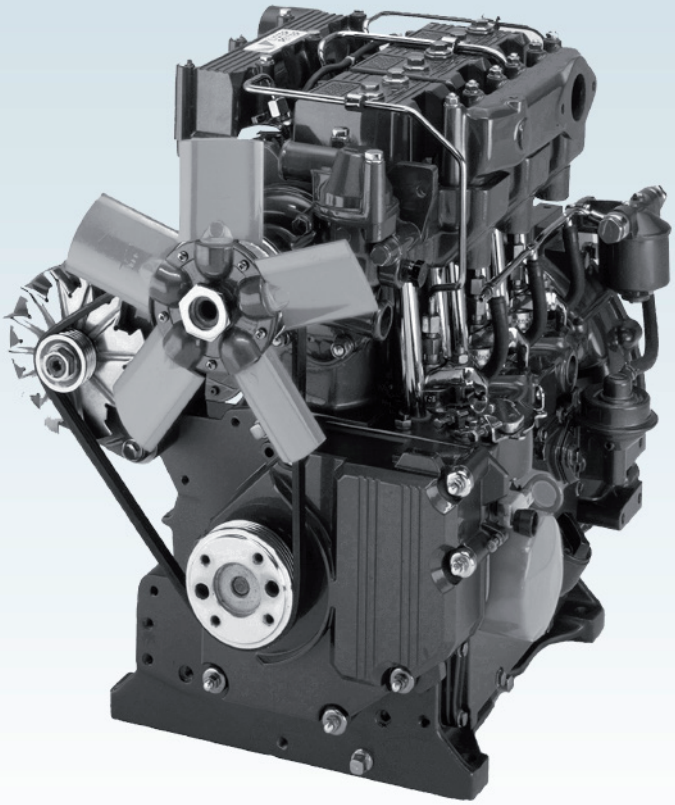
LISTER PETTER
POWER SYSTEMS

ALPHA SERIES

LPW, LPWS & TURBO ENGINES WORKSHOP MANUAL



P027-08240

Associated Publications

Master Parts Manual P027-08046
Technical Handbook P027-08247
Operators Handbook P027-08201

Note:

Some information is not yet available and will be included in a later edition.

Associated Publications
Operators Handbooks
LPW, LPWS, LPWT
- *English..... P027-08182*
- *German P027-08182/ger*
- *Italian.....P027-08182/ita*
- *French P027-08182/fre*
- *Spanish P027-08182/spa*
- *Portuguese P027-08196*

LPW, LPWS, LPWT
- *English..... P027-08270*
- *French P027-08270/fre*
- *Spanish P027-08270/spa*

Master Parts Manuals
LPW/LPWS P027-08041
LPWS 400 Series P027-08111

Disclaimer
The information, specifications, illustrations, instructions and statements contained within this publication are given with Lister Petter Power Systems' 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, the Distributor nor the Dealer shall in any circumstances be held liable for any inaccuracy or the consequences thereof.
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CONTENTS

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 Power Systems Distributor or Dealer for further advice and technical assistance.
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Parts that have not been approved by the Lister Petter Power Systems 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.
Various technical/sales leaflets are available; please contact your Lister Petter Power Systems Distributor or Dealer for details.

Training

Comprehensive training in the correct operation, service and overhaul procedures of engines is available at the Lister Petter Power Systems International Product Training Centre.
Please contact Lister Petter Power Systems 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 Power Systems Distributor should be consulted.
There are Lister Petter Power Systems 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 or www.listerpetter.com

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.

⚠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.

1. GENERAL INFORMATION

1.1 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

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 following are applied throughout this publication.

⚠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.

Protective Clothing and Equipment

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.

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.
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 Power Systems. 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.

Personal Safety

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.

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 sharp corners or rough surfaces so as to avoid any possibility of chaffing taking place.

Alternator Precautions

a. Never remove any electrical cable without first disconnecting the battery.

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.

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 unsealing 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.

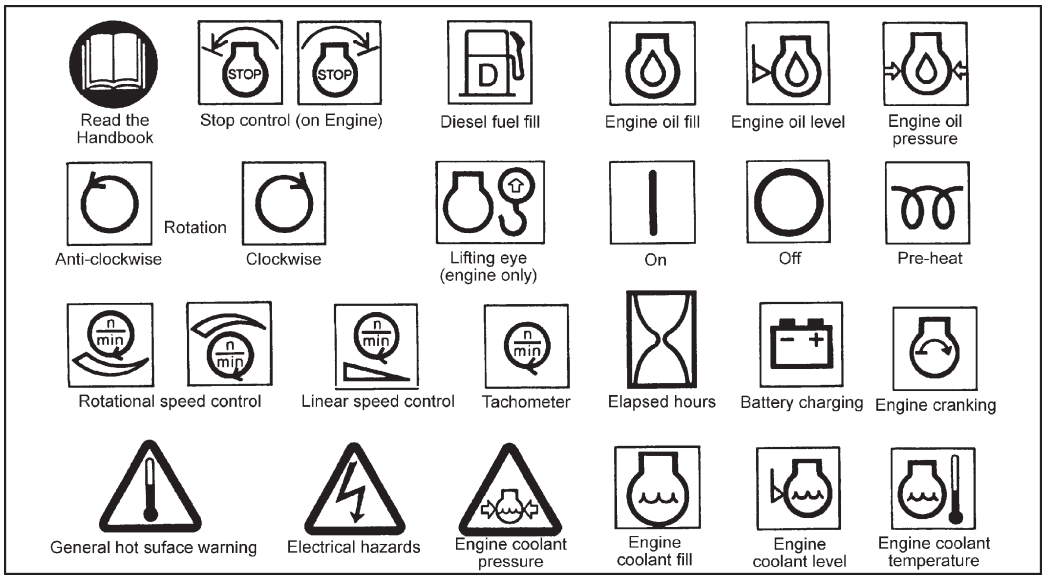
d. The materials used in the manufacture and treatment of some filters and elements may cause irritation or discomfort if they come into contact with the eyes or mouth and they may give off toxic gasses if they are burnt.

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.

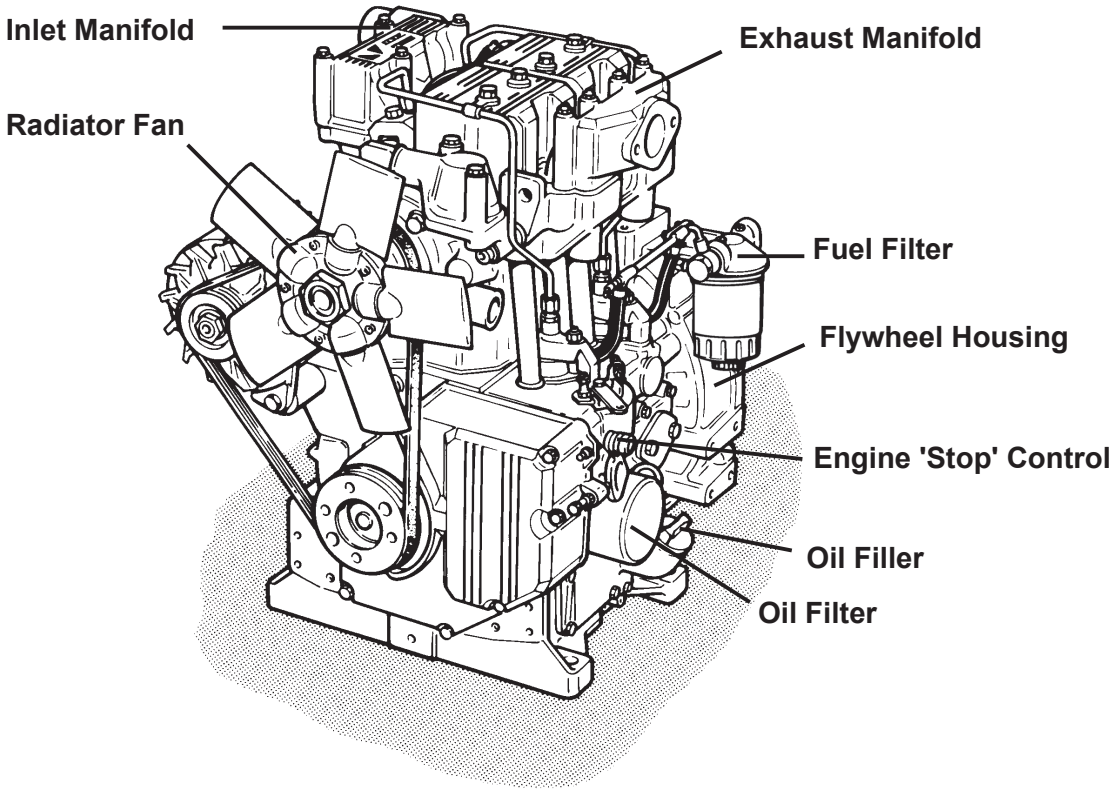
1.2 SAFETY SYMBOLS

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

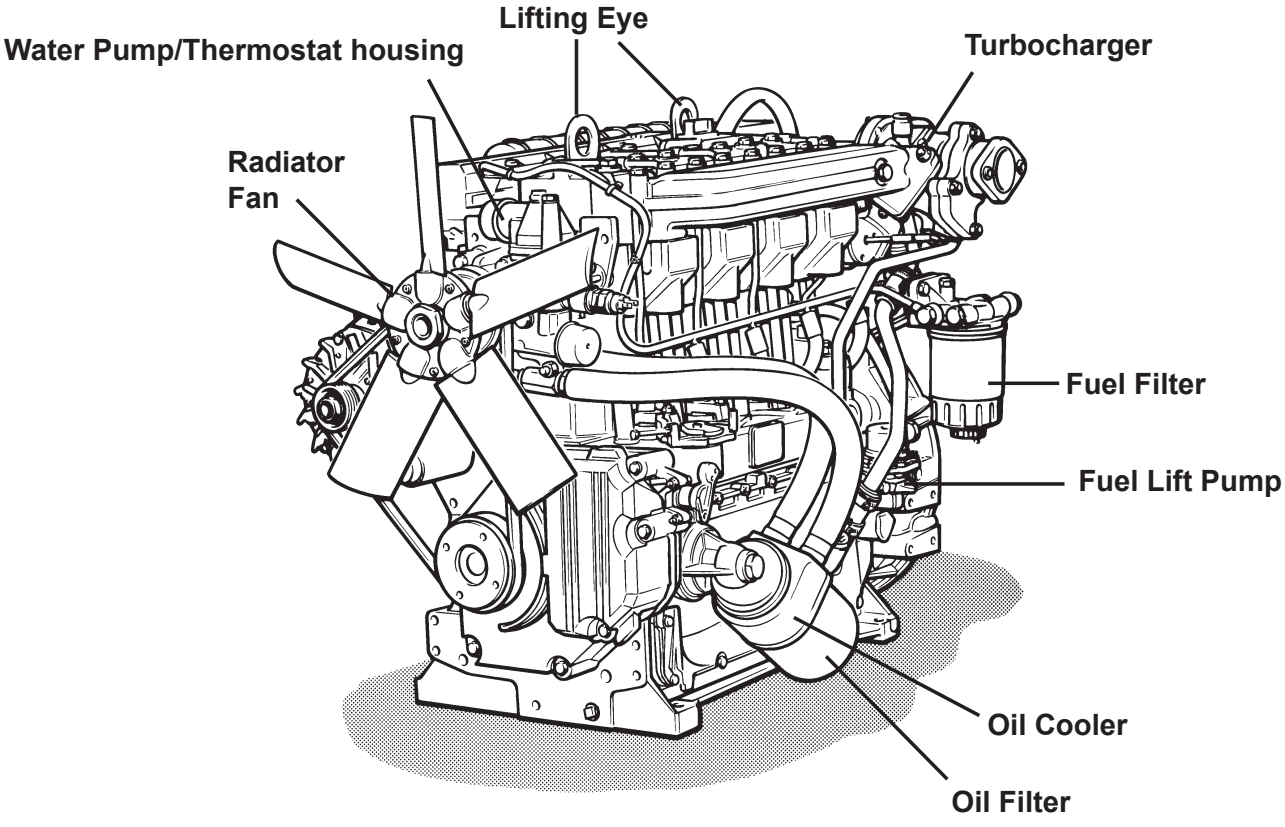


1.3 ENGINE FEATURES

LPW2



LPWT4



1.4 ENGINE IDENTIFICATION

1.4.1 Nomenclature

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.
LPWS2, 3 and 4 - two, three and four cylinder, indirect injection, naturally aspirated water cooled diesel engines.
LPWST4 - four cylinder, indirect injection, turbocharged water cooled diesel engine.

1.4.2 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 Power Systems 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 Power Systems. A full list of builds is given in "7. Engine Build Details".

1.4.3 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:

06 00123 LPW3 A 01

06 ..... Year of manufacture code (06 = 2006)
00123 ..... Consecutive number of engine
LPW3 ..... Model (T = turbocharger, S = indirect injection, G = gas fuelled)
A ..... Anti clockwise rotation
01 ..... Build of engine

1.5 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.

1.5.1 Battery Polarity

The electrical system for all engines is 12 or 24 volt negative earth (check with meter).

1.5.2 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 Power Systems recommend that a battery shouldprovide 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).

Note:

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

1.5.3 Connecting Batteries

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

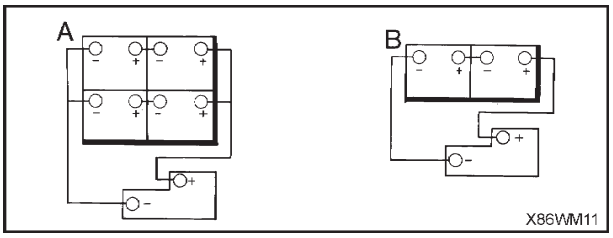


Figure 1.5.3 Battery Connections

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.

1.5.4 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.

1.5.5 Disconnecting a Slave Battery

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

1.5.6 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°)
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, LPWST4	12V	190A	255A	380A	670A
	24V	75A	105A	160A	300A

1.5.7 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 Power Systems recommend that a battery shouldprovide 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).

1.5.8 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°)
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 preheat and while cranking.

2. ENGINE SERVICING AND ADJUSTMENTS

2.1 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 "05.5 Spanner Torques".

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.

2.2 THE AIR CLEANER

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

Every effort should be taken to ensure that the air cleaner draws in combustion air at the prevailing ambient temperature. Any increase in combustion air temperature above the standard engine reference condition of 25°C (77°F) will incur an engine derate factor.

2.2.1 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.

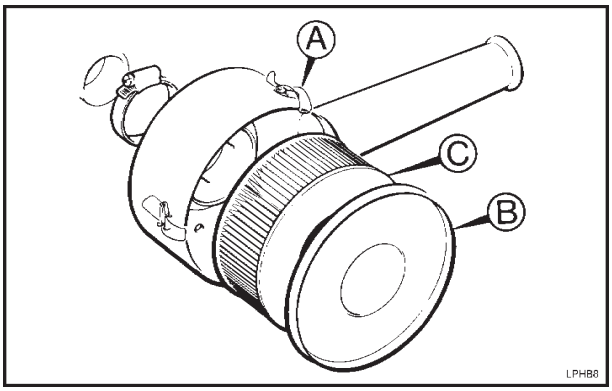


Figure 2.2.1 Light Duty Air Cleaner

2.2.2 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

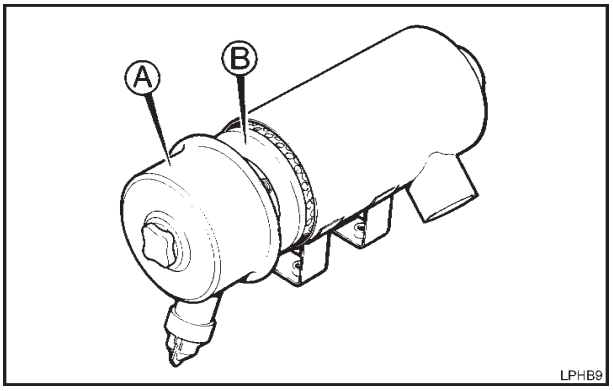


Figure 2.2.2 Cyclonic Type Air Cleaner

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.

2.2.3 Intake Restriction

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

2.3 THE MANIFOLDS AND SILENCER

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). Exhaust manifold bolts on turbocharged engines LPW(S)T4 must be torqued to 21Nm (15.5lbf-ft).
Whenever the manifolds are replaced all traces of the old exhaust gaskets and joints must be removed and new ones fitted.

⚠ WARNING

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

2.3.1 The Inlet Manifold Restrictor

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

	Builds
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, all 400 Series
LPWS3	07, 18, 41, 57, all 400 Series
LPWS4	18, 57, all 400 Series

2.3.2 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.

2.3.3 Exhaust Back Pressure

The maximum permissible back pressure figures are 762mm WG (30.0in WG) except the LPW(S)T4 which are 508mm WG (20.0in WG).

2.4 THE COLD START AID

Cold start aids are not fitted to LPWG engines.

2.4.1 LPW and LPWT

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

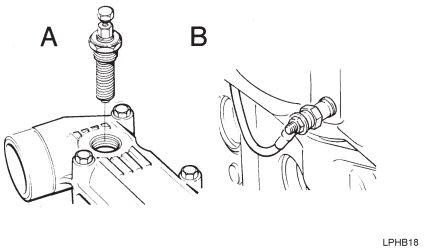


Figure 2.4.1 Manifold Heater Plug

2.4.2 LPWS

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

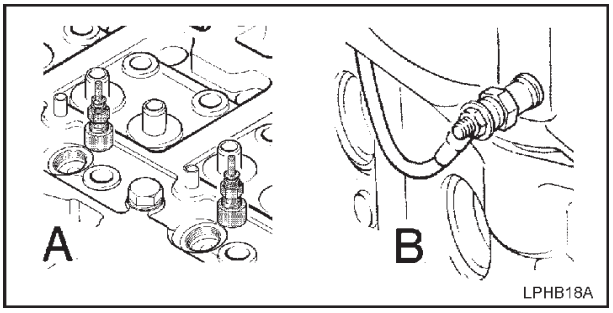


Figure 2.4.2 Glow Plug Locations
A - LPW and LPWST4 400 Series Builds
B - All Other 300 Series Builds

On all LPWS engines, other than 400 series builds, the plugs are fitted into the side of the cylinder head as shown at 'B' in Figure 2.4.2.
On all 400 series builds, the plugs are fitted into the top of the cylinder head between the injector and cylinder head cover, as shown at 'A' in Figure 2.4.2.

Fitting Glow Plugs to 400 Series Builds

1. Fit the glow plug (B) into the adaptor (A) and torque it to 15.0Nm (11.0lbfft).

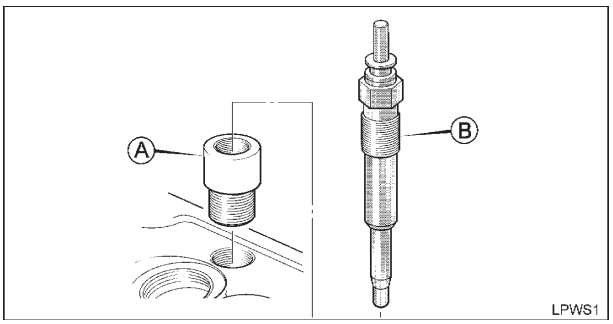


Figure 2.4.3 Glow Plug - 400 Series Builds

2. Screw the plug and adaptor assembly into the cylinder head and torque it to 27.0Nm (20.0lbf ft).
3. Fit the electrical feed cable.

2.5 THE TURBOCHARGER - LPW(S)T4

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.

2.5.1 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 nut (D).

Note:

If the turbo is dismantled it must be sent back to Garrett to be balanced.

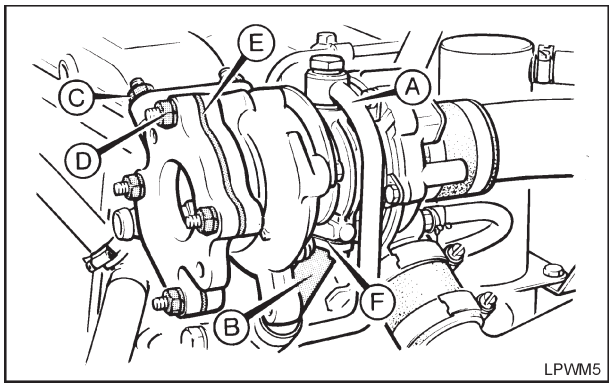


Figure 2.5.1 The Turbocharger

2.5.2 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 "2.5 The Turbocharger - LPW(S)T4".

2.6 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; this is normal.

2.6.1 LPWT4 and LPWST4 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.

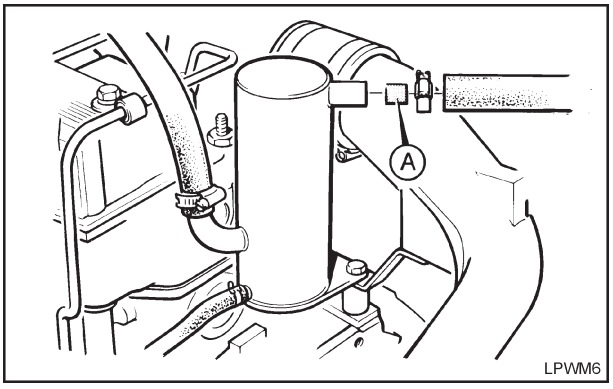


Figure 2.6.1 LPWT4 Oil Separator and Breather

The combined oil separator and breather is the same as that fitted to the LPW(S)T4. It is fitted above the flywheel housing and attached to the air inlet and the flywheel end cylinder head cover.

2.7 THE STARTER MOTOR

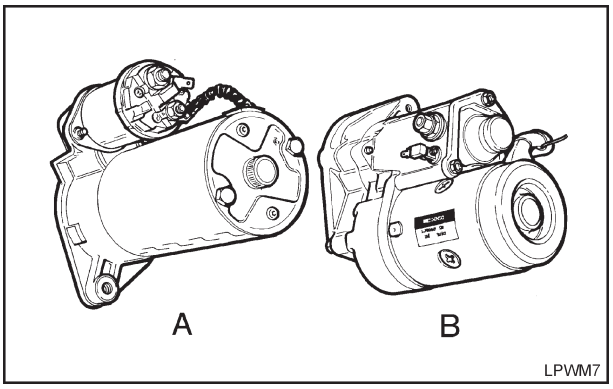


Figure 2.7.1 Starter Motors
A - Lucas (discontinued)
B - Denso and UniPoint

2.7.1 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 2.7.3'.
5. Torque the connections to the values given in "2.7.3 Starter Motor Terminal Torques".

2.7.3 Starter Motor Terminal Torques

Starter Motor	Battery + Terminal 1	Link Terminal 2
Lucas/Magnetti Marrelli (discontinued)	4.0-4.2	3.1-3.2
	2.95-3.01	2.3-2.4
Denso Starter	5.89-11.77	5.89-11.77
	4.34-8.68	4.34-8.68
UniPoint Starter	5.89-11.77	5.89-11.77
	4.34-8.68	4.34-8.68

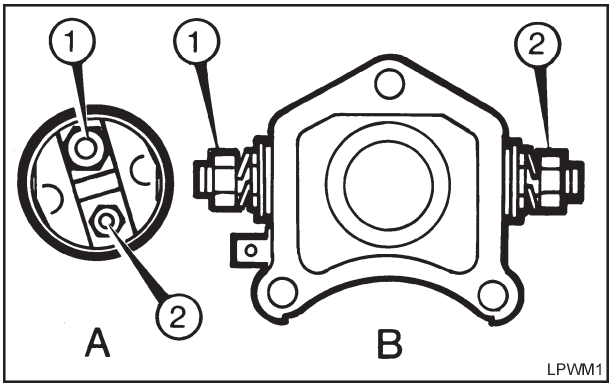


Figure 2.7.3 Starter Motor Terminals
A - Lucas
B - Denso and UniPoint

2.8 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 gear cover 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.

⚠ CAUTION

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

2.8.1 Terminal Identification

Terminal	Mitsubishi	Magnetti Marelli
Battery +	B	+
Warning light	L	IND
Phase tape	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.

2.8.2 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.

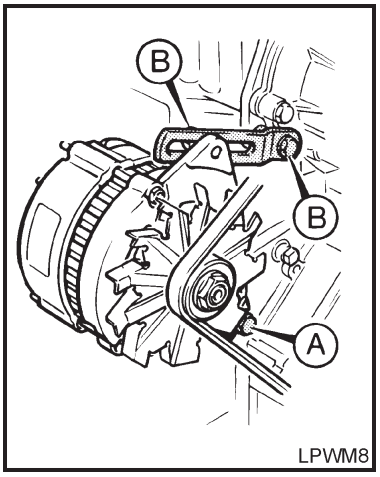


Figure 2.8.2 Magnetti Marelli Alternator Adjustment Arm LPW/LPWS

2.8.3 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.

2.9 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 "5.3 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.

2.9.1 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).

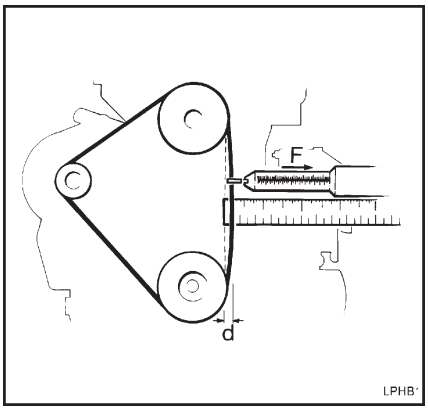


Figure 2.9.1 Checking Belt Tension
LPW, LPWS, LPW

⚠ CAUTION

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

2.9.2 Drive Belt Tension Value

	Belt Tension Force (F)	
	N	lbf
New Belt	31.0-33.0	7.0-7.5
Used Belt	22.0-24.0	5.0-5.4

2.10 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.

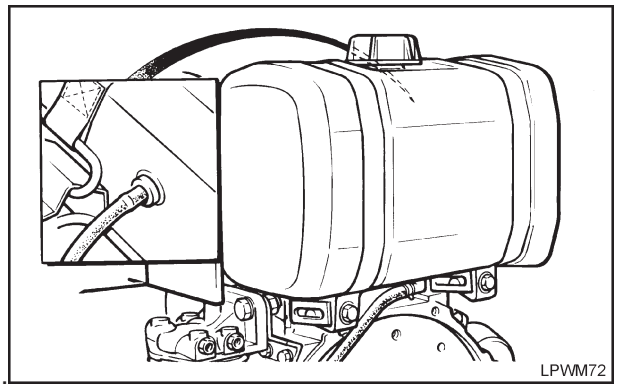


Figure 2.10.1 The Fuel Tank

2.10.1 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 the back of the tank.
4. Slacken, or remove, the two setscrews securing the straps to the mounting bracket base.
5. Remove the tank.

2.10.2 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.

2.10.3 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.

2.11 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 fitted. 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.

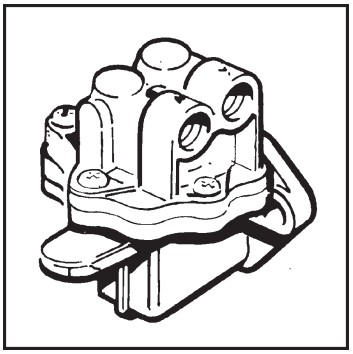


Figure 2.11.1 Industrial Fuel Lift Pumps - Pienne/Corona pump

2.11.1 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. If a new push rod is being fitted, grease it with Shell Alvania 2 prior to assembly.
6. Ensure the pump and crankcase mating surfaces are clean and dry before fitting a new paper joint.
7. Refit the pump, plain and spring washers and nuts. Torque the two nuts to 21.0Nm (15.5lbf ft).
8. Replace the inlet and outlet fuel pipes.

2.12 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.

2.12.1 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.

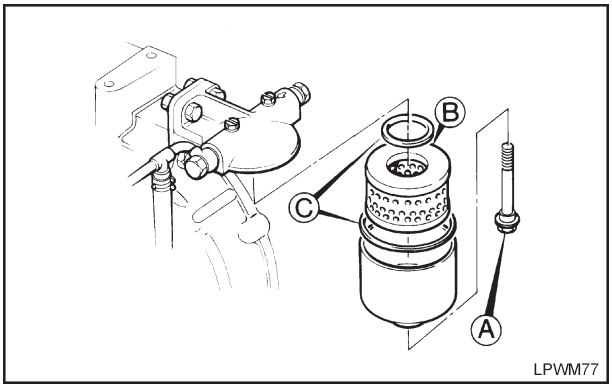


Figure 2.12.1 Fuel Filter

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.

2.12.2 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.

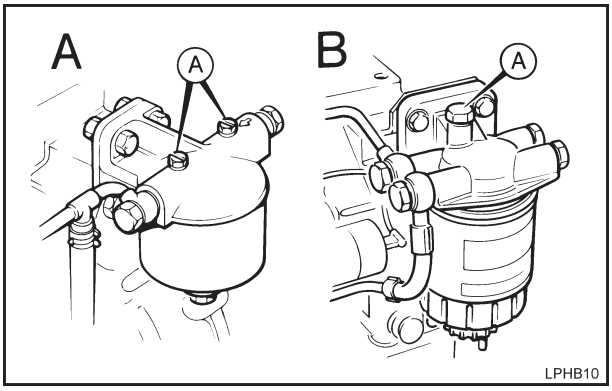


Figure 2.12.2 Priming the Fuel Filter

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.

2.13 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.

Fuel pump part numbers for the various engine builds are given in '2.13.6 Fuel Pump Part Numbers'.

2.13.1 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.

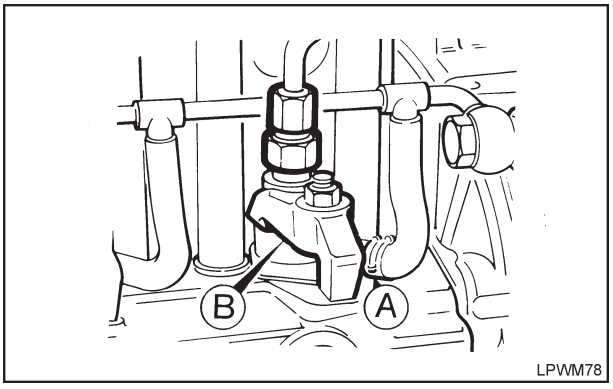


Figure 2.13.1 Fuel Pump

3. Pull the pipe off of the fuel pump.
4. Turn the engine control anti clockwise 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.

2.13.2 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).

2.13.3 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 "2.53 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.

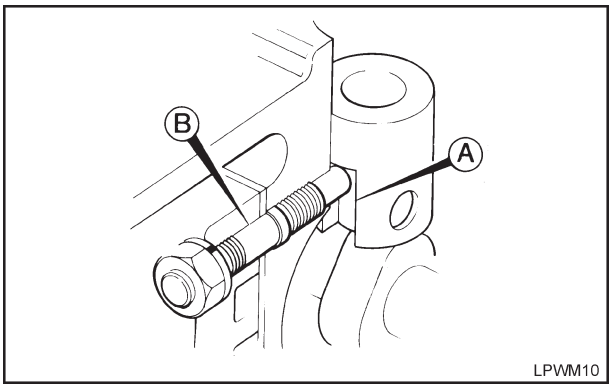


Figure 2.13.3 Fuel Pump Tappet and Stud

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).

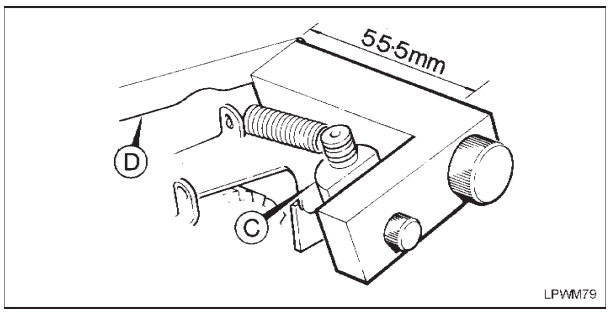


Figure 2.13.3 Setting the Rack - 317 -50114 - Lister Service Tool

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 anti clockwise 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 anti clockwise 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 "2.55 Setting the Stop/Run Lever".

2.13.4 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.

2.13.5 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 or white	0.125mm (0.005in).
Black	0.250mm (0.010in).

2.14 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
1º	1 Green
2º	1 Green and 1 slate blue or white
3º	1 Green and 1 black
4º	2 Green and 1 black

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

2.14.1 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 "2.15 Fuel Pump Timing Values", from TDC.
   The correct figure for the type and build of engine must be used.
4. Carefully rotate the flywheel anti clockwise 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.

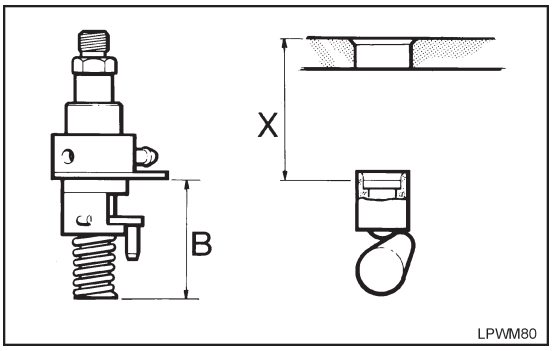


Figure 2.14.1 Fuel Pump Timing Dimension
B = 51.2mm (2.012in) at port closure

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 time.

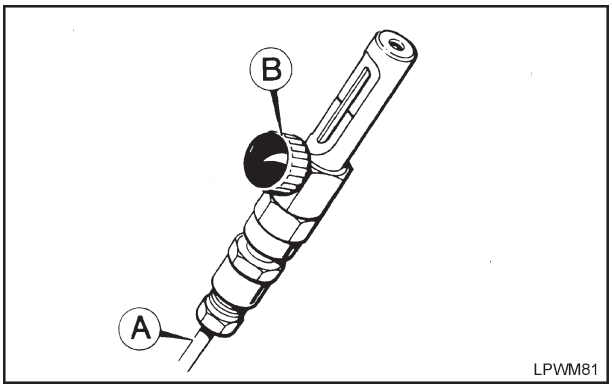


Figure 2.14.2 Fuel Pump Timing Gauge - 317-50518 -
Lister Petter Service Tool

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 "2.15 Fuel Pump Timing Values", is visible.
12. Remove the gauge and replace the pump to injector pipe.

2.15 FUEL PUMP TIMING VALUES

Build	Speed Setting	Engine	ºBTDC	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	LPW	20º	3.097
		LPWS3, 4		
01, 02,03,13,42,46,48,49, 51,52	Variable - up to 3000r/min	LPWS2	22º	3.735
07,57,LPWS2 41	Fixed - 1500r/min	LPW	20º	3.097
07,57		LPWS	18º	2.519
58,79,113, LPWS 18	Fixed - 1800r/min	LPW	20º	3.097
58,79,113		LPWS	18º	2.519
11,76,108	Variable - up to 3000r/min	LPWS	18º	2.519
27,28,74,81,LPW 41	Dual - 1500/1800r/min	LPW	20º	3.097
45,47	Variable - up to 2800r/min	LPW	20º	3.097
		LPWS	22º	3.735
71,72	Fixed - 1800 or 2000r/min	LPW	18º	2.519
84	Variable - 850/2500r/min	LPW	20º	3.097
10,83	Fixed - 3600r/min	LPW	24º	4.428
104	Variable - up to 3600			
18,173,174	Fixed - 1800 or 2000r/min	LPW	16º	1.994
177	Dual 1500/1800r/min	LPW	16º	1.994
70	Variable - up to 3000r/min set at 2800r/min	LPW3	20º	3.097
		LPWS4	22º	3.735
71	Fixed - 2000r/min	LPW2, 4	18º	2.519
72	Fixed - 1800r/min	LPW2, 4	18º	2.519
73	Variable - up to 2500r/min	LPWS4	18º	2.519
76	Variable - up to 3000r/min	LPWS2	22º	3.735
	Variable - up to 2800r/min	LPWS3,4	18º	2.519
79	Fixed - 1800r/min	LPW	20º	3.097
80	Fixed - 1800r/min	LPWS	18º	2.519
		LPW2	20º	3.097
81	Fixed dual - 1500 or 1800r/min	LPW	20º	3.097
82	Fixed - 3000r/min	LPW	20º	3.097
83	Fixed - 3600r/min	LPW	24º	4.428
84	Variable - 950 to 2500r/min	LPW4	20º	3.097
400 Series	All fixed and variable speeds	LPWS	20º	3.097

LPWT4

All builds	All fixed and variable speeds	24º	4.428

LPWST4

All builds	All fixed speeds	15º	1.433

2.16 THE FUEL INJECTOR

Fuel Injector Part Numbers For Alpha Engines

LPW/LPWT4 - (Industrial Engines)	751-19700
LPW/LPWT4 - (Marine Engines)	751-45250
LPWT4 - Low Speed (Industrial Engines)	754-45260
LPWT4 - Low Speed (Marine Engines)	754-45261
a LPWS Pre Nov 1998 - (Industrial Engines)	751-40760
b LPWS Pre Nov 1998 - (Marine Engines)	751-40920
c LPWS 300 Series Engines	751-17111
d LPWS 400 Series Engines	751-17113
e LPWS (Supersedes above 300/400Series engines)	751-60290
LPWST4 (400 Series Engines)	751-60290

Note:

Type (c) and (d) injectors were introduced from 1st Nov 1998 for US/EPA exhaust emissions compliance, and cannot be fitted to the earlier (a) and (b) type engines.

Type (e) LPWS injector now supersedes injector types (c) and (d).

LPW & LPWT4 ENGINES

LPW ENGINES		
Engine Type	Build Number	Part Number
INDUSTRIAL		
LPW2	01, 02, 09, 10, 27, 28, 51, 52, 57, 58, 59, 72, 74, 79, 81, 82, 83, 627	751-19700
LPW3	01, 02, 09, 10, 14, 27, 28, 51, 59, 74, 79, 81, 82, 83, 113, 581, 627	
LPW4	01, 02, 07, 09, 10, 14, 27, 28, 51, 57, 59, 71, 72, 74, 79, 81, 82, 83, 109, 581, 627	
MARINE		
LPW2	41, 42, 44, 46, 47, 48, 841, 842, 844, 846, 847, 848	751-45250
LPW3		
LPW4		

LPWT4 ENGINES		
Engine Type	Build Number	Part Number
INDUSTRIAL		
High Speed	01, 02, 03, 04, 09, 59, 78, 82, 301, 302, 351, 352, 384	751-19700
Low Speed	07, 08, 57, 58, 74, 81, 308, 358, 374, 379, 380, 681	754-45260
MARINE		
High Speed	42, 44, 46, 47, 48, 842, 844, 846, 847, 848	751-45250
Low Speed	41, 841	754-45261

LPWS & LPWST4 ENGINES

LPWS ENGINES - (PRE NOV 1998)		
Engine Type	Build Number	Part Number
INDUSTRIAL		
LPWS 2	01, 02, 03, 51	751-40760
LPWS 3	01, 07, 09, 57	
LPWS 4	01, 07, 57	
MARINE		
LPWS 2	42, 47	751-40920
LPWS 3	42, 47	
LPWS 4	42, 47, 49	

LPWS 300 SERIES ENGINES - (AFTER NOV 1998)		
Engine Type	Build Number	Part Number
LPWS 2	301, 302, 351, 379	751-17111 Superseded by 751-60290
LPWS 3	301, 302, 351, 376, 379	
LPWS 4	301, 302, 311, 351, 376, 379, 384	

LPWS 400 SERIES ENGINES		
Engine Type	Build Number	Part Number
LPWS 2	402, 407, 408, 409, 418, 440, 442, 443, 444, 446, 447, 448, 452, 457, 458, 459, 467, 468, 474, 479	751-17113 Superseded by 751-60290
LPWS Bio 2	007, 008	
LPWS 3	402, 407, 408, 409, 440, 442, 443, 444, 446, 447, 448, 452, 457, 458, 459, 467, 468, 474, 476, 479	
LPWS Bio 3	007, 008	
LPWS 4	402, 407, 408, 409, 411, 440, 442, 443, 444, 446, 447, 448, 452, 457, 458, 459, 467, 468, 474, 476, 479, 484	
LPWS Bio 4	007, 008	

LPWST4 400 SERIES ENGINES		
Engine Type	Build Number	Part Number
LPWST4	407, 408, 440, 443, 457, 458, 474, 479	751-60290

LPW and LPWT4 engines are direct injection engines, and LPWS and LPWST4 engines are indirect injection engines. There are differences in the size of the fuel injector, sealing washer, and the injector pipes and therefore they are not interchangeable.

LPWS 300 and 400 Series fuel injectors are not interchangeable with the earlier LPWS (Pre November 1998) fuel injectors.

It is important to maintain the fuel injection equipment, injection pipes, and unions between the fuel supply filter and the injector in an absolutely clean condition. A minute particle of dirt can easily block an injector nozzle hole and this will give rise to exhaust smoke, difficult starting, and poor engine performance.

2.16.1 Fuel Injector Settings

		bar	atmos
LPW	New	245/255	242/252
	Used	240	237
LPWT4	1500/1800r/min	250/258	247/255
	All others	245/255	242/252
LPWS	400 Series	150/160	140/158
	All others - new	123/140	121/138
	All others - used	121/131	119/129
LPWST4	400 Series	150/160	140/158

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).

2.16.2 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.

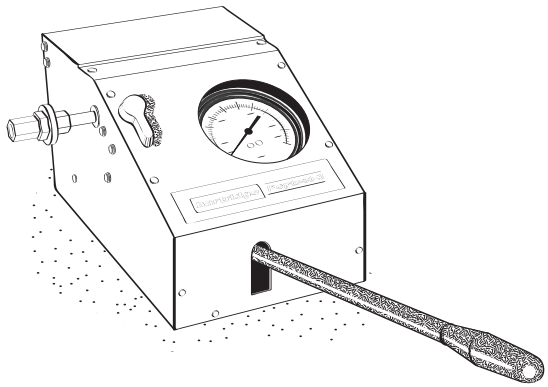


Figure 2.16.2 Typical Injector Tester - 317-50517 Lister Petter Service Tool

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 be set to the correct pressure. The complete faulty injector should then be sent to an accredited service depot for reconditioning.

All sprays on 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 using a suitable test rig.
The injector top plug must be torqued to:
LPW ..... 47.0Nm (35.0lbf ft).
LPWS ..... 81.0Nm (65.0lbf ft).

2.16.3 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).

2.16.4 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.

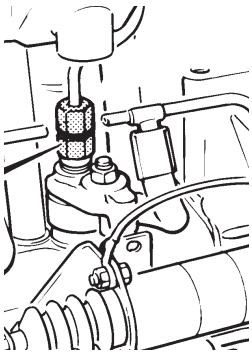


Figure 2.16.4 Delivery Valve Holder

4. Slacken the LPW injector clamp bolt.
5. Remove the pump to injector pipe.
6. 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 anti clockwise.

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. 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 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.

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

42 00014 LPWS2
42 00041 LPWS3
42 00685 LPWS4

41 00324 LPW2
41 00001 LPW
41 00570 LPW4

2.17 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 preset.

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 drilling 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 high speed oil jets supply oil under pressure to the pistons and governor gears.

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

** Running in oil (green oil) no less than 50hrs, no more than 100hrs.*

⚠ 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.

2.18 LUBRICATING OIL PRESSURE

		bar	lbf in²
LPW	Idling	1.0	14.5
	3000r/min	2.0	29.0
LPWS	Idling	1.0	14.5
	3000r/min	2.0	29.0
LPW(S)T	Idling	1.0	14.5
	3000r/min	2.5	36.3

Note:

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

2.19 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.

2.20 OIL AND FILTER CHANGES

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
On engines built since 1 January 2005 (serial number plate year code 05) lubricating oil filter 328-21600 replaced 201-55370, 751-10620 and 751-12870; refer to "2.22.1 Oil Filter Identification".

Note:

Continuous operation under heavy loads in ambient temperatures above 35°C (95°F) causes the oil to deteriorate faster.

To help assist engine running-in, all LPW, LPWS and LPW(S)T4 engines are despatched with an initial fill lubricating oil which must be changed with the filter, at 100 hours and then as specified below.

Ambient Temperature	Periods in Hours			
	LPW	LPWT	LPWS	LPWST
Up to 35ºC	500	250	250	250
Above 35ºC	250	125	125	125

2.21 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.

2.21.1 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.

2.21.2 Refilling the Oil Sump

Before refilling the oil sump ensure the new oil meets the specification and viscosity as given in "3. 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.

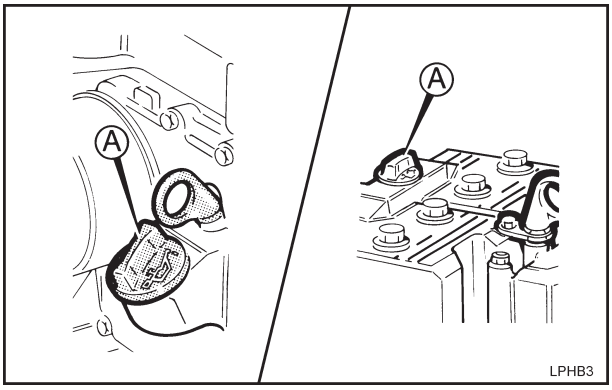


Figure 2.21.2 Oil Filler

2.21.3 The Oil Sump Capacity - less filler

⚠ CAUTION

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

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

	LPW/LPWS2	LPW/LPWS3	LPW/LPWT/ LPWS4/ LPWST4
litres	5.85	8.25	11.5
pints	10.29	14.52	20.23
US quarts	6.18	8.72	12.12

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

	LPW/LPWS2	LPW/LPWS3	LPW/LPWT/ LPWS4/ LPWST4
litres	3.00	3.75	5.50
pints	5.28	6.60	9.68
US quarts	3.17	3.96	5.81

2.21.4 Capacity Between Dipstick Marks

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

	LPW/LPWS2	LPW/LPWS23	LPW/LPWT/ LPWS4/ LPWST4
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

	LPW/LPWS2	LPW/LPWS3	LPW/LPWT/ LPWS4/ LPWST4
litres	1.50	1.75	2.20
pints	2.64	3.08	3.87
US quarts	1.59	1.85	2.32

2.22 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 2.22.1*'.

Note:

On engines built since 1 January 2005 (serial number plate year code 05) filter 328-21600 replaced 201-55370, 751-10620 and 751-12870; refer to "7.2 Oil and Filter Change Periods". Refer to "7.2 Oil and Filter Change Periods" for revised oil change periods.

Only filters approved by Lister Petter Power Systems 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.

2.22.1 Oil Filter Identification

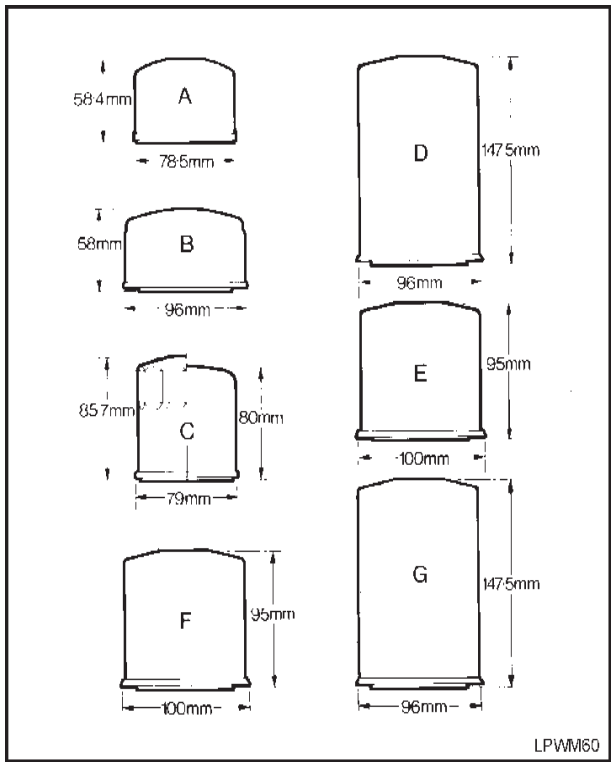


Figure 2.22.1 Oil Filter Identification and Part Numbers
A - 751-12870
B - 751-10620
C - 201-55370
D - 328-11500
E - 328-21600
F - 751-43850
G - 751-43860

2.22.2 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

2.22.3 Oil Filter Part Numbers

Note:

On engines built since 01.01.2005 (serial number plate year code 05) filter 328-21600 replaced 201-55370, 751-10620 and 751-12870. Refer to "5.2 Oil and Filter Change Periods" for revised oil change periods.

Engine	Build	Filter
LPW2	01 02 09 10 27 41 44 46 47 72 74 79 81 82 83	201-55370
LPW3	01 02 09 10 14 27 40 41 44 46 47 79 81 82 83 113	382-21600
	74	201-55370
LPW4	01 02 09 10 14 27 41 46 47 79 81 82 83	328-21600
	71 72 74	201-55370
LPWS2	01 02 03 42 47 402 407 408 409 411 484	201-55370
LPWS3	01 07 09 42 47 301 402 407 408 409 411 484	328-21600
	376	751-43850
LPWS4	03 13 18 42 47 49 301 302 384 402 407 408 409 411 484	328-21600
	376	751-43860
	311 411	328-11500
LPWT4	03 04 07 08 09 41 42 46 74 81 82 301 302 380	328-21600
	57 58 59 78 351	328-11500
	384	751-10620

2.22.4 Changing the Oil Filter

Before changing the filter read the precautions in "2.17 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.

2.22.5 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 filer.

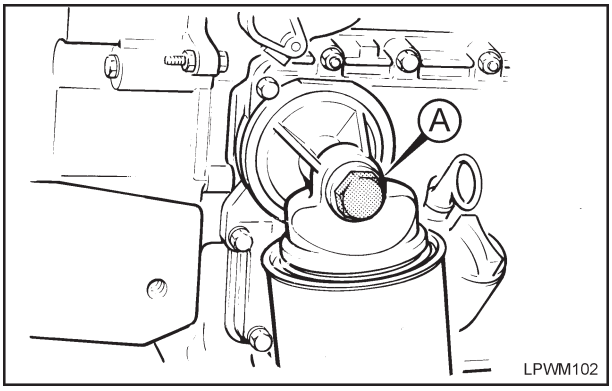


Figure 2.23.2 Oil Filter Location
LPA3 Builds 57, 59; LPW3 Builds 28, 51, 59; LPWS3 Build 51, 57

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).

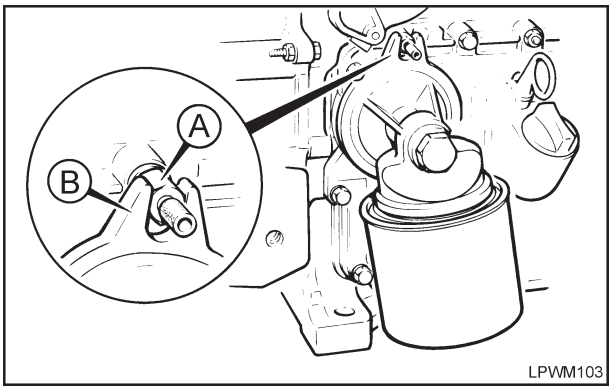


Figure 2.23.3 Oil Filter Location
LPW/LPWS4 Builds 28, 51, 52, 57, 58, 59

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).

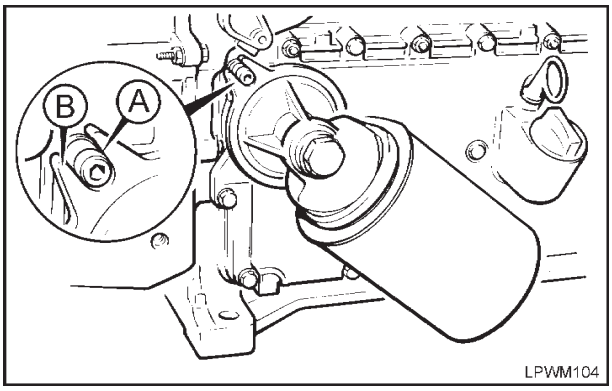


Figure 2.23.4 Oil Filter Location

2.23 THE OIL COOLER - LPW(S)T4

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.

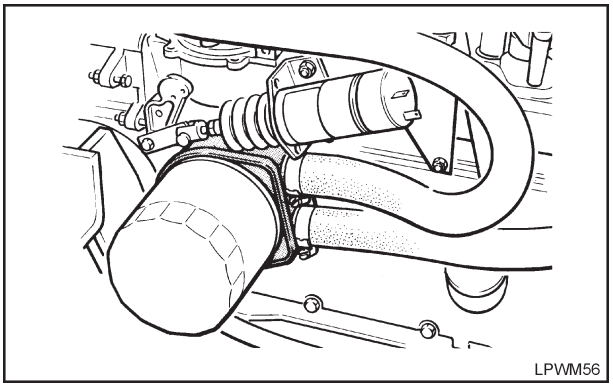


Figure 2.23.1 Industrial Oil Coler

2.24 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 LPWST4 an oil filler is fitted into one of the covers. This arrangement is also available as an accessory
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 LPW and LPWS engines have mono block heads and gaskets.
LPW4, LPWT4 and LPWST4 cylinder heads are not interchangeable.

⚠ 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 "2.50 The Water Circulating Pump".

1. Remove the LPW inlet manifold heater plug, if necessary, and the inlet and exhaust manifolds.
2. Slacken the fuel pump to injector pipe unions at both ends and then remove the pipe.
3. On LPW engines remove the injector clamp and lift out the injectors. On LPWS engines unscrew and remove the injectors.
4. If necessary, remove the LPWS glow plugs; refer to "2.4 The Cold Start Aid".
5. 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.
6. On LPW(S)T4 engines remove the breather flexible pipe from the cylinder head cover.
7. Remove the lifting eye.
8. Remove the cylinder head covers and gaskets.
9. Remove the valve rocker retaining nuts (A) and washers.
10. Remove the valve rockers.

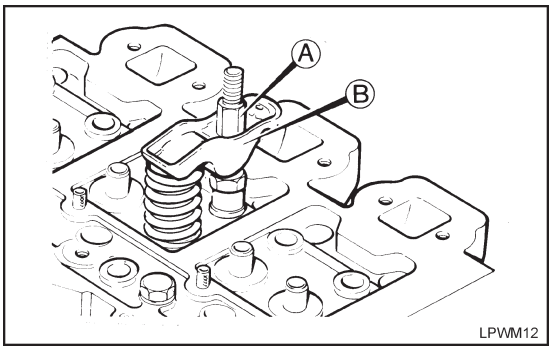


Figure 2.24.1 Valve Rocker Removal

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

2.24.1 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 "2.26 Cylinder Head Clearance".
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 2.24.2'.

1. Fit the hydraulic tappets into the crankcase; refer to "2.25 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.

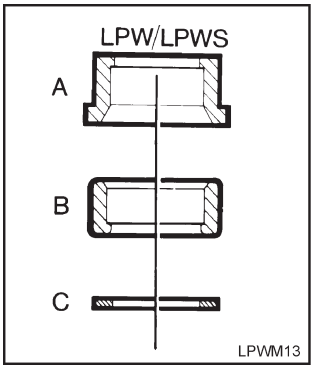


Figure 2.24.2 Push Rod Tube Seals
A - Cylinder head seal
B - Crankcase seal
C - Crankcase seal washer

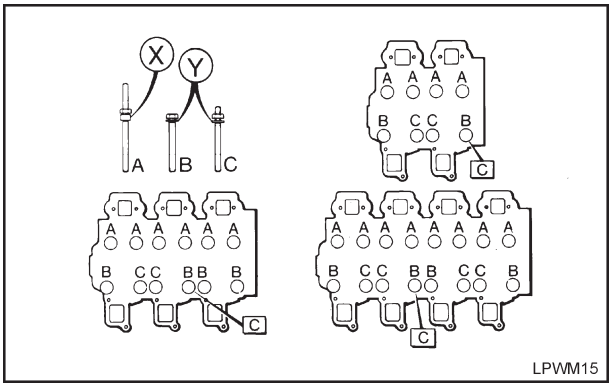


Figure 2.24.3 Head Bolt Locations - LPW /LWS

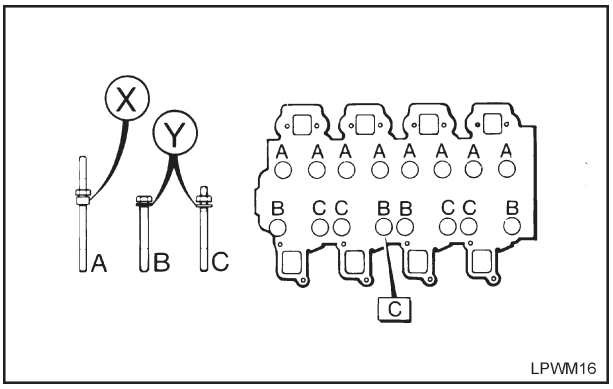


Figure 2.24.4 Head Bolt Locations - LPW(S)T4

4. 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 & LPWS only).

Note:

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.

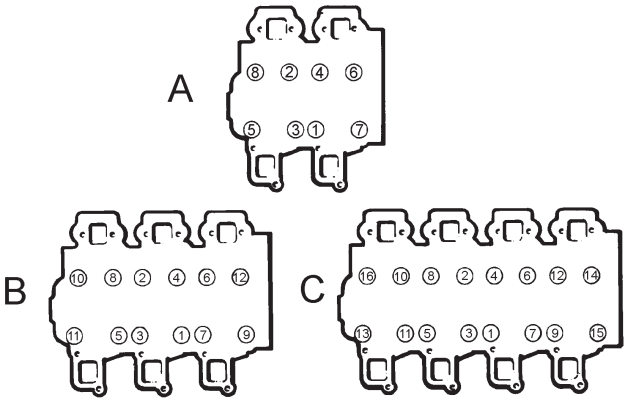


Figure 2.24.5 Cylinder Head Bolt Torque Sequence
A - LPW/LPWS2
B - LPW/LPWS3
C - LPW/LPWT/LPWS/LPWST4

5. Lightly oil the push rods and replace them.
6. Press down on the top of the push rods while very slowly turning the crankshaft until they are at their lowest point of travel.
7. Replace the valve rocker (B), pivot, plain washer under the nut and the nut (A).

Note:

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

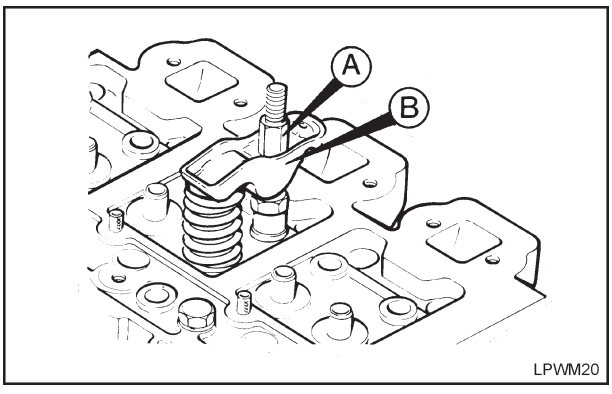


Figure 2.24.6 Valve Rocker

8. 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.

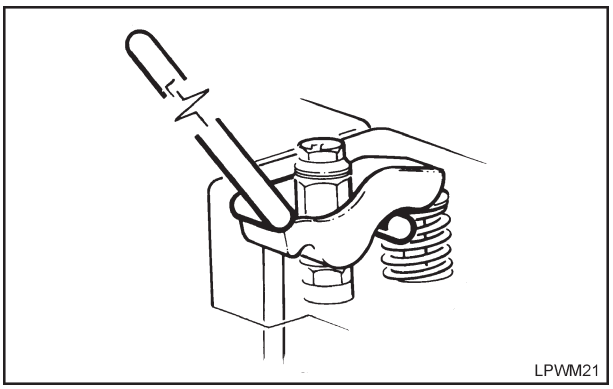


Figure 2.24.7 Valve Tappet Compressing Tool 317-50107

9. 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.

10. Replace the lifting eye, fuel pipes and the manifolds.
11. On LPW(S)T4 engines replace the breather flexible pipe to the cylinder head cover.
12. If the LPW manifold heater or the LPWS glow plugs are fitted, refer to "2.4 The Cold Start Aid", and replace them.

2.25 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.

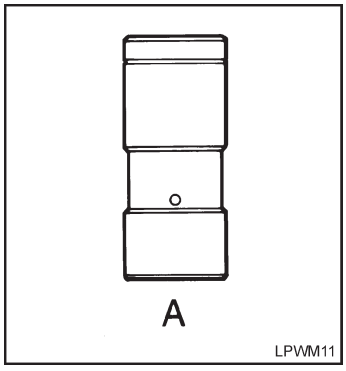


Figure 2.25.1 Hydraulic Tappet - A - 751-11730

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.

2.26 CYLINDER HEAD CLEARANCE

2.26.1 Checking the Clearance

⚠ 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.
3. Using two pieces of lead wire 1.6mm (0.06in) diameter and 50mm (1.9in) long form two 'U' shape lops.

⚠ 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 2.16.2' 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.

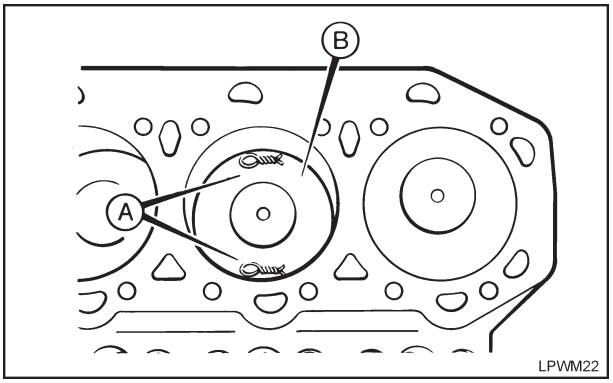


Figure 2.26.1 Checking Cylinder Head Clearance with Wire (an LPW head is shown)

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 "2.26.2 Cylinder Head Gaskets".
9. Replace the push rods and cylinder heads after referring to "2.24.2 Refitting a Cylinder Head".

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, LPWST4 754-40891

2.27 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 "2.27.3 The Valve Seats".
Care must be taken to ensure that all valve associated items are retained in their respective cylinder orientation.

2.27.1 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.

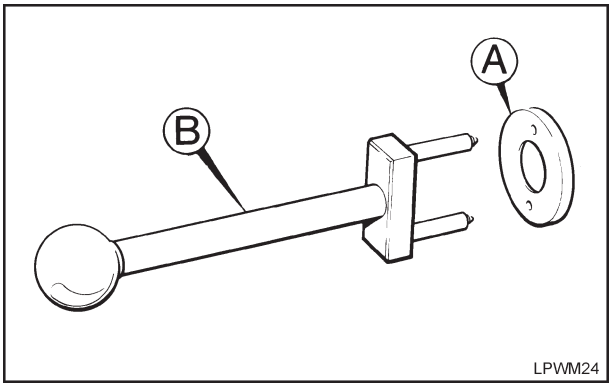


Figure 2.27.1 Valve Spring Compressor - 393155

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.

2.27.2 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.
For all diesel fuelled engines new valve guides and valve stem seals have been introduced; see "2.28 The Valve Guides" and 'Figure 2.27.3'.
If more than one valve was removed ensure they are replaced in their original 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.

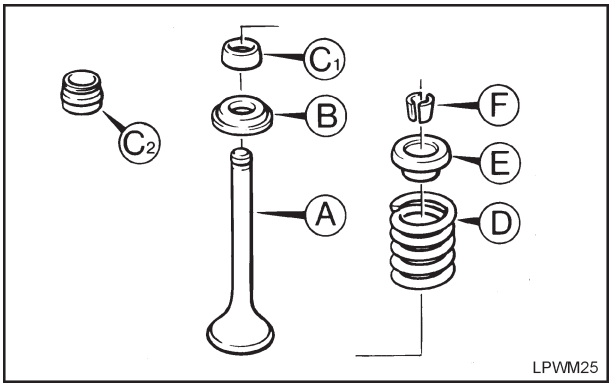


Figure 2.27.2 Valve Assembly
A - Valve
B - Valve spring plate
C1 - Early valve stem seal and LPWG engines
C2 - Later valve stem seal
D - Valve spring
E - Valve spring plate
F - Collets

5. Fit a new valve stem seal (C), see "2.28 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 the inlet and exhaust 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 2.27.3'.

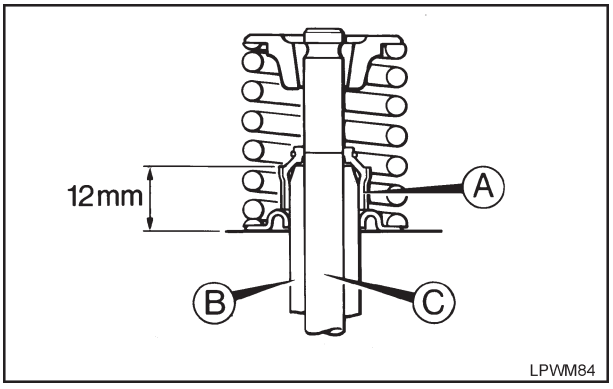


Figure 2.27.3 Later Valve Guide Seal Location
A - Valve guide seal
B - Valve guide
C - Valve stem

6. Replace the valve spring (D) and spring carrier (E).
7. Fit the adaptor (A), see 'Figure 2.27.1', 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.

2.27.3 The Valve Seats

Valve seat inserts are only fitted to LPWT4 and LPWST4 and LPWS Bio 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.

		Valve Seat Depth	
		Inlet Seat	Exhaust Seat
LPW	mm	0.9-1.26	1.29-1.64
	in	0.0374-0.0496	0.0524-0.0646
LPWT4	mm	1.545-1.855	
	in	0.0606-0.0732	
LPWS	mm	0.9-1.26	1.29-1.64
	in	0.0374-0.0496	0.0524-0.0646

2.27.4 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.

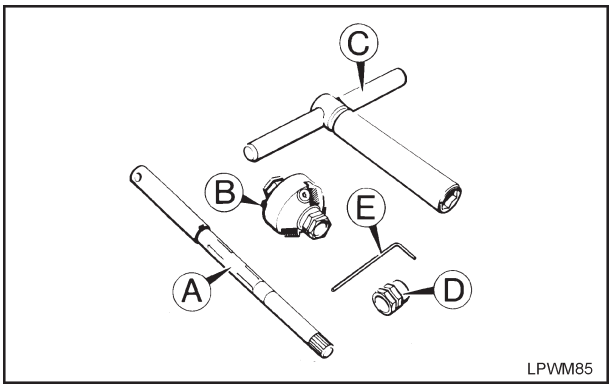


Figure 2.27.4 Valve Seat Kit - 317-50042
A - Adjustable mandrel
B - Cutting tool
C - 'T' handle
D - Adaptor
E - Allen key

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.

2.28 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 LPW(S)T4. 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 00396 LPW3
42 00850 LPW3
42 00687 LPW4
42 00770 LPWS4

2.28.1 Valve Guide and Seal Part Numbers

	Later Type
Guide	751-10903
Seal	751-41701

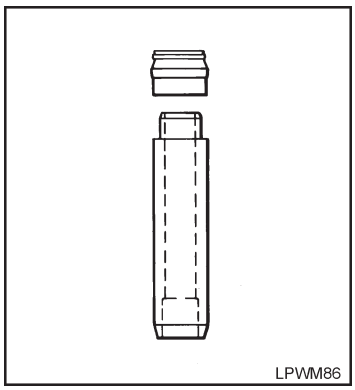


Figure 2.28.1 Valve Guides and Seals
Later type

2.28.2 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).

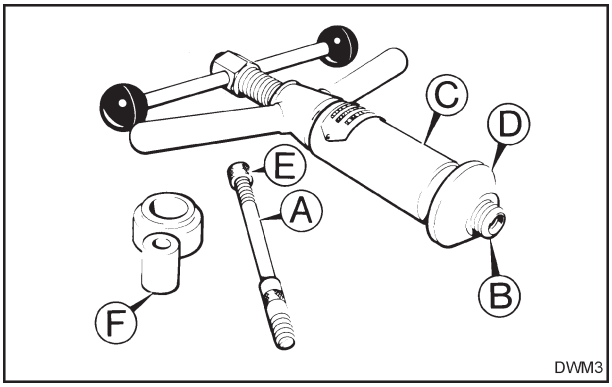


Figure 2.28.2 Valve Guide Tool and Depth Stop
Lister Petter Service Tool
317-50033
317-50108
317-50057
317-50075

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.

2.28.3 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 counter bored 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.

2.29 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 LPW(S)T4 crankcase doors are not interchangeable.

2.29.1 Removing the Crankcase Door

1. Remove the two fuel pipes from the lift pump.
2. Remove the LPW(S)T4 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.

2.29.2 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.

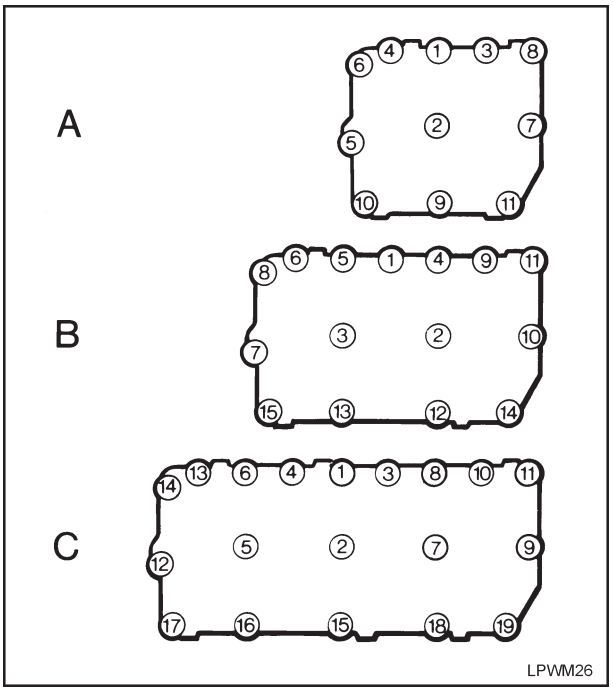


Figure 2.29.2 Crankcase Door Tightening Sequences
A - 2 cylinder engines
B - 3 cylinder engines
C - 4 cylinder engines

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

2.30 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 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.

2.30.1 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.

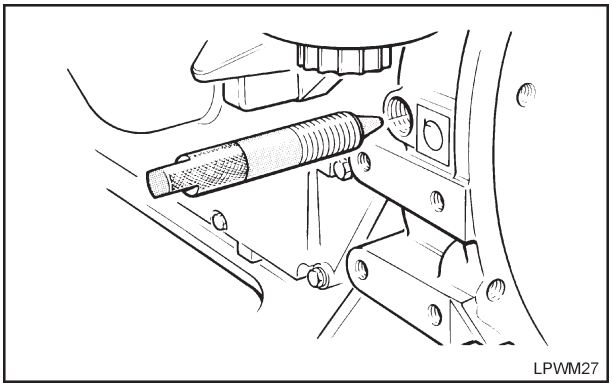


Figure 2.30.1 Fitting the Flywheel Locking Tool

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.

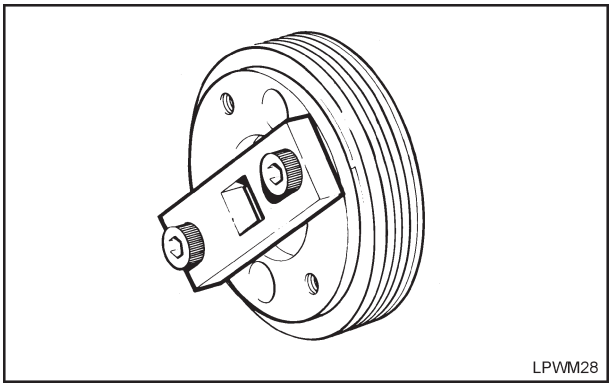


Figure 2.30.2 Pulley Tool

5. **On Later Engines:**
   Use a suitable socket and wrench and unscrew the left hand thread crankshaft pulley bolt and remove the pulley anti clockwise.
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.

2.30.2 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 Power Systems; 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 the 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.

2.30.3 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 arts 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.

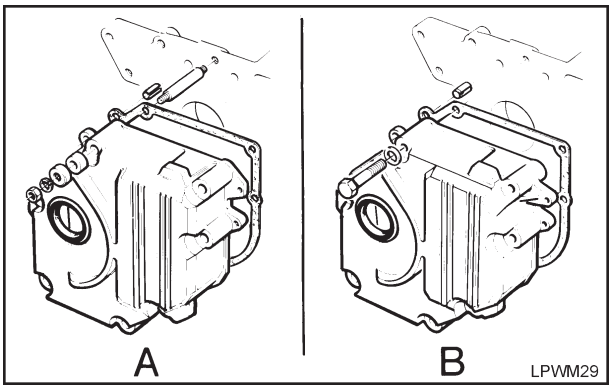


Figure 2.30.3 Gear End Cover
A - Early Type Fixing; B - Late Type Fixin

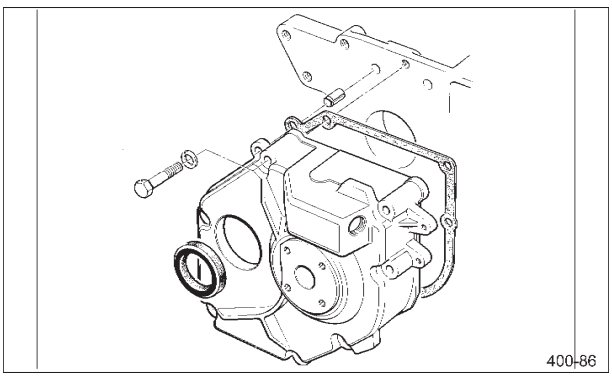


Figure 2.30.4 Gear End Cover - LPWS 400 Series

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

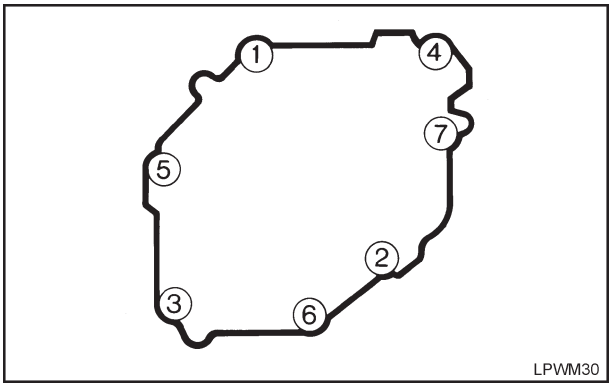


Figure 2.30.5 End Cover Torque Sequence

2.31 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.

⚠ CAUTION

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

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

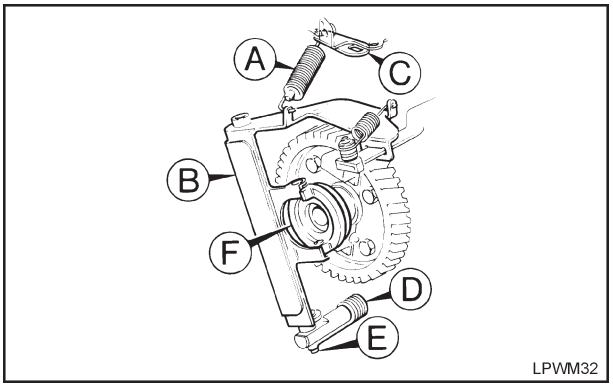


Figure 2.31.1 Removing the Governor

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

2.31.2 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.

2.31.3 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 ears exactly.

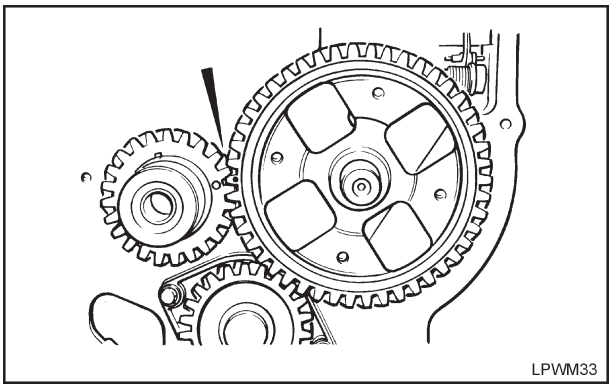


Figure 2.31.3 Camshaft Timing Marks

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

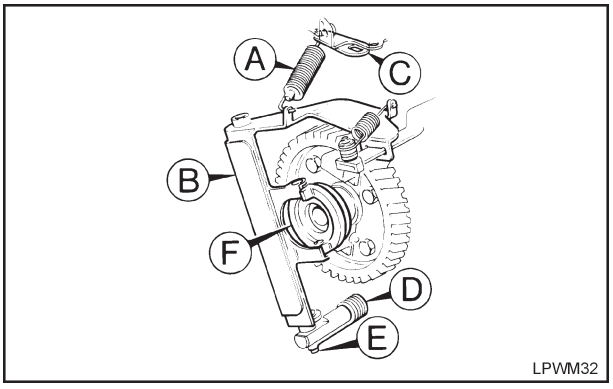


Figure 2.31.4 Thrust Plate Spring

6. 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.
7. Replace the end cover and torque the bolts to 9.0Nm (6.5lbf ft) in the sequence shown.

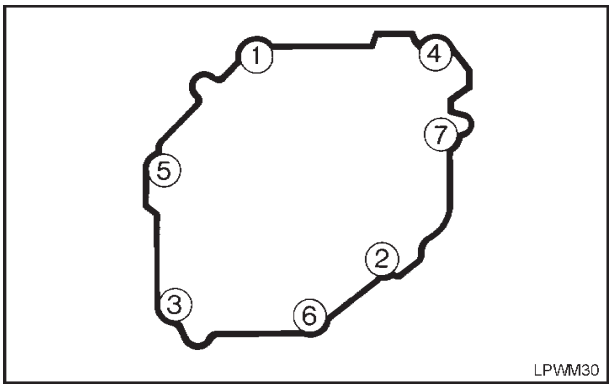


Figure 2.31.5 End Cover Torque Sequence

8. Replace the dipstick, fuel lift pump and fuel pumps.
9. Refer to "2.24.2 Refitting a Cylinder Head" and replace the cylinder head.

2.31.4 Camshaft End float

The camshaft end float is factory set at 0.07-0.20mm (0.004-0.008in) and cannot be adjusted.
If the end float is greater than that given the camshaft must be replaced.

2.31.5 Checking the End float

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.

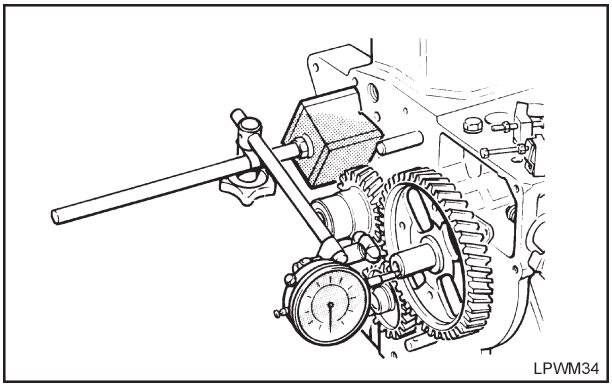


Figure 2.31.6 Checking Camshaft End float

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 end float.

2.32 THE CAMSHAFT BUSH

2.32.1 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 in use.

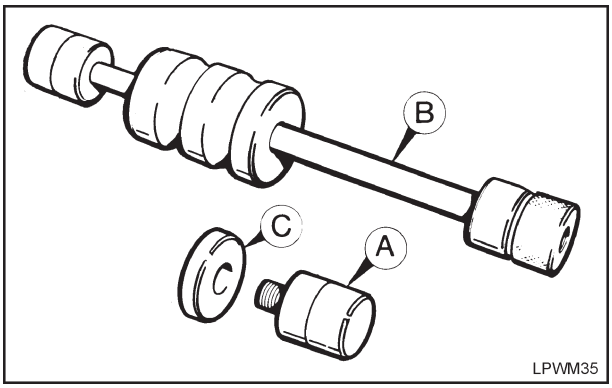


Figure 2.32.1 Camshaft Bush Tool
Service Tool Kit No 317-50118

2.32.2 Fitting a New Bush

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

2.33 THE PISTON

The piston is made of low expansion alloy with a recessed combustion chamber in the crown and is fitted with three rings.
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 and LPWST4 piston and connecting rod assemblies are not interchangeable with any other.

2.33.1 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.

2.33.2 Piston Assemblies

LPWT4 and LPWST4 Engines:
LPWT4 and LPWST4 engines have only been fitted with controlled expansion piston assemblies and these are not interchangeable with any other.

All Other Engines:
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.

2.33.3 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.

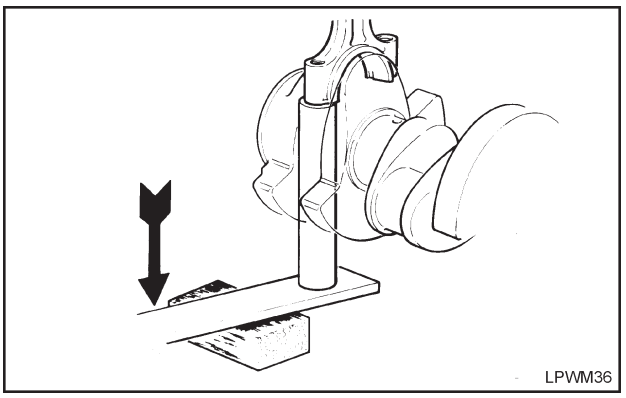


Figure 2.33.3 Piston Lifting Tool 317-50113

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.

2.33.4 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 "5.7.4 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.

2.33.5 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.

⚠ CAUTION

Ensure the correct type of piston for the engine is being replaced.

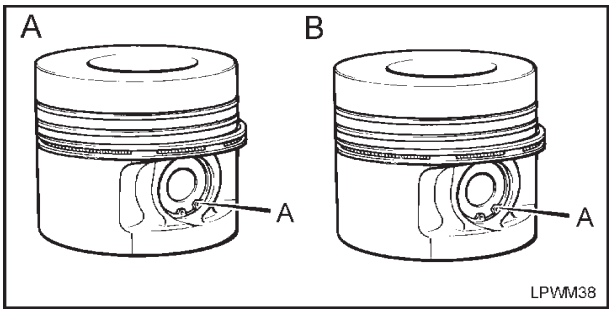


Figure 2.33.5 Piston
A - LPW; B - LPWS 400 Series

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.

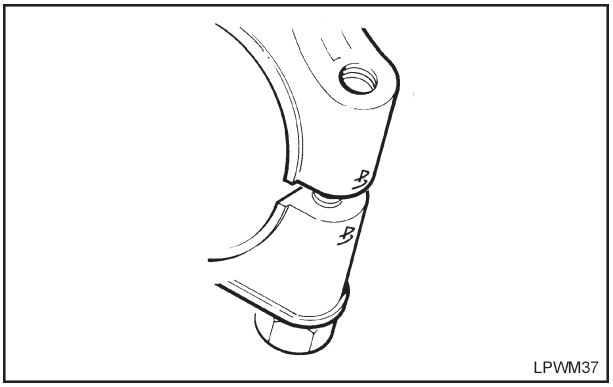


Figure 2.33.6 Connecting Rod and Cap Identification Marks

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

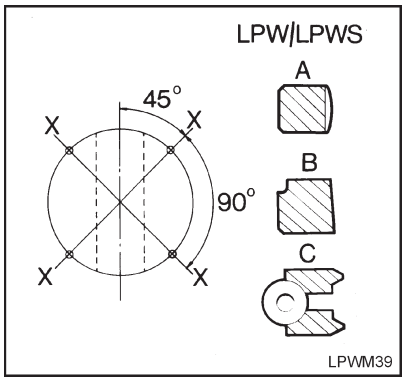


Figure 2.33.7 Piston Ring and Gap Positions
A - Firing ring; B - Compression ring; C - Oil control ring;
X - Piston ring gap positions

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. Big end bolts are not supplied in the overhaul kit.

2.34 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 (fitted as standard on all engines except turbo), and oil cooling jets must also be fitted. Oil jet screws only fitted on engines above 1800rpm.

⚠ CAUTION

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

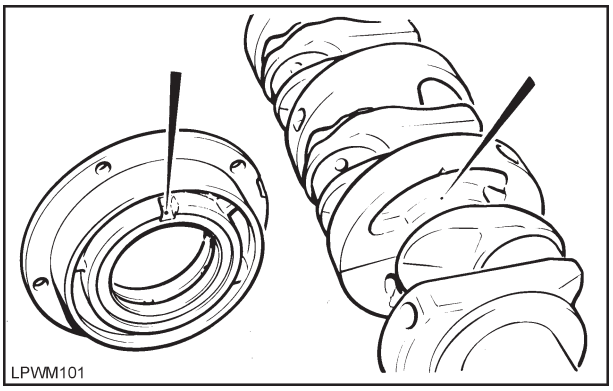


Figure 2.34.1 Oil Jet

2.35 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 "2.33.6 Fitting a Piston".

2.35.1 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.

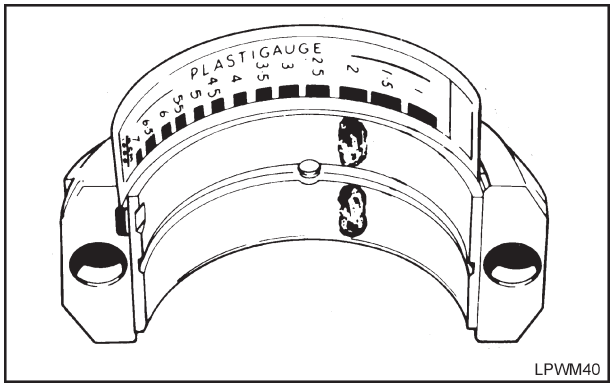


Figure 2.35.1 Checking Bearing Clearance

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 "5.7.4 Dimensions of Wearing Parts".

2.36 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 LPWST4) 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 2.36.1', and suitable lifting equipment are used when removing, handling or replacing the flywheel.

2.36.1 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 its rotation.

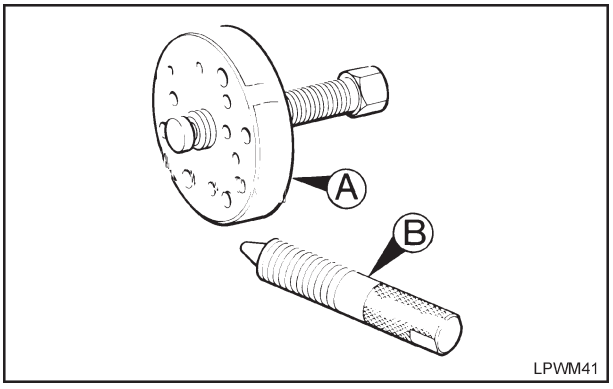


Figure 2.36.1 Flywheel Tools
A - Puller 317-50100
B - Locking tool 317-50057

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.

2.36.2 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.

2.37 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.

2.37.1 Removing the Flywheel Housing

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

2.37.2 Fitting the Flywheel Housing

1. Replace the bolts finger tight.
2. Align the previously scribed marks.
3. Torque the retaining bolts to 79.0Nm (58.0lbf ft).

2.38 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.

2.38.1 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 clean M6 bolt, 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.

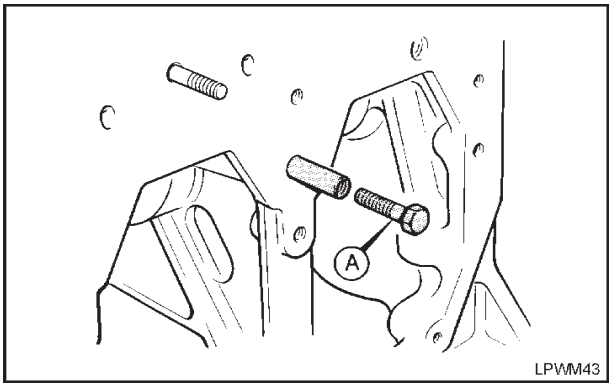


Figure 2.38.1 Removing the Bearing Housing

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.

2.38.2 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 thrust washers 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.

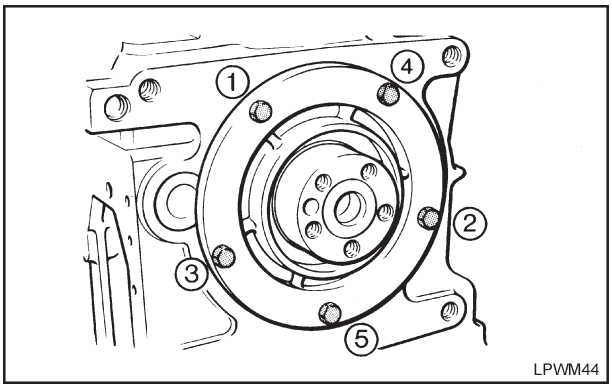


Figure 2.38.2 Bearing Housing Tightening Sequence

5. Check the crankshaft end float as described in "2.42 Crankshaft End float".
6. Replace the oil lip seal as described in "2.32 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.

2.39 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 Power Systems; 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.

2.39.1 Fitting the Oil Seal

The sealing lip must be lightly greased prior to fitting the seal.

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

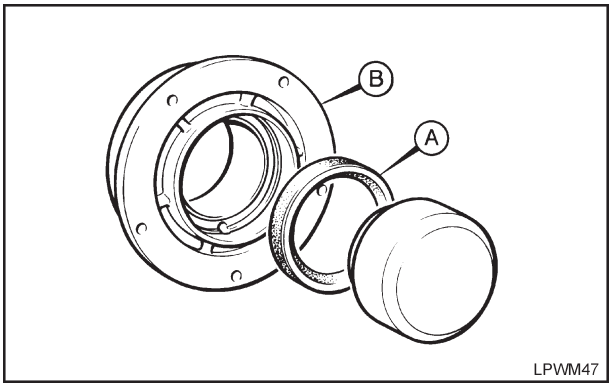


Figure 2.39.1 Oil Seal Tool, 317-50104

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.

2.39.2 Refitting Oil Seals

The seal is to be driven further into its housing by 3mm (0.12in) in order to establish a new sealing surface for the seal element.

2.40 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).

2.41 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 in the centre main 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.

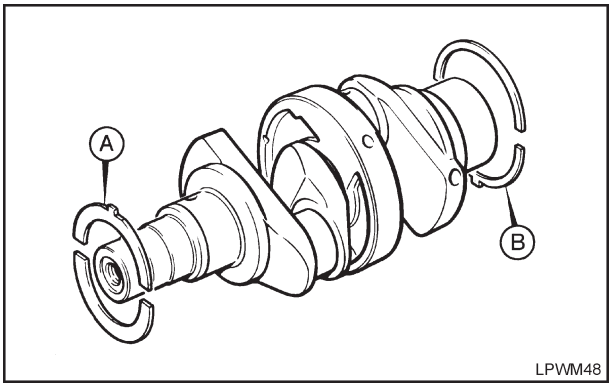


Figure 2.41.1 Thrust Washers
A - Gear end
B - Flywheel end bearing housing

2.41.1 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.

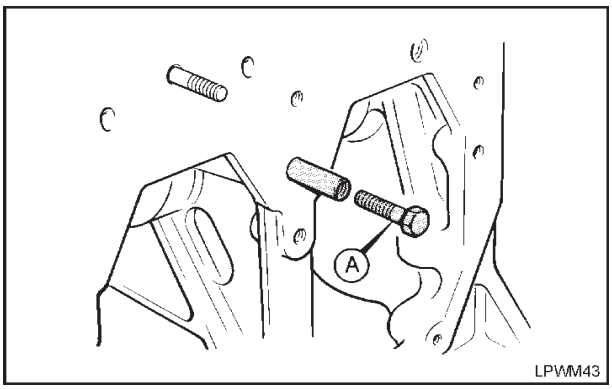


Figure 2.41.2 Removing the Centre Bearing Dowel

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. Keep the bearing

half as matched pairs.

9. Remove the thrust washers from the gear end of the crankcase and the flywheel end main bearing housing.

2.41.2 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 crank pins and also the connecting rod bearings.
d. Examine all bearing surfaces for scoring and wear.
e. Examine the thrust washers for damage and wear.

2.41.3 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).

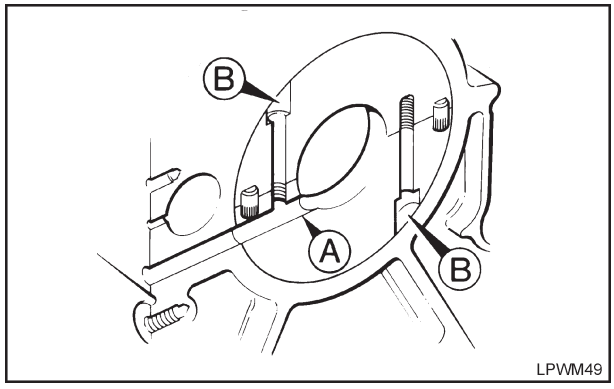


Figure 2.41.3 Dowel Hole Alignment
A - Bearing housing dowel hole
B - Capscrew head recess

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 "2.38.2 Refitting the Main Bearing Housing" and "2.39.1 Fitting the Oil Seal".
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 "2.42.1 Checking Crankshaft End float".

2.42 CRANKSHAFT END FLOAT

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

2.42.1 Checking Crankshaft End float

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

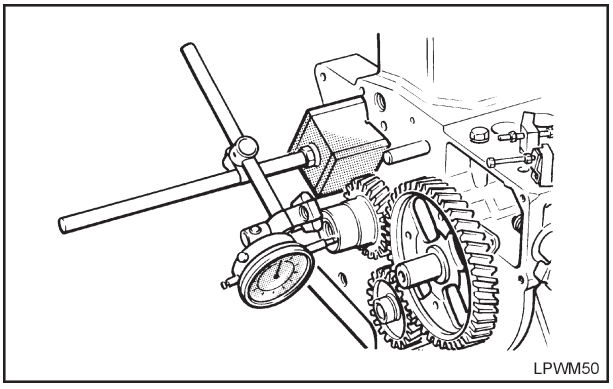


Figure 2.42.1 Checking Crankshaft End float

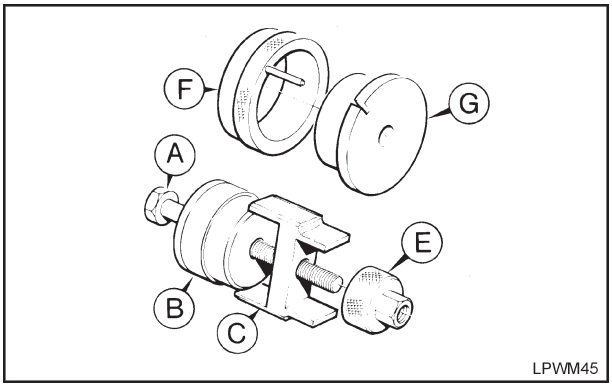


Figure 2.43.1 Main Bearing Tool

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 end float.
4. The end float should be:
   0.18-0.45mm (0.007-0.018in).
   This is maintained by fitting a single 0.38mm (0.015in) or 0.55mm (0.022in) aluminium shim behind the bearing housing flange. Only one shim be used to achieve the end float.

2.43 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.

2.43.1 Removing Main Bearings

Before attempting to remove the bearings from the main bearing housing it should be firmly held in a soft-jawed vice. Service tool kit Part number 317-50118 is required for the following operation.

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

2.43.2 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 2.43.2'.

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).

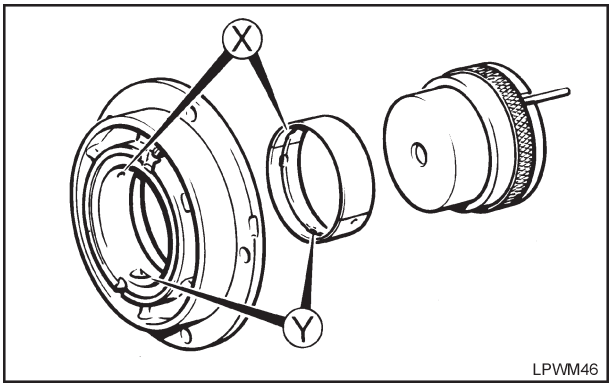


Figure 2.43.2 Main Bearing Housing Oil Hole

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).

2.43.3 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).

2.44 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 (all except turbo).
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.

2.44.1 Removing the Pump and Strainer

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

Note

Oil pumps for LPWT engines and LPW(S) engines are not interchangeable.

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

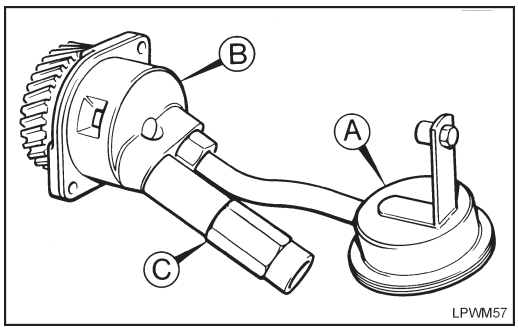


Figure 2.44.1 Oil Strainer and Pump
A - Strainer; B - Pump; C - Relief valve

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.

2.44.2 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.

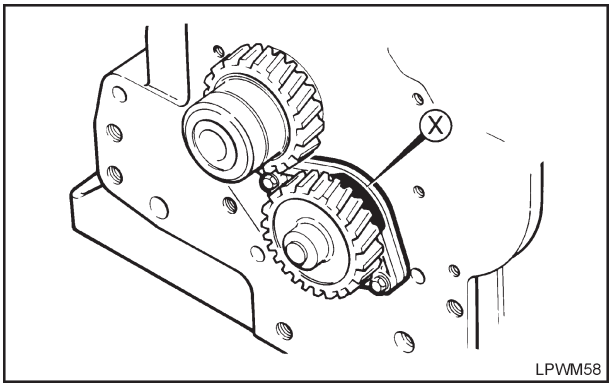


Figure 2.44.2 Oil Pump Locating Cutout

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 leaving 6mm gap.
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.

2.45 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.

2.45.1 Radiator Cooling

Radiators can be engine or remote mounted including some which may not have been originally fitted by Lister Petter Power Systems.
The radiator capacity must be determined then added to that given in "2.45.2 Engine Block Coolant Capacity".
An additional amount must also be taken into consideration for the capacity of the hoses on remote radiator applications.

2.45.2 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. Aluminium radiators require 50% mix of water and coolant.
Lister Petter Power Systems engines are often built with aluminium core radiators rather than copper nowadays. In order to protect and ensure the longevity of all water system components, the water used is critical. Like vehicle manufacturers we are now recommending mixing de-ionized or distilled water with your antifreeze or coolant inhibitor.
When topping up or refilling the engine's water system, do not use tap water, typical minerals and ions found in tap water can be corrosive to internal engine components including radiators, and can cause a more rapid depletion of the anti-corrosion additives found in most antifreeze.
Action required:
Refer to your coolant additive manufacturer to establish the lower temperature operating range if appropriate.
When topping up coolant please ensure that the "top up" is of the correct concentrate mix and not just water. It is recommended that this process is repeated at minimum 12 month service intervals.
The specification of the coolant concentrate should comply with one of the following:
BS6580 : 1985; MIL-A-11755D; MIL-A-46153/B.

⚠ CAUTION

The cooling system is pressurised, extreme care must be taken when removing the radiator cap if the engine is hot.

Engine	litre	pint	US gal
LPW/LPWS2	2.1	3.7	0.55
LPW/LPWS3	2.5	4.4	0.66
LPW/LPWS4	3.0	5.3	0.79

2.45.3 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.

2.45.4 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.

2.45.5 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. The position of the water bleed screw is to the right and rear of the water pump back plate.
3. Slowly refill the system with clean fresh water and coolant concentrate to a 40% concentration through the filler cap.
   See 2.45.2 Engine Block Coolant Capacity.
4. Replace the filler cap and vent plug.
5. Run the engine for a few minutes and check the coolant level.

2.46 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.

2.47 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.

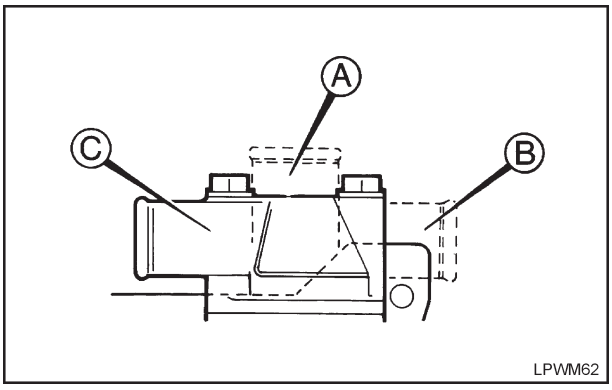


Figure 2.47.1 Thermostat Housing Cover
A - LPW3, LPWS4 Build 70
B - Builds 40,41,42,43,44,45,46,47,48,49, 71,72,173,174
C - All other builds

2.47.1 Thermostat Identification

There have been a number of different thermostats used but these have been standardised to three. Each has a colour code on the top and the temperature rating stamped on the lower skirt.

Illustration	Part Number	ºC Rating
A	751-40982	88º
B	751-40981	74º
C	751-40983	74º

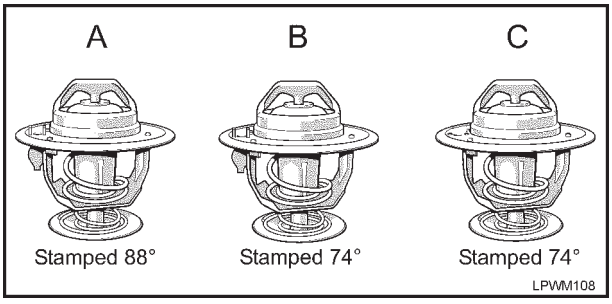


Figure 2.47.2 Thermostat Identification

Note:

On 751-40983 thermostat the jiggle pin is not fitted and 2 x 5mm diameter holes are added.

2.47.2 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.

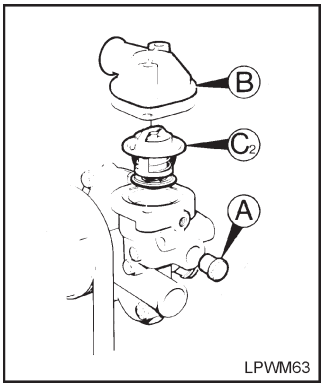


Figure 2.47.3 Removing the Thermostat
C_1 - Early type
C_2 - Current type

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.

2.47.3 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 2.47.1'.
4. Replace the engine temperature switch, if fitted.
5. Replace the radiator top hose.
6. Refill and bleed the system with clean fresh water and coolant concentrate to a 40% concentration.
   See 2.45.2 Engine Block Coolant Capacity.

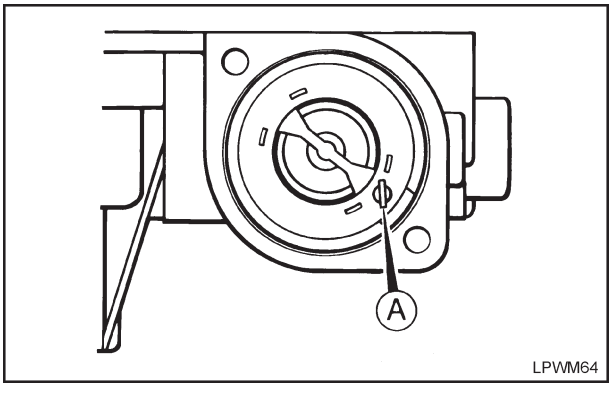


Figure 2.47.4 Replacing the Thermostat

2.47.4 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.

	ºC	ºF
74º Thermostat Starts to Open	72-76º	162-169º
Fully Open	85-88º	185-190º
88º Thermostat Start to Open	86-90º	187-194º
Fully Open	99-102º	210-216º

2.48 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 or dusty conditions.
There are a number of radiator options available, including some which are remote mounted away from the engine and some may not have been originally fitted by Lister Petter Power Systems.
Details for the radiator can be found in the relevant Master Parts Manual.

2.48.1 The Radiator Cap

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

Cap Part Numbers

15.0lb/in^2 027-07878

2.48.2 Radiator Coolant Capacity

There are a number of radiator options available, including some which may not have been originally fitted by Lister Petter Power Systems.
For these reasons it is advisable to ascertain the radiator capacity which must then be added to that given in "2.45.2 Engine Block 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.

2.48.3 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.

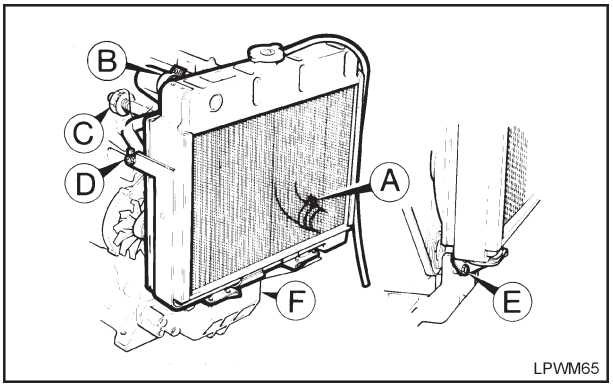


Figure 2.48.1 Radiator Mountings

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.

2.48.4 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 and bleed the system with clean fresh water and coolant concentrate to a 40% concentration.

2.49 THE RADIATOR FAN

There are two types of radiator fan (these are not interchangeable) and they can only be fitted to a compatible water pump.

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 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 the correct one.

There are a number of radiator fan options available, including some which may be remote mounted away from the engine and some may not have been originally fitted by Lister Petter Power Systems.

Details for the various fans can be found in the relevant Master Parts Manual.

2.49.1 The 'London' Fan

'London' fans originally fitted, or supplied, by Lister Petter Power Systems 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.

These fans are mounted directly onto the water pump being retained by a torque loaded nut.

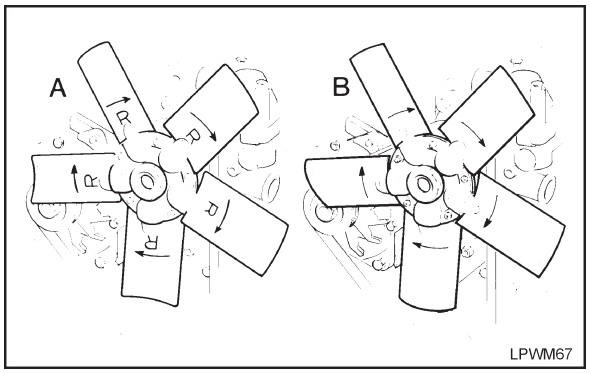


Figure 2.49.1 'London' Fan Blade Profiles
A - Pusher
B - Puller

Removing and Fitting the 'London' Fan

1. Drain and remove the radiator.
2. Remove the fan drive belt.
3. Use a 1½ 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 "2.9 The Drive Belt".
8. Replace the radiator.
9. Refill the system with clean fresh water and coolant concentrate to a 40% concentration.

2.49.2 The 'Fral' Fan

These fans are mounted indirectly onto the water pump with a spacer between the fan and pump. The fan is retained by three bolts.

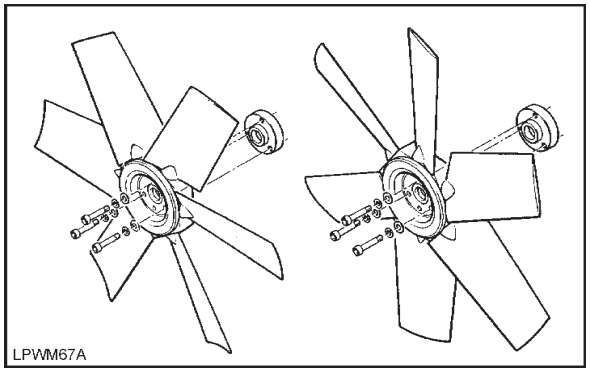


Figure 2.49.2 'Fral' Fan Blade Profiles
A - Pusher; B - Puller

Fan Data

Part Number	Diameter (mm)	Type	Blade Pitch	Spacer Width (mm)
751-45750	381.0	Puller	35º	40.0
751-45746	250.0	Pusher	40º	-
751-45756	250.0	Puller	35º	12.0
751-45741	315.0	Pusher	35º	-
751-45751	315.0	Puller	35º	12.0
751-46741	315.0	Pusher	35º	25.0
751-45740	381.0	Pusher	35º	25.0
751-45750	381.0	Puller	35º	40.0
751-45750	381.0	Puller	35º	12.0
751-45758	400.0	Puller	35º	40.0
751-46050	400.0	Pusher	40º	25.0
751-45758	400.0	Puller	40º	40.0
751-46050	400.0	Pusher	25º	25.0
751-45750	381.0	Puller	35º	12.0
751-45741	315.0	Pusher	35º	25.0
751-45740	381.0	Pusher	35º	-

Removing and Fitting the 'Fral' Fan

1. Drain and remove the radiator.
2. Remove the fan drive belt.
3. Remove the three bolts..
4. Lift off the fan and spacer.
5. Fit the spacer spigot into the back of the fan and replace the fan with the three bolts.
6. Replace the fan drive belt and tension it; refer to "2.9 The Drive Belt".
7. Replace the radiator.
8. Refill the system with clean fresh water and coolant concentrate to a 40% concentration.

2.50 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.

'London' and 'Fral' water pumps and their respective radiator fans are not interchangeable.

2.50.1 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.

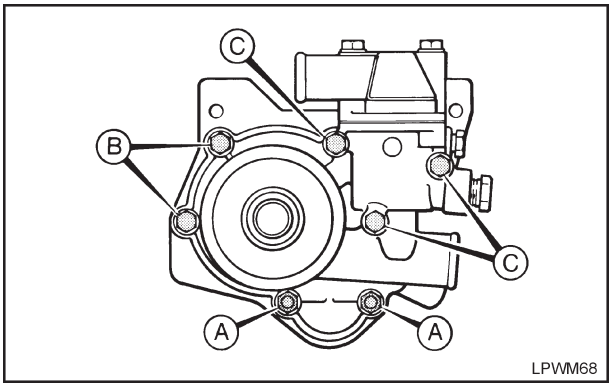


Figure 2.50.1 Water Pump Bolt Locations
A - M8 x 45mm studs (M8 x 55mm on Build 70)
B - M8 x 45mm bolts
C - M8 x 75mm bolts

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.

2.50.2 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 "2.9 The Drive Belt".
4. Replace the radiator.
5. Refill and bleed the system with clean fresh water and coolant concentrate to a 40% concentration.

2.51 THE 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.

2.51.1 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.

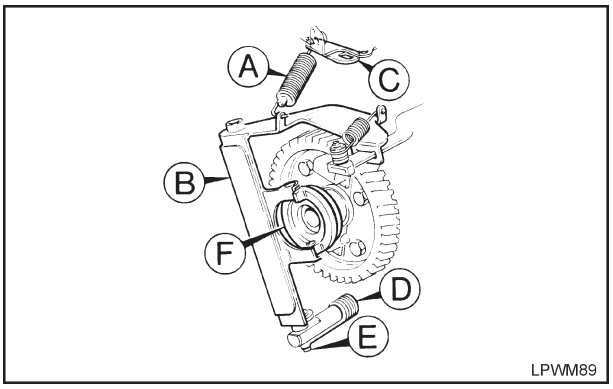


Figure 2.51.1 Removing the Governor

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.

2.51.2 Fitting the Governor

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

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 "2.51.3 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.

Note:

After the governor lever has been assembled, lift the lever until it abuts against the top pivot support and check that it falls freely under its own weight.

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.

Note:

It is essential that the governor lever and rack assembly moves freely after being fitted.

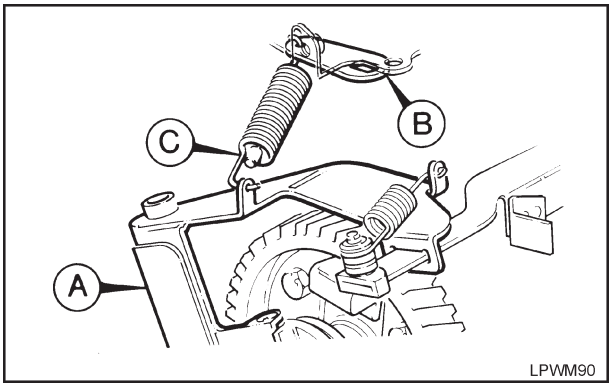


Figure 2.51.2 Speeder Spring Location
A - Governor Lever Assembly
B - Speeder Spring Lever
C - Fixed End of the Spring

8. Follow the procedures given in "2.53 Setting the "Governor".

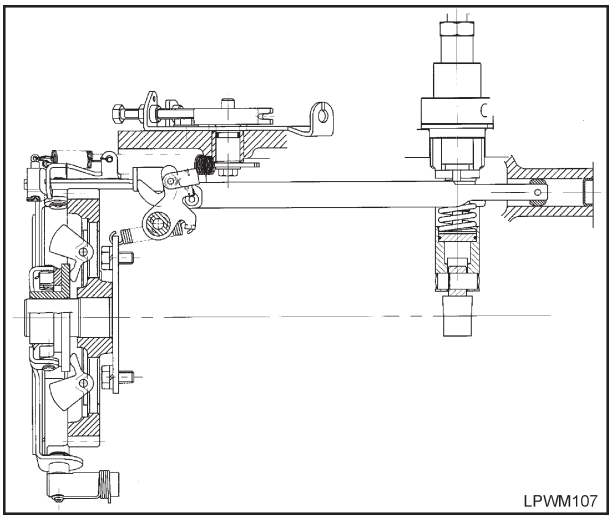


Figure 2.51.3 Schematic Diagram of the Governor

2.51.3 Governor Sleeve and Washer Combinations

LPW

Build	Part Number		
	Thrust Collar	Governor Sleeve	Steel Washer
All except LPW2 - 72, 74, 92 LPW3 - 74 LPW4 - 71, 72, 74, 91, 92	751-12823	751-10288	751-13130
74	Thrust Collar 751-12823 Thrust Washer 751-15950 Governor Sleeve 750-12660 Thrust Washer 751-15940		
LPW2 - 72 LPW4 - 71, 72	Thrust Collar 751-12824 Thrust Washer 751-15950 Governor Sleeve 750-12660 Thrust Washer 751-15940		

LPWT4

All except 7, 8, 57, 58, 74, 81, 308, 358, 374, 379, 380, 384, 681, 841, 846, 848, 848S	751-12823	751-10288	751-13130
7, 8, 57, 58, 74, 81, 308, 358, 374, 379, 380, 384, 681, 841, 846, 848, 848S	Thrust Collar 751-12823 Thrust Washer 751-15950 Governor Sleeve 750-12660 Thrust Washer 751-15940		

LPWS

All except 407, 408, 409, 440, 443, 444, 457, 458, 468, 474, 479, LPWS2 418, LPWS2 467, LPWS3 467	751-12823	751-10288	751-13130
407, 408, 409, 440, 443, 444, 457, 458, 468, 474, 479, LPWS2 418, LPWS2 467, LPWS3 467	Thrust Collar 751-12823 Thrust Washer 751-15950 Governor Sleeve 750-12660 Thrust Washer 751-15940		

LPWST4

All except 407, 408, 457, 458, 481	751-12823	751-10288	751-13130
407, 408, 457, 458, 481	Thrust Collar 751-12823 Thrust Washer 751-15950 Governor Sleeve 750-12660 Thrust Washer 751-15940		

2.52 GOVERNOR WEIGHTS AND SPRINGS

2.52.1 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.

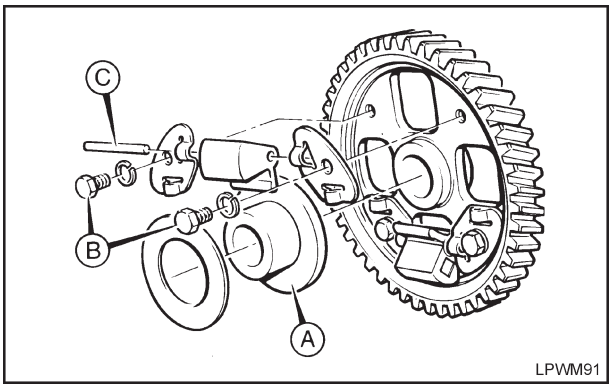


Figure 2.52.1 Changing Governor Weights

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.

2.52.2 Governor Weights and Springs - LPW2,3

Engine	Build	Part Number of Weight	Number of Weights	Part Number of Speeder Spring	Spring Colour Code
LPW2	1, 2, 51, 52, 602, 846, 848	751-11091	2	751-15720	Green/White
LPW3	1, 2, 14, 51, 602, 846, 848				
LPW2	57	751-12980	4	751-12894	Black/White
LPW2	58, 79	751-12980	4	751-12895	Black
LPW3	79, 113				
LPW2 & 3	9, 59, 82, 844	751-15460	4	751-16612	Yellow
LPW2 & 3	10, 83	751-15460	4	751-17790	Red
LPW2	27, 28, 81, 627, 841	751-12983	4	751-47100	Blue/Red
LPW3	14, 27, 28, 74, 81, 581, 627, 841				
LPW2	72, 92	750-12684	4	751-40906	Green/Silver
LPW2	74	750-12684	4	751-19130	Yellow/Green

2.52.3 Governor Weights and Springs - LPW4

Build	Part Number of Weight	Number of Weights	Part Number of Speeder Spring	Spring Colour Code
1, 2, 14, 51, 602, 846, 848	751-11091	2	751-15720	Green/White
7, 57	751-12980	4	751-12894	Black/White
79	751-12980	4	751-12895	Black
9, 59, 82, 109, 844	751-15460	4	751-16612	Yellow
10, 83	751-15460	4	751-17790	Red
27, 28, 81, 581, 627, 841	751-12983	4	751-47100	Blue/Red
71, 72, 91, 92	750-12684	4	751-40906	Green/Silver
74	750-12684	4	751-19130	Yellow/Green

2.52.4 Governor Weights and Springs - LPWT4

Build	Part Number of Weight	Number of Weights	Part Number of Speeder Spring	Spring Colour Code
1, 3, 4, 78, 301, 302, 351	751-11091	2	751-15710	White/White
7, 8, 57, 58, 81, 308, 358, 380, 681, 841	751-12983	4	751-19130	Yellow/Green
9, 59, 82, 844	751-15460	4	751-12894	White/Black
384, 846, 848	751-46760	4	751-15720	Green/White
74	750-12684	4	751-19130	Yellow/Green
374, 379	750-12684	4	751-40906	Green/Silver

2.52.5 Governor Weights and Springs - LPWS2 and 3

Engine	Build	Part Number of Weight	Number of Weights	Part Number of Speeder Spring	Spring Colour Code
LPWS2	402, 442, 446, 448	751-11091	2	751-15300	None
LPWS3	402, 442, 446, 448, 452, 476				
LPWS2	407, 408, 418, 440, 443, 457, 458, 467, 468, 474, 479	751-12983	4	751-19130	Yellow/Green
LPWS3	407, 408, 440, 443, 457, 458, 467, 468, 479				
LPWS2	409, 444	751-15460	4	751-16613	Blue
LPWS3	409, 444				
LPWS2	474	750-12684	4	751-19130	Yellow/Green
LPWS3	474	751-12983	4	751-47100	Blue/Red

2.52.6 Governor Weights and Springs - LPWS4

Build	Part Number of Weight	Number of Weights	Part Number of Speeder Spring	Spring Colour Code
402, 442, 446, 448, 452, 476, 484	751-11091	2	751-15300	None
407, 408, 440, 443, 457, 458, 467, 468, 474, 479	751-12983	4	751-19130	Yellow/Green
409, 444	751-15460	4	751-16613	Blue
411	751-46760	4	751-15720	Green/White
474	750-12684	4	751-19130	Yellow/Green

2.52.7 Governor Weights and Springs - LPWST4

Build	Part Number of Weight	Number of Weights	Part Number of Speeder Spring	Spring Colour Code
407, 408, 458, 481	751-12983	4	751-19130	Yellow/Green

2.53 SETTING THE GOVERNOR

2.53.1 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.

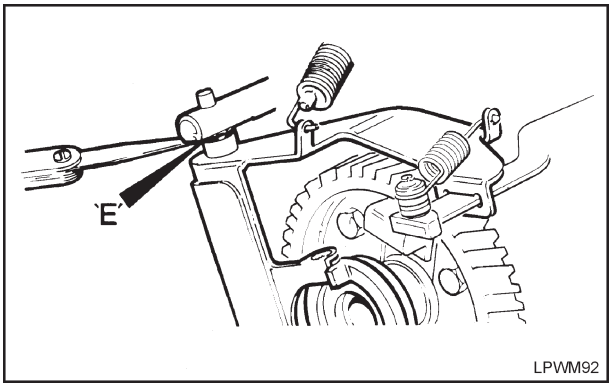


Figure 2.53.1 Governor 'E' Setting

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 end float 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.

2.53.2 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

Before dismantling the governor check and retain a note of the 'G' setting vale.

⚠ 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.

⚠ CAUTION

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

The following instructions only apply to engines not fitted with tamperproof nuts.
The adjustment should not be made until the engine control lever has been correctly set.

2.54 SPEED QUADRANTS

2.54.1 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) anti clockwise increases the engine speed.

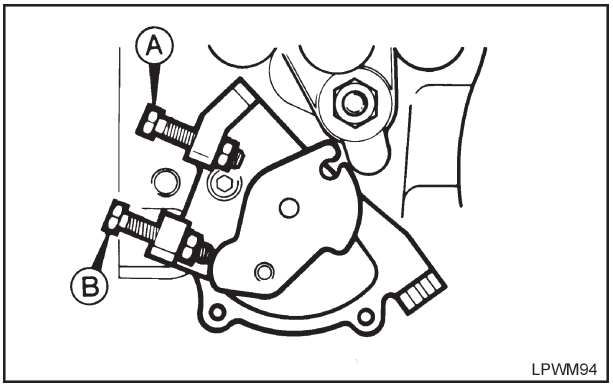


Figure 2.54.1 Fixed Speed Adjustment

2.54.2 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 quadrant, at the required maximum speed, and then locked in position with the locknut.
Rotating the setscrew anti clockwise increases the engine speed.

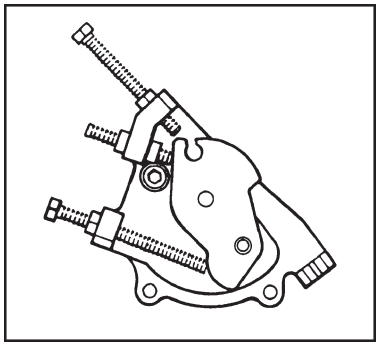


Figure 2.54.2 Variable Speed Adjustment

2.55 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) anti clockwise 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).

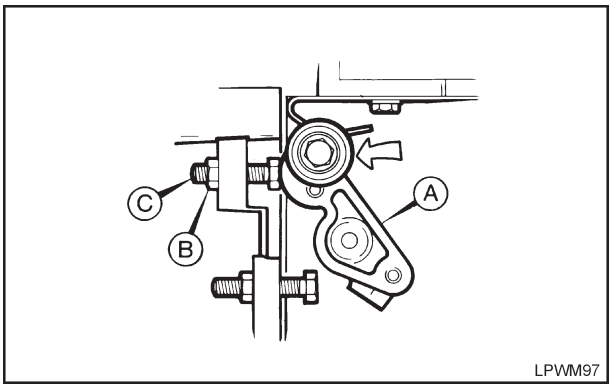


Figure 2.55.1 Setting the Control Lever

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(T) - screw the setscrew (C) out a further 1.5 turns.
   LPWS(T) - screw the setscrew (C) out a further 2.5 turns.
1. Move the engine control (B) to the run position.

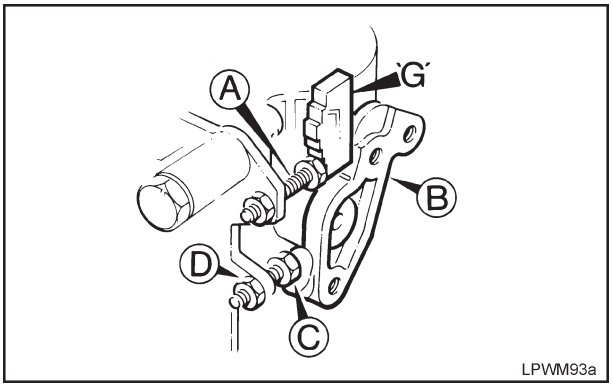


Figure 2.55.2 Governor 'G' Setting

2. Insert a gauge of the appropriate ‘G’ dimension, as shown in the table below, between the head of the setscrew (A) and the top of the radiused part of the engine control (B).
3. Adjust the setscrew (C) until the engine control just touches the setting gauge, Service Tool Kit 317-50118.
4. Tighten the setscrew locknut (D).
5. Remove the gauge.

Governor 'G' Settings

For all other builds not given in the following table the initial settings to be used are:-
LPW, LPWS..... 23.0mm
LPWT4..... 27.0mm

Engine	Builds	'G' Setting (mm)
LPW	01, 18, 40, 51, 84, 177	23.5
	02, 05, 07, 08, 10, 27, 28, 34, 37, 38, 41, 42, 44, 45, 46, 47, 48, 52, 57, 58, 59, 70, 79, 80, 81, 82, 83	25.0
	71, 72	24.0
LPWS	01, 03, 04, 13, 40, 51	23.5
	02, 05, 07, 08, 09, 11, 12, 15, 18, 41, 42, 43, 44, 45, 46, 47, 52, 57, 58, 59, 70, 73, 79	25.0
LPWS2	76	25.0
LPWS3	76	23.5
LPWS4	76	23.5
LPWT4	01, 07, 08, 34, 35, 36, 40, 41, 43, 51, 57, 58, 81, 84	25.5
	03, 04	25.0
	02, 05, 09, 37, 42, 44, 46, 52, 59, 76, 82	26.0

2.56 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 "2.56.2 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.

2.56.1 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.

Idling Speeds:

LPWT:
Build 84..... 950r/min
All other 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

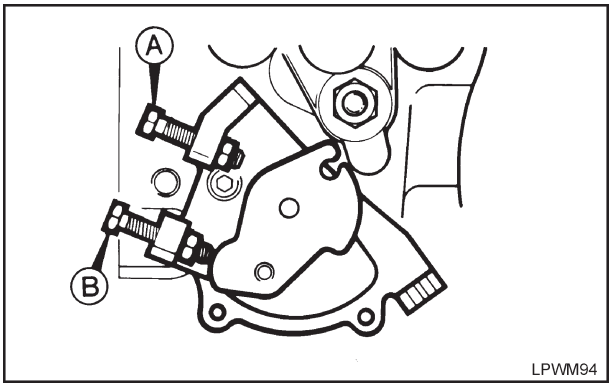


Figure 2.56.1 Idling Speed Adjustment

2.56.2 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.

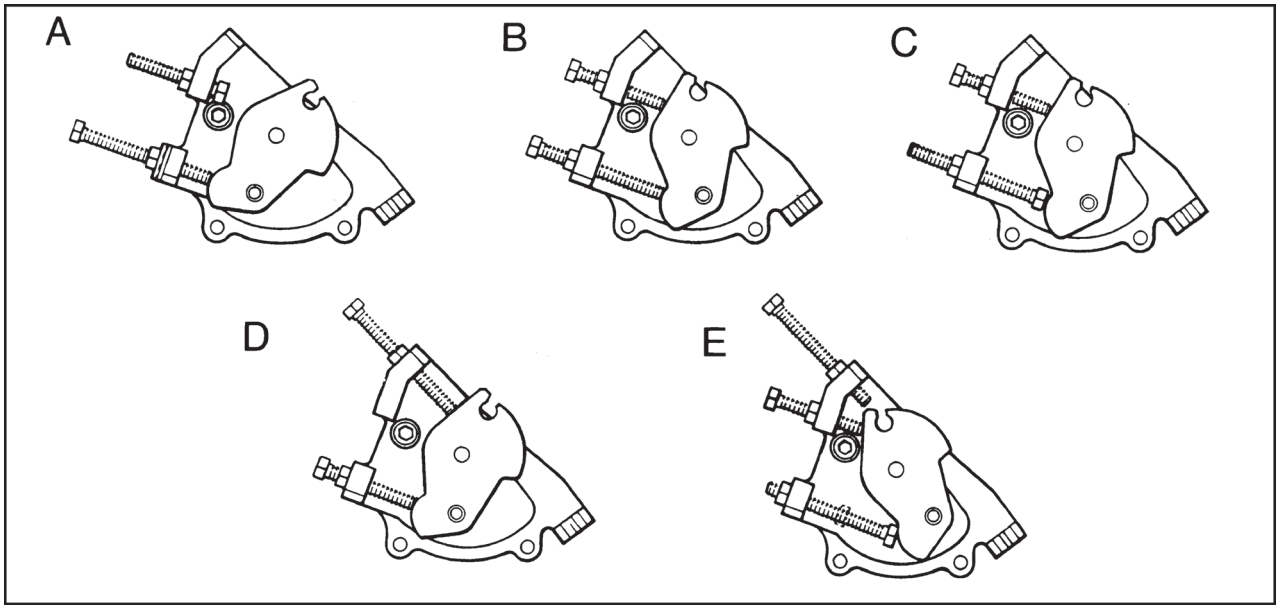


Figure 2.56.2 Speed Adjustment Setscrews; MA - Tamperproof screw
A - Variable Speed; B - Fixed Speed 3000/3600rpm; C - Fixed Speed 1500rpm; D - Fixed Speed 1800rpm; E - Dual Speed

2.57 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.

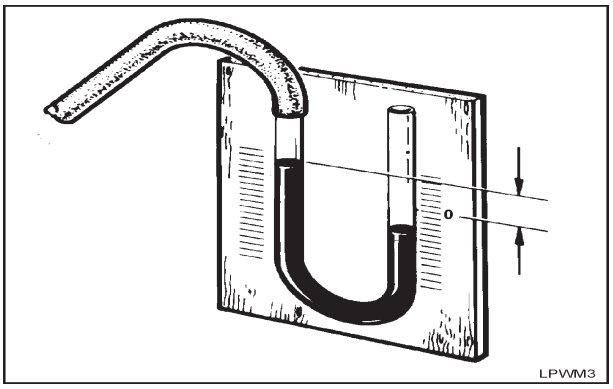


Figure 2.57.1 Manometer

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.

2.57.1 Engines Running up to 1800 r/min

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

2.57.2 Engines Running above 1800 r/min

	Minimum	Average
min WG	20.0	35.0
in WG	0.79	1.37

3. ENGINE FLUIDS

3.1 ENGINE FLUIDS - LUBRICATING OIL

3.1.1 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:

LPW, LPWT, LPWS(T).....P027-08270

⚠ CAUTION

Lister Petter Power Systems recommend that oils of different brands or types are not mixed together.

3.1.2 European Oil Specifications

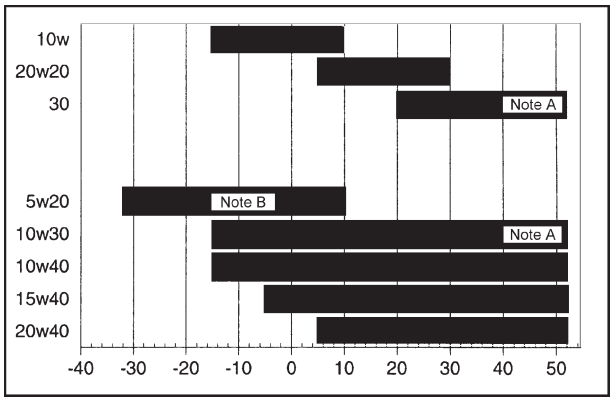
ACEA specifies the following:

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.

3.1.3 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 Power Systems 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.

3.1.4 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 Power Systems Distributor.

Past and Current US API Grade Oils

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 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.

3.2 ENGINE FLUIDS - FUEL

3.2.1 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.

⚠ 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.

3.2.2 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.

3.3 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.

3.3.1 Concentrate Specification

Lister Petter engines are often built with aluminium core radiators rather than copper nowadays. In order to protect and ensure the longevity of all water system components, the water used is critical. Like vehicle manufacturers we are now recommending mixing de-ionized or distilled water with your antifreeze or coolant inhibitor.
When topping up or refilling the engine’s water system, do not use tap water, typical minerals and ions found in tap water can be corrosive to internal engine components including radiators, and can cause a more rapid depletion of the anti-corrosion additives found in most antifreeze.
Action required:
Refer to your coolant additive manufacturer to establish the lower temperature operating range if appropriate.
When topping up coolant please ensure that the “top up” is of the correct concentrate mix and not just water. It is recommended that this process is repeated at minimum 12 month service intervals.
The specification of the coolant concentrate should comply with one of the following:
BS6580 : 1985; MIL-A-11755D; MIL-A-46153/B.

⚠ CAUTION

The cooling system is pressurised, extreme care must be taken when removing the radiator cap if the engine is hot.

3.3.2 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 "2.45.2 Engine Block Coolant Capacity", the radiator, or heat exchanger, and associated pipework capacities.

4. OPERATING INSTRUCTIONS

4.1 INDUSTRIAL ENGINE OPERATING INSTRUCTIONS

The following information is of a general nature and should be read in conjunction with, or substituted by, the equipment manufacturers instructions.

4.1.1 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 LPW(S)T4 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.

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.

Oil Pressure Switch

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

Should the engine fail to start within 30 seconds, release the key and attempt to restart after allowing sufficient time for all moving parts to stop.

Heater and Glow Plugs

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

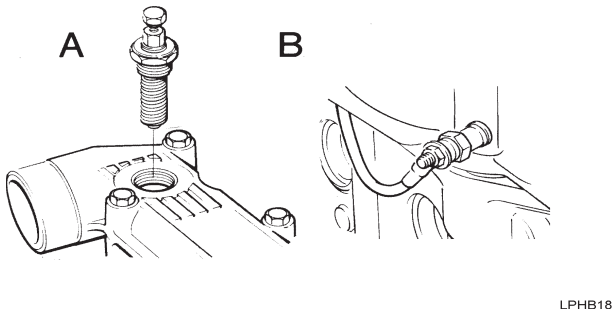


Figure 4.1.1 Manifold Heater Plug

LPWS engines are fitted with a 12V glow plug for each cylinder as standard. On all engines, other than LPWS 400 series builds, the plugs are fitted into the side of the cylinder head as shown at (B) in 'Figure 4.1.1'.

On all 400 series builds, the plugs are fitted into the top of the cylinder head between the injector and cylinder head cover, as shown at (A) in Figure 4.1.2.

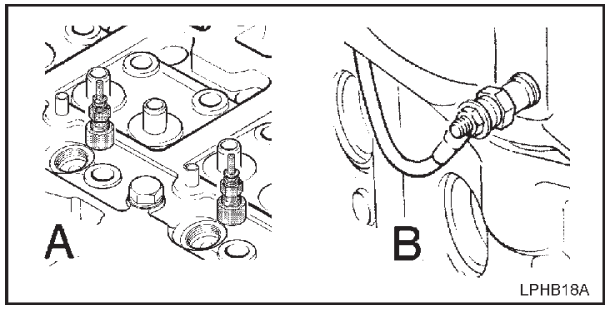


Figure 4.1.2 Glow Plug Locations
A - LPWS 400 Series Builds; B - All Other Builds

LPWST4 engines are fitted with a 696W plug and a12V glow plug for each cylinder as standard.

Key start

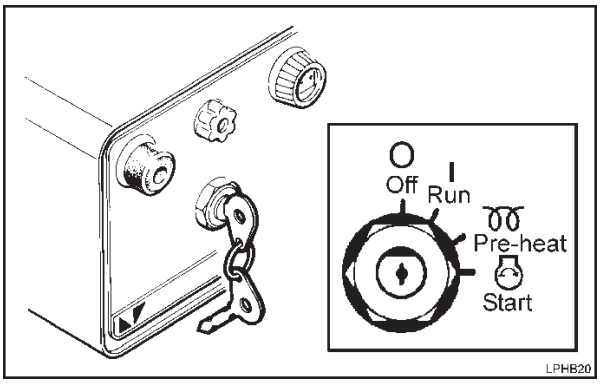


Figure 4.1.3 Key Start

Starting Control

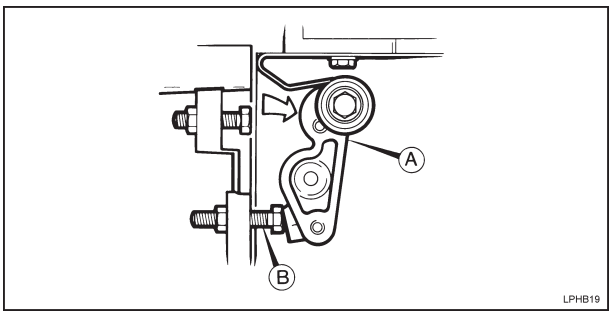


Figure 4.1.4 Engine Control Lever

4.1.2 Starting - LPW

⚠ CAUTION

These instructions only apply to LPW2, 3 and 4 engines.

Refer to "4.1.1 Preliminary Instructions"

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.
3. Turn the key clockwise to the ‘Start’ position and turn it to the 'Run' position immediately the engine starts.
4. On variable speed engines reduce the speed as necessary.

4.1.3 Starting - LPWS

⚠ CAUTION

These instructions do not apply to 400 Series engines.

Refer to "4.1.1 Preliminary Instructions"

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.
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.
4. For ambient starting temperatures below -10°C (14°F) turn the key clockwise to the ‘Preheat’ position for 15 to 20 seconds before turning the key to the ‘Run’ position.

Immediately the engine fires the key must be moved anti clockwise to the Preheat’ position until the engine has attained full speed.

5. When the engine has attained full speed the key must be moved anti clockwise to the ‘Run’ position.
6. On variable speed engines reduce the speed as necessary.

4.1.4 Starting - LPWS 400 Series

⚠ CAUTION

These instructions only apply to 400 Series engines.

Refer to "4.1.1 Preliminary Instructions"

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.
3. For ambient starting temperatures above -10°C (14°F) turn the key clockwise and hold it in the ‘Heat’ position for 5 to 10 seconds before turning it to the ‘Start’ position.
4. For ambient starting temperatures below -10°C (14°F) turn the key clockwise to the ‘Preheat’ position for 15 to 20 seconds before turning the key to the ‘Start’ position.
5. Immediately the engine starts the key must be moved anti clockwise to the 'Run’ position.
6. On variable speed engines reduce the speed as necessary.

4.1.5 Starting - LPW(S)T

⚠ CAUTION

These instructions only apply to 400 Series engines.

Refer to "4.1.1 Preliminary Instructions"

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.
3. For ambient starting temperatures above -10°C (14°F) turn the key clockwise and hold it in the ‘Heat’ position for 5 to 10 seconds before turning

it to the ‘Start’ position.
4. For ambient starting temperatures below -10°C (14°F) turn the key clockwise to the ‘Preheat’ position for 15 to 20 seconds before turning the key to the ‘Start’ position.
5. Immediately the engine starts the key must be turned anti clockwise and held in the 'Preheat’ position until the engine has attained full speed.
6. When the engine has attained full speed the key must be moved anti clockwise to the ‘Run’ position.
7. On variable speed engines reduce the speed as necessary.

4.1.6 Stopping the Industrial Engine

These are only applicable to engines with key start.
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.

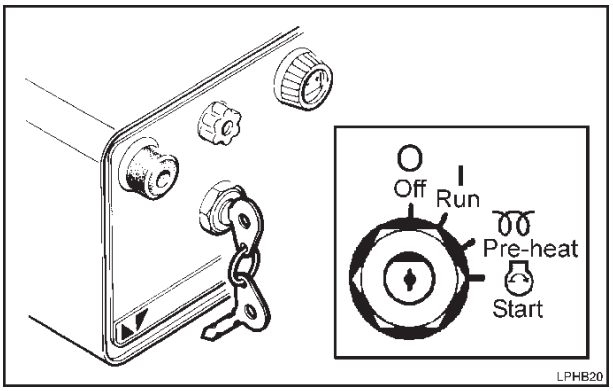


Figure 4.1.5 Key Start

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.

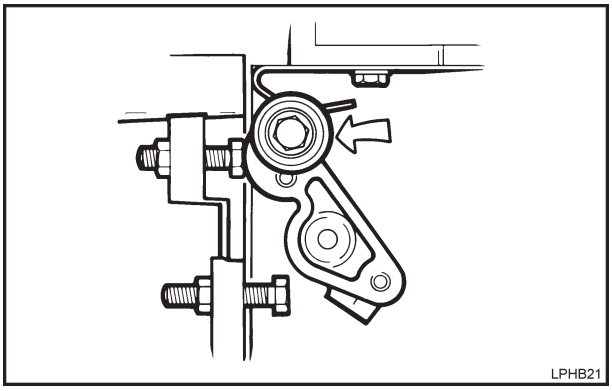


Figure 4.1.6 Stopping

4.1.7 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.

4.1.8 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 tarts.

4.1.9 Stopping the Engine

1. If possible remove the load from the engine.
2. Turn the key to the ‘STOP’ position.

5. ROUTINE MAINTENANCE

5.1 PRELIMINARY INSTRUCTION

⚠ 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 "1.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 Power Systems 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 "5.3 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.

⚠ 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.

5.1.1 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.

5.1.2 Initial Attention

Change the first fill lubricating oil and filter at 100 hours.
All subsequent oil changes must be as specified in "5.2 Oil and Filter Change Periods".
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 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.

5.1.3 Interim Maintenance

These checks are to be carried out daily and are in addition to those given in "5.3 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.

5.2 OIL AND FILTER CHANGE PERIODS

5.2.1 LPW, LPWT and LPWS Engines

On engines built since 1 January 2005 (serial number plate year code 05) lubricating oil filter 328-21600 replaced 201-55370, 751-10620 and 751-12870; refer to "2.23.1 Oil Filter Identification".

To help assist engine running-in, all engines are despatched with an initial fill lubricating oil which must be changed with the filter, at 100 hours and then as specified below.

Ambient Temperature	Periods in Hours		
	LPW	LPWT	LPWS
Up to 35ºC	500	250	250
Above 35ºC	250	125	125

Note:

Continuous operation under heavy loads in ambient temperatures above 35°C (95°F) causes the oil to deteriorate faster.

⚠ 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.

5.3 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.

5.3.1 All Engines

Also refer to "5.2 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.
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 LPW(S)T4 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.
Every 2000 Hours
The above and the following items.
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.
Replace the fuel lift pump diaphragm: see Note.
Check coolant strength, and inhibitor if necessary.
Check all fuel and leak off pipes - replace if necessary.
Every 6000 Hours
The previous items plus:
Decarbonise, if performance has deteriorated, renew all joints or seals as necessary.
Replace radiator coolant hoses.
Check water pump, replace 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 prescribed 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.

5.4 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 Molydisulphide (Achesons Colloids Compound Grade 1168 or equivalent)	Coat both joint faces.
Camshaft journals and bores		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.
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.

LPW(S)T Engines

Oil stainer '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		

Sealing compounds and mating face instructions are given in "Section 5.4".

5.5 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]		
	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		
Cylinder head cover nut		
Crankcase door bolt	11.0	8.0
Fuel lift pump blanking plate nuts	13.5	10.0
Glow plug	15.0	11.0
Glow plug to adaptor - LPWS 400 Series Builds		
Alternator adjusting link fixing bolt to backplate	16.0	12.0
Water pump studs (not bolts)		
Fuel filter swivel union plug	20.0	15.0
Fuel lift pump nuts	21.0	15.5
Injector clamp nut		
Axial fan bracket bolt		
Alternator bolt		
Water pump bolts and nuts		
Deep sump bolts[3]		
Centre bearing housing bolts		
Exhaust manifold stud - LPW(S)T4		
Turbocharger fixing nuts		
Turbocharger exhaust flange nuts		
Turbocharger oil feed plugs		
Breather separator bolts - LPW(S)T4		

5.5.1 Stator Motor Terminal Torques

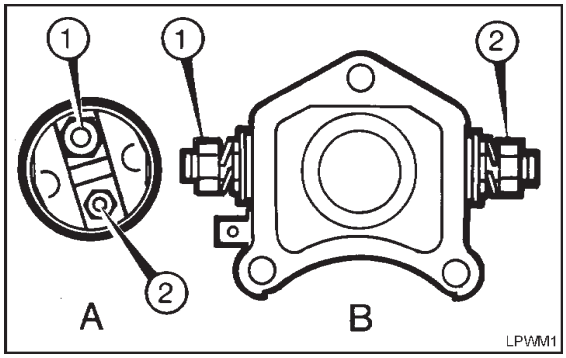


Figure 5.5.1 Starter Motor Terminal Identification
A - Lucas/Magnetti Marrelli; B - Denso

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 - 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*		
Stage 1	8.0	6.0
Stage 2:		
With 'High Boss' crankcase	61.0	48.0
Prior to 'High Boss' crankcase	48.0	35.0
Starter motor bolt	41.0	30.0
Oil pump relief valve		
Oil filter adaptor bolt - LPW(S)T4		
Injector nozzle nut - LPW	46.0	34.0
Fuel pump delivery valve holder	47.0	35.0
Injector - LPWS	68.0	50.0
Flywheel bolt* - not LPW(S)T4		
Flywheel housing screw	79.0	58.0
Flywheel bolt* - LPW(S)T4	81.0	65.0
Injector nozzle nut - LPWS		
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.

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
UniPoint Starter	Nm	5.89-11.77	5.89-11.77
	lbf ft	4.34-8.68	4.34-8.68

5.6 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.

5.7 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.

5.7.1 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.***

5.7.2 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.

5.7.3 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)

5.7.4 Dimensions of Wearing Parts

All Engines	Initial Dimension, mm	Initial Clearance, mm	Maximum Clearance, mm
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 control piston ring width	3.978 - 3.990	0.050 - 0.082	0.14
Oil control 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		
Back lash between gears		0.025 - 0.150	0.20

5.8 LONG TERM STORAGE

5.8.1 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.

5.8.2 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. Check to ensure the drive belt pulley grooves are corrosion free.
d. Fill the fuel tank.
e. Refill the cooling system, adding new coolant concentrate to a 50% concentration.
f. Refill the lubricating oil sump with new oil of the correct specification and viscosity.
g. Remove the batteries from store. If they are still fully charged reconnect them to the engine.
   Coat the terminals with petroleum jelly.
h. Start the engine and check for coolant, fuel and oil leaks before applying load.

6. TROUBLESHOOTING

6.1 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 Power Systems 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.

6.2 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 Power Systems 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 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.
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 electrical feed.
Automatic shutdown, if protective devices are fitted.	Investigate the cause and rectify.

Problem	Method of Correction
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 airflow 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.
Undercharging	
Excessive electrical load from added accessories.	Remove accessories or fit higher output alternator.
Poor electrical connections to alternator or battery.	Inspect, clean and rectify the cause.
Faulty battery.	Test, recharge or replace.
Faulty battery.	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.

7. ENGINE BUILD DETAILS

7.1 GENERAL INFORMATION

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 Power Systems to determine the exact engine specification and which parts are non-standard.
For details of emissions certification for these engines please refer to Lister Petter Power Systems or your local Lister Petter Power Systems Distributor.

7.2 BUILD DETAILS

Build and details		LPW				LPWS			
		2	3	4	T4	2	3	4	T4
01	Variable speed 850-3000r/min 100% load. Class B1	•	•	•	•	•	•	•	
02	Variable speed 850-3000r/min 110% load. Class B1	•	•	•		•	•	•	
03	Variable speed 850-3000r/min 90% load. ECE R24.03				•	•	•	•	
04	Variable speed 850-3000r/min 90% load. ECE R24.03				•				
07	Constant speed 1500r/min 110% load. Class A1			•	•		•		
08	Constant speed 1800r/min 110% load. Class A1. US EPA				•				
09	Constant speed 3000r/min 110% load. Class A1	•	•	•	•		•		
10	Constant speed 3600r/min 110% load. Class A1	•	•	•					
14	Variable speed 850-3000r/min 100% load. ECE R24.03		•	•					
27	Dual speed set at 1500r/min	•	•	•					
28	Dual speed set at 1500r/min. Deep sump	•	•	•					
51	Variable speed 850-3000r/min 100% load.	•	•	•					
52	Variable speed 850-3000r/min 110% load. Class B1	•							
57	Constant speed 1500r/min 110% load. Class A1	•		•	•		•	•	
58	Constant speed 1800r/min 110% load. Class A1	•			•				
59	Constant speed 3000r/min 110% load. Class A1	•	•	•	•				
71	Constant speed 2000r/min 100% load. Class A1			•					
72	Constant speed 1800r/min 100% load. Class A1	•		•					
74	Dual speed 1500/1800r/min, set at 1800r/min - Onan Genset Build	•	•	•	•				
78	Constant speed 1800r/min 110% load. Class A1				•				
79	Constant speed 1800r/min 110% load. Class A1	•	•	•					
81	Dual speed, set at 1500r/min	•	•	•	•				
82	Constant speed 3000r/min 110% load. Class A1	•	•	•	•				
83	Constant speed 3600r/min 110% load. Class A1	•	•	•					
91	Constant speed 2000r/min 100% load. Class A1			•					
92	Constant speed 1800r/min 100% load. Class A1	•		•					
109	Constant speed 3000r/min 110% load. Class A1			•					
113	Constant speed 1800r/min 110% load. Class A1		•						
301	Variable speed 850-3000r/min 100% load. Class B1				•		•	•	

Build and details		LPW				LPWS			
		2	3	4	T4	2	3	4	T4
302	Variable speed 850-3000r/min 110% load. Class B1				•		•	•	
351	Variable speed 850-3000r/min 100% load. Class B1. Deep sump				•		•	•	
358	Constant speed 1800r/min. Deep sump. US EPA				•				
374	Constant speed 1800r/min. US EPA				•	•	•	•	
379	Constant speed 1800r/min. US EPA				•	•	•	•	
380	Constant speed 1800r/min. US EPA				•				
384	Variable speed 1250-2750r/min				•				
	Variable speed 950-2895r/min							•	
402	Variable speed 850-3000r/min, 110% load					•	•	•	
407	Constant speed 1500r/min. 110% load. Class A1					•	•	•	•
408	Constant speed 1800r/min. 110% load. Class A1					•	•	•	•
409	Constant speed 3000r/min. 110% load. Class A1					•	•	•	
411	Variable speed 850-2800r/min							•	
418	Constant speed 1800r/min. 110% load. Class A1					•			
440	Fixed speed 1500r/min, 110% load, std crankcase, e/cover for water pump drive. Class A1 - Marine Auxiliary					•	•	•	
442	Variable speed 850-3000r/min, 110% load, standard crankcase, e/cover for water pump drive - Marine Propulsion					•	•	•	
443	Fixed speed 1800r/min, 110% load, std crankcase, e/cover for water pump drive. Class A1 - Marine Auxiliary					•	•	•	
444	Fixed speed 3000r/min, 110% load, std crankcase, e/cover for water pump drive. Class A1 - Marine Auxiliary					•	•	•	
446	Variable speed 850-3000r/min, 110% load, standard crankcase, e/cover for water pump drive - Marine Auxiliary/Propulsion					•	•	•	
448	Variable speed 850-3000r/min, 110% load, crankcase with cut off feet, e/cover for water pump drive - Marine Propulsion					•	•	•	
457	Fixed speed 1500r/min, 110% load, deep sump. Class A1							•	
458	Fixed speed 1800r/min, 110% load, deep sump. Class A1					•	•	•	•
467	Fixed speed 1500r/min, 110% load, arranged for long running periods. Class A1					•	•	•	
468	Fixed speed 1800r/min, 110% load, arranged for long running periods. Class A1					•	•	•	
474	Fixed speed 1800r/min, 110% load, 2 cylinder even fire. Class A1					•	•	•	
476	Variable speed 1150-2800						•	•	
479	Fixed speed 1800r/min, 110% load, 2 cylinder even fire. Class A1					•	•	•	
481	Fixed speed 1500r/min, 110% load. Class A1								•
484	Variable speed 950-2895							•	
581	Dual speed, set at 1500r/min. Deep sump		•	•					
602	Variable speed 850-3000r/min, 110% load, arranged for long running periods	•	•	•	•				
627	Dual speed 1500/1800r/min, set at 1500r/min, arranged for long running periods	•	•	•					
681	Dual speed 1500/1800r/min, set at 1500r/min, arranged for long running periods				•				
841	Dual speed 1500/1800r/min, set at 1500r/min, std crankcase, e/cover for water pump drive - Marine Auxiliary	•	•	•	•				

Build and details		LPW				LPWS			
		2	3	4	T4	2	3	4	T4
844	Fixed speed 3000r/min, A1 governing, 110% load, std crankcase, e/cover for water pump drive - Marine Auxiliary	•	•	•	•				
846	Variable speed 850-3000r/min, 110% load, std crankcase, e/cover for water pump drive - Marine Auxiliary / Propulsion	•	•	•	•				
848	Variable speed 850-3000r/min, 110% load, crankcase with cut off feet, e/cover for water pump drive - Marine Propulsion	•	•	•	•				
848S	Variable speed 850-3000r/min, 110% load, crankcase with cut off feet, e/cover for water pump drive, short lubricating oil strainer for life boat duties - Sabb Marine Propulsion				•				

8. TECHNICAL DATA

8.1 TECHNICAL DATA - LPW

		LPW2	LPW3	LPW4	LPWT4
Type of fuel injection		Direct			
Number of cylinders		2	3	4	4
Direction of rotation - looking on flywheel		Anti clockwise			
Nominal cylinder bore - refer to "07.7 Dimensions of wearing Parts" for machining tolerances	mm	86.0	86.0	86.0	86.0
	in	3.38	3.38	3.38	3.38
Stroke	mm	80.0	80.0	80.0	80.0
	in	3.15	3.15	3.15	3.15
Cylinder capacity - total	litre	0.930	1.395	1.860	1.860
	in^3	56.75	85.13	113.50	113.50
Compression ratio		18.5:1	18.5:1	18.5:1	18.5:1
Mean piston speed at 3000r/min	m/sec	7.99	7.99	7.99	7.99
	ft/min	1575	1575	1575	1575
Firing order - (number 1 cylinder is at the gear end)		1 - 2	1 - 2 - 3	1 - 3 - 4 - 2	
Lubricating oil pressure at 3000r/min and with the oil at 110ºC (230ºF)	bar	2.0	2.0	2.0	2.5
	lbf/in^2	29.0	29.0	29.0	36.3
Lubricating oil pressure at idle	bar	1.0	1.0	1.0	1.0
	lbf/in^2	14.5	14.5	14.5	14.5
Oil pressure relief valve setting	bar	2.6 - 3.2	2.6 - 3.2	2.6 - 3.2	2.6 - 3.2
	lbf/in^2	37.7-46.4	37.7-46.4	37.7-46.4	37.7-46.4
Number of flywheel ring gear teeth		96	96	96	96
Idling speed: Build 73 Build 76 LPW4 Build 84 All other Builds	r/min	800 - 850			
	r/min	1025 - 1050			
	r/min	950 - 1000			
	r/min	850 - 900			
Minimum full load speed	r/min	1500			
Fuel lift pump maximum lift	mm	3048	3048	3048	3048
	in	120	120	120	120
Fuel lift pump maximum head	mm	600	600	600	600
	in	23.6	23.6	23.6	23.6
Radiator fan ratio		1.4:1	1.4:1	1.4:1	1.4:1
Maximum continuous crankshaft end thrust	kgf	180	180	180	180
	lbf	400	400	400	400
Dry engine weight - approximate and based on Build 01. Refer to Lister Petter Power Systems for actual figures	kg	112	150	180	180
	lb	247	330	396	396
Maximum permissible intake restriction at full load	mm H_2O	254	254	254	254
	in H_2O	10.0	10.0	10.0	10.0
Maximum permissible exhaust back pressure	mm H_2O	760	760	760	760
	in H_2O	30.0	30.0	30.0	30.0
Maximum top hose temperature	°C	103º	103º	103º	103º
	°F	217º	217º	217º	217º
Fuel filter nominal rating	micron	5 - 7	5 - 7	5 - 7	5 - 7
Oil filter nominal rating	micron	25 - 30	25 - 30	25 - 30	25 - 30

8.2 TECHNICAL DATA - LPWS

		LPWS2	LPWS3	LPWS4	LPWST4
Type of fuel injection		Indirect			
Number of cylinders		2	3	4	4
Direction of rotation - looking on flywheel		Anti-clockwise			
Nominal cylinder bore - refer to "07.7 Dimensions of wearing Parts" for machining tolerances	mm	86.0	86.0	86.0	86.0
	in	3.38	3.38	3.38	3.38
Stroke	mm	80.0	80.0	80.0	80.0
	in	3.15	3.15	3.15	3.15
Cylinder capacity - total	litre	0.930	1.395	1.860	1.860
	in^3	56.75	85.13	113.50	113.50
Compression ratio		22:1	22:1	22:1	22:1
Mean piston speed at 3000r/min	m/sec	7.99	7.99	7.99	
	ft/min	1575	1575	1575	
Firing order - (number 1 cylinder is at the gear end)		1 - 2	1 - 2 - 3	1 - 3 - 4 - 2	1 - 3 - 4 - 2
Lubricating oil pressure at 3000r/min and with the oil at 110ºC (230ºF)	bar	2.0	2.0	2.0	2.0
	lbf/in^2	29.0	29.0	29.0	29.0
Lubricating oil pressure at idle	bar	1.0	1.0	1.0	1.0
	lbf/in^2	14.5	14.5	14.5	14.5
Oil pressure relief valve setting	bar	3.4 - 4.1	3.4 - 4.1	3.4 - 4.1	
	lbf/in^2	48.0 - 60.0	48.0 - 60.0	48.0 - 60.0	
Number of flywheel ring gear teeth		96	96	96	96
Idling speed:	r/min	800 - 850			
Build 73	r/min	1025 - 1050			
Build 76	r/min	950 - 1000			
Build 84 All other Builds	r/min	850 - 900			
Minimum full load speed	r/min	1500			
Fuel lift pump maximum lift	mm	3048	3048	3048	
	in	120	120	120	
Fuel lift pump maximum head	mm	600	600	600	
	in	23.6	23.6	23.6	
Radiator fan ratio		1:1	1:1	1:1	
Maximum continuous crankshaft end thrust	kgf	180	180	180	
	lbf	400	400	400	
Dry engine weight - approximate and based on Build 01. Refer to Lister Petter Power Systems for actual figures	kg	112	150	180	
	lb	247	330	396	
Maximum permissible intake restriction at full load	mm H_2O	254	254	254	254
	in H_2O	10.0	10.0	10.0	10.0
Maximum permissible exhaust back pressure	mm H_2O	762	762	762	
	in H_2O	30.0	30.0	30.0	20.0
Maximum top hose temperature	°C	103º	103º	103º	
	°F	217º	217º	217º	
Fuel filter nominal rating	micron	5 - 7	5 - 7	5 - 7	

9. DISMANTLE AND REBUILD

9.1 DISMANTLING AN ENGINE

⚠ 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.

⚠ CAUTION

These notes, based on an LPW engine, are of a general nature and are included as an aide memoire and in no way are they intended as instructions.

9.1.1 Preliminary Instructions

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 water.
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

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

1. Remove the radiator hoses.
2. Remove the radiator after disconnecting the top and bottom mountings.
3. Remove the starter motor.
4. Slacken the alternator or jockey pulley.
5. Remove the radiator fan drive belt.
6. Remove the alternator or belt tensioner.
7. Remove the radiator fan (left hand thread).
8. Remove the inlet and exhaust manifolds.
9. Remove the fuel pump to injector pipes.
10. Remove the injectors; LPW have clamps, LPWS are screwed in.
11. Remove the cylinder head covers.
12. Remove the lifting eye (s).
13. Remove the valve rockers and push rods.
14. Remove the water pump.
15. Remove the cylinder head and gasket.
16. Lift out the push rod tubes, rubber seals and washers.
17. Remove the remaining fuel pipes and the fuel filter.
18. Remove the radiator support bracket.
19. Remove the oil filter.
20. Remove the dipstick and crankcase door.
21. Remove the oil pressure relief valve and the oil strainer.
22. Remove the connecting rod caps.
23. Carefully remove the carbon build-up from the top of the cylinder bore.
24. Turn the crankshaft until the piston is at TDC.
25. Lift out the piston and connecting rod.
26. Fit the flywheel locking tool.
27. Remove the front pulley (left hand thread).
28. Move the engine control to the stop position.
29. Remove each fuel pump; take care to retain the shim pack with each pump.
30. Remove the gear end cover.
31. Release the speeder spring from the governor lever assembly.
32. Remove the governor lever assembly and the governor rack.
33. Remove the governor sleeve.
34. Remove the governor weights.
35. Use a suitable magnet to remove the hydraulic tappets and the fuel pump tappets.
36. Rotate the engine until the governor weight slots in the camshaft are vertical
37. Remove the two camshaft thrust plate screws and the control lever tension spring.
38. Carefully withdraw the camshaft.
39. Remove the oil pump.
40. Remove the crankshaft pinion.
41. Remove the flywheel.
42. Remove the flywheel housing.
43. Remove the flywheel end main bearing housing.
44. Use a manifold bolt to remove the centre main bearing locating dowel.
45. Gently withdraw the crankshaft.
46. Remove all the main and the camshaft bearing shells.

9.2 REBUILDING AN ENGINE

Tables showing torque values and recommended jointing compounds can be found in “5. Routine Maintenance”
When assembling the engine, use normal engine lubricating oil to spray all moving parts during assembly. All bearing surfaces must be well lubricated including the valve stems and the cups of the push rods.
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.
Replace all joints and gaskets.

1. Replace the main bearing shells.
2. Replace the camshaft bearing.
3. Fit the gear end thrust bearings.
4. Replace the crankshaft; ensure the centre bearing dowel hole is correctly aligned.
5. Fit the centre main bearing locating dowel.
6. Fit the flywheel end thrust bearings.
7. Fit the main bearing housing.
8. Check the crankshaft end float.
9. Fit the flywheel housing.
10. Replace the flywheel.
11. Heat the crankshaft pinion and fit it with the timing marks outwards.
12. Replace the oil pump.
13. Replace the engine control and speeder spring.
14. Replace the camshaft aligning the timing marks and ensure the thrust plate is located correctly.
15. Replace the fuel pump tappets.
16. Replace the hydraulic tappets.
17. Replace the governor weights and governor sleeve.
18. Replace the governor lever assembly and springs.
19. Set the governor.
20. Replace the fuel pumps.
21. Replace the gear end cover.
22. Adjust the engine control.
23. Fit the crankshaft pulley (left hand thread).
24. Replace the piston and connecting rod.
25. Replace the oil pump relief valve and strainer.
26. Replace the crankcase door and dipstick.
27. Replace the oil filter.
28. Replace the radiator support bracket.
29. Replace the push rod tube seals, washers and the push rod tubes.
30. Replace the cylinder head and gasket.
31. Replace the push rods and the valve rockers.
32. Replace the cylinder head covers.
33. Replace the fuel injector pipes.
34. Replace the fuel injectors.
35. Replace the water pump.
36. Replace the manifolds.
37. Replace the radiator fan (left hand thread).
38. Replace the alternator or tensioner.
39. Replace the starter motor.
40. Fit the fan drive belt and tension it.
41. Replace the radiator and hoses.
42. Replace the fuel filter and all other fuel pipes.

10. CONVERSION FACTORS

10.1 FORMULAE

BMEP

$$\text{Bar} = \frac{\text{kW} \times 60000 \times 20000}{\text{Cylinders} \times \text{r/min} \times \text{bore area (mm}^2\text{)} \times \text{stroke (mm)}}$$

$$\text{lbf/in}^2 = \frac{\text{bhp} \times 792000}{\text{Cylinders} \times \text{r/min} \times \text{bore area (in}^2\text{)} \times \text{stroke (in)}}$$

Torque

$$\text{Nm} = \frac{\text{kW} \times 9549}{\text{r/min}} \times \text{load factor}$$

$$\text{lbf ft} = \frac{\text{bhp} \times 5252}{\text{r/min}} \times \text{load factor}$$

Load factor:
No overload = 1,0
10% overload = 1,1

Fuel Consumption

A Specific Gravity of 0.84 is assumed

$$\text{l/h} = \frac{\text{g/kWh} \times \text{kW}}{840} \times \text{load factor}$$

$$\text{pt/h} = \frac{\text{lb/bhp h} \times \text{bhp}}{1.05} \times \text{load factor}$$

Load Factor - Naturally aspirated engines

100% = 1.0	50% = 0.58
75% = 0.78	25% = 0.40

Load Factor - Turbocharged engines

100% = 1.0	50% = 0.55
75% = 0.76	5% = 0.38

Oil Consumption

A Specific Gravity of 0.886 is assumed

$$\text{litres/24hours} = \frac{\text{g/kWh} \times \text{kW}}{4922}$$

$$\text{pints/24hours} = \frac{\text{lb/bhp h} \times \text{bhp}}{0.15}$$

Piston Speed

$$\text{metres/second} = \frac{\text{stroke (mm)} \times \text{r/min}}{30000}$$

$$\text{feet/minute} = \frac{\text{stroke (in)} \times \text{r/min}}{6}$$

Mechanical Efficiency

$$\% = \frac{\text{bhp}}{\text{ihp}} \times 100$$

Cyclic Irregularity

$$\frac{\text{max flywheel speed - min flywheel speed}}{\text{mean flywheel speed}}$$

Power

$$\text{kW} = \frac{\text{r/min} \times \text{torque(Nm)}}{9549}$$

$$\text{bhp} = \frac{\text{r/min} \times \text{torque (lb ft)}}{5252}$$

10.2 CONVERSION FACTORS

The conversion tables in this section have been derived from BS350.
To use the tables the left hand base unit is multiplied by the relevant conversion factor given in one of the right hand columns.
For example:
To convert 6.28 metres to inches using the 'Length' Table
6.28 x 39.3701 (factor from third column) = 247.244 inches

It is not good practice to round-up the conversion factors given.

Rate of Flow - Volume

	cubic metre per second - m^3/sec	litre per second l/sec	cubic foot per second - ft^3/sec	UK gallon per second - gal/sec
1 m^3/sec		1000.0	35.3147	219.969
1 l/sec	0.0010		0.0353	0.2200
1 ft^3/sec	0.0263	28.3168		6.2288
1 UK gal/sec	4.5460×10^{-3}	4.5461	0.1605	

1 UK gallon = 1.2009 US gallon

Pressure - Table 1

	newton per square millimetre N/mm^2	kilogram-force per square centimetre kgf/cm^2	pound-force per square inch lbf/in^2	pound-force per square foot lbf/ft^2
1 N/mm^2		10.1972	145.038	20885.4
1 kgf/cm^2	9.8066×10^{-2}		14.2233	2048.16
1 lbf/in^2	6.8947×10^{-3}	0.703		144.000
1 lbf/ft^2	4.7880×10^{-5}	4.8824×10^{-4}	6.9444×10^{-3}	

Pressure - Table 2

	bar bar	atmosphere atm	kilogram-force per square centimetre kgf/cm^2	pound-force per square in lbf/in^2
1 bar		0.9869	1.0197	14.5038
1 atm	1.0132		1.0332	14.6959
1 kgf/cm^2	0.9807	0.9678		14.2233
1 lbf/in^2	0.0689	0.0680	0.073	

Pressure - Table 3

	inch of water in H_2O	foot of water ft H_2O	millimetre of mercury mm Hg	inch of mercury in Hg
1 in H_2O		0.0833	1.8683	0.0735
1 ft H_2O	12.000		22.4198	0.8827
1 mm H_2O	0.5352	0.0446		0.0394
1 in Hg	13.5951	1.1329	25.400	

1 in H_2O = 0.00248 bar

Torque (Moment of Force)

	newton metre Nm	kilogram-force metre kgf m	pound-force foot lbf ft	pound-force inch lbf in
1 Nm		0.1020	0.7376	8.8507
1 kgf m	9.8066		7.230	86.8507
1 lbf ft	1.3558	0.1382		12.000
1 lbf in	0.1130	0.0115	0.0833	

The kilogram is known as the kilopond (kp) in Germany. 1 kgf m = 1 kp m

Force (Mass x Acceleration)

	newton N	kilogram-force kgf	pound-force lbf	poundal pdl
1 newton		0.1019	0.2248	7.2230
1 kilogram-force	9.8066		2.2046	70.9316
1 pound-force	4.4482	0.4536		32.1740
1 poundal	0.1382	0.0141	0.0311	

The kilogram is known as the kilopond (kp) in Germany. 1 kgf m = 1 kp m
1 pdl = 1 lb ft/s²
1 N = 1 kg m/s²

Energy - Table 1

	kilowatt hour kWh	kilogram-force metre - kgf m	foot-pound force ft lbf	horsepower hour hp h
1 kWh		3.6709×10^{5}	2.6552×10^{6}	1.3410
1 kgf m	2.7240×10^{-6}		7.2330	3.6530×10^{-6}
1 ft lbf	3.7661×10^{-7}	0.1382		5.0505
1 hp h	0.7457	2.7373×10^{6}	1.98×10^{6}	

Energy - Table 2

	joule J	horsepower hour hp h	calorie cal	British thermal unit Btu
1 joule		3.7250×10^{-7}	0.2388	9.4781×10^{-4}
1 hp h	2.6846×10^{6}		641186	2544.43
1 cal	4.1868	1.5596×10^{-6}		3.9683×10^{-3}
1 Btu	1055.06	3.9301×10^{-4}	251.996	

Power - Table 1

	kilowatt kW	metric horsepower CV	brake horsepower bhp	British thermal unit per hour - Btu h
1 kW		1.3596	1.3410	3412.14
1 CV	0.7355		0.9863	2509.63
1 bhp	0.7457	1.0139		2544.43
1 Btu h	0.00029	3.9846×10^{-4}	3.9301×10^{-4}	

Power - Table 2

	watt W	kilo calorie per hour k cal/h	British thermal unit Btu
1 watt		0.08598	3.4121
1 k cal/h	1.1630		3.9683
1 Btu	0.2930	0.2519	

Specific Fuel Consumption

	pounds per horsepower hour lb/hp h	pounds per Cherval Vapeur hour lb/CV h	grams per kilowatt hour g/kW h	grams per Cheval Vapeur hour g/CV h
1 lb/hp h		0.9862	608.27	447.33
1 lb/CV h	1.0140		616.80	453.59
1 g/kW h	1.6440×10^{-3}	1.621×10^{-3}		0.7354
1 g/CV h	2.235×10^{-3}	2.205×10^{-3}	1.3600	

The Cheval Vapeur (CV) is also known as the metric horsepower (1CV = 1CH = 1PS)
1 lb = 453.592 grams

California Proposition 65 Warning
Diesel engine exhaust and some of its constituents are known to the State of California to cause cancer, birth defects, and other reproductive harm.

ALPHA SERIES ENGINE WORKSHOP MANUAL
P027-08240, EDITION 15, NOVEMBER 2017

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