any diesel engine can be dangerous in the hands of inexperienced people.
Before attempting to start any engine the operator should read the "Safety Precautions" and be conversant with the use of the engine controls and the correct starting procedures.

⚠ CAUTION

ETHER BASED COLD START AIDS MUST NOT BE USED UNDER ANY CIRCUMSTANCES.

⚠ WARNING

EXHAUST GASSES CONTAIN CARBON MONOXIDE WHICH IS A COLOURLESS, ODOURLESS AND POISONOUS GAS THAT CAN CAUSE UNCONSCIOUSNESS AND DEATH.

⚠ CAUTION

On LPWT4 engines serious damage to the turbocharger bearing can result if for any reason the turbocharger housing is not full of oil.
It is recommended that these engines run at 'no load' after starting for 30 seconds, to ensure an adequate oil supply to the turbocharger, and 30 seconds before stopping to allow the heat from the bearing to dissipate.

05.1.2 Start/Stop Control

The basic engine has a plastic knob fitted to the control and other variants for automatic or remote operation are available.

Engines not fitted with a fuel control solenoid have a spring clip to hold the engine control in the stop position.

05.1.3 Starting - LPA and LPW

⚠ CAUTION

These instructions do not apply to LPWT4 engines; refer to "05.1.4 Starting - LPWS and LPWT4".

If an oil pressure switch bypass button is fitted it must be depressed during engine cranking and until the engine attains full speed.

If the engine fails to start within 30 seconds, release the key and attempt to restart after allowing sufficient time for all moving parts to stop.

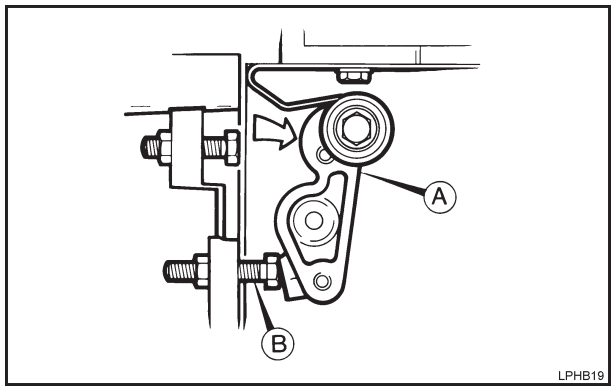

Figure 5.1.1 Starting

1. Move the engine control lever (A) clockwise until it is against the stop screw (B).
2. On variable speed engines move the speed control to the fast position.

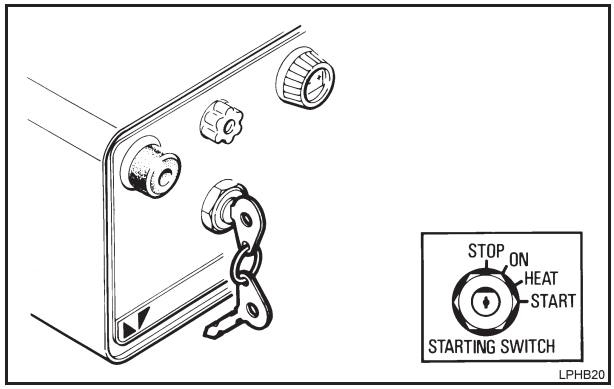

Figure 5.1.2 Key Start

3. Turn the key clockwise to the 'START' position and release it immediately the engine starts.
4. Reduce the engine speed as necessary.

05.1.4 Starting - LPWS and LPWT4

If an oil pressure switch bypass button is fitted it must be depressed during engine cranking and until the engine attains full speed.

If the engine fails to start within 30 seconds, release the key and attempt to restart after allowing sufficient time for all moving parts to stop.

1. Move the engine control lever (A) clockwise until it is against the stop screw (B).

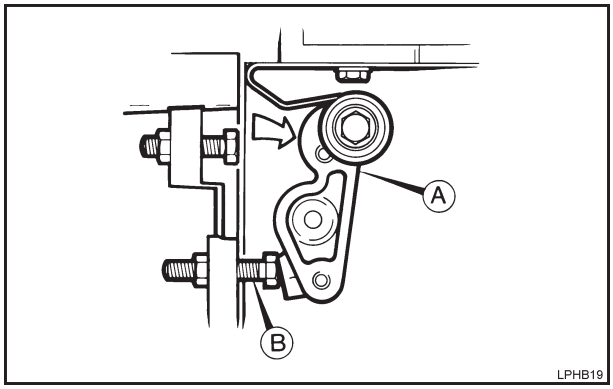

Figure 5.1.3 Starting

2. On variable speed engines move the speed control to the fast position.

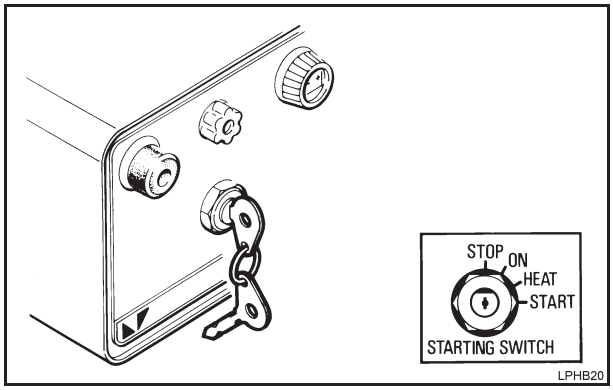

Figure 5.1.4 Key Start

3. For ambient starting temperatures above -10°C (14°F) turn the key clockwise and hold it in the 'HEAT' position for 10 to 15 seconds before turning it to the 'START' position to energise the starter.
4. For ambient starting temperatures below -10°C (14°F) turn the key clockwise to the 'HEAT' position for 15 to 20 seconds before turning the key to the 'START' position to energise the starter.

   Immediately the engine starts the key must be moved anticlockwise to the 'HEAT' position until the engine has attained full speed.
5. Reduce the engine speed as necessary.

05.1.5 Stopping the Industrial Engine

1. If possible remove the load from the engine.
2. If a variable speed control is fitted reduce the engine speed.
3. On engines fitted with a fuel control solenoid turn the key to the 'STOP' position.

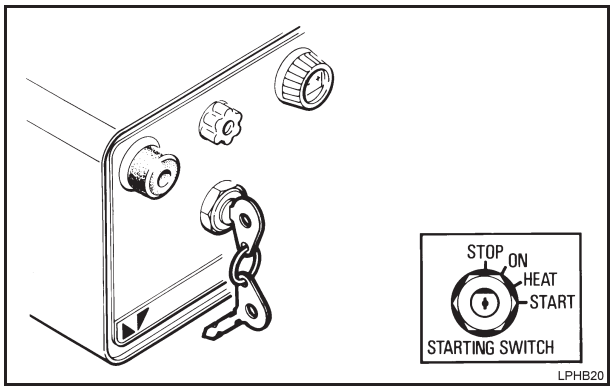

Figure 5.1.5 Key Start

4. On non-automatic engines move the engine control lever anti-clockwise into the stop position and turn the key to the 'STOP' position.

⚠ CAUTION

Turning the key to the 'STOP' position alone will not stop the engine unless a fuel control solenoid is fitted.

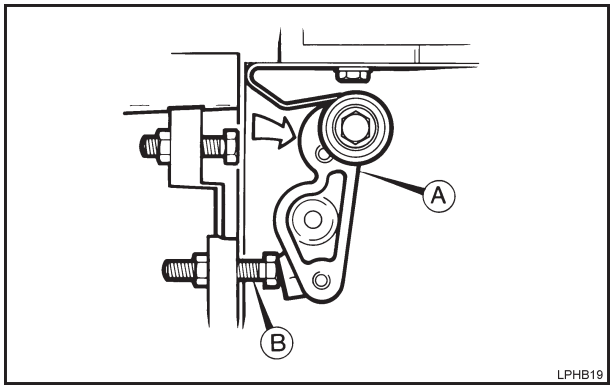

Figure 5.1.6 Stopping

05.2 LPWG OPERATING INSTRUCTIONS

The following information is of a general nature and should be read in conjunction with, or substituted by, the equipment manufacturers instructions.

05.2.1 Preliminary Instructions

⚠ WARNING

Starting any engine can be dangerous in the hands of inexperienced people.
Before attempting to start any engine the operator should read the "Safety Precautions" and be conversant with the use of the engine controls and the correct starting procedures.

⚠ WARNING

EXHAUST GASSES CONTAIN CARBON MONOXIDE WHICH IS A COLOURLESS, ODOURLESS AND POISONOUS GAS THAT CAN CAUSE UNCONSCIOUSNESS AND DEATH.

05.2.2 Starting

⚠ WARNING

IF THE ENGINE FAILS TO START WITHIN 30 SECONDS, RELEASE THE KEY AND ATTEMPT TO RESTART AFTER ALLOWING SUFFICIENT TIME FOR ALL MOVING PARTS TO STOP. FAILURE TO OBSERVE THIS MAY RESULT IN AN EXPLOSIVE MIX IN THE EXHAUST SYSTEM.

1. Press and hold the low oil pressure switch bypass button during engine cranking and until the engine attains full speed.
2. Turn the key clockwise to the 'START' position and release it immediately the engine starts.

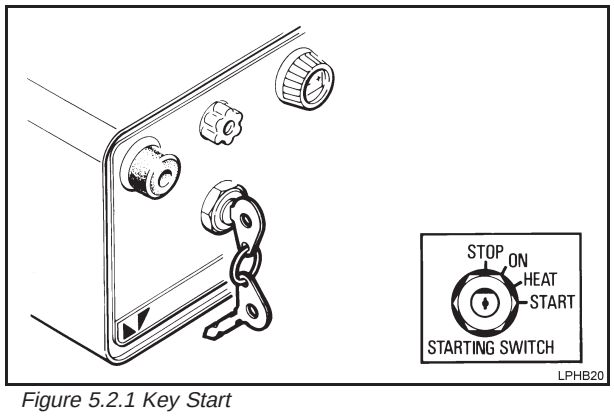

Figure 5.2.1 Key Start

05.2.3 Stopping the Engine

1. If possible remove the load from the engine.
2. Turn the key to the 'STOP' position.

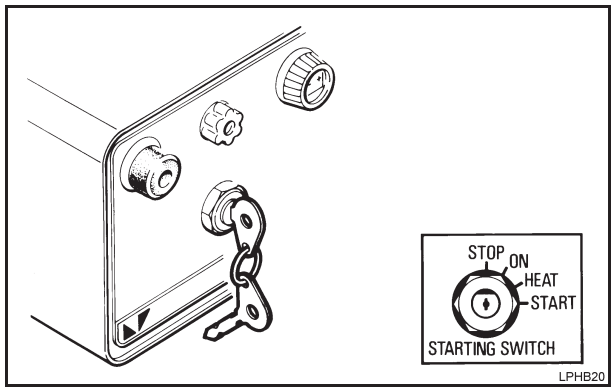

Figure 5.2.2 Key Start

05.3 MARINE PROPULSION OPERATING INSTRUCTIONS

The following information is of a general nature and should be read in conjunction with, or substituted by, the equipment manufacturers instructions.

05.3.1 Preliminary Instructions

Before attempting to start any engine the operator should be conversant with the use of the engine controls and the correct starting procedures.

05.3.2 Start/Alarm Panel

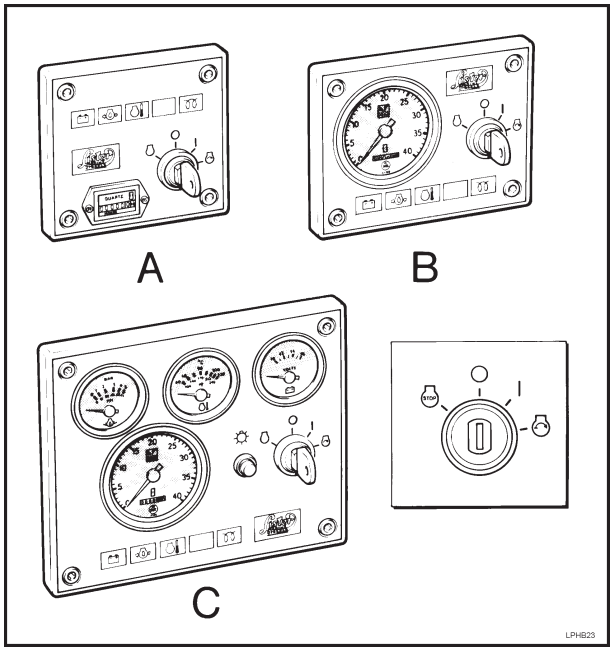

Figure 5.3.1 Typical Start/Alarm Panels

04.3.3 Audible Alarm

Most panels will be fitted with an audible alarm which will sound with the keyswitch in the 'I' and 'STOP' positions or if an alarmed fault occurs on the engine.

05.3.4 Stop Control

A 'T' shaped stop control handle may be fitted. This handle must be pushed in before attempting to start, and when the engine is running.

The handle is pulled out to stop the engine. If the engine is fitted with a fuel control solenoid a start/stop control handle will not be fitted and the engine can be stopped by using the panel start key.

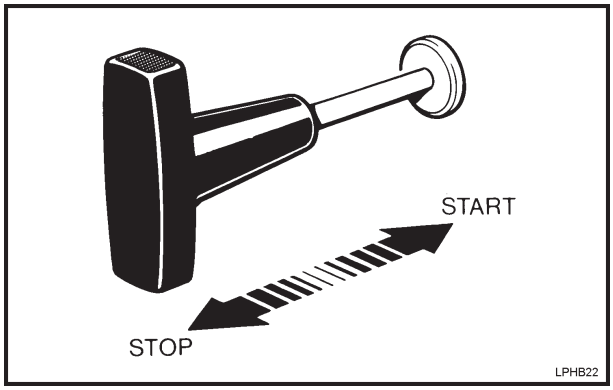

Figure 5.3.2 Stop Control

04.3.5 Gear and Speed Control

With the engine running and the control lever in the centre position the gearbox is in 'Neutral' and the engine will be idling.

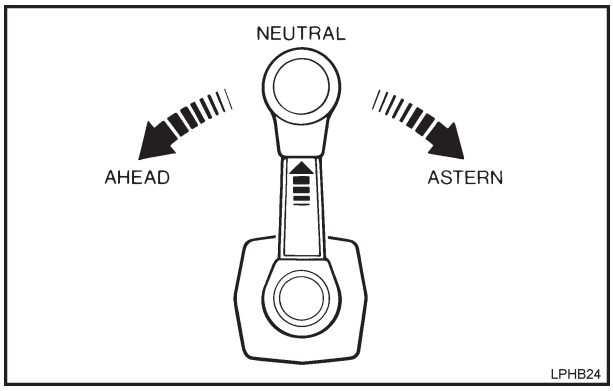

Figure 5.3.3 Gear and Speed Control

As the control is moved anti-clockwise from 'Neutral' the gearbox engages 'Ahead', further progressive movement of the control increases the speed. When the control is moved clockwise from 'Neutral' the gearbox engages 'Astern', further progressive movement of the control increases the speed.

On some types of gear/speed control lever the gearbox drive can be disengaged by pressing the button in the centre of the control lever boss.

05.3.6 Starting the Marine Engine

To ensure smoother operation and contribute to a longer engine life it is advisable to allow the engine to warm up for several minutes, with the gearbox disengaged, at a speed of approximately 1100-1500r/min before moving off.

1. On non-automatic engines ensure the stop handle is pushed in.
2. Move the gear/speed control lever to 'Neutral'.

   On some types of gear/speed control lever the gearbox ahead/astern selector can be disengaged by pressing a button in the centre of the lever.
3. With the gearbox disengaged move the gear/speed control anti-clockwise towards 'Ahead' to approximately half throttle.
4. On LPWS engines turn the keyswitch to the 'I' position until the 'PREHEAT' light goes out.

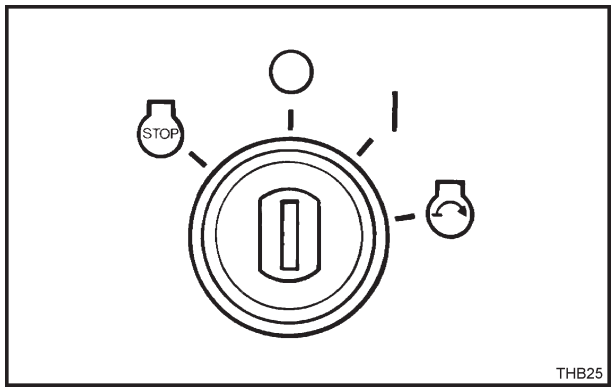

Figure 5.3.4 Key Start

5. Turn the keyswitch to the 'ENGINE CRANKING' position to energise the starter motor and release it immediately the engine starts.

   If the engine fails to start within 30 seconds, release the key and attempt to restart after allowing sufficient time for all moving parts to stop.

05.3.7 Dual Electric Start Panels

The engine can be started from either start panel and the panel used for starting will be considered the 'Master Panel' for the duration of the engine run.

Both panels will be illuminated and operative even though the 'Slave Panel' is not switched on. The 'Master Panel' should be used to stop the engine.

In an emergency the start/stop key on either panel can be used to stop the engine.

If the 'Slave Panel' is used to stop the engine the alarms will continue to sound on both panels until both start/stop keys are turned to the 'O' position.

⚠ CAUTION

If both keys are turned to the 'O' position while the engine is running the panels and alarms will not indicate and the engine will continue to run until one key is turned to the 'Stop' position.

⚠ WARNING

Under no circumstances should the 'Slave Panel' key be turned to the '1' position while the engine is running.

05.3.8 Stopping the Marine Engine

1. Move the gear/speed control lever to 'Neutral'.
2. On non-automatic engines pull the stop handle out.
3. Turn the keyswitch anti-clockwise to the 'STOP' position.
4. When the engine has stopped turn the keyswitch clockwise to the 'O' position.
5. On non-automatic engines push the stop handle in.

⚠ CAUTION

Turning the keyswitch to the 'STOP' position alone will not stop the engine unless a fuel control solenoid is fitted.

Section 06. Marine Gearboxes

06.1 THE NEWAGE GEARBOX

This information is included, and intended, to be used as a guide for the user.

The gearbox manufacturers publication should be consulted for additional information on operating and routine maintenance procedures.

Current Designation	Previous Designation
PRM150	PRM Delta
PRM260	PRM160

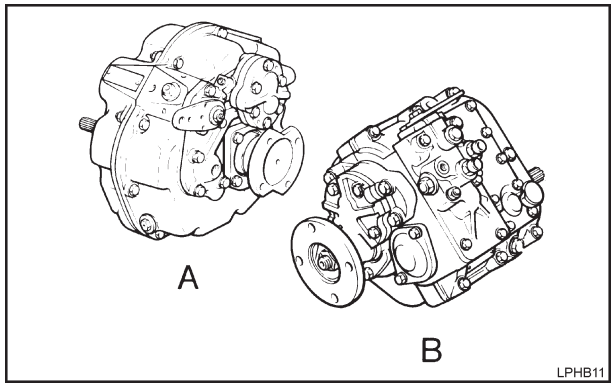

Figure 6.1.1 The Gearbox
A - PRM 150
B - PRM 260

06.1.1 Gearbox Serial Number

The serial number of the gearbox is stamped on a plate attached to the top half of the gearbox; a specimen number is shown below.

123456 A1234
160D3

123456 A1234 .....Serial number
160D .....Type of gearbox
3 .....Reduction

06.1.2 Lubricating Oil Specification

The gearbox is filled with Shell Rotella SAE 10W/30 prior to despatch. This oil has been approved as being suitable over the full range of operating conditions in ambient temperatures up to 52°C (125°F).

06.1.3 Oil Precautions

⚠ WARNING

New lubricating oil may cause skin irritation.
Contact with used lubricating oil can cause cancer, birth defects or other reproductive harm.

⚠ WARNING

Using the gearbox with insufficient oil may lead to low oil pressure, unsatisfactory operation, overheating and possible failure.
Using the gearbox with too much oil may lead to overheating and oil leaks.

⚠ WARNING

Extreme care must be taken to ensure that waste oil, solvents or other toxic wastes are disposed of in accordance with local regulations to prevent contamination.

06.1.4 Lubricating Oil Capacity

The capacities given are approximate figures and are given for guidance. The oil level should be topped up to the 'full' mark on the dipstick.

	litre	pint	US pint
PRM 150	1.4	2.50	2.96
PRM 260	1.0	1.76	2.11

06.1.5 Emergency Operation

The gearboxes are fitted with a device enabling it to be locked in the 'ahead' position should there be an hydraulic failure.

06.1.6 PRM 150 Gearbox

1. Remove nine bolts securing the rear manifold to the gearcase.
2. Taking care not to lose the small Allen key located inside remove the manifold complete with oil pump.
3. Rotate the gearbox input shaft until two socket screws in the clutch gear align with the two holes in the rear of the gearcase.

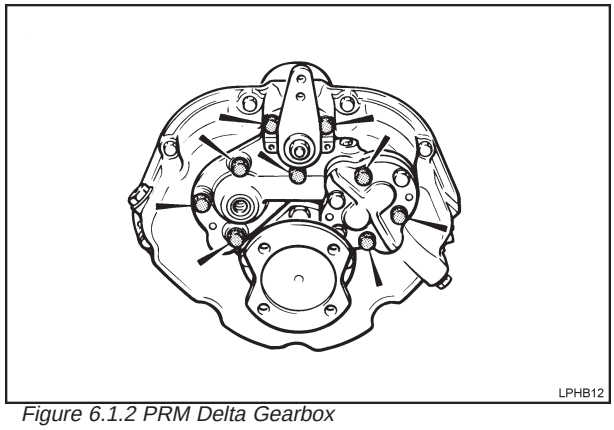

Figure 6.1.2 PRM Delta Gearbox

4. Lock up the clutch plates by inserting the Allen key through the two holes and tightening each screw in turn.
5. Refit the rear manifold and torque the nine bolts to 30.0Nm 22.0lbf ft).
6. Ensure sufficient oil remains in the gearbox to avoid further damage.

06.1.7 PRM 160 Gearbox

1. Remove the top cover located alongside the valve block.
2. Rotate the shaft until one of the grooves on the outer edges of the clutch end plate is uppermost.
3. Using one of the cover setscrews screw it tightly into the threaded hole in the clutch plate directly

beneath the groove to clamp the clutch and provide drive.

4. Check that the dipstick does not foul the head of the bolt that was used. If it does remove the dipstick and plug the hole.
5. Ensure sufficient oil remains in the gearbox to avoid further damage.
6. Refit the top cover and torque the bolts to 30.0Nm 22.0lbf ft).

06.1.8 Checking the Oil Level

The oil should be changed annually or at the same intervals as the engine oil changes.

If the oil becomes contaminated by water or suffers mechanical damage the gearbox, oil cooler and hoses must be flushed and the gearbox refilled with new oil to the correct specification.

1. Run the engine and gearbox for a few minutes to ensure that there is oil in the oil cooler circuit.
2. Stop the engine.
3. Remove the dipstick (A) by unscrewing it and wipe the blade.

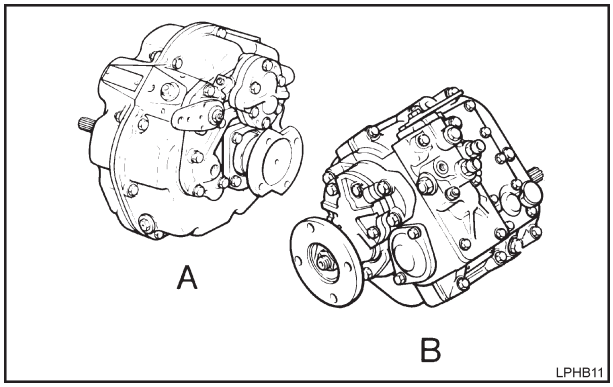

Figure 6.1.3 Dipstick/Oil Filler

4. Replace the dipstick taking care to ensure it is fully screwed down.
5. Remove the dipstick and check the oil level.
6. Add more oil, of the correct specification, if necessary.
7. Replace the dipstick taking care to ensure it is fully screwed down.

06.1.9 Control Linkage Adjustment

Care must be taken to ensure the linkage moves the gearbox operating lever approximately 2.0mm (0.078in) before the lever stop in both the forward and backward travel.

06.1.10 After the First 25 Hours Running

1. Run the engine until the gearbox reaches operating temperature.
2. Stop the engine.
3. Drain the gearbox and oil cooler system.
4. Refill the gearbox with oil.
5. Run the engine for a few minutes and follow the instructions in "06.1.8 Checking the Oil Level".

Frequency	Work to be Carried Out
Daily	Check the oil level.
	Check for oil leaks, especially around the output shaft oil seal and from all gaskets.
Annually	Check the oil cooler hoses and connections.
	Check the propeller shaft alignment. The maximum misalignment is 0.05mm (0.002in).
	Check that the operating linkage is correctly adjusted.

06.1.11 Spanner Sizes

	Gearbox	
	PRM 160	PRM 260
Dipstick	18mm	18mm
Drain Plug	15mm	15mm
Case Bolts	8mm	9/16" AF
Manifold	8mm	-
Cover Plate Bolts	-	1/2" AF
Control Block	-	1/2" AF

06.2 THE HURTH GEARBOX

This information is included and intended to be used as a guide for the user.

The gearbox manufacturers publication should be consulted for additional information on operating and routine maintenance procedures.

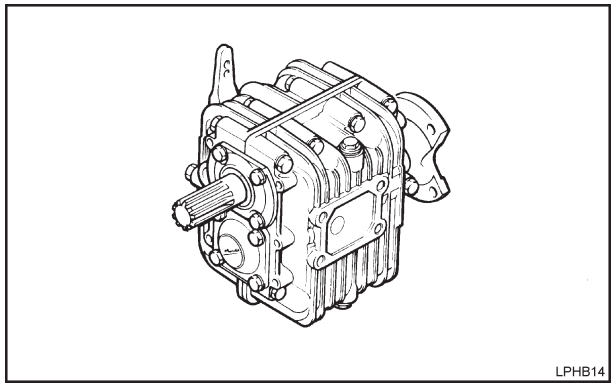

Figure 6.2.1 The Gearbox

06.2.1 Gearbox Serial Number

The serial number of the gearbox is stamped on a plate attached to the top of the gearbox; a specimen number is shown below.

HBW100-R2
15-60145

HBW100 ..... Type
R2 ..... Reduction
15-60145 ..... Serial number

06.2.2 Lubricating Oil Specification

The gearbox is filled with Shell Donax TA prior to despatch. This oil has been approved as being suitable over the full range of operating conditions in ambient temperatures up to 52°C (125°F).

06.2.3 Oil Precautions

⚠ WARNING

New lubricating oil may cause skin irritation.
Contact with used lubricating oil can cause cancer, birth defects or other reproductive harm.

⚠ WARNING

Using the gearbox with insufficient oil may lead to low oil pressure, unsatisfactory operation, overheating and possible failure.
Using the gearbox with too much oil may lead to overheating and oil leaks.

⚠ WARNING

Extreme care must be taken to ensure that waste oil, solvents or other toxic wastes are disposed of in accordance with local regulations to prevent contamination.

06.2.4 Lubricating Oil Capacity

The capacities given are approximate figures and are given for guidance.

The oil level should be topped up to the 'full' mark on the dipstick.

	litre	pint	US pint
HBW 50	0.30	0.53	0.63
HBW 100	0.35	0.62	0.74
HBW 125	0.55	0.97	1.16
HBW 150	0.55	0.97	1.16

06.2.5 Sailing and Moving in Tow

Rotation of the propeller, without load while the boat is sailing, being towed or anchored in a river, will have no detrimental effect on the gearbox; neither will operating the engine with the propeller stopped.

⚠ CAUTION

When the boat is sailing with the engine stopped the gear lever must be in the 'zero' position.
The gear lever must NEVER be put into the position corresponding to the direction of travel.

06.2.6 Oil Change Periods

The oil should be changed for the first time after 25 hours, then at least annually or at the same intervals as the engine oil changes.

06.2.7 Checking the Oil Level

1. Run the engine and gearbox for a few minutes to ensure there is oil in the oil cooler circuit.
2. Stop the engine.
3. Remove the dipstick (A) by unscrewing it and wipe the blade.

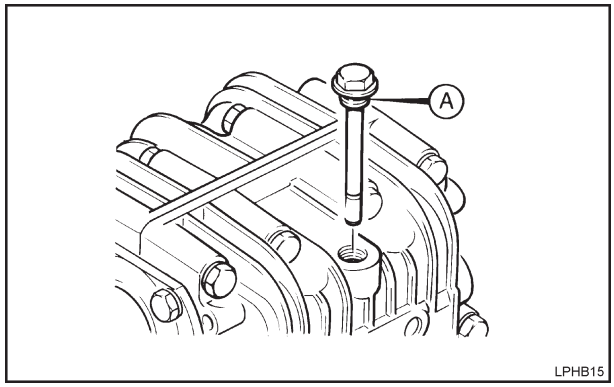

Figure 6.2.1 Dipstick/Oil Filler

4. Replace the dipstick taking care to ensure it is not screwed into the gearbox casing.
5. Remove the dipstick and check the oil level.
6. Add more oil, of the correct specification, if necessary.
7. Replace the dipstick; take care to ensure it is fully screwed down.

06.2.8 The Control Linkage Adjustment

The control cable or rod should be arranged at right angles to the actuating lever in the 'Neutral' position.

It is important to ensure the operating lever on the control console coincides with the 'Neutral' position of the gearbox operating lever.

Care must be taken to ensure the linkage moves the gearbox operating lever at least 35.00mm (1.38in) for the outer pivot point (A) and at least 30.0mm (1.18in) for the inner pivot (B) in both the forward and backward travel from the 'Neutral' position.

The operating lever clamping screw (C) should be torqued to 18.0Nm (13.3lbf ft).

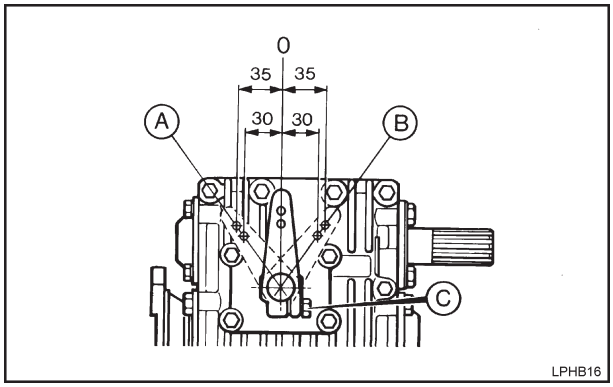

Figure 6.2.2 Control Lever Adjustments

⚠ CAUTION

It is important to ensure the clearance between the lever (D) and the lever cover plate (E) is a minimum of 0.5mm (0.02in).
The position of the cover plate is factory adjusted and no attempt should be made to change it.

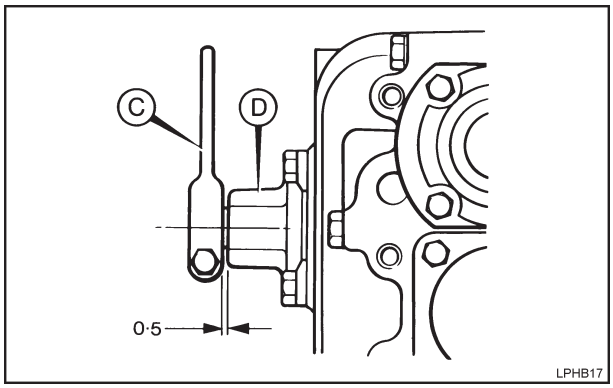

Figure 6.2.3 Control Lever Adjustments

Section 07. Routine Maintenance

07.1 PRELIMINARY INSTRUCTIONS

⚠ WARNING

Routine maintenance must be performed by qualified persons who are conversant with the hazards of fuels, electricity and machinery.
Read the Safety Precautions in "Section 01. General Information" and observe all instructions and precautions in this publication.

These recommendations and instructions cover several engine models therefore they are of a general nature.

The engines are assembled to predetermined builds and individual engines may include optional equipment not specifically covered in this book in which case any Lister Petter Distributor or Dealer can be consulted.

- The engine should receive regular attention during the first 50 hours of its life from new and after a major overhaul.
- Long periods of light or 'no load' running early in the engine's life may lead to cylinder bore glazing and high oil consumption.
- The instructions given in "1.16.5 Maintenance Schedules" are based on average operating conditions and cover the minimum requirements to keep an engine running at peak performance with trouble free operation.
- Under very dusty conditions, air cleaners, lubricating oil and fuel filters will require more frequent attention
- Decarbonising may be required more often if the engine has been running on light loads for long periods.
- Before carrying out any maintenance work on an engine it is advisable to remove the battery.

  The battery and alternator must be disconnected before commencing any electric welding when a pole strap is directly or indirectly connected to the engine.
- It is essential to ensure that nuts and bolts are tightened to the torques specified in this manual.
- When reassembling an engine lubricate all moving parts with engine oil.
- Renew nuts and bolts that have been taken from high stress locations. In particular nuts and/or bolts from the connecting rods should be renewed.
- The fuel injector can only be checked and set off the engine using suitable specialist test equipment.
- A Hurth or Newage gearbox may be fitted to the engine and the gearbox manufacturers publication should be consulted for information on operating and routine maintenance procedures. Basic information can be found in "06 Marine Gearboxes".

⚠ WARNING

ON NO ACCOUNT ALLOW ANY UNPROTECTED SKIN TO COME INTO CONTACT WITH THE INJECTOR SPRAY AS THE FUEL MAY ENTER THE BLOOD STREAM WITH FATAL RESULTS.

⚠ WARNING

SOME ENGINES MAY BE FITTED WITH SEALS OR 'O' RINGS MANUFACTURED FROM 'VITON' OR A SIMILAR MATERIAL.
WHEN EXPOSED TO ABNORMALLY HIGH TEMPERATURES, IN EXCESS OF 400°C (752°F), AN EXTREMELY CORROSIVE ACID IS PRODUCED WHICH CANNOT BE REMOVED FROM THE SKIN.
IF SIGNS OF DECOMPOSITION ARE EVIDENT, OR IF IN DOUBT, ALWAYS WEAR DISPOSABLE HEAVY DUTY GLOVES.

07.1.1 Waste Disposal Precautions

- Extreme care must be taken to ensure that waste fuel, oil, filter elements, acid, coolant concentrate, paint, solvents or other toxic wastes are disposed of in accordance with local regulations to prevent contamination.

07.1.2 Initial Attention

To help assist engine running-in, all engines are despatched with an initial fill lubricating oil which must be changed after 100 hours.

All subsequent oil changes must be as specified in "1.16.5 Maintenance Schedules".

It is recommended that the following receive attention after the engine has run 50 hours and again after 250 hours.

- Check and tighten nuts, bolts and unions paying particular attention to the fuel system.
- Check the drive belt tension.
- Check the lubricating oil level and top up if necessary.
- Check the LPW/LPWS radiator coolant level and top up if necessary.

  A 40% coolant concentration must be maintained at all times.
- Observe the exhaust at the normal full load. The exhaust must be free from soot.

  A black exhaust means that the engine is overloaded or that the injection equipment is out of order.
- Do not allow the engine to run with a dirty exhaust without investigating the cause as this may result in an expensive breakdown.

07.1.3 Interim Maintenance

These checks are to be carried out daily and are in addition to those given in "05.4 Routine Maintenance - schedule hours".

1. Check the coolant, lubricating oil and fuel levels.
2. Check for coolant, lubricating oil and fuel leaks.
3. Clean the air cleaner under very dusty operating conditions.
4. Examine the cooling fan for damage.
5. Ensure all guards are firmly attached and not damaged.
6. Check the coolant hoses and replace them if they are swollen or perished.

07.2 OIL AND FILTER CHANGE PERIODS

07.2.1 LPA, LPW, LPWT and LPWS Engines

To help assist engine running-in, all engines are despatched with an initial fill lubricating oil which must be changed with the filter, after 100 hours and then as specified below.

Before attempting to change the lubricating oil or filter read the safety precautions in "Section 01. General Information"

1. Identify the type and build of engine; see "01.4.3 Engine Serial Number
2 Ensure the new oil meets the correct specification as given in the Operators Handbook.

All Builds Except 28, 51, 52, 57, 58, 59

	Periods in Hours	
Ambient Temperature	LPA/LPW	LPWS
Up to 35°C (95°F)	250	100
Above 35°C (95°F)	125	75

Note:
The oil and filter change periods, given in hours, apply when engines are operating regularly at temperatures exceeding 35°C (95°F) at high speeds and duty factors.

Builds 28, 51, 52, 57, 58, 59

	Periods in Hours	
Ambient Temperature	LPA/LPW	LPWS
Up to 35°C (95°F)	500	250
Above 35°C (95°F)	250	150

Note:
The oil and filter change periods, given in hours, apply when engines are operating regularly at temperatures exceeding 35°C (95°F) at high speeds and duty factors.

07.2.2 LPWG Engines

To help assist engine running-in, all engines are despatched with an initial fill of BP 7455 lubricating oil which must be changed, with the filter, after 100 hours and then as specified below. The first fill oil is formulated specifically for gaseous-fuelled engines.

Before attempting to change the lubricating oil or filter read the safety precautions in "Section 01. General Information"

After the first-fill oil and filter change at 100 hours subsequent oil and filter changes should occur every 250 hours of operation.

Any attempt to extend this interval should be in conjunction with a lubricating oil analysis programme, to ensure that the Total Acid Number (TAN) and nitration levels remain within acceptable limits.

⚠ WARNING

Continuous operation under heavy loads in ambient temperatures above 35°C (95°F) causes the oil to deteriorate faster. Under these circumstances the oil and filter should be changed every 125 hours.

The engines should be serviced with Mobil Pegasus 480 SAE40, Mobil Delvac Super GEO 15W 40 or a similar type of lubricating oil. If these oils are not available, a name brand detergent lubricating oil specified for automotive gasoline engines can be used.

The required minimum zinc content for LPWG lubricating oil is 800 parts per million (ppm). Most lubricating oils for flat tappet engines have a zinc content of about 1200 ppm.

⚠ WARNING

Do not use lubricating oils formulated for large industrial gas engines with roller tappets, as the zinc content is insufficient to protect the camshaft and flat tappets.

07.3 ROUTINE MAINTENANCE - SCHEDULE HOURS

Both schedules are based on average operating conditions and cover the minimum requirements to keep an engine running at peak performance with trouble free operation.

07.3.1 All Engines Except LPWG

Also refer to "07.2 Oil and Filter Change Periods".

Daily
Check the coolant level.
Check the supply and level of fuel.
Check the level and condition of the lubricating oil.
Clean the air cleaner if the engine is operating in very dusty conditions.

After the First 100 Hours
On marine propulsion engines check the idling speed and reset it if necessary.

Every 125 Hours
The above and the following items.
Clean the air cleaner if the engine is operating in moderately dusty conditions.
Check for fuel, coolant and lubricating oil leaks.
Check the serviceability of the battery.

Every 250 Hours
The above and the following items.
Check the condition and tension of the radiator drive belt.
Check the radiator fins for contamination or blockage.
Clean the fuel injector nozzles if the exhaust is dirty.
Renew the fuel filter element if the fuel is not perfectly clean.

Every 500 Hours
The above and the following items.
Renew the fuel filter element.
Renew the air cleaner element.
Check the air induction system for leaks, damage and restrictions.
Clean the LPWT4 crankcase breather canister and hoses

Every 1000 Hours
The above and the following items.
Check all external nuts, bolts and unions for tightness.
Ensure that all guards are firmly attached and not damaged.
Replace the fuel lift pump diaphragn; see Note:

Every 2000 Hours
The above and the following items.
Decarbonise, if performance has deteriorated, renewing all joints and seals as necessary.
Drain and clean the engine mounted fuel tank, if fitted.
Check the engine and speed controls for free movement.
Clean and check, or replace, the fuel injector nozzles.
Check the radiator fins and radiator fan blades for damage.
Replace the radiator fan drive belt irrespective of condition.
Check the lubricating oil pressure.
Renew the air cleaner element.

Every 6000 Hours
The previous items and give the engine a major overhaul, if necessary.

Every Year - LPW and LPWS
Drain, flush and refill the cooling system adding new coolant concentrate to a 40% concentration.

Every Year - All Engines
Drain and replace the lubricating oil and filter, irrespective of their condition, if the engine has run for less than 250 hours in the preceding twelve months.
On marine engines change the air cleaner element if it was not changed at the presribed intervals.

Every Two Years
Replace the coolant hoses irrespective of their condition.

Note:
It is recommended that the fuel lift pump diaphragm is inspected at more frequent intervals if it is known the fuel is contaminated. It should also be inspected at regular intervals on engines in low duty cycle applications; for example, stand-by generating sets.

07.3.2 LPWG Engines

Also refer to "07.2 Oil and Filter Change Periods".

Daily
Check the coolant level.
Check the level and condition of the lubricating oil.
Clean the air cleaner if the engine is operating in very dusty conditions.

Every 125 Hours
The above and the following items.
Clean the air cleaner if the engine is operating in moderately dusty conditions.
Check for coolant and lubricating oil leaks.
Check the serviceability of the battery.

Every 250 Hours
The above and the following items.
Check the condition and tension of the radiator drive belt.
Check the radiator fins for contamination or blockage.
Drain and replace the lubricating oil and filter.
Check the condition of the coolant hoses and clamps.

Every 500 Hours
The above and the following items.
Clean the crankcase breather system components.
Renew the air cleaner element.
Check the air induction system for leaks, damage and restrictions.
Replace the spark plugs.
Clean the crankcase breather canister and hoses

Every 1000 Hours
The above and the following items.
Check all external nuts, bolts and unions for tightness.
Ensure that all guards are firmly attached and not damaged.
Replace the high tension leads.

Every 2000 Hours
The above and the following items.
Overhaul the carburetor
Check the engine controls for free movement.
Check the radiator fins and radiator fan blades for damage.
Replace the radiator fan drive belt irrespective of condition.
Check the lubricating oil pressure.
Renew the air cleaner element.

Every 6000 Hours
The previous items and give the engine a major overhaul, if necessary.

Every Year
Drain, flush and refill the cooling system adding new coolant concentrate to a 40% concentration.
Drain and replace the lubricating oil and filter, irrespective of their condition, if the engine has run for less than 250 hours in the preceding twelve months.

Every Two Years
Replace the coolant hoses irrespective of their condition.

07.4 SEALING COMPOUNDS

Component	Compound to Use	Applying the Compound
Cylinder head cover		Assemble the joint dry and with all surfaces dry and clean.
Core plugs	Loctite 572.	Coat the outside of the plug or the bore. Do not allow the compound to enter the camshaft bore.
Oil sump drain plug	Hylomar PL32/M, Loctite 572 or Hylogrip 760.	Coat the threads.
Oil seals	Grease	Lightly grease the sealing lip before fitting.
Cylinder head gasket		Assemble the gasket dry and with all surfaces clean and dry. Assemble LPA gaskets with the raised corrugations against the crankcase.
Stop/run and speed control bushes		Press the bushes into the crankcase dry.
Push rod tube seals	Grease or Hellerine Rubber Lubricant	To aid assembly, lightly coat the bore of the seal.
Main bearing housing shims	Wellseal	Coat both sides of each shim.
Dipstick	Grease or Hellerine Rubber Lubricant	To aid fitting, lightly coat the exposed part of the 'O' ring.
Fuel pump tappet stud	Loctite 270	Coat the stud end thread which fits into the crankcase.
Thermostat housing cover	Hylomar PL32/M	Coat both joint faces.
Camshaft journals and bores	Molydisulphide (Achesons Colloids Compound Grade 1168 or equivalent)	Coat all of the camshaft journals, except the gear end.
Flywheel housing drain plug	RTV Silicon Compound.	Coat the plug flange.
Oil pressure switch adaptor	PTFE tape	Wind the tape around the external adaptor threads.
Rocker lever spacer - LPA only	Wellseal	Before assembly coat both sides of the spacer.
Flywheel housing - Marine Builds only	Loctite 573 or 574	Apply a bead to the housing immediately before assembly.
Injector nozzle washer	Grease	Lightly coat the injector side of the washer.
Crankshaft thrust washers	Grease	Lightly coat the crankshaft side of the washers.
All other joints and shims		Assemble dry and with all surfaces clean and dry.

LPWT4 Only

Oil strainer 'O' rings:	Grease	Lightly coat with grease to aid assembly.
Rocker cover breather tube	Loctite 648	Coat the end of each tube prior to fitting it.
Crankcase door turbocharger oil drain tube		
Crankcase door breather separator drain tube:		

07.5 SPANNER TORQUES

The tolerance for all torque settings is ±10% except those marked with a * when it is +5% -0%. For practical purposes the figures have been rounded.

Description of Component	Nm	lbf ft
Turbocharger oil drain pipe clips	2.0	1.5
Stop/run control assembly screw	7.0	5.0
Crankshaft pulley stud [1, 2]		
Turbocharger oil drain flange bolts	9.0	6.5
End cover nuts or bolts	9.0	6.5
Fuel filter bracket screw		
Inlet and exhaust manifold bolts		
Oil pump setscrew		
Camshaft thrust plate screws		
Governor weight plate screws		
Air cowling fasteners - LPA		
Cylinder head cover nut		
Crankcase door bolt	11.0	8.0
Alternator adjusting link	16.0	12.0
Fixing bolt to backplate		
Water pump studs (not bolts)		
Fuel filter union plug	20.0	15.0
Fuel lift pump nuts	21.0	15.5
Injector clamp nut		
Axial fan bracket bolt - LPA		
Alternator bolt		
Water pump bolts and nuts		
Deep sump bolts [3]		
Centre bearing housing bolts		
Exhaust manifold stud - LPWT4		
Turbocharger fixing nuts		
Turbocharger exhaust flange nuts		
Turbocharger oil feed plugs		
Breather separator fixing bolts - LPWT4		

Description of Component	Nm	lbf ft
Injector pipe nuts - LPWS	22.0	16.0
Glow plug - LPWS	27.0	20.0
Oil strainer tube nut		
Main bearing housing nuts		
Injector pipe nuts - LPA, LPW	28.0	21.0
Radiator fan nut - LPW, LPWS [1]	30.0	22.0
Fuel pump clamp	34.0	25.0
Valve rocker nut		
Connecting rod bolt *	35.0	26.0
Radiator fan spacer - Build 70		
Cylinder head bolt - LPA *		
Stage 1	8.0	6.0
Stage 2:		
With 'High Boss' crankcase [4]	61.0	48.0
Prior to 'High Boss' crankcase [4]	48.0	35.0
Starter motor bolt	41.0	30.0
Oil pump relief valve		
Oil filter adaptor bolt - LPWT4		
Injector nozzle nut - LPA, LPW	46.0	34.0
Fuel pump delivery valve holder	47.0	35.0
Injector - LPWS	68.0	50.0
Flywheel bolt * - not LPWT4		
Flywheel housing screw	79.0	58.0
Flywheel bolt * - LPWT4 Injector nozzle nut - LPWS	81.0	65.0
Cylinder head bolt - LPW, LPWT, LPWS *		
Stage 1	8.0	6.0
Stage 2	48.0	35.0
Stage 3	88.0	65.0
Crankshaft pulley [1, 2] or pulley bolt [1]	300.0	221.0

Notes to Both Tables:
1 - Left hand thread
2 - Early engines
3 - Builds 28, 51, 52, 57, 58, 59
4 - The lower torque figure is used on earlier engines and the higher figure for later 'High Boss' cylinder barrels On earlier barrels the bosses and threads are below the top fin. On the 'High Boss' arrangement the bosses and threads are at the top of the barrel.

07.5.1 Stater Motor Terminal Torques

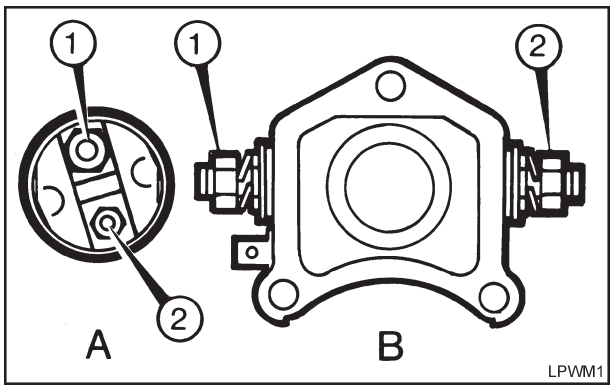

Figure 7.5.1 Starter Motor Terminal Identification
A - Lucas/Magnetti Marrelli
B - Denso

Starter Motor		Battery +Terminal 1	Link Terminal 2
Lucas/Magnetti Marrelli	Nm	4.0-4.2	3.1-3.2
	lbf ft	2.95-3.01	2.3-2.4
Denso Starter	Nm	5.89-11.77	5.89-11.77
	lbf ft	4.34-8.68	4.34-8.68

07.6 DECARBONISING

Decarbonising should be carried out after 2000 hours running or if the engine shows loss of compression or blow-by past the piston.

Thoroughly clean and examine the following items for damage or wear and renew any defective parts as necessary.

a. Piston.
b. Piston rings, grooves and oil holes.
c. Combustion chamber in the top of the piston.
d. Valve ports, valves and valve seats.
e. Exhaust manifold, piping and silencer.
f. Fins on the cylinder, cylinder head and injector.
g. Injector nozzle.

07.7 DIMENSIONS OF WEARING PARTS

The following information is given as a guide to the extent by which components may reasonably be expected to wear, without appreciable loss of performance.

To maintain the engine in good running order it is therefore recommended that when the 'Maximum Clearance' figure is reached, one or more components affecting the clearance be replaced.

The wear to be allowed in parts refitted to an engine depends on the life required to the next overhaul and the relative cost of labour and materials. If labour costs are high it may pay to replace parts before the maximum wear condition is reached to avoid further work before the next scheduled overhaul.

07.7.1 Cylinder Bore Wear

The maximum advisable piston to cylinder clearance given is the clearance between the bottom of the piston skirt, across the faces, and the cylinder bore measured in the region of travel of the piston skirt. ***The clearance is not to be measured at the top of the bore.***

07.7.2 Piston Ring Wear

The ring gaps given in the table are those to be anticipated when checking rings in an unworn part of the bore. For every 0.01mm (0.0004in) by which the actual bore size exceeds the initial dimension, the ring gap will increase by approximately 0.03mm (0.0012in).

The firing ring side clearance is measured with a new ring flush with the top piston land.

07.7.3 Oversize and Undersize Items

Oversize pistons and piston rings, and undersize big end and main bearing shells are available.

Non-standard sizes are marked, by the amount they are under or oversize, as a suffix to the part numbers stamped or etched on the part.

Piston Rings - on the face of the ring.

Pistons - on the top surface.

Bearings - on the steel outside surface of the bearing.

Sizes Available

0.254mm (0.010in).

0.508mm (0.020in).

0.762mm (0.030in) - not available oversize.

07.8 DIMENSIONS OF WEARING PARTS

LPA2 and 3	Initial Dimension mm	Initial Clearance mm	Maximum Clearance mm
Controlled Expansion Pistons			
Cylinder bore	76.000 - 76.025	0.0750 - 0.030	0.40
Piston diameter - bottom of skirt across thrust face	75.970 - 75.950		
Piston ring gaps	0.25 - 0.50	0.25 - 0.579	1.27
Top piston ring width	1.728 - 1.740	0.11 - 0.142	0.19
Top piston ring groove width	1.850 - 1.870		
2nd piston ring width	1.978 - 1.990	0.09 - 0.122	0.17
2nd piston ring groove width	2.080 - 2.100		
Oil control piston ring width	3.975 - 3.990	0.05 - 0.085	0.15
Oil control piston ring groove width	4.040 - 4.060		
Non-Controlled Expansion Pistons			
Cylinder bore	76.000 - 76.025	0.140 - 0.175	0.40
Piston diameter - bottom of skirt across thrust face	75.850 - 75.860		
Piston ring gaps	0.230 - 0.480	0.230 - 0.559	1.25
Top piston ring width	1.725 - 1.750	0.102 - 0.152	0.20
Top piston ring groove width	1.852 - 1.877		
2nd piston ring width	1.959 - 1.984	0.051 - 0.101	0.15
2nd piston ring groove width	2.035 - 2.060		
Oil control piston ring width	3.965 - 3.990	0.040 - 0.090	0.15
Oil control piston ring groove width	4.030 - 4.055		
LPW/LPWS2, 3 and 4			
Cylinder bore	86.000 - 86.025	0.039 - 0.134	0.40
Piston diameter - bottom of skirt across thrust face	85.891 - 85.901		
Controlled Expansion Pistons			
Piston ring gaps	0.25 - 0.50	0.25 - 0.579	1.39
Top piston ring width	1.728 - 1.740	0.090 - 0.122	0.17
Top piston ring groove width	1.830 - 1.850		
2nd piston ring width	1.978 - 1.990	0.050 - 0.082	0.14
2nd piston ring groove width	2.040 - 2.060		
Oil piston ring width	3.978 - 3.990	0.050 - 0.082	0.14
Oil piston ring groove width	4.040 - 4.060		
Non-Controlled Expansion Pistons			
Piston ring gaps	0.260 - 0.510	0.260 - 0.589	1.40
Top piston ring width	1.710 - 1.740	0.060 - 0.115	0.16
Top piston ring groove width	1.800 - 1.825		
2nd piston ring width	1.965 - 1.990	0.050 - 0.100	0.15
2nd piston ring groove width	2.040 - 2.065		
Oil control piston ring width	3.965 - 3.990	0.040 - 0.090	0.15
Oil control piston ring groove width	4.030 - 4.055		

All Engines	Initial Dimension mm	Initial Clearance mm	Maximum Clearance mm
Connecting rod big end bore	53.525 - 53.545	0.025 - 0.080	0.12
Bearing shell thickness	1.740 - 1.750		
Crankpin diameter	49.985 - 50.000		
Flywheel end main bearing housing bore	74.040 - 74.065	0.040 - 0.10	0.14
Bearing shell thickness	1.990 - 2.000		
Crankshaft journal diameter	69.985 - 70.000		
Gear end main bearing housing bore	58.535 - 58.560	0.035 - 0.095	0.135
Bearing shell thickness	1.740 - 1.750		
Crankshaft journal diameter	54.985 - 55.000		
Centre main bearing housing bore	58.535 - 58.560	0.035 - 0.095	0.135
Bearing shell thickness	1.740 - 1.750		
Crankshaft journal diameter	54.985 - 55.000		
Thrust washer thickness (replace if less than 2.20mm)	2.310 - 2.360		
Gear end camshaft bush bore	34.990 - 35.085	0.010 - 0.120	0.17
Gear end camshaft journal diameter	34.965 - 34.980		
Centre camshaft bush bore	35.030 - 35.070	34.965 - 34.980	0.17
Centre camshaft journal diameter	34.965 - 34.980		
Flywheel end camshaft bush bore	35.030 - 35.070	34.965 - 34.980	0.17
Flywheel end camshaft journal diameter	34.965 - 34.980		
Camshaft thrust plate	2.850 - 2.900		
Connecting rod small end bush	25.005 - 25.017	0.0075 - 0.0245	0.05
Gudgeon pin diameter	24.9925 - 24.9975		
Hydraulic tappet diameter	21.386 - 21.405	0.020 - 0.064	0.11
Hydraulic tappet bore	21.425 - 21.450		
Valve spring free length (replace if 42.5mm or less)	43.7 - 45.5		
Valve guide bore - assembled	7.195 - 7.250	0.025 - 0.095	0.165
Valve stem diameter	7.155 - 7.170		
Fuel pump tappet diameter	21.959 - 29.980	0.020 - 0.100	0.14
Fuel pump tappet bore	22.000 - 22.050		
Backlash between gears		0.025 - 0.150	0.20

07.8 LONG TERM STORAGE

07.8.1 Preparing the Engine for Storage

The following routine should be carried out when it is known that the engine will not be required for some months.

If the following procedure is not carried out the engine should be run on full load for approximately 45 minutes once a month.

⚠ CAUTION

As a direct result of combustion the lubricating oil may contain harmful acids and therefore it should not be left in the sump if it is known engine will not be used for extended periods.

a. Replace the fuel in the tank with a small supply of suitable inhibition fluid.
b. Drain the lubricating oil from the sump and refill with new oil.
c. Run the engine for a period to circulate the oil through the system and to ensure the inhibition fluid is passed through the fuel pumps and injectors.
d. Stop the engine, drain the cooling system and drain the lubricating oil from the sump.

   The crankshaft should NOT be turned until the engine is again required for service.

   The inhibition fluid should be left in the fuel system.
e. Seal all openings on the engine with tape.
f. Remove the batteries and store them fully charged after coating the terminals with petroleum jelly.
g. Grease all external bright metal parts and the speed control linkage.
h. Tie labels on the engine clearly stating what steps have been taken to inhibit the engine during storage.

07.8.2 Returning the Engine to Service

Refer to the appropriate sections for the relevant detailed instructions as necessary to complete this work.

a. Remove the tie-on labels and all the protective coverings from openings and apertures.
b. Check the drive belt for deterioration and correct tension.
c. Fill the fuel tank.
d. Refill the cooling system, adding new coolant concentrate to a 50% concentration.
e. Refill the lubricating oil sump with new oil of the correct specification and viscosity.
f. Remove the batteries from store. If they are still fully charged reconnect them to the engine.

   Coat the terminals with petroleum jelly.
g. Start the engine and check for coolant, fuel and oil leaks before applying load.

Section 08. Troubleshooting

08.1 PRELIMINARY INFORMATION

Troubleshooting mechanical engine problems can be difficult. This section lists possible engine problems that could be encountered with possible causes and corrections. The information given is of a general nature as it covers the basic engine and your particular application may be different.

Electrical wiring diagrams can be found in 'Section 08'.

If you are in any doubt, contact your local Lister Petter distributor.

Before starting any dismantling procedure the following should be considered:

a. Do you know and understand the engine and all the related systems?

b. Do you have sufficient electrical and mechanical knowledge and skills to understand the symptoms?

c. Do you have suitable electrical diagnostic equipment available?

d. Do you have, or access to, the necessary Lister Petter spare parts before you commence dismantling.

08.2 METHOD OF TROUBLESHOOTING

1. Diagnose the problem by eliminating the easiest things first.
2. Before starting to remove or dismantle any components double check your observations.
3. During dismantling keep all cylinder related items together. This will ensure they are refitted in the original orientation.
4. When electrical troubleshooting always start at the battery first.

Problem	*Method of Correction*
Difficult Starting or Failure to Start	
Incorrect starting procedure.	Refer to the correct procedure.
Unsuitable lubricating oil (too heavy).	Use oil of the correct viscosity and specification.
Incorrect fuel.	Use fuel of the correct specification.
No fuel in the tank.	Refill the tank.
Choked fuel filter.	Replace the filter.
Air lock in the fuel system.	Check the fuel level. Prime the fuel filter.
Water or dirt in the fuel system.	Drain, flush, refill and prime the filter.
Dirty or faulty injector.	Replace the injector or have it serviced.
Discharged battery.	Recharge or replace the battery.
Fuel control solenoid not energised.	Check the electrical supply.
Poor battery connections.	Clean, replace and coat with petroleum jelly.
Faulty fuel pump.	Contact a Lister Petter distributor.
Excessive Carbon Deposits	
Choked air filter.	Dismantle and clean the cap and element.
Choked exhaust system.	Dismantle and clean.
Unsuitable fuel.	Use fuel of the correct specification.
Unsuitable lubricating oil.	Use oil of the correct viscosity and specification.
Continuous low, or no load running	Investigate your load management programme.
White Exhaust Smoke	
Water entering the cylinder.	Check the thermostat and cylinder head gasket.
Light Blue Exhaust Smoke	
Generally as a result of light load.	Investigate the load management programme.
Heavy Blue Exhaust Smoke	
Lubricating oil passing the piston rings.	Check the crankcase vacuum. Check for wear.
Stuck, worn or broken piston rings.	Check for damage, decarbonise, replace the rings.
Worn cylinder bore.	Replace the piston and piston rings.
Overfull oil sump.	Correct the level.
Black Exhaust Smoke	
Overload.	Reduce the load.
Choked air filter.	Dismantle and clean the cap and element.
Inlet air temperature too high.	Investigate the reason.
Water in the fuel system.	Drain, flush, refill and prime the filter.
Unsuitable fuel.	Use fuel of the correct specification.

Continued on the next page

Problem	*Method of Correction*
Engine Stops	
Lack of fuel.	Check the system. Refill the tank.
Air in the fuel system.	Prime the fuel filter.
Water in the fuel system.	Drain, flush, refill and prime the fuel filter.
Choked fuel filter.	Replace the filter.
Choked air filter	Dismantle and clean the cap and element.
Overload.	Reduce the load.
Overheating.	See the 'Overheating' section.
Loss of compression.	Check the piston rings and the valves.
Loss of electrical supply to the fuel control solenoid.	Check the eletrical feed.
Automatic shutdown, if protective devices are fitted.	Investigate the cause and rectify.
Lack or Loss of Power	
Loss of compression.	Check the piston rings and the valves.
Choked air filter.	Dismantle and clean the cap and element.
Choked exhaust system.	Dismantle and clean.
Overload.	Reduce the load.
Choked fuel filter.	Replace the filter.
Worn engine.	Give the engine a major overhaul.
Overheating	
Radiator fan belt too slack.	Replace and correctly tension.
Overload.	Reduce the load.
Lubricating oil level too low.	Add oil of the correct specification and viscosity.
Incorrect fuel.	Drain the system, add fuel of the correct specification.
Radiator air flow restricted.	Clean the radiator core fins.
Recirculation of exhaust gasses or cooling air.	Investigate and eliminate the cause.
Low level of coolant.	Refill and check for leaks.
Defective thermostat.	Remove and check or replace.
Faulty radiator cap.	Remove and check or replace.
Cooling system obstructed.	Drain, flush and refill.
High Fuel Consumption	
Incorrect type of fuel.	Drain the system, add fuel of the correct specification.
Overload.	Reduce the load.
Dirty or faulty injector.	Clean or replace.
Choked air filter.	Dismantle and clean the cap and element.

Continued on the next page

Problem	*Method of Correction*
Undercharging	
Excessive electrical load from added accessories.	Remove accessories or fit higher output alternater.
Poor electrical connections to alternator or battery.	Inspect, clean and rectify the cause.
Faulty battery.	Test, recharge or replace.
Faulty alternator.	Test or replace.
Overcharging	
Faulty alternator.	Test or replace.
Battery Requires Excessive Amounts of Water	
Battery case leaking	Clean surrounding area and replace the battery.
Deffective battery.	Test or replace the battery.
Battery charging rate is too high.	Check the alternator output or battery charging system.
Battery will not Charge	
Loose or corroded connections	Clean and tighten the connections.
Worn out battery.	Replace the battery.
Loose alternator drive belt.	Replace or re-tension the drive belt.
Starter Motor does not Operate	
Loose or corroded connections.	Clean and tighten the connections.
Worn out battery.	Replace the battery.
Faulty starter panel or connections.	Check the connections or replace the panel.

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