

SERVICE MANUAL

GENERATOR
G125RS T4F, G70RS T4F

EN - 9823/4700 - ISSUE 1 - 06/2021

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Foreword

The Operator's Manual



You and others can be killed or seriously injured if you operate or maintain the machine without first studying the Operator's Manual. You must understand and follow the instructions in the Operator's Manual. If you do not understand anything, ask your employer or JCB dealer to explain it.

Do not operate the machine without an Operator's Manual, or if there is anything on the machine you do not understand.

Treat the Operator's Manual as part of the machine. Keep it clean and in good condition. Replace the Operator's Manual immediately if it is lost, damaged or becomes unreadable.

Contents

01 - Machine

06 - Body and Framework

15 - Engine

18 - Fuel and Exhaust System

21 - Cooling System

33 - Electrical System

72 - Fasteners and Fixings

75 - Consumable Products

78 - After Sales



Notes:



SERVICE MANUAL
Volume 1

G125RS T4F, G70RS T4F

EN 9823/4700



SERVICE MANUAL
Volume 2

G125RS T4F, G70RS T4F

EN 9823/4700



SERVICE MANUAL
Volume 3

G125RS T4F, G70RS T4F

EN 9823/4700



SERVICE MANUAL
Volume 4

G125RS T4F, G70RS T4F

EN 9823/4700



Notes:



01 - Machine

Contents	Page No.
Acronyms Glossary	01-2
01-03 Safety	
01-03-03 Safety - Yours and Others	01-3
01-03-06 Safety Warnings	01-4
01-03-09 General Safety	01-5
01-03-12 Maintenance Safety	01-6
01-03-18 Operating Safety	01-8
01-03-27 Maintenance Positions	01-10
01-06 About this Manual	
01-06-06 Using the Manual	01-13
01-09 Description	
01-09-00 General	01-15
01-09-12 Main Component Locations	01-16
01-33 Cleaning	
01-33-00 General	01-21



Acronyms Glossary

CCV	Crankcase Ventilation
DEF	Diesel Exhaust Fluid
ECU	Electronic Control Unit
EGR	Exhaust Gas Recirculation
PIL	Parts Identification List
SCR	Selective Catalytic Reduction



03 - Safety

Contents	Page No.
01-03-03 Safety - Yours and Others	01-3
01-03-06 Safety Warnings	01-4
01-03-09 General Safety	01-5
01-03-12 Maintenance Safety	01-6
01-03-18 Operating Safety	01-8
01-03-27 Maintenance Positions	01-10



Notes:

03 - Safety - Yours and Others

Introduction

All machinery can be hazardous. When a machine is correctly operated and maintained, it is a safe machine to work with. When it is carelessly operated or poorly maintained it can become a danger to you (the operator) and others.

In this manual and on the machine you will find warning messages, you must read and understand them. They inform you of potential hazards and how to avoid them. If you do not fully understand the warning messages, ask your employer or JCB dealer to explain them.

Safety is not just a matter of responding to the warnings. All the time you are working on or with the machine you must be thinking of what hazards there might be and how to avoid them.

Persons not familiar with the controls of the machine should not attempt to operate it.

Do not start any work until you are sure that you and those around you will be safe.

If you are not sure of anything, about the machine or the work, ask someone who knows. Do not assume anything.

Remember:

- Be careful
- Be alert
- Be safe.

06 - Safety Warnings

Introduction

In this manual there are safety notices. Each notice starts with a signal word. The signal word meanings are given below.

The signal word 'DANGER' indicates a hazardous situation which, if not avoided, will result in death or serious injury.

The signal word 'WARNING' indicates a hazardous situation which, if not avoided, could result in death or serious injury.

The signal word 'CAUTION' indicates a hazardous situation which, if not avoided, could result in minor or moderate injury.

The signal word 'Notice' indicates a hazardous situation which, if not avoided, could result in machine damage.

The safety alert system symbol (shown) also helps to identify important safety messages in this manual. When you see this symbol your safety is involved, carefully read the message that follows.

Figure 1. The safety alert system symbol



09 - General Safety

Introduction

The following safety checklist is intended to help remind you of safety procedures and practices.

Safety is Your Responsibility

You must also refer to local regulations in the country your equipment is being used in. Some of the information may be repeated in the following warnings and cautions pages and in the main text.

- Do not change the application or specification of the generator. Install the generator in accordance with recommendations made in the Operator Manual. – Do not lift heavy objects on your own, use lifting equipment or obtain the help of an assistant.
 - Do not smoke when adding fuel to the tank or working in the engine bay area.
 - Always clean up spilt fluids, dispose of fluids, contaminated material etc. in accordance with local regulations. Do not pollute drains or the ground. – Use the right tools for the job. – Always make the equipment safe before completing any maintenance tasks, for instance disconnect the battery so that the generator can not be started.
 - Allow generator components to cool before attempting any maintenance tasks, components such as the exhaust can become extremely hot.
 - Do not adjust the generator, or add fuel, oil or coolant whilst it is running unless procedures in this manual instruct you to do so.
 - Do not siphon fluids by mouth.
 - Operate the generator in well ventilated areas, if using indoors then a purpose designed exhaust fume extraction unit is needed. – Keep other people at a safe distance when operating the generator or equipment.
 - Do not operate a generator if any mechanical or electrical guards have been removed or overridden.
 - Vapours from solvents, thinners and adhesives can be high flammable. In addition to fire risk, they can be toxic and in certain conditions cause unconsciousness, or death if inhaled. Use these items in well ventilated areas.
 - Seek medical advice immediately if your skin contacts high pressure fuel.
 - Make sure the generator is operated by one person correctly positioned at the controls.
 - Make sure you have adequate fire fighting equipment in your workshop, repair area. Contact your local fire prevention officer for advice.
- Turbocharger impeller blades operate at extremely high revolutions and the turbocharger unit becomes very hot. Allow the unit to cool before completing any maintenance. Keep tools and objects away from the impeller when the unit is operating.
 - Use only JCB recommended parts. These parts have been designed to give the generator its optimum performance. Using spurious parts may affect the integrity of the generator.

12 - Maintenance Safety

Introduction

Communications

Bad communications can cause accidents. If two or more people are working on the machine, make sure each is aware of what the others are doing. Before starting the engine make sure the others are clear of the danger areas. Examples of danger areas are: the rotating blades and belt on the engine, the attachments and linkages, and anywhere beneath or behind the machine. People can be killed or injured if these precautions are not taken.

You must stop the machine operation, isolate the controls and turn off the engine when persons are required to interact with the machine.

Machine Modifications

This machine is manufactured in compliance with prevailing legislative requirements. It must not be altered in any way which could affect or invalidate its compliance. For advice consult your JCB dealer.

Repairs

If your machine does not function correctly in any way, get it repaired straight away. Neglect of necessary repairs could result in an accident or affect your health. Do not try to do repairs or any other type of maintenance work you do not understand. To avoid injury and/or damage get the work done by a specialist engineer.

'O' rings, Seals and Gaskets

Badly installed, damaged or rotted 'O' rings, seals and gaskets can cause leakages and possible accidents. Renew whenever disturbed unless otherwise instructed. Do not use Trichloroethane or paint thinners near 'O' rings and seals.

Hot Components

Touching hot surfaces can burn skin. The engine and machine components will be hot after the unit has been running. Allow the engine and components to cool before servicing the unit.

Chemicals

Certain seals and gaskets (e.g. crankshaft oil seal) on JCB machines contain fluoroelastomeric materials such as Viton®, Fluorel™ and Technoflon®. Fluoroelastomeric materials subjected to high temperatures can produce highly corrosive hydrofluoric acid. This acid can severely burn. New fluoroelastomeric components at ambient temperature require no special safety precautions. Used fluoroelastomeric components whose temperatures have not exceeded 300 °C (571.6 °F) require no special safety precautions. If evidence of decomposition (e.g. charring) is found, refer to the next paragraph for safety instructions. Do not touch component or surrounding area. Used fluoroelastomeric components subjected to temperatures greater than 300 °C (571.6 °F) (e.g. engine fire) must be treated using the following safety procedure. Make sure that heavy duty gloves and special safety glasses are worn: Thoroughly wash contaminated area with 10% calcium hydroxide or other suitable alkali solution, if necessary use wire wool to remove burnt remains. Thoroughly wash contaminated area with detergent and water. Contain all removed material, gloves etc. used in this operation in sealed plastic bags and dispose of in accordance with Local Authority Regulations. Do not burn fluoroelastomeric materials.

Oil

Oil is toxic. If you swallow any oil, do not induce vomiting, seek medical advice. Used engine oil contains harmful contaminants which can cause skin cancer. Do not handle used engine oil more than necessary. Always use barrier cream or wear gloves to prevent skin contact. Wash skin contaminated with oil thoroughly in warm soapy water. Do not use petrol, diesel fuel or paraffin to clean your skin.

Fuel

Fuel is flammable, keep naked flames away from the fuel system. Stop the engine immediately if a fuel leak is suspected. Do not smoke while refuelling or working on the fuel system. Do not refuel with the engine running. Completely wipe off any spilt fuel which could cause a fire. There could be a fire and injury if you do not follow these precautions.

Fires

If your machine is equipped with a fire extinguisher, make sure it is checked regularly. Keep it in the correct machine location until you need to use it.

Do not use water to put out a machine fire, you could spread an oil fire or get a shock from an electrical fire. Use carbon dioxide, dry chemical or foam extinguishers. Contact your nearest fire department as quickly as possible.



Metal Splinters

You can be injured by flying metal splinters when driving metal pins in or out. Use a soft faced hammer or copper drift to remove and install metal pins. Always wear personal protective equipment.

18 - Operating Safety

Introduction

Care and Alertness

All the time you are working with or on the machine, take care and stay alert. Always be careful. Always be alert for hazards.

Clothing

You can be injured if you do not wear the correct clothing. Loose clothing can get caught in the machinery. Keep cuffs fastened. Do not wear a necktie or scarf. Keep long hair restrained. Remove rings, watches and personal jewellery.

Lifting Equipment

You can be injured if you use incorrect or faulty lifting equipment. You must identify the weight of the item to be lifted then choose lifting equipment that is strong enough and suitable for the job. Make sure that lifting equipment is in good condition and complies with all local regulations.

Training

Make sure that you have had adequate training and that you are confident in your ability to operate the machine safely before you use it. Where applicable you may be required to show competency to a national certification scheme. Ensure you comply with local legislation and jobsite rules. With a careful, well trained and experienced operator, your machine is a safe and efficient machine. With an inexperienced or careless operator, it can be dangerous. Do not put your life, or the lives of others, at risk by using the machine irresponsibly. Before you start to work, tell your colleagues what you will be doing and where you will be working. On a busy site, use a signalman.

Before doing any job not covered in this manual, find out the correct procedure. Your local JCB distributor will be glad to advise you.

Fuel

Fuel is flammable, keep naked flames away from the fuel system. Stop the engine immediately if a fuel leak is suspected. Do not smoke while refuelling or working on the fuel system. Do not refuel with the engine running. Completely wipe off any spilt fuel which could cause a fire. There could be a fire and injury if you do not follow these precautions.

Communications

Bad communications can cause accidents. Keep people around you informed of what you will be doing. If you will be working with other people, make sure any hand signals that may be used are understood by everybody. Worksites can be noisy, do not rely on spoken commands.

You must stop the machine operation, isolate the controls and turn off the machine when persons are required to interact with it.

Machine Condition

A defective machine can injure you or others. Do not operate a machine which is defective or has missing parts. Make sure the maintenance procedures in this manual are completed before using the machine.

Machine Limits

Operating the machine beyond its design limits can damage the machine, it can also be dangerous. Do not operate the machine outside its limits. Do not try to upgrade the machine performance with unapproved modifications or additional equipment.

Exhaust Gases

Breathing the machine exhaust gases can harm and possibly kill you. At time of machine installation in a confined space a system ventilation risk assessment must be carried out by suitably qualified personnel. If deemed necessary a suitable local exhaust ventilation system must be installed and operated when the machine is being used.

Sparks

Explosions and fire can be caused by sparks from the exhaust or the electrical system. Do not use the machine in closed areas where there is flammable material, vapour or dust.

Hazardous Atmospheres

This machine is designed for use in normal outdoor atmospheric conditions. It must not be used in an enclosed area without adequate ventilation. Do not use the machine in a potentially explosive atmosphere, i.e. combustible vapours, gas or dust, without first consulting your JCB dealer.

Regulations

Obey all laws, worksite and local regulations which affect you and your machine.

Hot Components

Touching hot surfaces can burn skin. The engine and machine components will be hot after the unit has been running. Allow the engine and components to cool before servicing the unit.



Alcohol and Drugs

It is extremely dangerous to operate machinery when under the influence of alcohol or drugs. Do not consume alcoholic drinks or take drugs before or while operating the machine or attachments. Be aware of medicines which can cause drowsiness.

27 - Maintenance Positions

Introduction

It is necessary to lockout the energy sources that can cause injury to personnel. If you do not obey these instructions, there is a risk of injury.

All equipment must be locked out to prevent accidental or inadvertent operation because such operations can cause injury to personnel. Do not operate any locked switch, valve or other energy isolating device.

If more than one person is necessary to lock out equipment, each must place his/her own personal lock on the energy isolating device(s). One designated individual of a work crew or a supervisor, with the knowledge of the crew, may lock out equipment for the whole crew. In such cases, it may be the responsibility of the individual to carry out all steps of the lockout procedure and inform the crew when it is safe to work on the equipment. Additionally, the designated individual must not remove a crew lock until it has been verified that all individuals are clear.

Lockout/Tagout Procedure

1. Identify which switch, valve or other energy isolating devices to be locked out. There may be more than one energy source to be locked out.
2. Do a job authorization before lockout procedure.
3. Inform the responsible person that which device needs to be locked out and why.
4. If the equipment is in operation, use normal procedure and shut down the equipment.
5. Operate the switch, valve or other energy isolating devices to disconnect or isolate the energy sources from the equipment.
6. Lockout energy isolating devices with an assigned individual lock.

Figure 2.



7. Dissipate the stored energy from the capacitors, springs, elevated machine members, rotating flywheels, and air, gas, steam or water pressure with the methods such as grounding, repositioning, blocking, bleeding down.
8. Make sure that there is no one near the equipment. Operate the push button or the normal operating controls and check that the energy sources are disconnected and the equipment will not operate.
9. Make sure to return the operating controls to the neutral position after the test.
10. The equipment is now locked out.

Restore Equipment into Service

1. Make sure that there is no one in the equipment area.
2. When you have completed your work, sign off your job authorization to the responsible person.
3. Remove the lock which you have installed.
 - 3.1. Do not attempt to remove any other Lockout/tagout device installed by other persons.
4. If necessary, operate the energy isolating devices to restore energy to equipment.



06 - About this Manual

Contents	Page No.
01-06-06 Using the Manual	01-13

06 - Using the Manual

Introduction

Information in this manual conforms to a standard JCB service manual format. The format uses section headings taken from a PIL (Parts Identification

List). These headings are assigned numerical identification references.

Table 1.

Example	Section	Main Assembly / Heading	Component / Sub-heading
PIL reference	33	03	03
Heading	Electrical System	Battery	Isolator Switch

Information within each PIL reference is included under a set of standard headings such as Introduction, Health and Safety, Technical Data and Operation for example. Where additional relevant

information is contained within another PIL reference a cross reference is provided.

The main systems information is contained in the manual as follows.

Table 2.

System	PIL Reference	Heading
Electrical System	PIL 33-03-03	Battery - Isolator Switch
	PIL 33-09-00	Power Distribution (including fuses and relays)
	PIL 33-00-50	Schematic Circuit
Electronic Diagnostic	PIL 33-57-00	Electronic Diagnostic (including Servicemaster)

Machine Variants

Where information is different depending on machine variant, the applicable information sets are included within the same PIL reference. Headings are included to identify which information is for which variant. Make sure you use the correct information.

Diagnostics

Information in this manual can help you diagnose machine faults.

Before attempting to diagnose possible faults check the following.

- Make sure that the operator understands the machine controls, functions and use. Refer to the applicable Operator Manual.
- Check that the maintenance record complies with the applicable schedule for the operating environment.
- Check that the fluids in use comply with the standards specified.
- Make sure that the machine electronic set-up is applicable.
- Use the applicable diagnostics tools.
- Use applicable generator controller interface (Deif or DSE) diagnostics.

Torque Tightening

When you replace components, always tighten the applicable fixings to the correct torque value. Use the torque tightening values contained in the individual procedures (Remove and Install, Disassemble and Assemble etc.). If no torque values are specified, use the standard torque tightening values. For the torque setting to be effective, do the following before you install the fixings. Refer to PIL 72-00-00.

- Make sure that all the applicable component assemblies are correct.
- Make sure that the applicable fixings are to the correct specification. If necessary discard the original fixings and replace them with new ones. The relevant procedures indicate when this is necessary.
- Make sure that the applicable fixings and threaded holes are free from contamination. This includes dirt, debris, old sealants and compounds, fluids and lubricants.



09 - Description

Contents	Page No.
01-09-00 General	01-15
01-09-12 Main Component Locations	01-16



00 - General

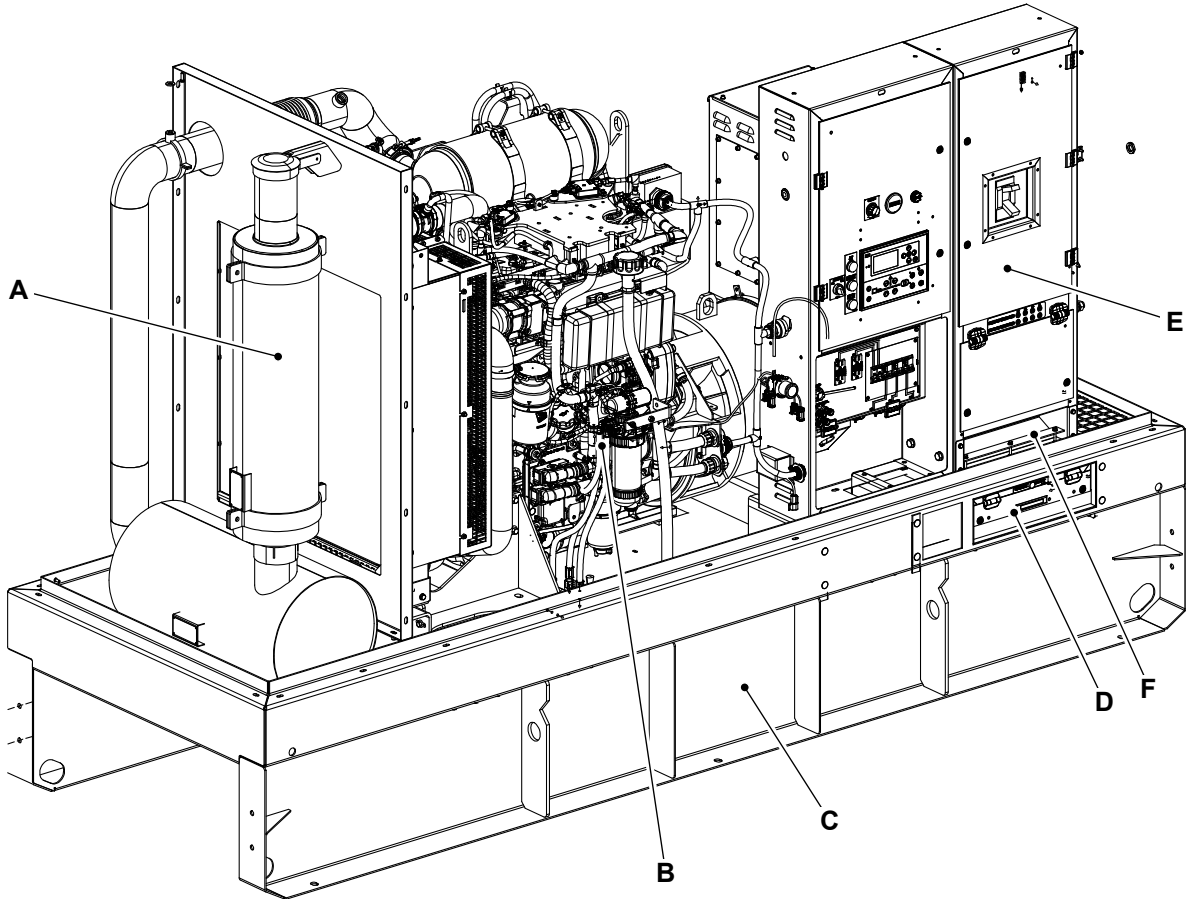
Technical Data

It is the responsibility of the installer to use correct size and type of cable to suit the application and conform to local regulations.

12 - Main Component Locations

Introduction

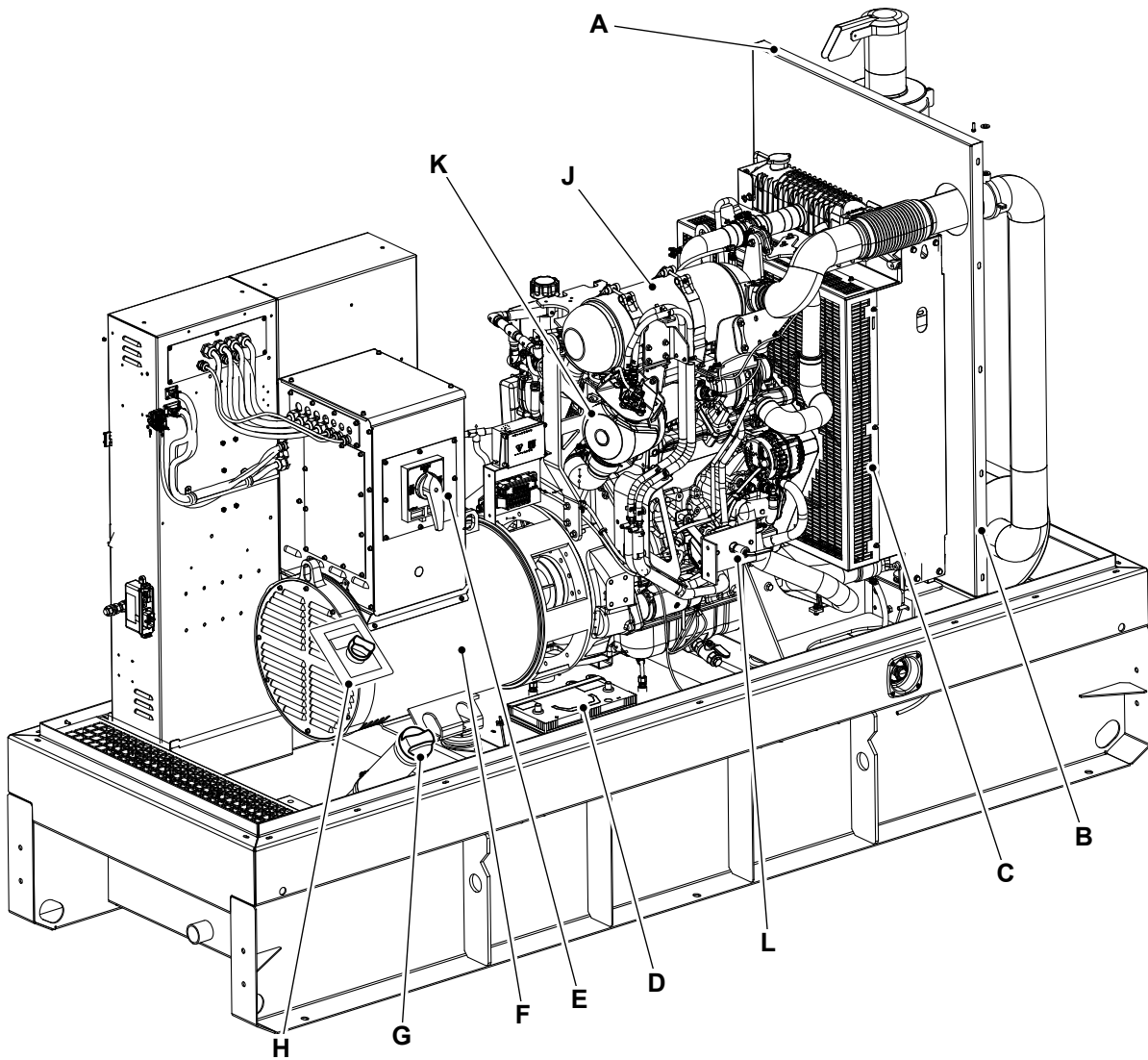
Figure 3.



- A** Exhaust system
- C** Skid
- E** Control panel access door

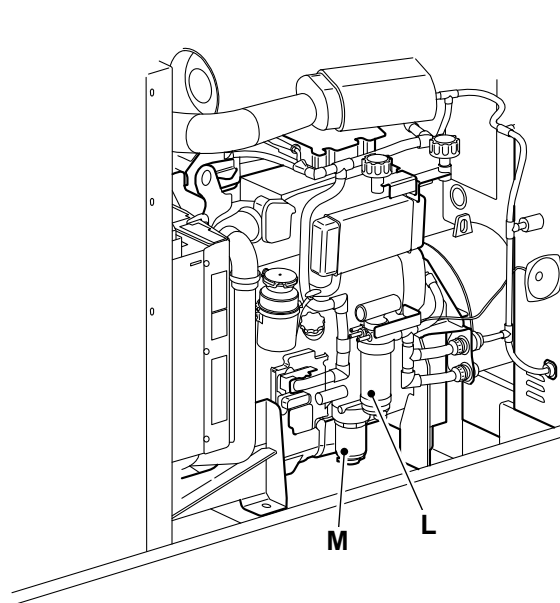
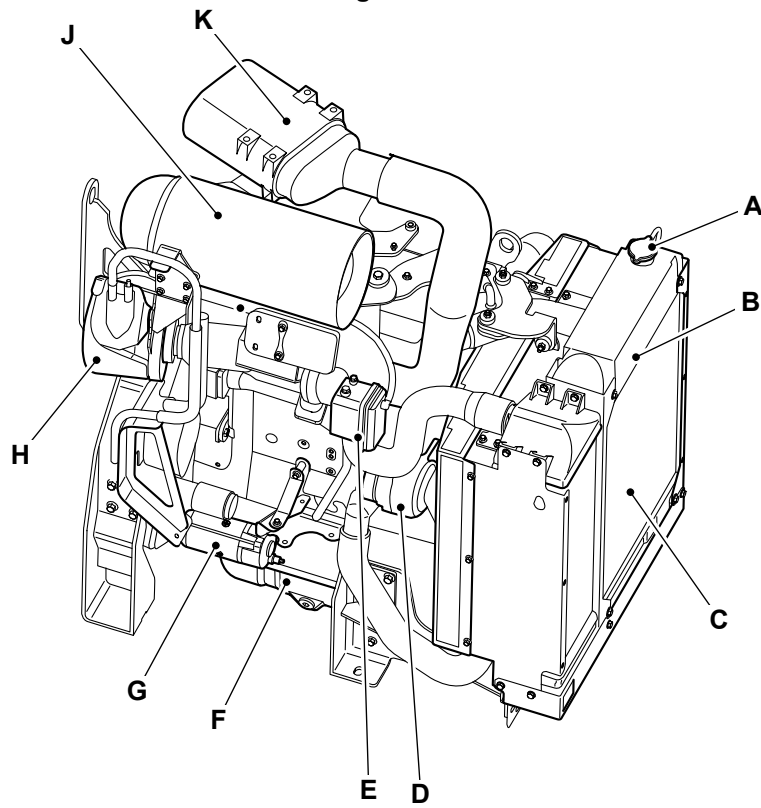
- B** Engine
- D** Camlock connections
- F** Power cables exit

Figure 4.



- | | |
|--|---|
| A Cooling filler access point | B Bulkhead |
| C Radiator | D Battery |
| E Voltage control rotary switch | F Alternator |
| G Fuel tank filler | H DEF (Diesel Exhaust Fluid) tank filler |
| J SCR (Selective Catalytic Reduction) | K Air filter |
| L Battery isolator | |

Figure 5.



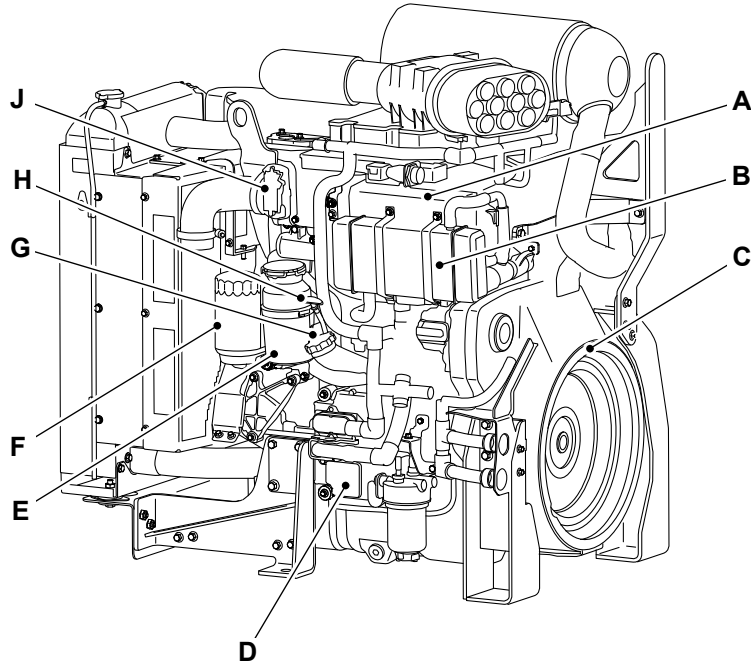
- A** Coolant filler
- C** Radiator
- E** Turbocharger
- G** Starter motor
- J** SCR

- B** Expansion tank
- D** Charge alternator
- F** Oil sump
- H** DEF injector
- K** Air filter

L Fuel filter - primary

M Fuel filter - secondary

Figure 6.



- A Inlet manifold
- C Flywheel housing
- E CCV (Crankcase Ventilation) filter
- G Engine oil filler
- J Throttle

- B EGR (Exhaust Gas Recirculation) cooler
- D ECU (Electronic Control Unit)
- F Engine oil filter
- H Engine dipstick



33 - Cleaning

Contents

Page No.

01-33-00 General	01-21
------------------------	-------

00 - General

Introduction	01-21
Preparation	01-23

Introduction

▲ WARNING When using cleaning agents, solvents or other chemicals, you must adhere to the manufacturer's instructions and safety precautions.

CAUTION To avoid burning, wear personal protective equipment when handling hot components. To protect your eyes, wear goggles when using a brush to clean components.

Notice: Cleaning metal parts with incorrect solvents can cause corrosion. Use only recommended cleaning agents and solvents.

Clean the product with water and/or steam. Do not let mud, debris etc. to collect on the product.

Before you do any service procedures that require components to be removed:

- The cleaning must be done either in the area of components to be removed, or in the case of major work, or work on the fuel system, the whole engine and the surrounding product must be cleaned.
- When cleaning is complete, move the product away from the wash area or alternatively, remove the material washed from the product.

When you remove components, be aware of exposure to dirt and debris. Cover any open ports and remove the deposits before proceeding.

Detergents

Do not use a full strength detergent. Always dilute the detergents as per the manufacturer's recommendations, or damage to the paint finish can occur.

Always obey the local regulations regarding the disposal of debris created from cleaning the product.

Use detergent to clean only non electrical components.

Exterior Cleaning

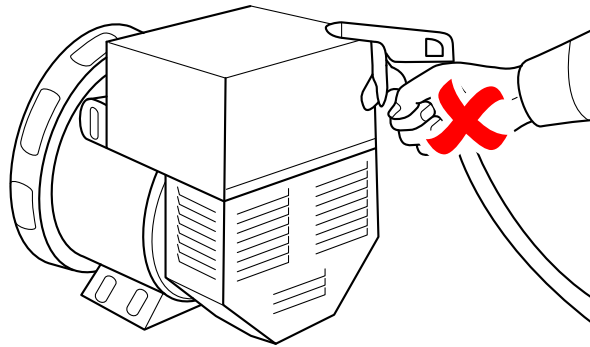
1. Stop the machine and allow it to cool for at least one hour. Do not attempt to clean any part of the machine while it is running.
2. Ensure all electrical loads are disconnected and the generator is made safe by disconnecting at the breaker, turning off the machine and activating the emergency stop switch.
3. Make sure that all electrical connectors are correctly coupled. If connectors are open install the correct caps or seal with waterproof tape.

4. Make sure that the oil filler caps and dipstick are correctly installed.
5. Apply an approved cleaning and degreasing agent with a brush. Obey the manufacturers instructions.
6. Wipe the outer body with a clean cloth.

Interior Cleaning

1. Make sure that the engine is switched off and the machine is fully isolated and locked off.
2. Prior to approaching or touching the alternator, ensure that it is not live and it is at room temperature; at this stage it is possible to clean it on the outside using compressed air.

Figure 7.



Never use liquids or water. Do not clean the electrical components inside with compressed air, because this could cause short circuits or other faults occurring.

Preparation

1. Stop the machine and allow it to cool for at least one hour. Do not attempt to clean any part of the machine while it is running.
2. Ensure all electrical loads are disconnected and the generator is made safe by disconnecting at the breaker, turning off the machine and activating the emergency stop switch.
3. Make sure that all electrical connectors are correctly coupled. If connectors are open, install the correct caps or seal with waterproof tape.
4. Make sure that the oil filler caps and dipstick are correctly installed.
5. Apply an approved cleaning and degreasing agent with a brush. Obey the manufacturers instructions.
6. Wipe the outer body with a clean cloth.
7. Make sure that the machine is fully dry before operating. If necessary, use an external blower or heater.



Notes:



06 - Body and Framework

Contents	Page No.
06-00 Body and Framework	
06-00-00 General	06-3
06-06 Moveable Panel and Cover	
06-06-00 General	06-5
06-06-18 Door Lock	06-10
06-63 Identification Label	
06-63-00 General	06-13
06-63-03 Machine	06-14
06-63-06 Engine	06-15



Notes:



00 - Body and Framework

Contents

Page No.

06-00-00 General 06-3



Notes:

00 - General

Check (Condition)

▲ WARNING Breathing the machine exhaust gases can harm and possibly kill you. At time of machine installation in a confined space a system ventilation risk assessment must be carried out by suitably qualified personnel. If deemed necessary a suitable local exhaust ventilation system must be installed and operated when the machine is being used.

CAUTION The exhaust pipe becomes extremely hot when the engine is running and will remain so for some time after the engine is stopped. If you touch the hot pipe you could be severely burned.

1. Obey all electrical system health and safety information.
[Refer to: PIL 33-00-00.](#)
2. Visually inspect the exterior of the machine for dirt, damage and cracks.
3. Clean the machine.
[Refer to: PIL 01-33-00.](#)
4. Check the condition of all access doors, hinges and locks.
5. Check the condition of the engine, cooling pack and alternator mounting bolts. If necessary, tighten all the fasteners to the correct torque value as required.
 - 5.1. Make a note that loose mounting bolts can cause severe vibrations and may damage the machine internal parts.
6. If installed, visually inspect the external socket pack for indications of damage.
7. During operation, be alert for mechanical problems that can create unsafe or hazardous conditions.
8. Examine the external surfaces for damage at specified intervals.
[Refer to: PIL 78-24-00.](#)
9. Clean the external surfaces to remove any dirt.
10. Check the condition of the door seals for damage. If necessary, replace the seals.
11. Check the door handles and locks for correct operation.
12. Make sure that there is no debris in the air inlet and outlets. Make sure that no objects are placed against them.
13. Check the condition of the full exhaust system with the exhaust manifold, muffler, and exhaust pipe with the generator set in operating condition.
 - 13.1. Check the condition of the exhaust system at specified intervals for leaks and damage.
[Refer to: PIL 78-24-06.](#)
 - 13.2. Check the condition of all the connections, welds, gaskets and joints for leaks.
 - 13.3. If there are any leaks, shutdown the generator and correct any leaks immediately.
 - 13.4. Check that the exhaust pipe exit is free from blockage and clear of debris.
 - 13.5. Make sure that no material or debris has come in contact with the exhaust system.
14. Check the operation of the control panel.
15. Check the condition of the power cables.
 - 15.1. Make sure that no power cable terminals are loose. Tighten the terminal bolts to the correct torque value. Refer to Table 3.
16. Check and record the controller event logs.
17. Check the condition of the bus bar terminals for tightness.
18. Check the condition of the generator set earth connections for tightness.
19. Check the condition of the battery connections for tightness.
20. Check the condition of the battery.
[Refer to: PIL 33-03-00.](#)
21. Check the condition of the engine, alternator and the control panel mountings for tightness.
22. Check the condition of the engine and controller harness for tightness.
23. Check all equipotential bonds for condition and tightness.
[Refer to: PIL 72.](#)

Table 3. Torque Values

Item	Description	Nm
A	M10 at control panel	44
A	M12 at alternator terminal block	42



06 - Moveable Panel and Cover

Contents	Page No.
06-06-00 General	06-5
06-06-18 Door Lock	06-10



00 - General

Introduction	06-5
Component Identification	06-6
Remove and Install	06-8

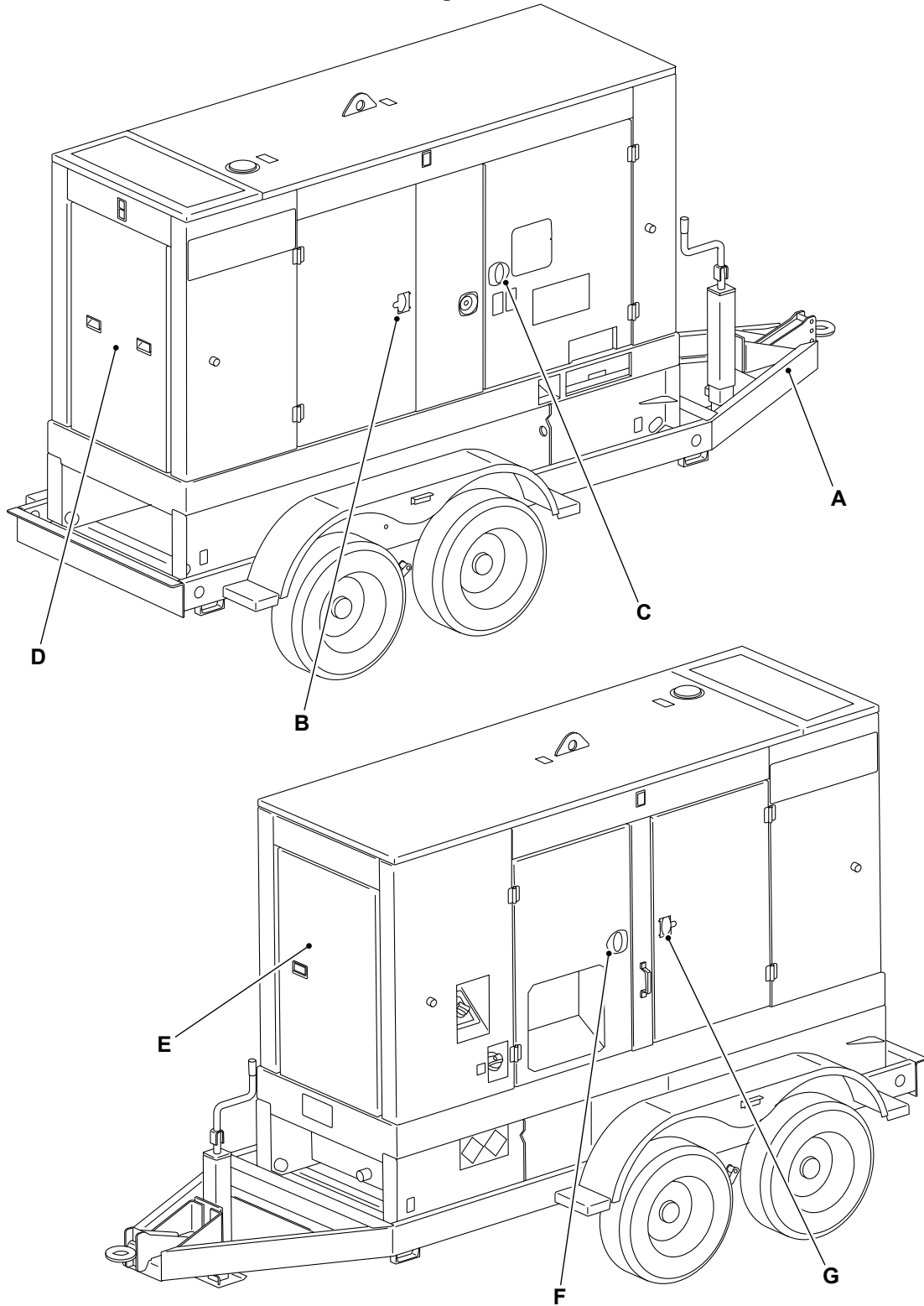
Introduction

Access panels provide easy access to the machine major components test and service points and other parts which require routine testing, servicing, adjusting, replacement or repair.

Before you operate the machine, make sure that all of the access panels are in their operation position and secure.

Component Identification

Figure 8.



A Trailer

B Right rear door



C Right front door
E Front door
G Left rear door

D Rear door
F Left front door

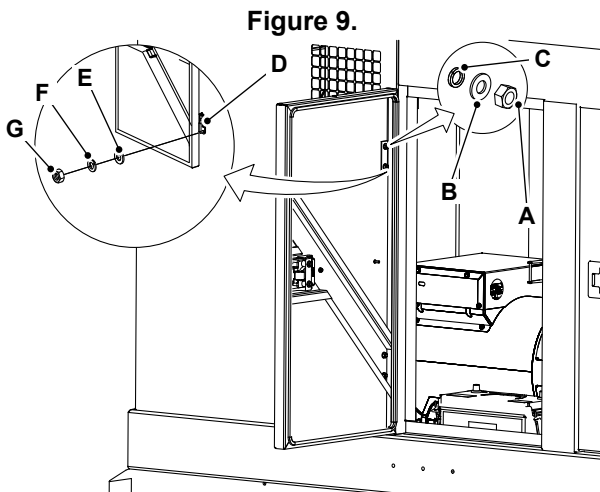
Remove and Install

▲ CAUTION This component is heavy. It must only be removed or handled using a suitable lifting method and device.

The following procedure is for the front left door. The procedure for the remaining doors is similar.

Remove

1. Make the machine safe.
Refer to: [PIL 01-03](#).
2. Disconnect the earth cable from the door.
3. Open the door.
4. Support the door with suitable lifting equipment.
5. Remove the spring washer 1 (x4), plain washer 1 (x4) and nut 1 (x4) from the hinge (x2) that attaches the door to the canopy.
6. Move the door away from the machine.
7. Remove the spring washer 2 (x4), plain washer 2 (x4) and nut 2 (x4) that attaches the hinge (x2) to the door.
8. Remove the hinge (x2) from the door.



- A Nut 1 (x6)
- B Plain washer 1 (x6)
- C Spring washer 1 (x6)
- D Hinge (x3)
- E Plain washer 2 (x6)
- F Spring washer 2 (x6)
- G Nut 2 (x6)

Install

1. The installation procedure is the opposite of the removal procedure. Additionally do the following steps.
2. Make sure that the generator is positioned on a flat level surface.
3. Make sure that the doors are straight and not damaged.
4. Check the hinges for tightness.
5. Make sure that the doors are closed and adjustments are made to the hinges to have an equal/parallel gap around the door.
6. Use the Go/No-go gauge and check the gap tolerance of all four service access doors. Make sure that the tolerance is within specified value.
Distance: $8 \pm 2\text{mm}$
7. Secure the door lock.
8. Use a hose with a complete spray head and spray water towards the top edge of the doors

Figure 10.



Figure 11.



from the specified angle. Make sure that you do not spray water directly at the door gaps and locks.

Angle: 30°

Figure 12.



18 - Door Lock

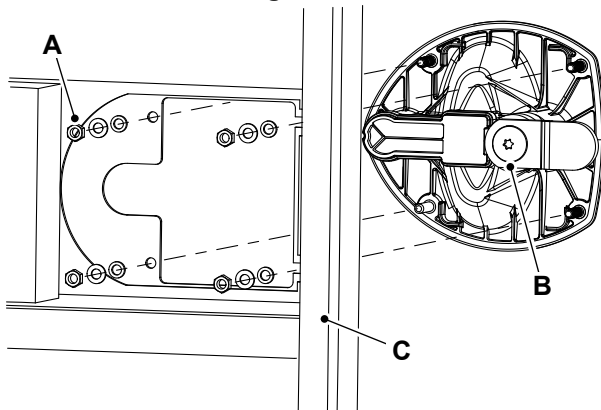
Remove and Install

The following procedure is for the rear left door lock.
The procedure for the remaining door locks is similar.

Remove

1. Make the machine safe.
[Refer to: PIL 01-03.](#)
2. Open the door.
3. Hold the door lock and remove the nuts (x4) and washers that attach the door lock.
4. Remove the door lock from the door.

Figure 13.



- A** Nuts (x4)
- B** Door lock
- C** Door

Install

1. The installation procedure is the opposite of the removal procedure. Additionally do the following step.
2. Tighten the fasteners to the correct torque value.



63 - Identification Label

Contents	Page No.
06-63-00 General	06-13
06-63-03 Machine	06-14
06-63-06 Engine	06-15



00 - General

Introduction

The machine has identification plates that contain important information relating to the specific machine details, for example VIN or PIN number and engine serial number. These serial numbers can help you identify exactly what equipment has been installed on the machine.

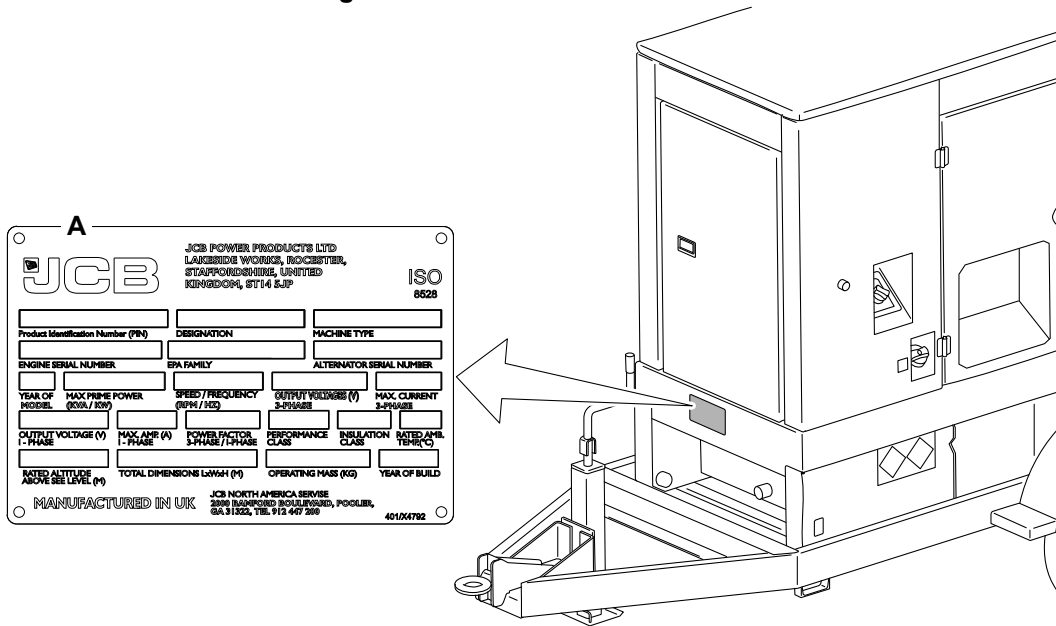
03 - Machine

Introduction

The data plate details the model designation, rating, weight, year of manufacture, output rating and other generating set specific information. The data plate and service plate are located in the control panel compartment. Refer to Figure 14.

The identification plate may vary by region due to the legislative requirements.

Figure 14. Identification Plate



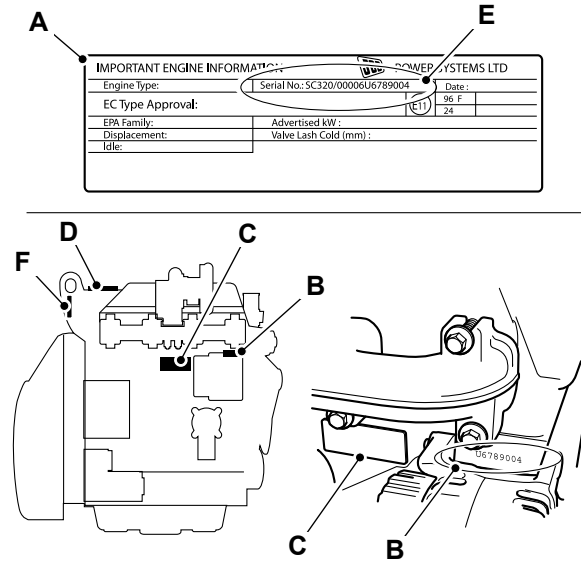
A Data plate

06 - Engine

Introduction

The engine data labels are attached on the cylinder block and rocker cover (if installed) as shown. Refer to Figure 15.

Figure 15.



A Engine data label

C Engine data label - cylinder block

E Engine identification number

B Stamp - cylinder block

D Engine data label - rocker cover

F Injector codes label - rocker cover

The data label includes the engine identification number.

Table 4. Example of the engine identification number

	SJ	320/40001	U	00001	04
Digit	1-2	3-10	11	12-16	17-18

Table 5.

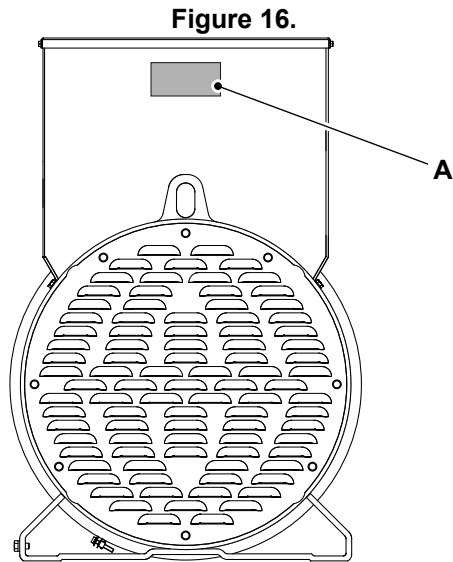
Digit 1-2	Engine Type
SJ	4.4L turbocharged and aftercooled electronic common rail fuel injection (Tier 4F) > 55kW
DJ	4.8L turbocharged and aftercooled electronic common rail fuel injection (Tier 4F) > 55kW

Table 6. Explanation of the engine identification number

Digit	Explanation
3-10	Engine part number
11	Country of manufacture. U = United Kingdom

Digit	Explanation
12-16	Engine serial number
17-18	Year of manufacture

An emission label is located on the alternator as shown. Refer to Figure 16.



A Emission label



15 - Engine

Contents	Page No.
Acronyms Glossary	15-3
15-00 Engine	
15-00-00 General	15-3
15-03 Crankcase	
15-03-00 General	15-43
15-03-06 Jet	15-45
15-06 Cylinder Head	
15-06-00 General	15-53
15-09 Bedplate	
15-09-00 General	15-61
15-12 Crankshaft	
15-12-00 General	15-65
15-12-03 Main Bearing	15-75
15-12-06 Front Oil Seal	15-77
15-12-09 Rear Oil Seal	15-80
15-12-12 Pulley	15-84
15-15 Camshaft	
15-15-00 General	15-87
15-18 Engine Belt	
15-18-00 General	15-95
15-18-03 Front End Accessory Drive (FEAD) Belt	15-98
15-18-21 Tensioner	15-102
15-21 Oil Filter	
15-21-00 General	15-105
15-24 Air Filter	
15-24-00 General	15-113
15-24-09 Dust Valve	15-116
15-27 Crankcase Ventilation Filter	
15-27-00 General	15-119
15-30 Valve	
15-30-00 General	15-123
15-30-12 Valve Spring	15-132
15-30-24 Stem Seal	15-133
15-33 Connecting Rod	
15-33-00 General	15-135
15-33-06 Big-End Bearing	15-139
15-36 Piston	
15-36-00 General	15-145
15-42 Rocker and Fittings	
15-42-00 General	15-157
15-42-06 Rocker Cover	15-168
15-42-21 Tappet	15-169
15-42-24 Tappet Cover	15-171



15-45 Oil Sump	
15-45-00 General	15-173
15-51 Timing Gear	
15-51-00 General	15-179
15-51-03 Crankshaft Gear	15-182
15-51-06 Camshaft Gear	15-185
15-51-09 Fuel Injection Pump Gear	15-186
15-51-15 Heavy Duty PTO Gear	15-189
15-51-22 Rear Case	15-192
15-54 Flywheel	
15-54-00 General	15-197
15-54-03 Housing	15-201
15-54-09 Gear Ring	15-205
15-60 Oil Pump	
15-60-00 General	15-207
15-63 Mount	
15-63-00 General	15-213
15-69 Oil Cooler	
15-69-00 General	15-217
15-72 Alternator	
15-72-00 General	15-223
15-72-03 Pulley	15-229
15-72-06 Voltage Regulator	15-230
15-75 Starter Motor	
15-75-00 General	15-233
15-75-03 Solenoid	15-240
15-75-06 Brush Gear	15-241
15-84 Sensor	
15-84-00 General	15-243
15-84-03 Crankshaft Position	15-254
15-84-06 Camshaft Position	15-258
15-84-09 Knock	15-262
15-84-14 Exhaust Manifold Temperature	15-265
15-84-16 Exhaust Manifold Pressure	15-267
15-84-17 Temperature and Manifold Air Pressure (TMAP)	15-270
15-84-18 Temperature and Mass Air Flow (TMAF)	15-273
15-84-19 Exhaust Temperature	15-276
15-84-24 Fuel Temperature	15-279
15-84-27 Fuel Rail Pressure	15-282
15-84-33 Coolant Temperature	15-284
15-84-42 Engine Oil Temperature	15-287
15-84-43 Engine Oil Level	15-290
15-84-48 Intercooler Outlet Temperature	15-293
15-87 Switch	
15-87-00 General	15-297
15-87-03 Engine Oil Pressure	15-298



Acronyms Glossary

CCV	Crankcase Ventilation
DC	Direct Current
DCU	Dosing Control Unit
DEF	Diesel Exhaust Fluid
DTC	Diagnostic Trouble Code
DTI	Dial Test Indicator
ECM	Engine Control Module
ECU	Electronic Control Unit
EGR	Exhaust Gas Recirculation
ESOS	Engine Shut-Off Solenoid
FEAD	Front End Accessory Drive
HPV	High Pressure Valve
IMV	Inlet Metering Valve
PTO	Power Take-Off
RPM	Revolutions Per Minute
SCR	Selective Catalytic Reduction
TDC	Top Dead Centre
TMAF	Temperature and Mass Air Flow
TMAP	Temperature Manifold Absolute Pressure
VGT	Variable Geometry Turbocharger



Notes:



00 - Engine

Contents

Page No.

15-00-00 General 15-3

00 - General

Introduction	15-3
Health and Safety	15-7
Technical Data	15-8
Component Identification	15-10
Operation	15-15
Fault-Finding	15-19
Drain and Fill	15-29
Clean	15-29
Check (Pressure)	15-31
Remove and Install	15-34
Store and Recommission	15-38

Introduction

This section contains information about the complete engine assembly. For specific engine technical information refer to the technical data section.

Make sure that the correct engine service tools, consumables and torque figures are used when you perform service procedures.

Renewal of oil seals, gaskets, etc., and any component showing obvious signs of wear or damage is expected as a matter of course.

It is expected that components will be cleaned and lubricated where appropriate, and that any opened hose or pipe connections will be blanked to prevent excessive loss of engine oil and ingress of dirt.

Basic Description

The JCB ecoMax engine is a 4 cylinder diesel engine in which the fuel is ignited by compression ignition. The engine operates on a four stroke cycle.

The engine is started by an electric starter motor. The starter motor turns the engine via a pinion and teeth on the engine flywheel. [Refer to: PIL 15-75.](#)

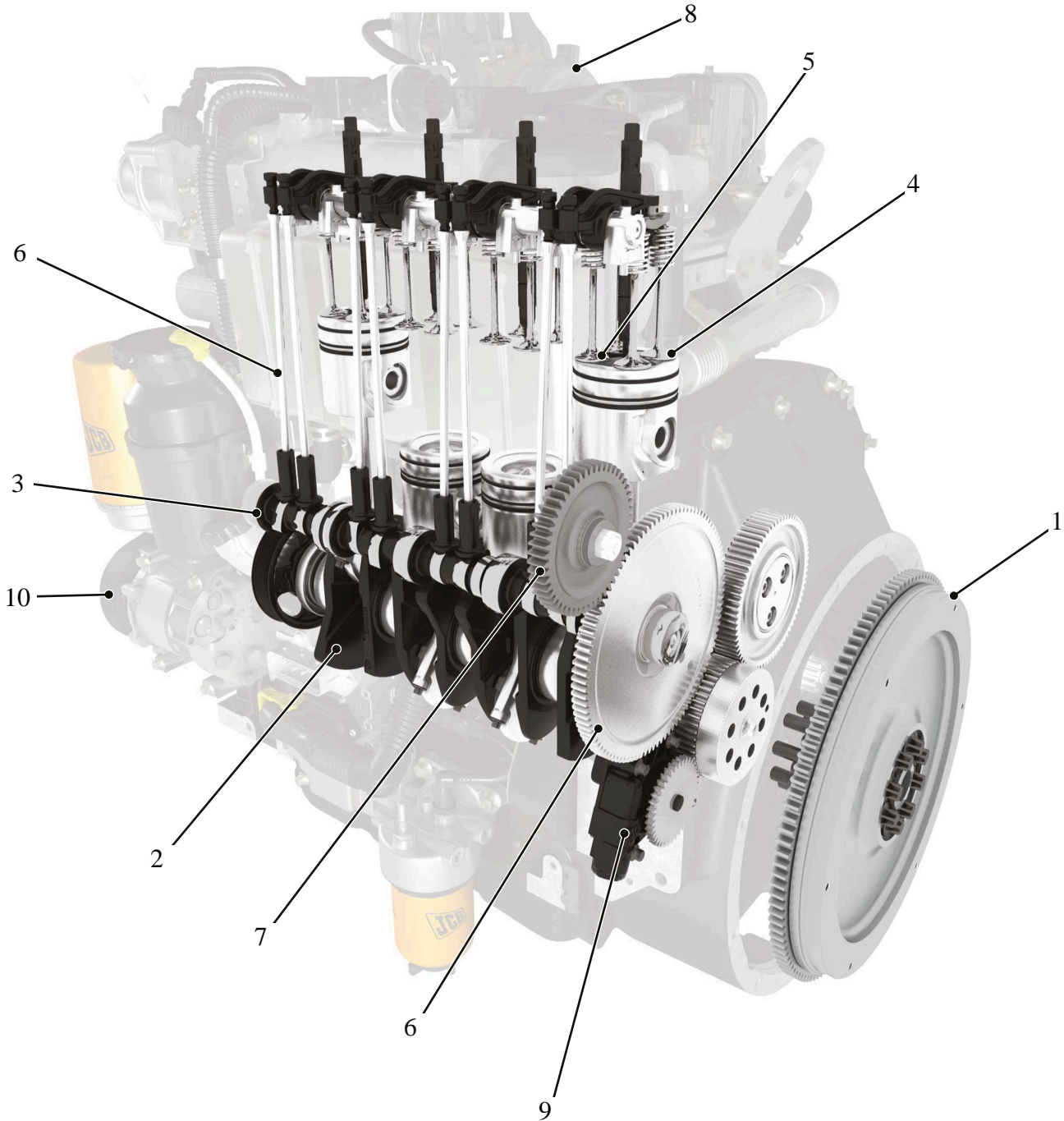
When the engine runs the crankshaft drives the camshaft via gears. The camshaft opens and closes the inlet and exhaust valves and via push rods in time with the four stroke cycle. The engine has 16 valves, 2 inlet and 2 exhaust valves for each cylinder.

The crankshaft also drives a high pressure fuel pump via gears. The pump is part of the electronically controlled common rail fuel injection system. [Refer to: PIL 18-00.](#)

Air is drawn into the engine, via the inlet manifold and exhaust gases exit via the exhaust manifold. The engine uses a VGT (Variable Geometry Turbocharger) which pressurises the air at the inlet manifold. Refer to PIL 18-36.

A mechanical lubrication oil pump is driven by the crankshaft via gears. The pump pressurises and circulates oil for engine lubrication and cooling purposes.

A drive belt driven by the crankshaft, drives ancillaries such as coolant circulation pump, alternator and radiator cooling fan.

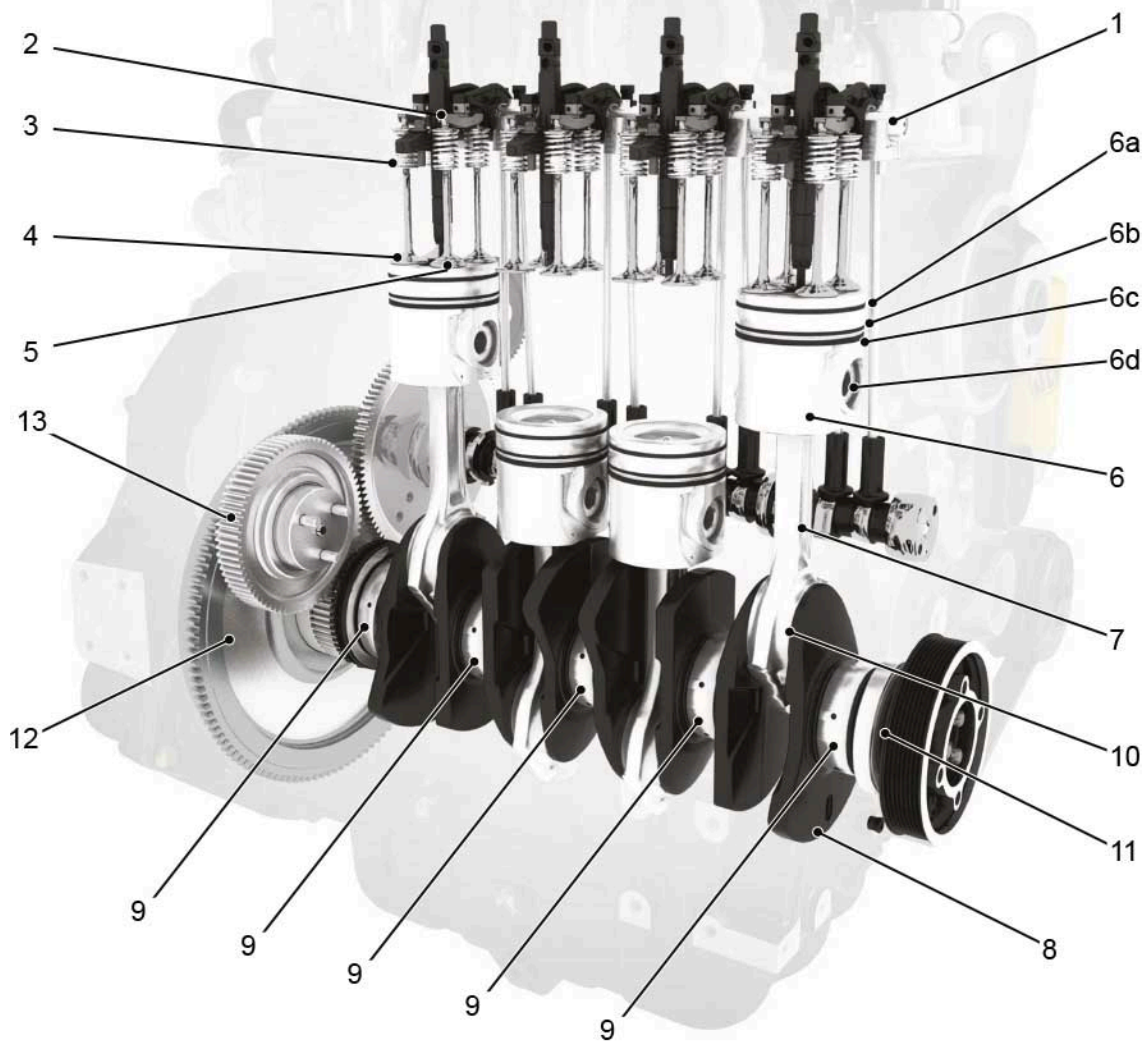
Figure 17.


- 1 Flywheel
- 3 Camshaft
- 5 Exhaust valves (x8)
- 7 High pressure fuel pump drive gear
- 9 Lubrication oil pump

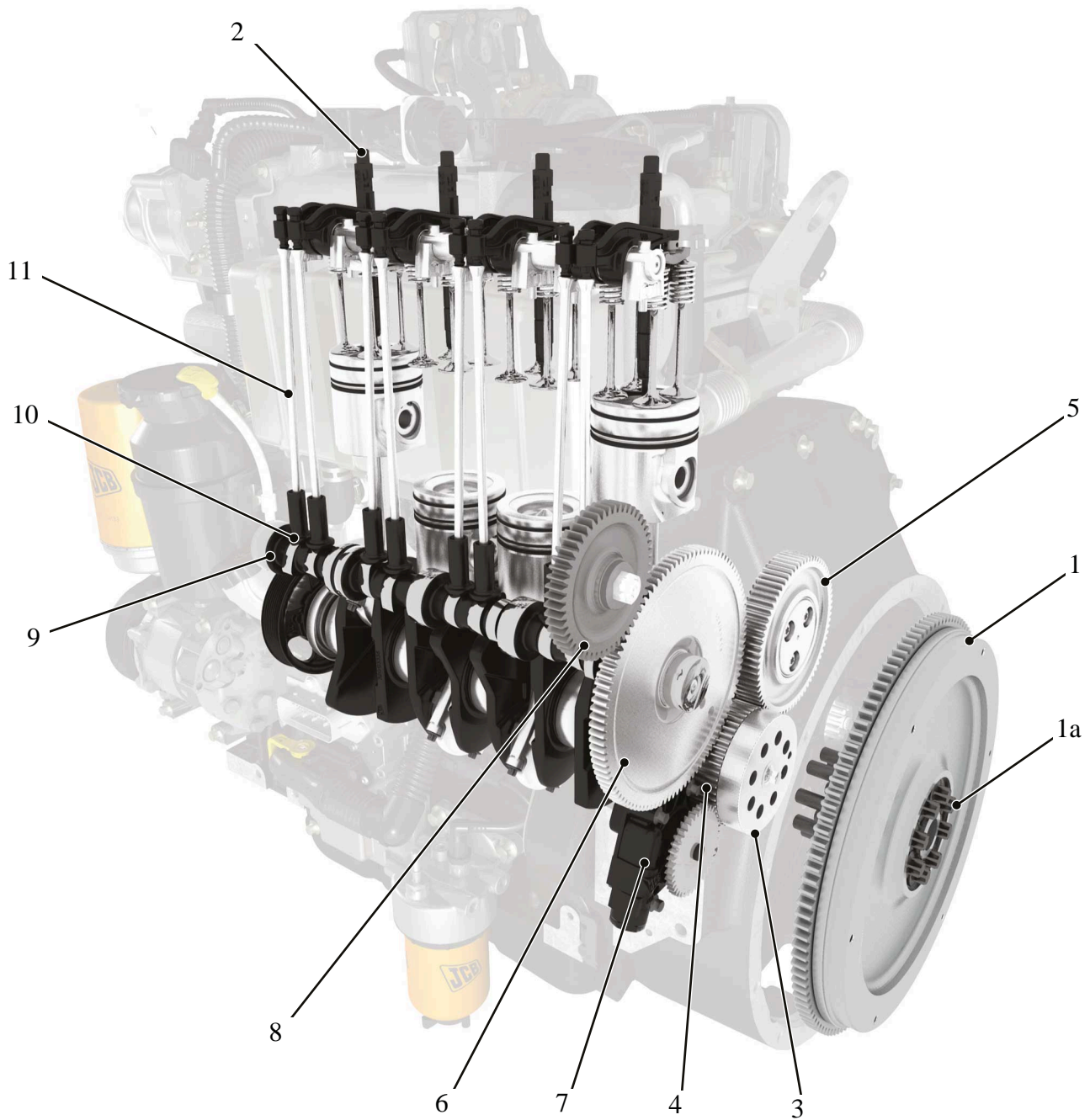
- 2 Crankshaft
- 4 Inlet valves (x8)
- 6 Push rods (x8)
- 8 Turbocharger
- 10 Front end drive belt

Internal

The following identifies the main internal components of a typical engine assembly. Some variants may differ in detail.

Figure 18.


- | | | | |
|-----------|--|-----------|--|
| 1 | Rocker assembly | 2 | Valve bridge piece (x8) |
| 3 | Valve spring (x16) | 4 | Inlet valve (x8) |
| 5 | Exhaust valve (x8) | 6 | Piston assembly (x4) |
| 6a | Piston ring - top compression (x4) | 6b | Piston ring - 2nd compression (x4) |
| 6c | Piston ring - oil control (x4) | 6d | Gudgeon pin (x4) |
| 7 | Connecting rod assembly (x4) | 8 | Crankshaft |
| 9 | Main bearing - crankshaft (x5) | 10 | Big end bearing - crankshaft / connecting rod (x4) |
| 11 | Front crankshaft oil seal | 12 | Flywheel |
| 13 | High duty PTO (Power Take-Off) idler gear (if installed) | | |

Figure 19.


- 1 Flywheel
- 2 Fuel injector (atomiser) (x4)
- 4 Crankshaft drive gear
- 6 Camshaft drive gear
- 8 High pressure fuel pump drive gear
- 10 Tappet (x8)

- 1A Flywheel - crankshaft fixing bolts (x8)
- 3 Flywheel hub
- 5 High duty PTO idler gear (if installed)
- 7 Lubrication oil pump
- 9 Camshaft
- 11 Push rod (x8)

Health and Safety

accordance with local regulations. Use authorised waste disposal sites.

Hot Components

Touching hot surfaces can burn skin. The engine and machine components will be hot after the unit has been running. Allow the engine and components to cool before servicing the unit.

Turning the Engine

Do not try to turn the engine by pulling the fan or fan belt. This could cause injury or premature component failure.

Notice: *The engine and other components could be damaged by high pressure washing systems. Special precautions must be taken if the machine is to be washed using a high pressure system. Make sure that the alternator, starter motor and any other electrical components are shielded and not directly cleaned by the high pressure cleaning system. Do not aim the water jet directly at bearings, oil seals or the engine air induction system.*

WARNING! *To bleed the injectors you must turn the engine. When the engine is turning, there are parts rotating in the engine compartment. Before starting this job make sure that you have no loose clothing (cuffs, ties etc) which could get caught in rotating parts. When the engine is turning, keep clear of rotating parts.*

Notice: *Clean the engine before you start engine maintenance. Obey the correct procedures. Contamination of the fuel system will cause damage and possible failure of the engine.*

Notice: *Do not exceed the maximum level of engine oil in the sump. If the maximum is exceeded, the excess must be drained to the correct level. An excess of engine oil could cause the engine speed to increase rapidly without control.*

WARNING! *The engine has exposed rotating parts. Switch off the engine before working in the engine compartment. Do not use the machine with the engine cover open.*

WARNING! *Hot oil and engine components can burn you. Make sure the engine is cool before doing this job. Used engine crankcase lubricants contain harmful contaminants. In laboratory tests it was shown that used engine oils can cause skin cancer.*

Notice: *A drive belt that is loose can cause damage to itself and/or other engine parts.*

WARNING! *Do not open the high pressure fuel system with the engine running. Engine operation causes high fuel pressure. High pressure fuel spray can cause serious injury or death.*

CAUTION! *It is illegal to pollute drains, sewers or the ground. Clean up all spilt fluids and/or lubricants. Used fluids and/or lubricants, filters and contaminated materials must be disposed of in*

Technical Data

For: JCB Tier 4F Engine 4 Cyl
 Page 15-8
 For: G70RS [HXN] Page 15-9
 For: G125RS [HXN] Page 15-9

(For: JCB Tier 4F Engine 4 Cyl)

Table 7.

Description	SJ Engine	DJ Engine
Engine Variants	Turbocharged with intercooler and exhaust after treatment system	Turbocharged with intercooler and exhaust after treatment system
Emission compliance	US-EPA Tier 4 Final, EU Stage IV	US-EPA Tier 4 Final, EU Stage IV
Rated speed	2200 rpm	2200 rpm (108kW), 2050 rpm (129kW)
Weight (Dry)	(Dry weight-No cooling fan drive) 496kg	(Dry weight-No cooling fan drive) 496kg
Number of cylinders	4	4
Nominal bore size	103mm	106mm
Stroke	132mm	135mm
Cylinder arrangement	In line	In line
Combustion Cycle	4-stroke	4-stroke
Firing order	1-3-4-2	1-3-4-2
Displacement	4.399L	4.765L
Compression ratio	16.7: 1	16.7: 1
Engine Compression	Compression variance between each cylinder should be no greater than 3.5bar (50.7psi)	Compression variance between each cylinder should be no greater than 3.5bar (50.7psi)
Direction of rotation (viewed from front {crankshaft pulley} end)	Clockwise	Clockwise
Valves	4 per cylinder	4 per cylinder
Valve clearances measured at the tappet end of the rockers (measured cold)		
- Inlet	0.15–0.21mm	0.15–0.21mm
- Exhaust	0.43–0.49mm	0.43–0.49mm
Lubricating oil pressure (Dependent on engine temperature and speed)	1.6–6.5bar (23.2–94.2psi)	1.6–6.5bar (23.2–94.2psi)
Fuel filter type	Screw-on canister (with drain facility)	Screw-on canister (with drain facility)
Oil pressure relief valve setting	6bar (87.0psi)	6bar (87.0psi)
Oil pressure switch setting	0.6bar (8.7psi) falling	0.6bar (8.7psi) falling
Oil pump ⁽¹⁾	Integral unit with relief valve	Integral unit with relief valve
Combustion system	Common rail direct Injection	Common rail direct Injection
High pressure fuel pump	High pressure with electronically controlled fuel metering	High pressure with electronically controlled fuel metering

(1) The oil pump is a non-serviceable part

(For: G70RS [HXN])

Table 8.

Manufacturer and Model	JCB 444 T4F SJ
Fuel	Diesel
Injection	Direct
Aspiration	Turbocharged
Cylinders	4
Cooling	Water
Governor	Electronic
After treatment	SCR (Selective Catalytic Reduction)
Fuel consumption @ 75% PRP	3.99 g/h
Fuel autonomy	33h
DEF (Diesel Exhaust Fluid) consumption @75% PRP	0.119 g/h
DEF autonomy	38h

(For: G125RS [HXN])

Table 9.

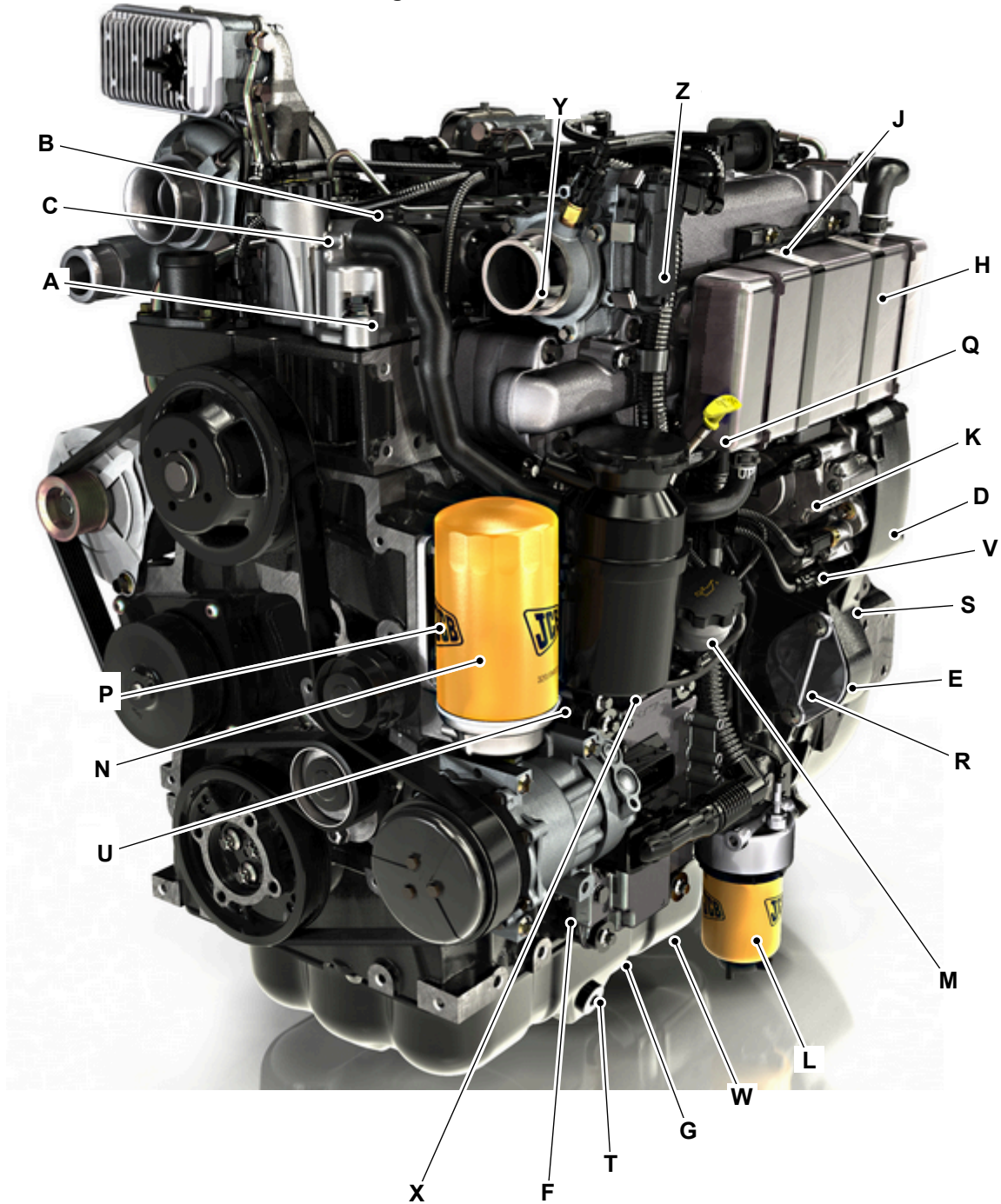
Manufacturer and Model	JCB 448 T4F DJ
Fuel	Diesel
Injection	Direct
Aspiration	Turbocharged
Cylinders	4
Cooling	Water
Governor	Electronic
After treatment	SCR
Fuel consumption @ 75% PRP	5.47 g/h
Fuel autonomy	24h
DEF consumption @75% PRP	0.164 g/h
DEF autonomy	28h

Component Identification

External

The following identifies the main components of a typical engine assembly visible from the exterior. Some variants may differ in detail.

Figure 20. Left hand Side



A Rocker cover
C Lubrication oil filler cap

B Fuel injectors and high pressure fuel pipes
D Timing gear case

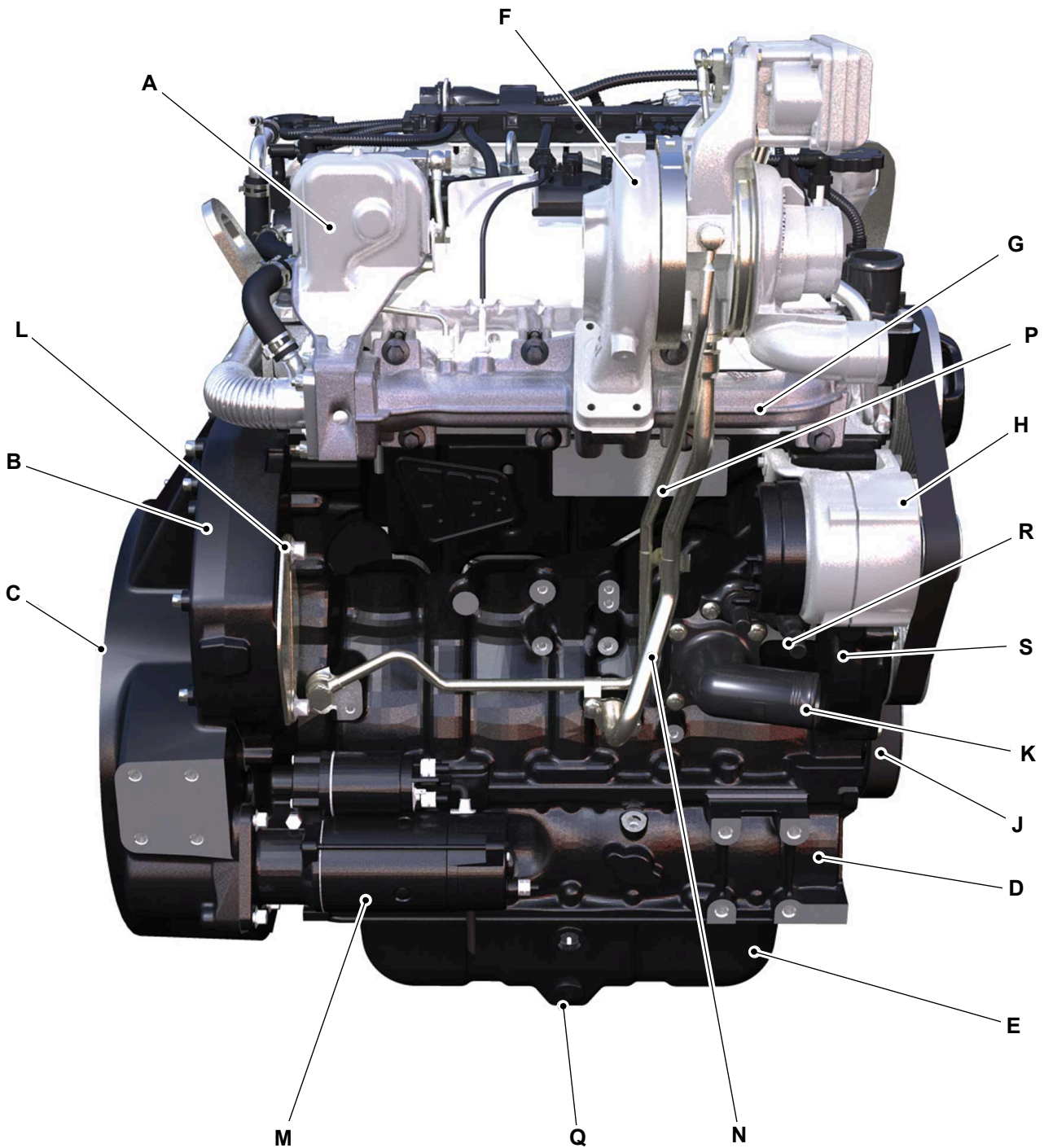


15 - Engine

00 - Engine

00 - General

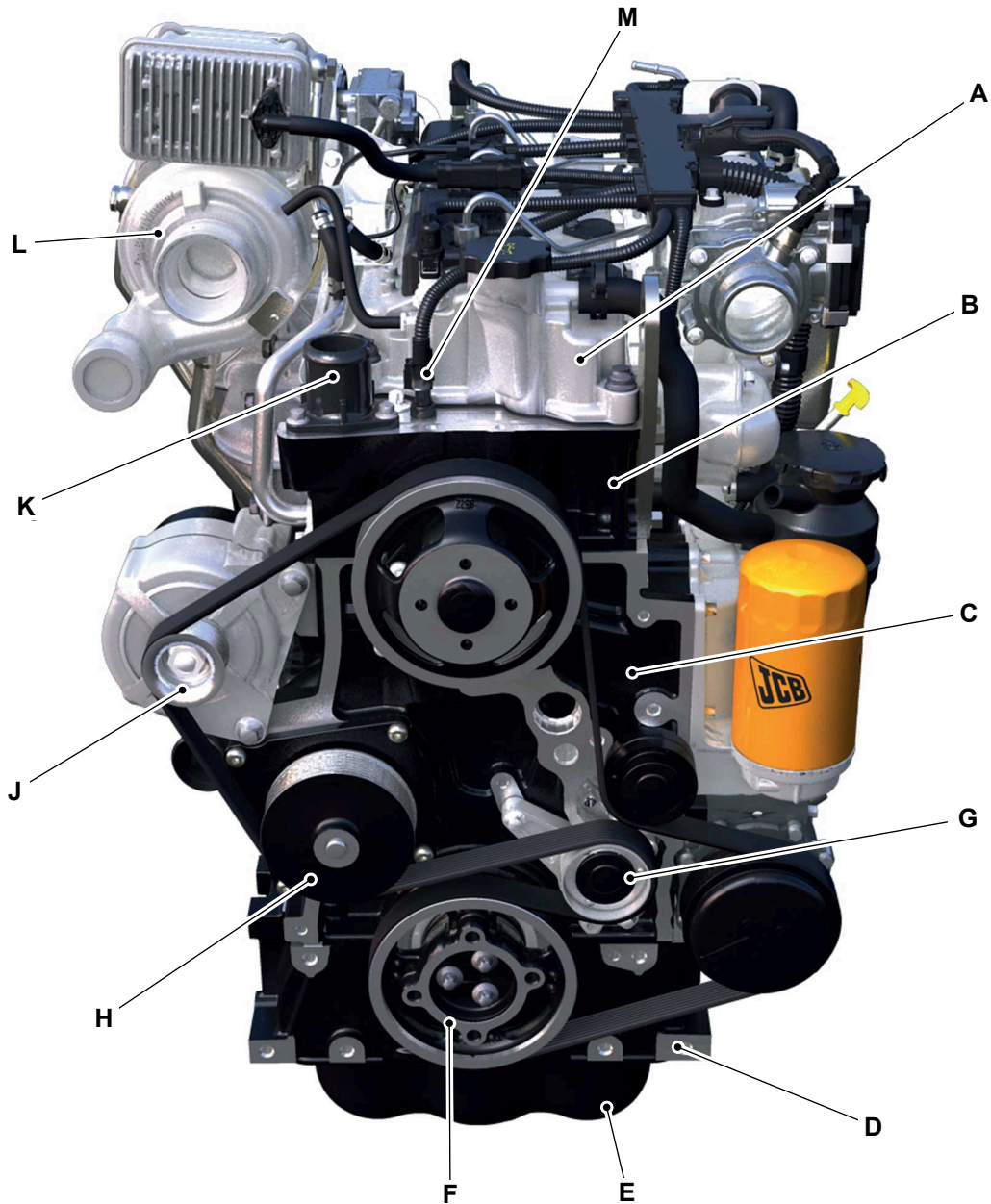
- | | |
|---|---|
| E Flywheel housing | F Bedplate |
| G Lubrication oil sump | H EGR (Exhaust Gas Recirculation) cooler |
| J Air inlet manifold | K High pressure fuel pump |
| L Fuel filter | M Lubrication oil filler cap |
| N Lubrication oil filter | P Lubrication oil cooler housing |
| Q Lubrication oil dipstick | R Low duty PTO (Power Take-Off) (blanking cover if no device is installed) |
| S Low pressure fuel line (to tank) | T Oil drain plug (sump) |
| U Oil filter housing drain plug | V IMV (Inlet Metering Valve) |
| W ECM (Engine Control Module) | X Crankcase ventilation filter assembly |
| Y Inlet manifold induction heater (if installed) | Z Intake throttle |

Figure 21. Right Hand Side


- A** EGR valve heatshield
- C** Flywheel housing
- E** Lubrication oil sump
- G** Exhaust manifold
- J** Coolant pump housing (crankcase)
- L** Heavy duty PTO (blanking cover if no device is installed)
- N** Turbocharger oil drain pipe
- Q** Oil drain plug (sump)

- B** Timing gear case
- D** Bedplate
- F** VGT (Variable Geometry Turbocharger)
- H** Alternator
- K** Coolant inlet/radiator hose connector
- M** Starter motor assembly
- P** Turbocharger oil feed pipe
- R** Coolant take off for cab heater

S Coolant take off for SCR (Selective Catalytic Reduction) system

Figure 22. Front End

A Rocker cover

C Crankcase

E Lubrication oil sump

G FEAD (Front End Accessory Drive) tensioner

J Alternator and drive pulley assembly

L VGT

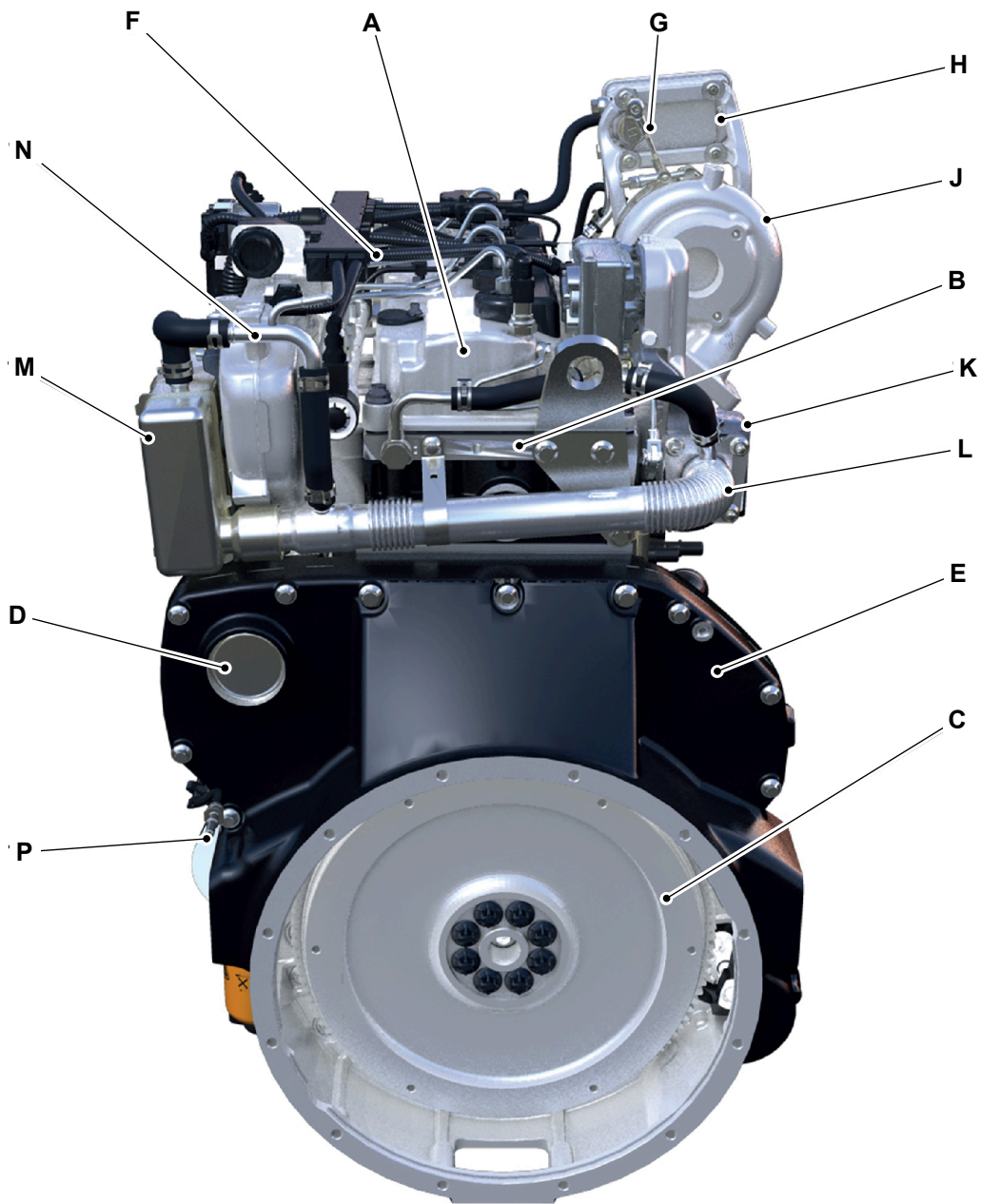
B Cylinder head

D Bedplate

F Crankshaft pulley

H Coolant pump and drive pulley assembly

M Coolant temperature sensor

Figure 23. Rear End


- A Rocker cover
- C Flywheel
- E Flywheel housing
- G VGT linkage
- J Turbocharger
- L EGR co-axial cooler
- N EGR water cooler pipe

- B Cylinder head
- D High pressure fuel pump drive gear cover
- F Engine electrical harness
- H VGT actuator
- K EGR valve
- M EGR plate cooler
- P Low pressure return pipe to tank

Operation

The Four Stroke Cycle - 4 Cylinder Engine

This section describes the cycle sequence, for the 4 cylinder engine.

With the crankshaft positioned as shown, the pistons in numbers 1 and 4 cylinders are at top dead centre and pistons in numbers 2 and 3 cylinders are at bottom dead centre.

It is important to note that number 1 cylinder is firing and about to start its power stroke. Rotating the crankshaft a further full rotation would position the pistons as described but the engine would be at a different stage in its four stroke cycle, with number 1 cylinder about to start its Induction stroke.

The stages in the four stroke cycle for each cylinder are as follows:

Table 10. The Four Stroke Cycle

Stage number	Piston operation	Valve operation
1	The piston is at the top of its Compression stroke and is about to start its Power stroke.	Inlet and exhaust valves closed
2	The piston is at the bottom of its Power stroke and is about to start its Exhaust stroke.	Inlet valves closed, exhaust valves about to open
3	The piston is at the bottom of its Induction stroke and is about to start its Compression stroke.	Exhaust valves closed, inlet valves about to close
4	The piston is at the top of its Exhaust stroke and is about to start its Induction stroke.	Valve Operation Exhaust valves about to close, inlet valves about to open

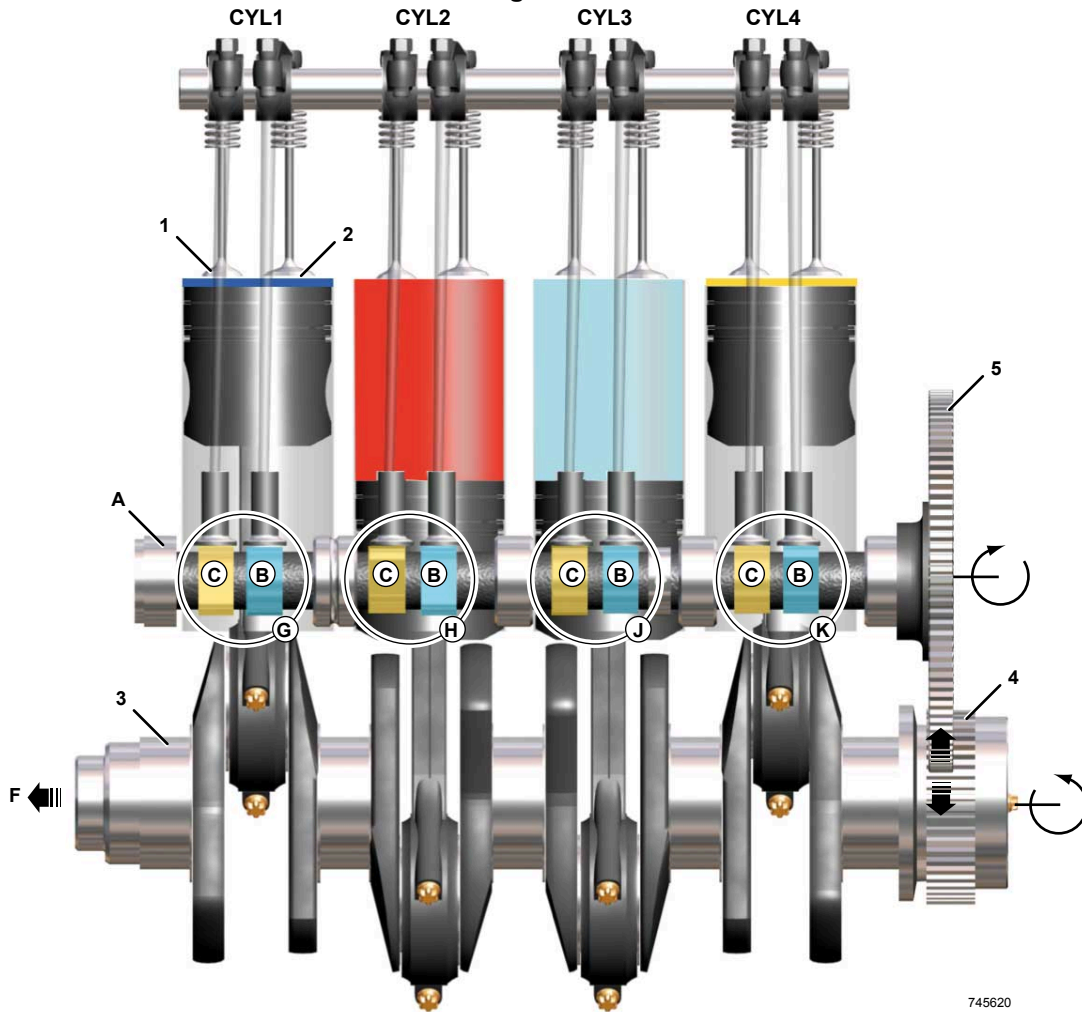
Firing Order

A cylinder is said to be firing, when the fuel / air mixture ignites and the piston is about to start its power stroke.

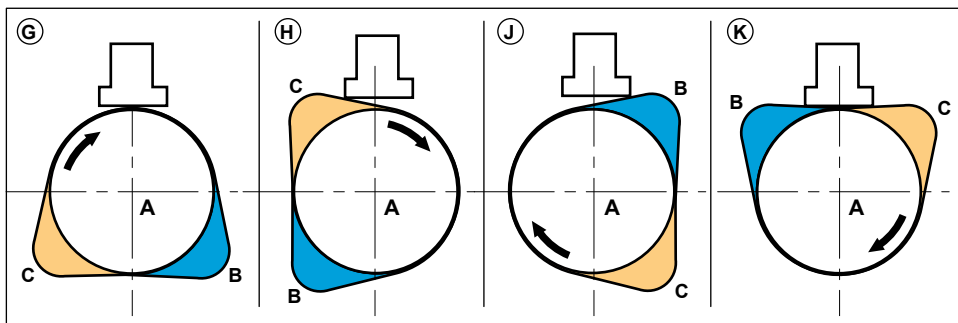
From the stages described, it can be seen that number 1 cylinder will be next to fire. Number 3 cylinder is starting its compression stroke and is next in the cycle, followed by cylinders 4 and 2.

The firing order is therefore; 1, 3, 4, 2.

Figure 24.



745620



- CYL1** Cylinder number 1
- CYL2** Cylinder number 2
- CYL3** Cylinder number 3
- A** Camshaft
- B** Camshaft lobe - Inlet valve operation
- C** Camshaft lobe - Exhaust valve operation
- 1** Exhaust valves
- 2** Inlet valves
- 3** Crankshaft
- 4** Crankshaft gear
- 5** Camshaft drive gear

- CYL4** Cylinder number 4
- F** Front of engine

Four Stroke Cycle

Induction

As the piston travels down the cylinder, it draws filtered air through inlet valves into the cylinder.

Compression

When the piston reaches the bottom of its stroke the inlet valves close. The piston then starts to rise up the cylinder compressing the air trapped in the cylinder. This causes the temperature and pressure of the air to rise. Fuel is injected into the cylinder when the piston is near to TDC (Top Dead Centre).

Power

The piston continues to rise after the start of fuel injection causing a further increase in pressure and temperature.

The temperature rises to a point at which the fuel/air mixture ignites. A cylinder is said to be firing, when the fuel/air mixture ignites.

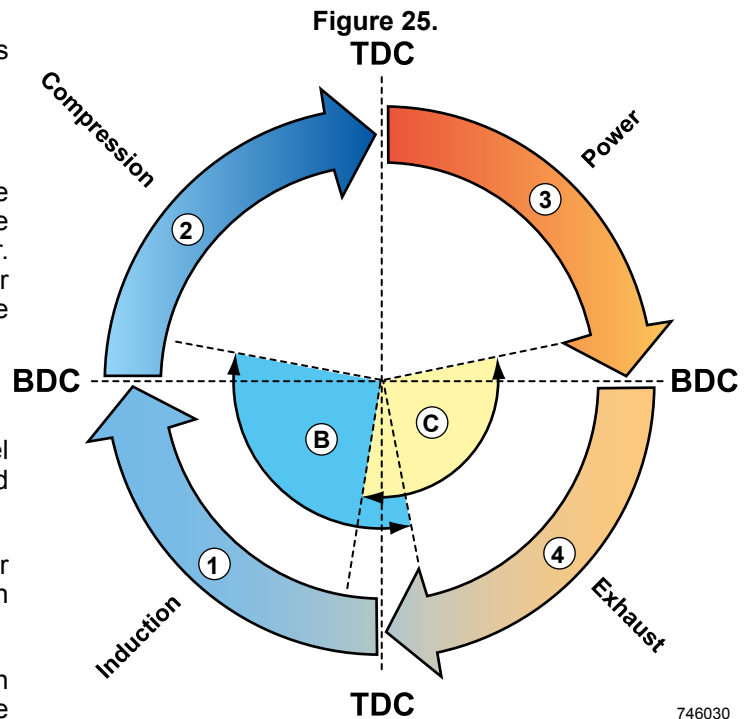
This combustion causes a very rapid rise in both temperature and pressure. The high pressure generated propels the piston downward turning the crankshaft and producing work.

Exhaust

Once the piston has reached the bottom of its travel, the exhaust valves open and momentum stored in the flywheel forces the piston up the cylinder expelling the exhaust gases.

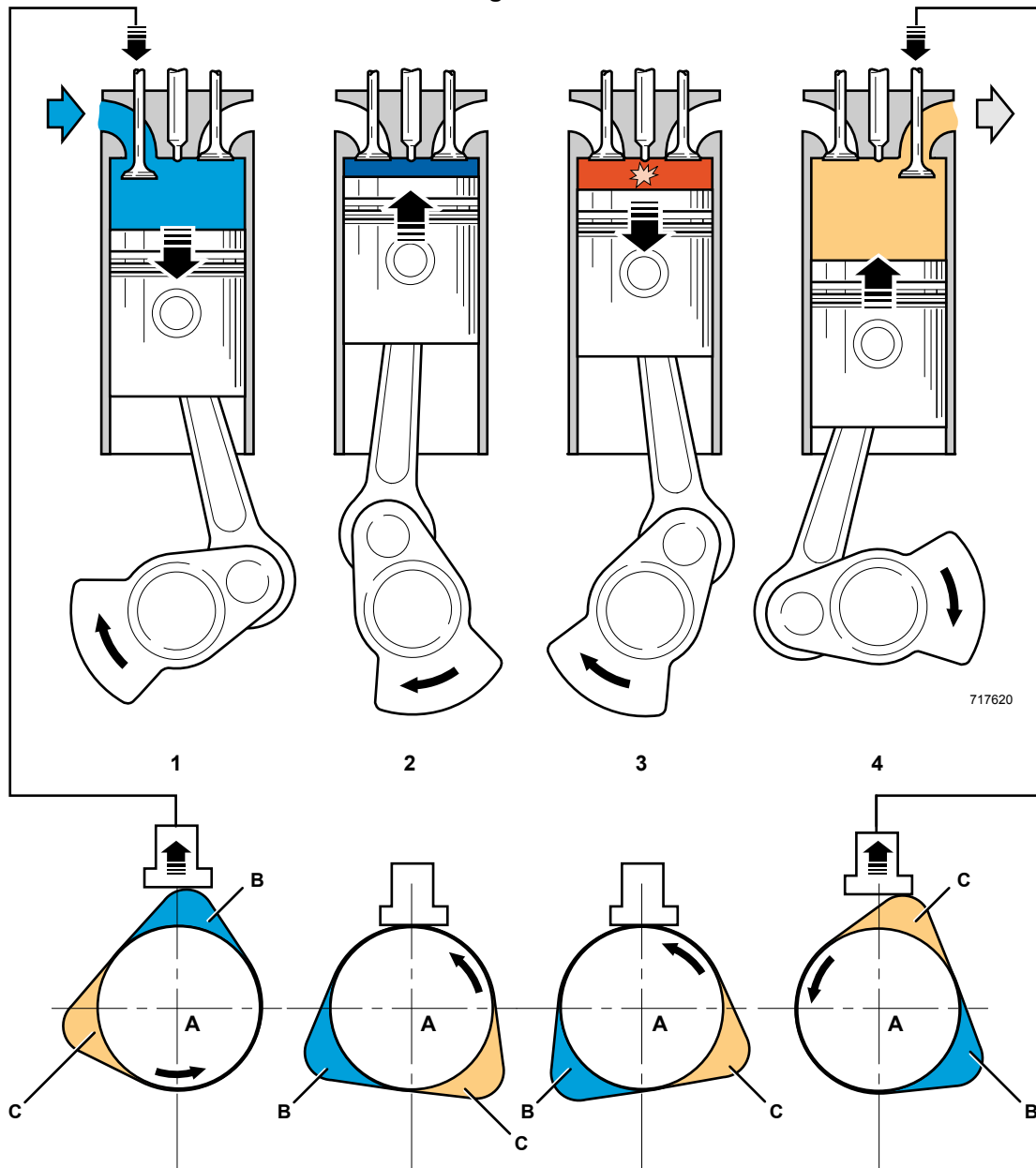
In a running engine these four phases are continuously repeated. Each stroke is half a

revolution of the crankshaft, thus, in one cycle of a four stroke engine, the crankshaft revolves twice.



- 1 Induction stroke
- 2 Compression stroke
- 3 Power stroke
- 4 Exhaust stroke
- A Camshaft
- B Camshaft lobe - Inlet valve operation
- C Camshaft lobe - Exhaust valve operation
- BDC Bottom dead centre
- TDC TDC

Figure 26.



717620

1 Induction stroke

3 Power stroke

A Camshaft

C Camshaft lobe - Exhaust valve operation

2 Compression stroke

4 Exhaust stroke

B Camshaft lobe - Inlet valve operation

Fault-Finding

Fault

Engine - Will Not Start or Difficult to Start	Table 11.	Page 15-19
Engine-Will Not Start or Difficult to Start	Table 12.	Page 15-20
Engine-Will Not Crank or Cranks Slowly	Table 13.	Page 15-20
Engine-Starts then Stops	Table 14.	Page 15-21
Engine-Poor Running	Table 15.	Page 15-21
Engine-Poor Running at Idle	Table 16.	Page 15-22
Engine-Compression Knocks	Table 17.	Page 15-22
Engine-Reduced Power Output	Table 18.	Page 15-22
Engine-Vibration Excessive	Table 19.	Page 15-23
Engine-Exhaust Smoke Excessive (Black Smoke)	Table 20.	Page 15-24
Engine-Exhaust Smoke Excessive (White/Blue Smoke)	Table 21.	Page 15-24
Engine-Will Not Shut Off	Table 22.	Page 15-24
Fuel-Consumption Excessive	Table 23.	Page 15-25
Fuel/Oil-Leaking from Exhaust Manifold	Table 24.	Page 15-25
Lubricating Oil-Consumption Excessive	Table 25.	Page 15-25
Lubricating Oil-Contaminated	Table 26.	Page 15-26
Lubricating Oil-Pressure Low	Table 27.	Page 15-26
Lubricating Oil-Pressure High	Table 28.	Page 15-26
Coolant-Loss	Table 29.	Page 15-26
Coolant-Over Temperature	Table 30.	Page 15-27
Coolant-Under Temperature	Table 31.	Page 15-27
Coolant-Contaminated	Table 32.	Page 15-28

Table 11. Engine - Will Not Start or Difficult to Start

Cause	Remedy
No fuel in supply tank.	Check the level in the fuel tank, use sight gauge or dipstick. Replenish as required.
Starter switch or starter electrical system failure.	Check the operation of the starter switch. Check the correct electrical wires for open or short circuits.
Improper starting procedure.	Verify proper starting procedure.
Fuel filter blocked with water or other contamination.	Drain fuel/water separator or replace fuel filter.
Defective fuel lift pump (fuel supply inadequate).	Check that the lift pump operates and delivers fuel to the high pressure fuel pump. Check the correct electrical wires for open or short circuits.
Fuel is aerated.	Check the fuel system for loose connections and possible air ingress points. Rectify and bleed the fuel system.
Check fuel inlet restriction.	Maximum inlet restriction to fuel lift pump must not exceed. Pressure: 0.133bar (1.9psi)
Air intake or exhaust system blocked.	Visually check the air intake and exhaust system for blockage or obstruction - remove as required. Check the air filter elements for signs of blocking - replace as required.
Fuel drain return line blocked, not connected properly.	Verify that the fuel return line is not obstructed and connected to the top of the fuel tank.
One or more fuel injector worn or malfunctioning.	Check the electronic fault codes. Check the electrical connections at the injectors.

Cause	Remedy
ECU (Electronic Control Unit) or electrical sensor fault.	Check the electronic fault codes. Check the electrical connections at the ECU and sensors.
Worn or malfunctioning high pressure fuel pump.	Check the electronic fault codes Do all the necessary fault finding checks before removal of the high pressure fuel pump.
Injectors contaminated	Check the injectors. Use the service master test procedure in service master tools actuator test. Test and replace as required.

Table 12. Engine-Will Not Start or Difficult to Start

Cause	Remedy
Starting procedure incorrect.	Verify proper starting procedure.
Air intake system blocked or restricted.	Visually check the air intake for blockage or obstruction - remove as required. Check the air filter elements for signs of blocking - replace as required.
Fuel is aerated.	Check the fuel system for loose connections and possible air ingress points. Rectify and bleed the fuel system.
Fuel lift pump not operating correctly (fuel supply inadequate).	Check that the lift pump operates and delivers fuel to the high pressure fuel pump. Check the correct electrical wires for open or short circuits.
Fuel is contaminated or incorrect grade diesel fuel used.	Stop the engine. Replace the fuel filters. Operate the engine with a temporary supply of the correct grade of clean fuel. Monitor the engine performance. Dirty fuel will cause damage to the high pressure fuel pump and injectors.
Fuel filter(s) blocked, fuel supply restricted.	Check/replace the fuel filter(s). Check fuel lines for restriction.
Fuel drain return line blocked, not connected properly.	Verify that the fuel return line is not obstructed and connected to the top of the fuel tank.
Check fuel inlet restriction.	Maximum inlet restriction to fuel transfer pump must not exceed. Pressure: 0.133bar (1.9psi)
One or more fuel injector worn or malfunctioning.	Check the electronic fault codes. Check the electrical connections at the injectors.
Inlet and exhaust valve clearances set incorrectly.	Set the valve clearances to the recommended clearances.
Engine compression low in one or more cylinders.	Check the engine compression.
ECU electrical sensor fault.	Check the electronic fault codes. Check the electrical connections at the ECU and sensors.
Worn or malfunctioning high pressure fuel pump.	Check the electronic fault codes. Contact your JCB Engine Dealer.

Table 13. Engine-Will Not Crank or Cranks Slowly

Cause	Remedy
Starting electrical circuit connections loose or corroded.	Clean and tighten connections.
Battery charge low.	Check battery voltage, charge the battery or replace as required. Make sure that the alternator is functioning correctly and charging the battery.
No electrical connection to starter solenoid.	Check voltage to solenoid.

Cause	Remedy
Crankshaft rotation restricted.	Use special tool 892/01147 (crankshaft turning tool) to manual turn the engine and check for any severe rotational resistance.
Solenoid or starter motor fault.	Replace starter motor.
Starter motor operating but not cranking.	Remove the starter motor and check for broken teeth on the ring gear or broken starter motor spring.

Table 14. Engine-Starts then Stops

Cause	Remedy
No fuel in supply tank.	Check the level in the fuel tank, use sight gauge or dipstick. Replenish as required.
Engine starting under load.	Check for added loading from malfunctioning accessories or driven units, brakes dragging and other changes in vehicle loading. Disengage the hydraulic controls.
Air intake or exhaust system blocked.	Visually check the air intake and exhaust system for blockage or obstruction - remove as required. Check the air filter elements for signs of blocking - replace as required.
Fuel is aerated.	Check the fuel system for loose connections and possible air ingress points. Rectify and bleed the fuel system.
Fuel lift pump not operating correctly (fuel supply inadequate).	Check that the lift pump is operating and delivering fuel to the injection pump.
Fuel is waxing due to extremely cold weather.	Verify by inspecting the fuel filter. Clean the system and use acclimatised fuel.
Fuel is contaminated or incorrect grade diesel fuel used.	Stop the engine. Replace the fuel filters. Operate the engine with a temporary supply of the correct grade of clean fuel. Dirty fuel will cause damage to the high pressure fuel pump and injectors.
Fuel filter(s) blocked, fuel supply restricted.	Check/replace the fuel filter(s). Check fuel lines for restriction.
Fuel drain return line blocked, not connected properly.	Verify that the fuel return line is not obstructed and connected to the top of the fuel tank.
ECU or Electrical sensor fault.	Check the electronic fault codes.

Table 15. Engine-Poor Running

Cause	Remedy
Engine is cold, coolant temperature sensor fault.	Check the electrical connection at the coolant sensor. Check the correct electrical wires for open or short circuits. Check the electronic fault codes. If engine will not reach operating temperature.
Fuel injection lines leaking.	Replace defective high pressure fuel lines. Do not repair defective fuel lines. If there is a fuel leak stop the engine and contact your JCB Engine Dealer.
Fuel is aerated.	Check the fuel system for loose connections and possible air ingress points. Rectify and bleed the fuel system.
Fuel lift pump not operating correctly (fuel supply inadequate).	Check that the lift pump operates and delivers fuel to the high pressure fuel pump. Check the correct electrical wires for open or short circuits.
Fuel filter(s) blocked, fuel supply restricted.	Check/replace the fuel filter(s). Check fuel lines for restriction.

Cause	Remedy
Inlet and exhaust valve clearances set incorrectly.	Set the valve clearances to the recommended clearances.
Worn or malfunctioning high pressure fuel pump.	Check the electronic fault codes. Contact your JCB Engine Dealer.
Camshaft or tappets damaged.	Contact your JCB Engine Dealer.

Table 16. Engine-Poor Running at Idle

Cause	Remedy
Coolant temperature sensor fault.	Check the electrical connection at the coolant sensor. Check the correct electrical wires for open or short circuits. Check the electronic fault codes. Test the coolant sensor.
Engine mounts over-tightened, damaged or loose.	Verify condition of mounts. Refer to the machine's service manual for correct adjustment procedure.
Fuel injection lines leaking.	Replace defective high pressure fuel lines. Do not repair defective fuel lines. If there is a fuel leak stop the engine and contact your JCB Engine Dealer.
Worn crank/connecting rod bearings (knocking under load).	Contact your JCB Engine Dealer.
Excessive camshaft bearing wear.	Contact your JCB Engine Dealer.
Worn or damaged pistons and/or piston rings.	Contact your JCB Engine Dealer.
One or more fuel injector worn or malfunctioning.	Check the electronic fault codes. Check the electrical connections at the injectors. Contact your JCB Engine Dealer.
Gear train noise.	Contact your JCB Engine Dealer.
Loss of Pilot injection on one or more cylinders.	Use service master to disable pilot injections to identify audibly if they are still present.

Table 17. Engine-Compression Knocks

Cause	Remedy
Fuel is aerated.	Check the low pressure fuel system for loose connections and possible air ingress points. Rectify and bleed the fuel system.
Fuel is contaminated or incorrect grade diesel fuel used.	Stop the engine. Replace the fuel filters. Operate the engine with a temporary supply of the correct grade of clean fuel. Monitor the engine performance. Dirty fuel will cause damage to the high pressure fuel pump and injectors.
ECU or electrical sensor fault.	Check the electronic fault codes. Check the electrical connections at the ECU and sensors.
Inlet and exhaust valve springs broken.	Contact your JCB Engine Dealer.
One or more fuel injector worn or malfunctioning.	Check the electronic fault codes. Check the electrical connections at the injectors. Contact your JCB Engine Dealer.

Table 18. Engine-Reduced Power Output

Cause	Remedy
Low DEF (Diesel Exhaust Fluid) in supply tank	Check the level in the DEF tank. Replenish as required.
No fuel in supply tank.	Check the level in the fuel tank, use sight gauge or dipstick. Replenish as required.
Oil level incorrect.	Check oil level.

Cause	Remedy
Engine overload.	Check for added loading from malfunctioning accessories or driven units, brakes dragging and other changes in vehicle loading. Disengage the hydraulic controls.
Throttle position sensor (TPS) system defective.	Check the throttle assembly. Check the electronic fault codes.
Fuel is contaminated or incorrect grade diesel fuel used.	Stop the engine. Replace the fuel filters. Operate the engine with a temporary supply of the correct grade of clean fuel. Monitor the engine performance. Dirty fuel will cause damage to the high pressure fuel pump and injectors.
Turbocharger boost control pipe leaking or damaged, or wastegate diaphragm ruptured.	Inspect and tighten fittings, repair pipes. Contact your JCB Engine Dealer.
Fuel injection lines leaking.	Inspect and correct as required leaks in the high pressure lines, fittings injector sealing washers, or delivery valves.
Extra injector sealing washer installed under injector.	Remove extra injector sealing washer.
Inlet and exhaust valve clearances set incorrectly.	Set the valve clearances to the recommended clearances.
Worn or malfunctioning high pressure fuel pump.	Check the electronic fault codes. Contact your JCB Engine Dealer.
Engine compression low in one or more cylinders.	Contact your JCB Engine Dealer.
Engine in reduced torque or limp home mode	Investigate the fault using Service master.

Table 19. Engine-Vibration Excessive

Cause	Remedy
Oil level over-full.	Check oil level.
Fan damaged or accessories faulty.	Check/replace the vibrating component. Refer to the machine's service manual for correct installation and torque figures.
Fan hub faulty.	Inspect/replace the fan hub. Refer to the machine's service manual for correct installation and torque figures.
Engine mounts loose or broken.	Check/replace engine mounts. Refer to the machine's service manual for correct installation and torque figures.
Inlet and exhaust valve clearances set incorrectly.	Set the valve clearances to the recommended clearances.
Engine compression low in one or more cylinders.	Contact your JCB Engine Dealer.
Alternator bearing worn or damaged.	Contact your JCB Engine Dealer.
Flywheel housing misaligned.	Contact your JCB Engine Dealer.
ECU or electrical sensor fault.	Check the electronic fault codes. Check the electrical connections at the ECU and sensors.
Drive line components worn or unbalanced.	Check and inspect drive line components such as propshafts. Refer to the machine's service manual for correct installation and torque figures.

Table 20. Engine-Exhaust Smoke Excessive (Black Smoke)

Cause	Remedy
Engine being lugged down.	Use appropriate gear for task.
Air intake or exhaust system blocked.	Visually check the air intake and exhaust system for blockage or obstruction - remove as required. Check the air filter elements for signs of blocking - replace as required.
Air leak between the turbocharger and the intake manifold (Turbocharged machines only).	Check/correct leaks in the air crossover tube, hoses, or manifold cover.
Intercooler faulty.	Check for blocked cooler matrix.
Exhaust leak at the Manifold or Turbocharger (Turbocharged machines only).	Check/correct leaks in the manifold or turbocharger gaskets. Look for a cracked manifold.
Turbocharger wastegate faulty.	Repair or replace wastegate.
Turbocharger malfunction.	Replace Turbocharger.
One or more fuel injector worn or malfunctioning.	Check the electronic fault codes. Check the electrical connections at the injectors.
Engine compression low in one or more cylinders. Smokes under load at all speeds, but mainly low to mid speed range.	Contact your JCB Engine Dealer.

Table 21. Engine-Exhaust Smoke Excessive (White/Blue Smoke)

Cause	Remedy
Improper starting procedure.	Verify proper starting procedure.
Fuel is contaminated or incorrect grade diesel fuel used.	Stop the engine. Replace the fuel filters. Operate the engine with a temporary supply of the correct grade of clean fuel. Monitor the engine performance. Dirty fuel will cause damage to the high pressure fuel pump and injectors.
Oil level incorrect.	Check oil level.
Diesel or hydraulic oil in sump.	Check oil consistency. If oil contamination is suspected check equipment such as PTO pump for hydraulic oil leaks pass the seal into the engine. Drain, flush and fill with clean oil.
One or more engine injector worn or malfunctioning. - white/ blue smoke at operating temperature.	Check the electronic fault codes. Check the electrical connections at the injectors.
Leaking valve stem seals - evident after long idle period and then acceleration.	Contact your JCB Engine Dealer.
One or more fuel injector worn or malfunctioning.	Check the electronic fault codes. Check the electrical connections at the injectors.
Piston rings not sealing - evident with persistent blue smoke at all speeds/load.	Contact your JCB Engine Dealer.

Table 22. Engine-Will Not Shut Off

Cause	Remedy
Stop switch or stop switch electrical system failure.	Check the operation of the stop switch. Check the correct electrical wires for open or short circuits.

Table 23. Fuel-Consumption Excessive

Cause	Remedy
Additional load on engine.	Check/repair accessories and vehicle components. Refer to the equipment manufacturer's procedures.
Operator technique.	Review operation for correct gear shifts, deceleration and idling.
Fuel leaks.	Check for external leaks at the fuel tank, fuel lines, filters and lift pump. Do not repair defective fuel lines. If there is a fuel leak stop the engine and contact your JCB Engine Dealer.
Engine compression low in one or more cylinders.	Check the engine compression.
ECU or electrical sensor fault.	Check the electronic fault codes. Check the electrical connections at the ECU and sensors.
One or more engine injector worn or malfunctioning.	Check the electronic fault codes. Check the electrical connections at the injectors.
Inlet and exhaust valve clearances set incorrectly.	Set the valve clearances to the recommended clearances.

Table 24. Fuel/Oil-Leaking from Exhaust Manifold

Cause	Remedy
Operating for extended periods under light or no load conditions.	Review operation for correct gear shifts, deceleration and idling.
Turbocharger lubricating oil drain line obstructed.	Check/clean line.
Exhaust leak at the manifold or turbocharger.	Check/correct leaks in the manifold or turbocharger gaskets. Look for a cracked manifold.
Valve guide seals are leaking.	Contact your JCB Engine Dealer.
ECU or electrical sensor fault.	Check the electronic fault codes. Check the electrical connections at the ECU and sensors.
One or more engine injector worn or malfunctioning.	Check the electronic fault codes. Check the electrical connections at the injectors.

Table 25. Lubricating Oil-Consumption Excessive

Cause	Remedy
Oil leaks.	Inspect the engine for visible signs of leaks. Pay particular attentions to seals, gaskets oil cooler and external connections.
Oil level over-full.	Check oil level.
Incorrect lubricating oil (specification of viscosity).	Make sure the correct lubricating oil is being used. Check for reduced viscosity from dilution with fuel. Fuel dilution in lubricating oil can originate from a defective high pressure fuel pump driveshaft seal. Review/reduce the lubricating oil change intervals.
Crank case ventilation (CCV) system blocked).	Check the breather tube area for signs of lubricating oil loss. Check and if necessary replace the CCV filter.
Lubricating oil cooler leak.	Check for lubricating oil in the coolant.
Turbocharger leaking lubricating oil to the air intake or exhaust (if fitted).	Inspect the air crossover tube for evidence of lubricating oil transfer.
Valve guide seals are leaking.	Contact your JCB Engine Dealer.
Piston rings not sealing - lubricating oil being consumed by the engine (blue smoke from exhaust).	Contact your JCB Engine Dealer.
Worn cylinder bores - lubricating oil being consumed by the engine (blue smoke from exhaust).	Contact your JCB Engine Dealer.
Glazed cylinder bores.	Contact your JCB Engine Dealer.

Table 26. Lubricating Oil-Contaminated

Cause	Remedy
Fuel in the lubricating oil, engine operating too cold.	Review the operation for excessive idling resulting in the engine running below normal temperature.
Lubricating oil sludge excessive.	Change oil and filter. Review oil and filter change period. If operating in arduous applications, change more. Make sure the correct lubricating oil is being used.
ECU or electrical sensor fault.	Check the electronic fault codes. Check the electrical connections at the ECU and sensors.
One or more engine injector worn or malfunctioning.	Check the electronic fault codes. Check the electrical connections at the injectors. Have oil sample analysed. Repair engine as required.

Table 27. Lubricating Oil-Pressure Low

Cause	Remedy
Oil level incorrect.	Check oil level.
Incorrect lubricating oil (specification of viscosity).	Make sure the correct lubricating oil is being used. Check for reduced viscosity from dilution with fuel. Fuel dilution in lubricating oil can originate from a defective high pressure fuel pump driveshaft seal. Review oil and filter change period. If operating in arduous applications, change more frequently.
Pressure switch or gauge fault.	Verify the pressure switch is functioning correctly.
Lubricating oil filter blocked.	Change lubricating oil filter. Review oil and filter change period. If operating in arduous applications, change more frequently.
Lubricating oil filter drain down valve not fitted.	Change lubricating oil filter.
Suction pump pressure relief valve stuck open.	Contact your JCB Engine Dealer.
Oil pump pressure relief valve stuck open.	Contact your JCB Engine Dealer.
Lubricating oil pump worn.	Contact your JCB Engine Dealer.

Table 28. Lubricating Oil-Pressure High

Cause	Remedy
Pressure switch or gauge fault.	Verify the pressure switch is functioning correctly.
Oil pump pressure relief valve stuck closed.	Contact your JCB Engine Dealer.
Incorrect lubricating oil (specification of viscosity).	Make sure the correct lubricating oil is being used. Review oil and filter change period. If operating in arduous applications, change more frequently.

Table 29. Coolant-Loss

Cause	Remedy
Incorrect coolant level.	Check the level.
Coolant leaking from engine radiator or cab heater.	Visually inspect the radiator heater, hoses and connection to locate the leak. If oil is present in the coolant, check for engine oil cooler leak.
External engine coolant leak.	Visually inspect the engine and components for seal, gasket hose connection leaks. Make sure all hose clips are in good condition and torqued to the recommended figure.
If the engine is coolant aftercooled, aftercooler leak.	Check/replace the aftercooler. Look for coolant in the intake manifold and in the oil.
Lubricating oil cooler leak.	Check/replace the oil cooler. Look for coolant in the oil.

Cause	Remedy
Cylinder head gasket leak.	Contact your JCB Engine Dealer.
Cylinder head cracked or porous.	Contact your JCB Engine Dealer.
Cylinder block coolant passages leaking.	Contact your JCB Engine Dealer.

Table 30. Coolant-Over Temperature

Cause	Remedy
Incorrect coolant level (low).	Check the level. Ensure low level is not as a result of a coolant leak.
External radiator matrix blocked with dirt or chaff.	Clean exterior or radiator matrix.
Air flow to the radiator inadequate or restricted.	Check/repair fan shroud, anti-recirculation sealing, shutters, fan sensors, fan speeds as required. Refer to the machine manufacturer's documentation for detailed information.
Coolant pump or fan drive belts loose.	Check/correct belt tension.
Radiator hose collapsed, restricted or leaking.	Check/replace hose.
Oil level over-full.	Check oil level.
Cooling system pressure cap incorrect or faulty.	Replace cap with the correct rating for the system.
Over concentration of anti-freeze.	Remove part of the coolant from cooling system and replace with water.
Temperature sensor gauge faulty.	Check the electronic fault codes. Verify that the gauge and temperature sensor are accurate.
Thermostat faulty, incorrect or missing.	Check/replace the thermostat.
Air or combustion gases in the cooling system.	Make sure the fill rate is not exceeded and the correct vented thermostat is installed. If aeration continued, check for a compression leak through the head gasket.
Coolant pump faulty.	Check/replace the coolant pump.
Vent line from engine and/or radiator blocked or incorrectly routed (sudden overheating).	Check routing and operation or vent line.
Leak between the top tank and the auxiliary tank (sudden overheating).	Check for coolant leakage between radiator auxiliary tank and radiator top tank.
Cooling passages in radiator, cylinder head, head gasket or block blocked.	Flush the system and fill with clean coolant.
ECU or electrical sensor fault.	Check the electronic fault codes. Check the electrical connections at the ECU and sensors.
One or more engine injector worn or malfunctioning.	Check the electronic fault codes. Check the electrical connections at the injectors.

Table 31. Coolant-Under Temperature

Cause	Remedy
Air flow across the radiator excessive.	Check/repair fan shroud, anti-recirculation sealing, shutters, fan sensors, fan speeds as required. Refer to the machine manufacturer's documentation for detailed information.
Temperature sensor gauge faulty.	Check the electronic fault codes. Verify that the gauge and temperature sensor are accurate.
Thermostat faulty (open - not sealing).	Check/replace the thermostat.
Coolant not flowing by temperature sensor	Check/clean coolant passages.

Table 32. Coolant-Contaminated

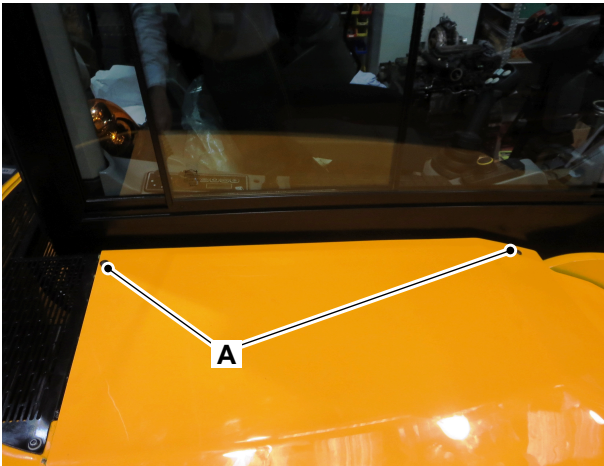
Cause	Remedy
Coolant rusty, operation without correct mixture of antifreeze and water.	Drain and flush the cooling system. Fill with correct mixture of antifreeze and water. Review the coolant change interval. Refer to the Operation and Maintenance Manual.
Engine oil cooler, or cooler housing allowing cross contamination of coolant with engine oil.	Remove the oil cooler assembly and check relevant sealing elements for damage.

Drain and Fill

Open

1. Remove the bolts (x2) that secure the top of the cover to the upper structure.

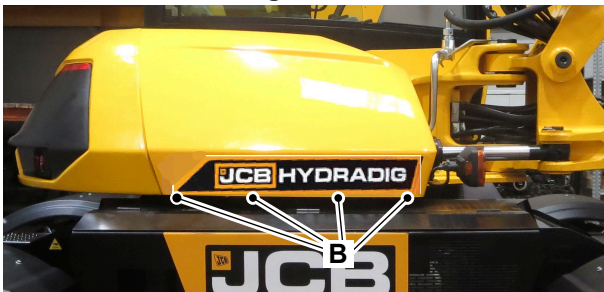
Figure 27.



A Bolts (x2)

2. Remove the bolts (x4) that secure the bottom of the cover to the upper structure.

Figure 28.



B Bolts (x4)

3. Remove the cover from the machine.

Close

1. Install the cover to the machine. Make sure that the tabs at the top of the cover are located correctly.
2. Install the bolts (x2).
3. Install the bolts (x4).

Clean

▲ Notice: Clean the engine before you start engine maintenance. Obey the correct procedures. Contamination of the fuel system will cause damage and possible failure of the engine.

Notice: The engine and other components could be damaged by high pressure washing systems. Special precautions must be taken if the machine is to be washed using a high pressure system.

Make sure that the alternator, starter motor and any other electrical components are shielded and not directly cleaned by the high pressure cleaning system. Do not aim the water jet directly at bearings, oil seals or the engine air induction system.

Before carrying out any service procedures that require components to be removed, the engine must be properly cleaned.

Cleaning must be carried out either in the area of components to be removed or, in the case of major work, or work on the fuel system, the whole engine and surrounding machine must be cleaned.

Stop the engine and allow it to cool for at least one hour. DO NOT attempt to clean any part of the engine while it is running.

1. Make sure that the electrical system is isolated.
2. Make sure that all electrical connectors are correctly coupled. If connectors are open fit the correct caps or seal with waterproof tape.
3. Cover the alternator with a plastic bag to prevent water ingress.
4. Seal the engine air intake, exhaust and breather system.
5. Make sure that the oil filler caps and dipstick are correctly installed.
6. Use a low pressure water jet and soft bristle brush to soak off caked mud or dirt.
7. Apply an approved cleaning and degreasing agent with a brush. Obey the manufacturers instructions.
8. Use a pressure washer to remove the soft dirt and oil. Important: DO NOT aim the water jet directly at oil seals or electrical connectors and electronic components such as ECU (Electronic Control Unit)'s, alternator or fuel injectors. DO NOT place the jet nozzle closer than the specified distance to any part of the engine or exhaust system.

Length/Dimension/Distance: 600mm

9. When the pressure washing is complete move the machine away from the wash area, or alternatively, clean away the material washed from the machine.
10. Before working on specific areas of the engine use a compressed air jet to dry off any moisture. When the area is dry use a soft clean brush to remove any sand or grit particles that remain.
11. When removing components be aware of any dirt or debris that may be exposed. Cover any open ports and clean away the deposits before proceeding.

Additional cleaning must be carried out prior to working on the high pressure fuel system.

Check (Pressure)

Special Tools

Description	Part No.	Qty.
Pressure Gauge (0-40 Bar)	892/00278	1
Dummy Injector	892/12347	1
Digital Hydraulic Pressure Test Kit	998/11051	1

This test is used to diagnose suspected poor compression in one or more of the engine cylinders.

Engine Compression Test

This test is used to diagnose suspected poor compression in one or more of the engine cylinders.

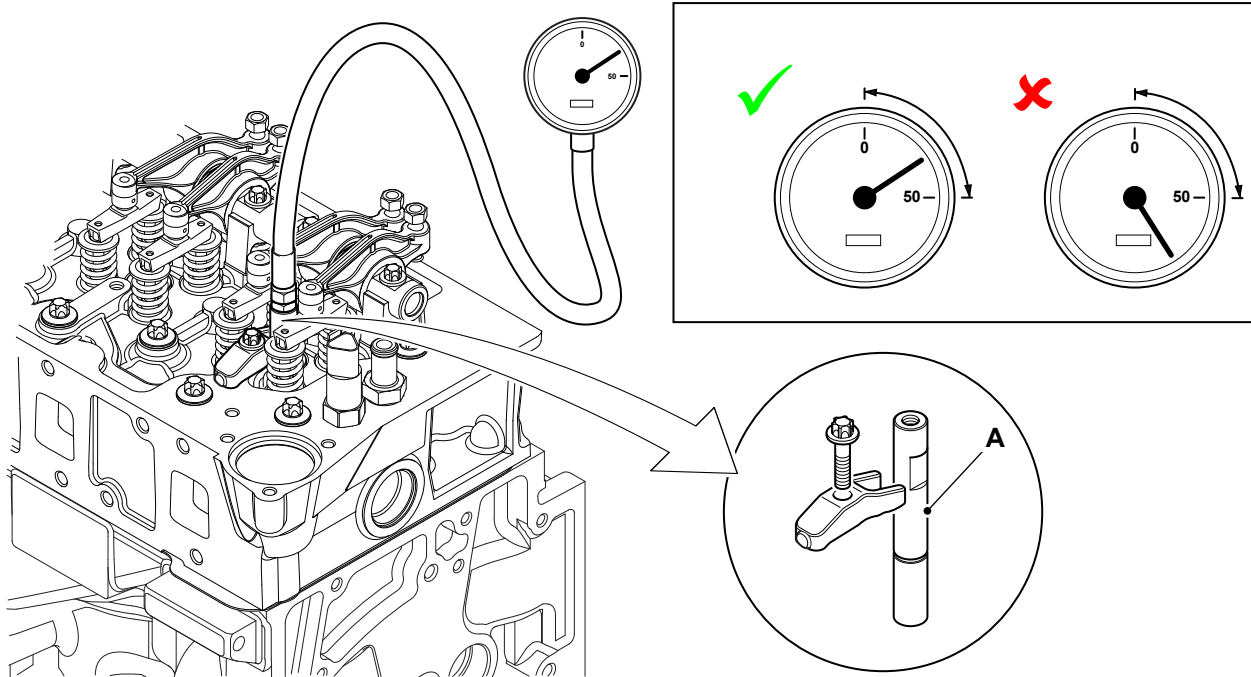
Several factors can influence the compression pressure, the following conditions are assumed:

- The valve clearances have been set correctly. [Refer to: PIL 15-30-00.](#)
- The correct engine oil has been used.
- The engine oil level is correct. [Refer to: PIL 15-21-00.](#)
- The battery and starting circuit is fully charged and in good condition, e.g. good earth paths, cable connections tight etc.

When comparing the figures recorded in the following procedures, there should be a minimum variation of 3.5bar (50.7psi) between each cylinder. If the variation is greater than this figure, remove the

cylinder head and closely inspect the cylinder bores, pistons and piston rings for signs of wear or damage. Repair as necessary.

1. Get access to the engine.
2. Remove all of the fuel injectors.
[Refer to: PIL 18-18-03.](#)
 - 2.1. Make sure that the injectors are labelled for correct installation in the same cylinders at a later stage.
3. Install the dummy injector in one of the vacant cylinder injector bores. Refer to Figure 29.
[Special Tool: Dummy Injector \(Qty.: 1\)](#)
 - 3.1. The dummy injector is drilled and tapped 1/8-28 BSP x 8 mm deep to accept a standard pressure gauge fitting.
4. Connect a suitable pressure gauge to the dummy injector.
5. Operate the starter motor to crank the engine.
 - 5.1. Do not crank for longer than the specified time period.
Duration: 20s
 - 5.2. Record the gauge reading.
6. Repeat steps 2 to 5 again for the remaining cylinders.

Figure 29.


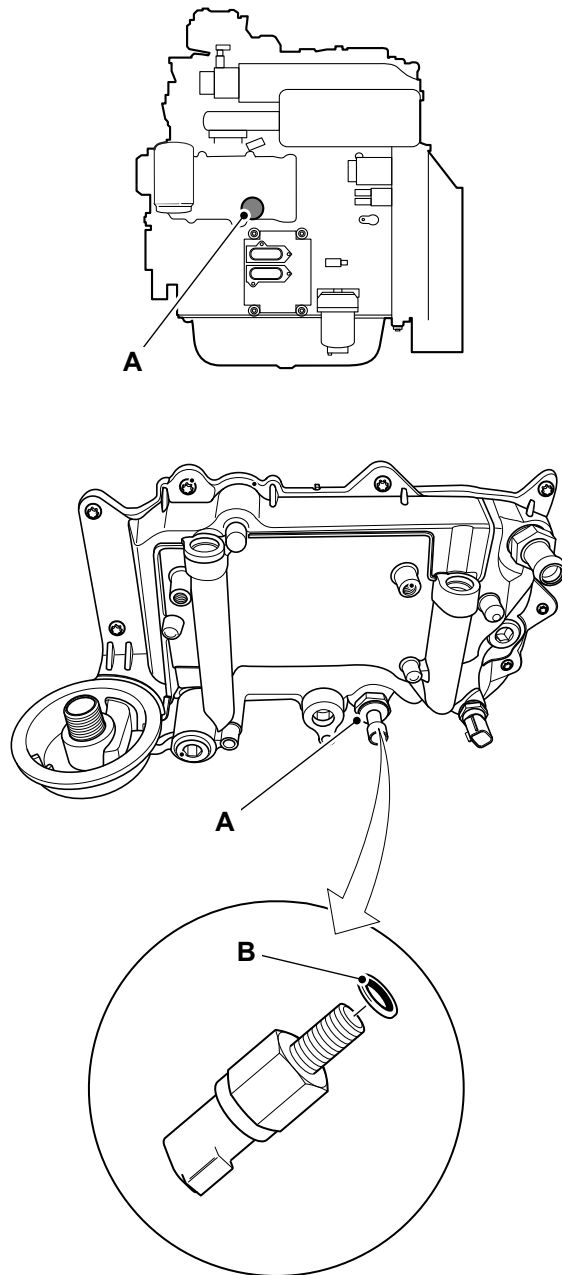
A Dummy Injector

Engine Oil Pressure

Use the following procedures to measure the engine oil pressure. Several factors can influence the engine oil pressure, the following conditions are assumed:

- The correct engine oil has been used.
 - The engine oil level is correct. [Refer to: PIL 15-21-00.](#)
1. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.
 2. Get access to the engine.
 3. Disconnect the electrical connector to the oil pressure switch, remove the switch from the oil cooler housing.
 4. Install a suitable adaptor into the vacant pressure switch port (M10 x 1.5mm thread) and a pressure test gauge. Make sure that the gauge has a sealing washer as shown.

[Special Tool: Pressure Gauge \(0-40 Bar\) \(Qty.: 1\)](#)
[Special Tool: Digital Hydraulic Pressure Test Kit \(Qty.: 1\)](#)

Figure 30.


- A** Oil pressure switch
B Sealing washer

5. Start the engine and allow a few seconds to gain oil pressure, increase the engine revs to the rated speed. Record the pressure gauge reading, refer to Technical Data, for the recommended circuit pressure.

Refer to: [PIL 15-00-00](#).

6. Remove the pressure gauge and install the pressure switch.

High Lubrication Oil Pressure

High oil pressure will be evident when starting in cold conditions. Typically the pressure will be 1 to 2 bar and higher in cold operation, the pressure should drop when the engine reaches normal operating temperature.

If the pressure remains high when operating temperature is achieved, check the oil level, if this is correct, suspect the oil pump relief valve is at fault.

Low Lubrication Oil Pressure

Several factors can be the cause of low lubricating oil pressure:

- Low oil level - typically evident as a loss of pressure when operating on uneven ground or on a gradient.
- Blocked oil filter - a blocked filter will show as a gradual loss of pressure.
- Blocked suction strainer (pick-up pipe) - typically evident as low pressure on start up, if the blockage frees itself in the sump, the pressure will pick up to normal.
- Coolant in the oil - coolant in the lubricating oil will show as a milky discolouration of the oil and an increase in oil level. Check for damaged core plugs, lubricating oil cooler, cylinder head and/or gasket.
- Fuel in the oil - fuel in the oil will result in thin black lubricating oil, the oil will also have a diesel fuel smell. Check for fuel injection pump shaft seal leakage, piston ring wear, or injector leakage if fuel is evident in the oil.
- Damaged oil pump - oil pressure will be high at low oil temperature but fall when oil becomes hotter.

Remove and Install

Special Tools

Description	Part No.	Qty.
Front Lifting Eye	320/09062	1
Rear Lifting Eye	320/09063	1
Engine Lifting Spreader Bar	892/01382	1
Fuel Injection Equipment Cap Kit (444/448 T4i/T4F/BS4/STV Engine)	892/12359	1

Lifting Equipment

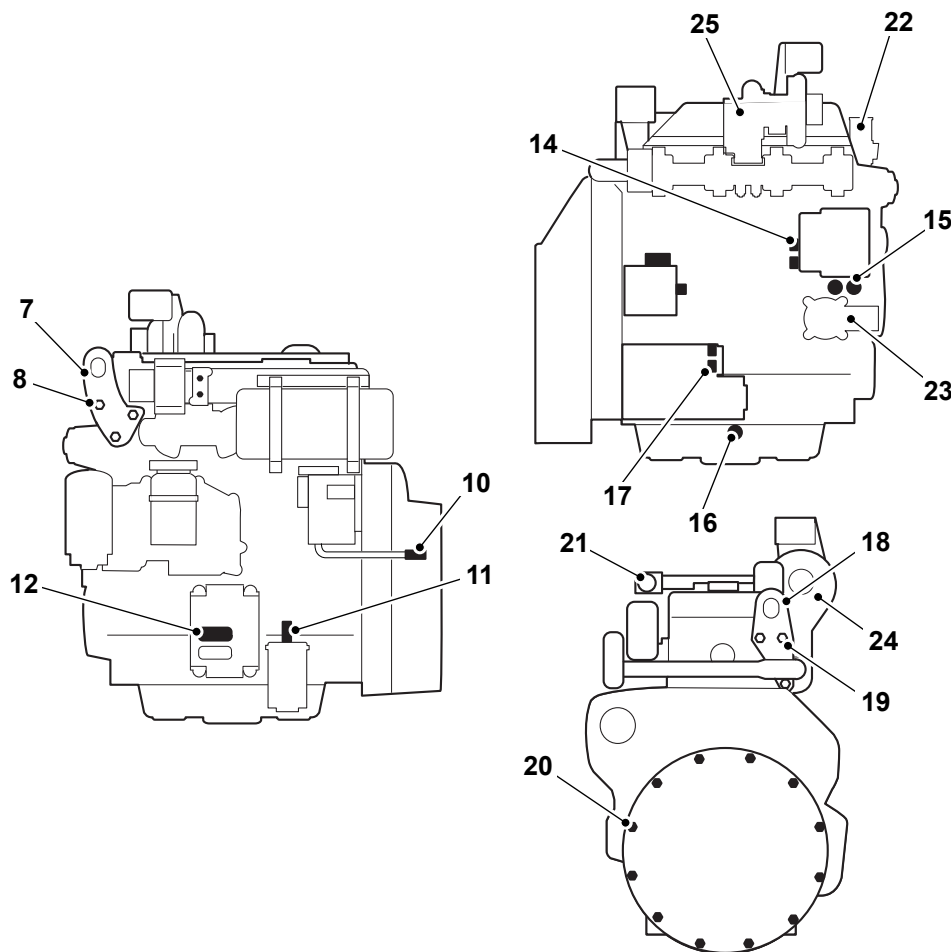
You can be injured if you use incorrect or faulty lifting equipment. You must identify the weight of the item to be lifted then choose lifting equipment that is strong enough and suitable for the job. Make sure that lifting equipment is in good condition and complies with all local regulations.

The lifting equipment used must be an approved type and capable of lifting the engine safely. The recommended lifting equipment is shown. Use a spreader bar when lifting the engine. Never attempt to manually lift heavy components on your own. Always use lifting equipment, or obtain the help of an assistant. Inspect the lifting eyes for signs of damage. The lifting eyes must be correctly torqued to the crankcase. Make sure the lifting equipment does not damage any of the engine dressing and the rocker cover.

Component Identification

The following component identification is for a typical engine installation. There will be some component differences depending on the machine variant. Before attempting to remove the engine ensure that all the necessary components have either been removed, or safely disconnected from the engine.

Figure 31.



7 Front lifting eye

8 Lifting eye fixing bolts

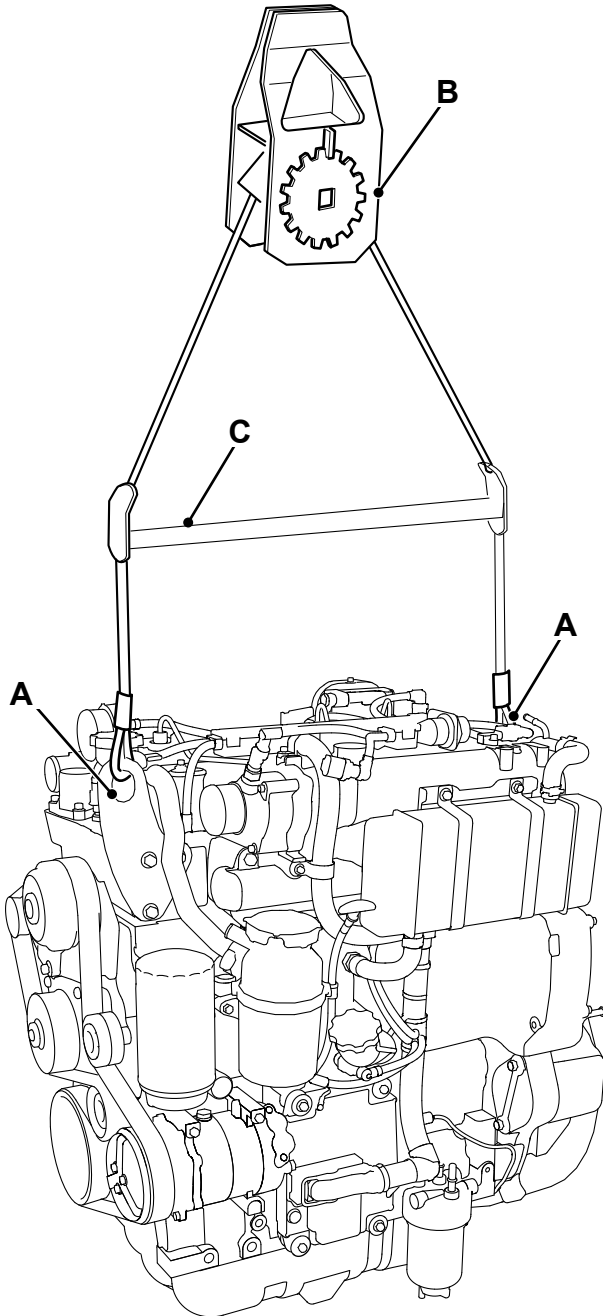
- | | | | |
|-----------|--|-----------|---|
| 10 | Fuel line connector - return to tank line | 11 | Fuel line connector at fuel filter - feed line from fuel pump |
| 12 | Electrical connector - ECM (Engine Control Module) machine side connector (grey) | 14 | Electrical connections - alternator |
| 15 | Hose connection - cab heater | 16 | Electrical sensor - engine oil level |
| 17 | Electrical connections - starter motor | 18 | Rear lifting eye |
| 19 | Lifting eye fixing bolts | 20 | Fixing bolts - gearbox to engine |
| 21 | Electrical connector - engine harness | 22 | Top hose |
| 23 | Bottom hose | 24 | Air inlet hose |
| 25 | Exhaust pipe | | |

Before Removal

1. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.
2. Position the machine on firm level ground. Make the machine safe.
[Refer to: PIL 01-03.](#)
3. Discharge the hydraulic pressure.
4. Get access to the engine.

Remove

1. Disconnect and remove the battery.
2. Drain the engine oil.
[Refer to: PIL 15-00-00.](#)
3. Drain the engine coolant.
[Refer to: PIL 21-00-00.](#)
4. Disconnect the air inlet hose.
5. Disconnect the turbocharger outlet hose.
6. Disconnect the charge air hose.
7. Disconnect the exhaust system.
8. Label the cab heater hoses at the engine block connectors. Release the hose clips and disconnect the hoses.
9. Disconnect the top coolant hose.
10. Disconnect the bottom coolant hose.
11. Disconnect the wiring connections from the starter motor.
[Refer to: PIL 15-75-00.](#)
12. Disconnect the wiring connections from the alternator.
[Refer to: PIL 15-72-00.](#)
13. Disconnect the fuel supply and return pipes. Plug all the open ports and hoses to prevent contamination.
[Special Tool: Fuel Injection Equipment Cap Kit \(444/448 T4i/T4F/BS4/STV Engine\) \(Qty.: 1\)](#)
14. If necessary, remove the cooling pack.
15. Disconnect the electrical harness at the ECM machine side connector. Important: Do not touch the connector pins on the ECM or harness connectors. Cover the connectors to prevent contamination.
16. Disconnect the electrical harness at the glow plug connector.
17. Make sure that all relevant harnesses and hoses are unclipped from the engine and tied out of the way.
18. If necessary, drain the hydraulic tank. Disconnect and plug the hydraulic suction and delivery lines at the transmission pump and gear pump. Label the hoses to aid installation.
19. Remove the gearbox/hydraulic pump to engine retaining bolts and pull the gearbox/hydraulic pump clear of the engine.
 - 19.1. Make sure that the torque converter stays mounted on the gearbox shaft.
20. Attach slings to the engine lifting eyes.
[Special Tool: Front Lifting Eye \(Qty.: 1\)](#)
[Special Tool: Rear Lifting Eye \(Qty.: 1\)](#)
[Special Tool: Engine Lifting Spreader Bar \(Qty.: 1\)](#)
21. Take the weight of the engine on the hoist and remove the engine mounting bolts.
22. Withdraw the engine in a level attitude until the hydraulic pump is clear of the chassis. Raise the engine to lift it clear of the machine.
23. Lower the engine into a suitable stand that is capable of supporting the weight of the engine.

Figure 32.


- A** Lifting eye mounting bolts
- B** Lifting equipment
- C** Spreader bar

Install

1. The installation procedure is the opposite of the removal procedure. Additionally do the following steps.
2. It is vitally important that the torque converter is installed at the gearbox and engine flywheel correctly. Failure to locate the torque converter correctly will result in damage to the gearbox oil pump on engine start up.

3. Fill the cooling system.

[Refer to: PIL 21-00-00.](#)

- 3.1. When you fill the cooling system make sure you use the correct water/antifreeze mixture. A 50% mixture should be maintained even if frost protection is not required.

[Refer to: PIL 75-09-03.](#)

4. Fill and check the hydraulic fluid level.

5. Fill and check the engine oil level.

[Refer to: PIL 15-00-00.](#)

- 5.1. Make sure the correct oil is used.

[Refer to: PIL 75-03-03.](#)

6. Bleed the fuel system.

[Refer to: PIL 18-00-00.](#)

7. Check the hydraulic, fuel and cooling systems for leaks.

8. Check the operation of all drive and hydraulic services.

Table 33. Torque Values

Item	Nm
A	47

Store and Recommission

Engines should be stored in the original shipping packaging. Damaged or disturbed packaging should be made weatherproof immediately.

If an engine is shipped with oil, it should be stored in the correct (upright) position.

If an engine is shipped dry of oil, after 6 months it should be filled with oil to the correct level and re-inhibited, refer to hot test description.

All floor stock engines should be stored under cover in dry conditions and not subjected to extreme variations in temperature or humidity.

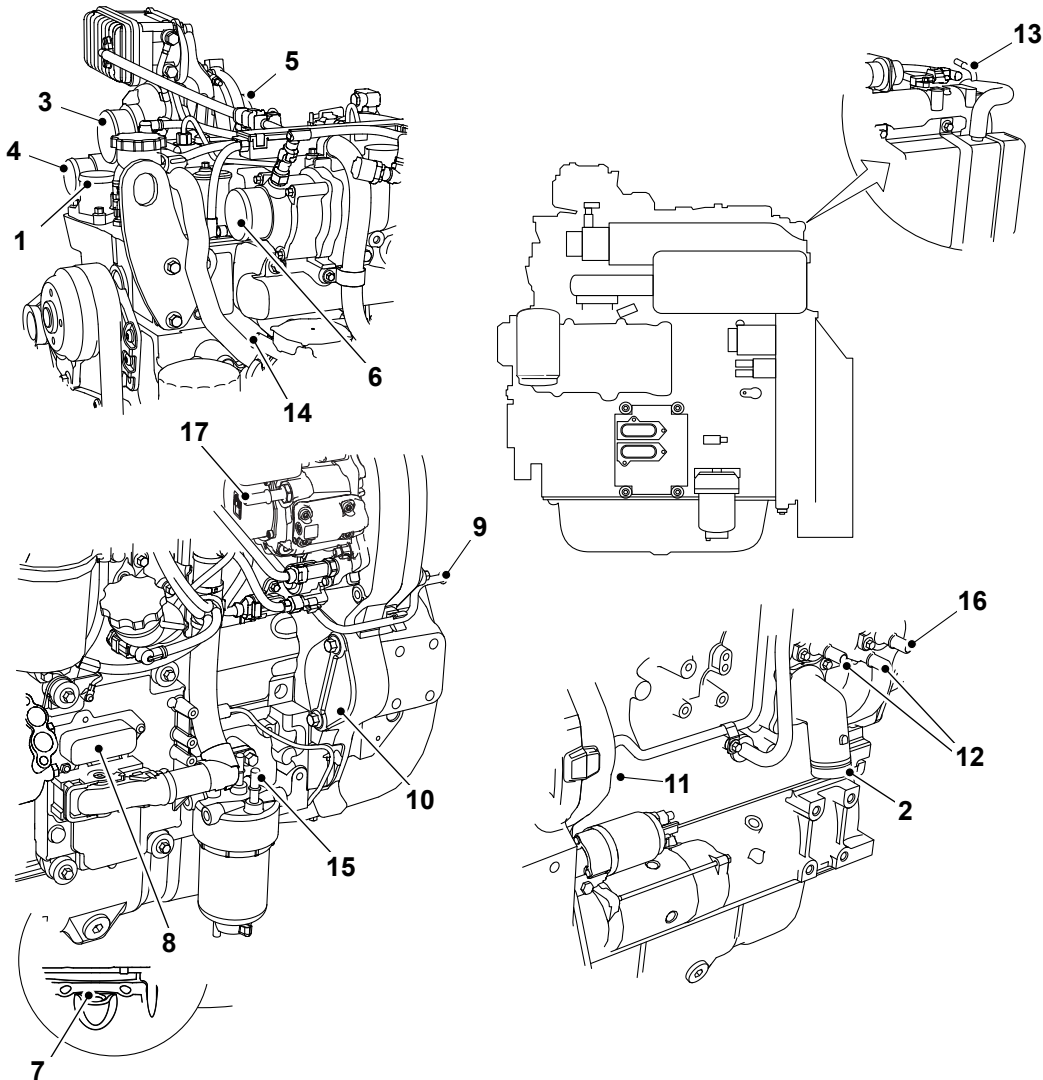
If an engine is to be placed into storage, all external signs of surface coating damage or corrosion should be cleaned and re-coated. Electrical connectors and components should be coated with a protective spray.

The DEF (Diesel Exhaust Fluid) tank should be at least 20% full before being placed in to storage.

Capping Engine Openings

All openings on the engine must be suitably capped to prevent ingress of water and contamination by foreign particles.

Figure 33.



1 Top hose cap

2 Bottom hose cap

- 3 Turbocharger intake cap
- 5 Turbocharger exhaust outlet cap
- 7 Dipstick plug

- 9 Fuel spill back line cap

- 11 Heavy duty PTO (if installed) cap
- 13 Coolant circuit de-gas spigot

- 15 Low pressure fuel filter inlet spigot

- 4 Turbocharger compressor outlet cap
- 6 Inlet manifold cap
- 8 ECM (Engine Control Module) machine harness connector cap
- 10 Low duty PTO (Power Take-Off) (if installed) cap
- 12 Cab heater feed and return spigots
- 14 CCV canister outlet on the closed loop breathing circuit (55kW)
- 16 SCR (Selective Catalytic Reduction) coolant feed spigot (if installed)

12 Month Revalidation Procedure

1. Pre-inspection:
 - 1.1. Inspect packaging for signs of damage.
 - 1.2. Inspect the caps for signs of damage.
 - 1.3. Inspect openings for signs of water or dirt ingress.
 - 1.4. Inspect the engine for signs of external corrosion.
 - 1.5. Inspect the engine for signs of fluid leaks.
 - 1.6. Check that the DEF tank level is above the specified level.
Percentage: 20%
2. From storage:
 - 2.1. Remove the air intake caps.
 - 2.2. Make sure the engine oil level is correct.
 - 2.3. Using a suitable power supply at the correct voltage, crank the engine over.
 - 2.4. During cranking, check that the oil pressure switch opens using a multimeter. The switch is closed when there is no or low oil pressure and opens when oil pressure reaches a set point. After three separate 20 second cranking periods, If the oil pressure switch does not open (indicating no, or low oil pressure), contact your JCB engine dealer.
 - 2.5. Recap all engine openings.
 - 2.6. Coat any exposed bare metal with a suitable product.
 - 2.7. Electrical connectors and components should be coated with a protective spray if exposed.
 - 2.8. Cover in weatherproof packaging.
 - 2.9. Place in storage, under cover on level ground or shelving.
 - 2.10. Record details of work as required.
 - 2.11. Do not expose to extremes of temperature or humidity.

Notice: Do not operate the starter motor for more than 20 s at one time. Let the starter motor cool for at least 2 min.

Table 34. Oil Pressure Switch Set Points

Oil pressure switch closed	>0.6bar (8.7psi)
Oil pressure switch open	<0.6bar (8.7psi)

OEM Commissioning Check on Engine Installation After More Than 12 Months

1. Flush the coolant system with proprietary flushing solution.
2. Refill the coolant system with 50/50 mix of long life antifreeze mixture.
3. Hot test engine according to the hot test profile. Refer to Table 35.
4. Drain engine oil and replace engine oil filter.
5. Refill with the correct oil and inhibit the cooling system using the correct product.
6. Drain the DEF tank.
7. Fill the DEF tank with clean good quality DEF. Leave to stand for the specified time period.
Duration: 72h
8. Record details of work as required.

Hot Test Description

▲ WARNING When using cleaning agents, solvents or other chemicals, you must adhere to the manufacturer's instructions and safety precautions.

All engines despatched from JCB will have been subjected to a hot test (checking items such as oil pressure, engines speeds, torque values etc.) and therefore the interior surfaces will have been coated with engine oil.

All coolant galleries are coated with CRODAFLUID PA75 corrosion inhibitor.

Stored engines will require re-inhibiting every 12 months, this will include hot testing the engine using a dynamometer. The hot test profile is:

Table 35. Hot Test Profile

Stage	Mode	Speed (rpm)	Torque (Nm)	Time (secs)
1	Speed/ Torque	830	0	50
2	Speed/ Torque	1300	50	60
3	Speed/ Torque	2500	0	60
4	Speed/ Torque	1300	0	25
5	Speed/ Torque	800	0	35



03 - Crankcase

Contents	Page No.
15-03-00 General	15-43
15-03-06 Jet	15-45



Notes:

00 - General

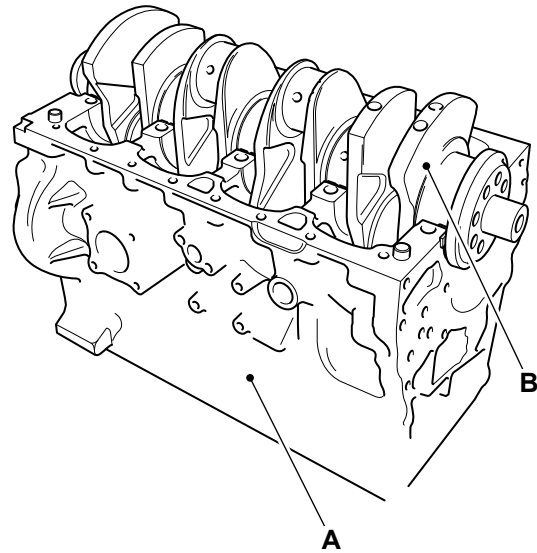
Introduction 15-43
Technical Data 15-44

Introduction

The crankcase is the housing for the crankshaft. The enclosure forms the largest cavity in the engine and is located below the cylinders. It is integral with the cylinder bank and forms an engine block. It has an opening in the bottom to which an oil sump is attached with a gasket and bolted joint.

The crankcase protects the crankshaft and connecting rods from foreign objects it also keeps the engine oil contained and allows the oil to be pressurised and also provide the rigid structure with which to join the engine to the power alternator.

Figure 34.



- A** Crankcase
- B** Crankshaft

Technical Data

Table 36. Crankcase and Bedplate Data

	4.4L	4.8L
Cylinder bore ⁽¹⁾	103–103.02mm	106–106.02mm
Surface finish for cylinder head joint ⁽³⁾	Rz < 15µm, Rmax < 20µm	Rz < 15µm, Rmax < 20µm
Diameter of first oversize bore	103.5–103.52mm	106.5–106.52mm
Diameter of second oversize bore	104–104.02mm	
Main bearing bore (without bearings)		
Numbers 1 to 4	92–92.02mm	92–92.02mm
Number 5	105–105.02mm	105–105.02mm
Main bearing bore (with bearings)		
Numbers 1 to 4	88.047–88.09mm	88.047–88.09mm
Number 5	100.047–100.09mm	100.047–100.09mm
Camshaft bore		
Numbers 1 to 4	60.04–60.07mm	60.04–60.07mm
Number 5 (bush)	60.29–60.32mm	60.29–60.32mm
Permissible wave profile	wt < 10µm (2.5mm distance)	wt < 10µm (2.5mm distance)

(1) Nominal diameter to be measured 63mm below the cylinder head face.

(3) The crankcase to cylinder head surface may be skimmed and restored using the oversize gaskets (0.25mm and 0.5mm).

06 - Jet

Introduction	15-45
Operation	15-46
Check (Condition)	15-48
Remove and Install	15-48

Introduction

The piston cooling jet sprays engine oil on to the underside of the pistons to keep them cool during the combustion process. Depending on the application, saddle jets or J-jets will be installed. The oil jet also provides lubrication for internal engine components such as the connecting rod small end bearing.

Operation

For: DJ Engine Page 15-46

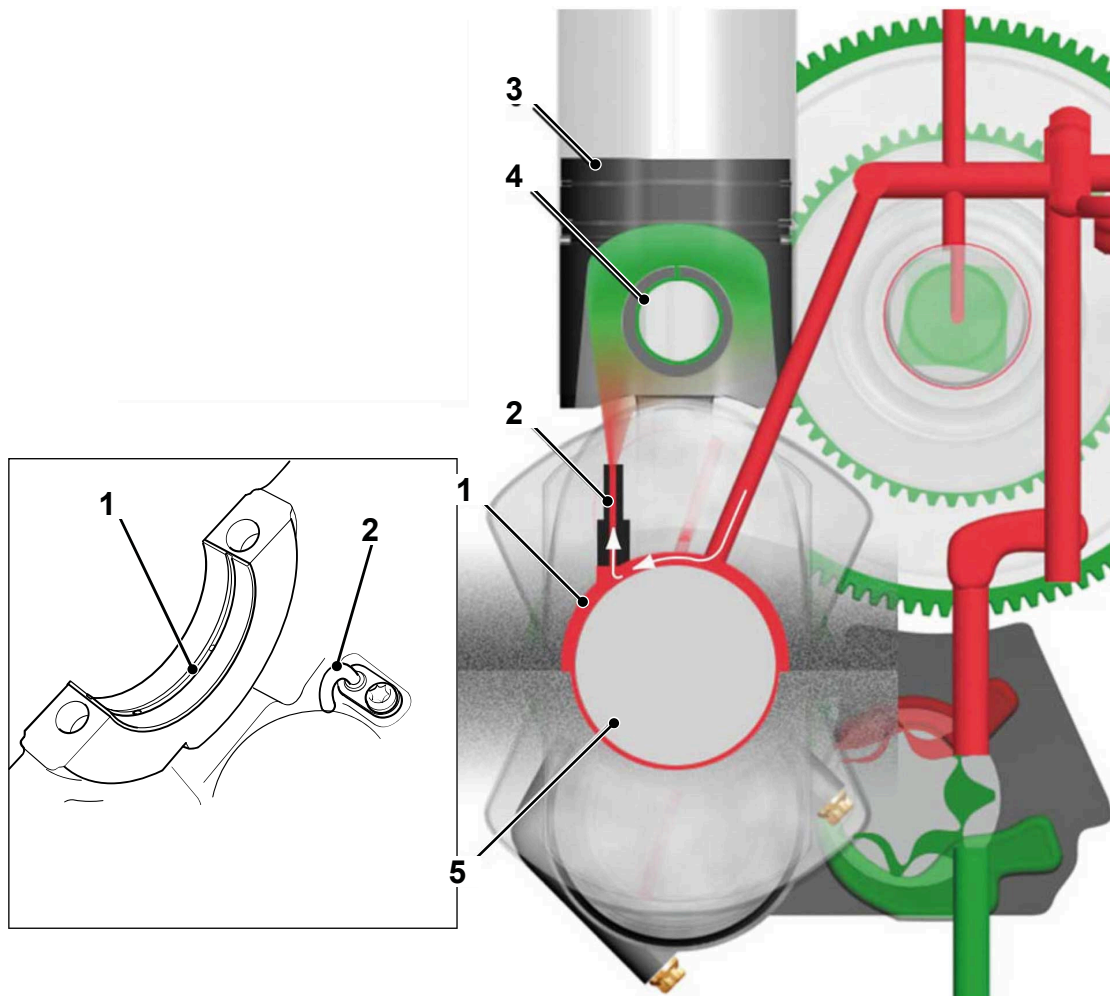
For: SJ Engine Page 15-46

(For: DJ Engine)

Oilways connect the J-shaped jets fixed to the crankcase at the underside of each cylinder bore.

The jets spray oil directly to the under side of the pistons effectively transferring heat away from the top of the pistons. Oil spray also enters the small end bearing bushes via a feed hole on the top of each connecting rod.

Figure 35.



- 1 Groove
- 3 Pistons
- 5 Crankshaft

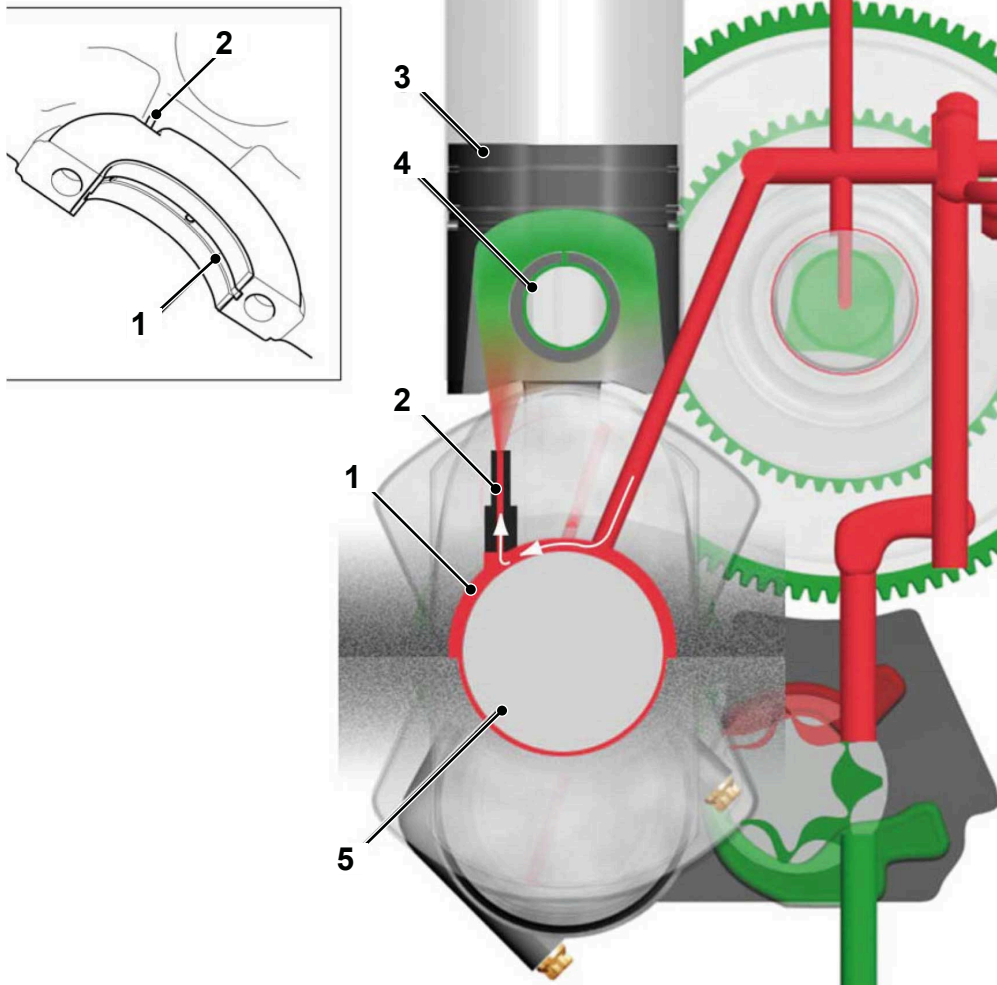
- 2 Oil J-jet
- 4 Bearing bushes

(For: SJ Engine)

The groove around the diameter of the upper main bearing shells allows oil transfer to an oil jet located in the crankcase bearing saddle. Jets are installed at the main bearing positions.

The jets spray oil directly to the under side of the pistons effectively transferring heat away from the top of the pistons. Oil spray also enters the small end bearing bushes via a feed hole on the top of each connecting rod.

Figure 36.



- 1 Groove
- 3 Pistons
- 5 Crankshaft

- 2 Oil jet
- 4 Bearing bushes

Check (Condition)

1. Check the oil jet is not bent. If the oil jet is suspected to be bent it must be replaced.
2. Use compressed air to check for any restriction or blockage.

Remove and Install

For: DJ Engine Page 15-48

For: SJ Engine Page 15-49

(For: DJ Engine)

Special Tools

Description	Part No.	Qty.
Crankshaft Turning Tool (95.25mm PCD)- JCB 4 Cylinder Ecomax and Dieselmax	892/01147	1

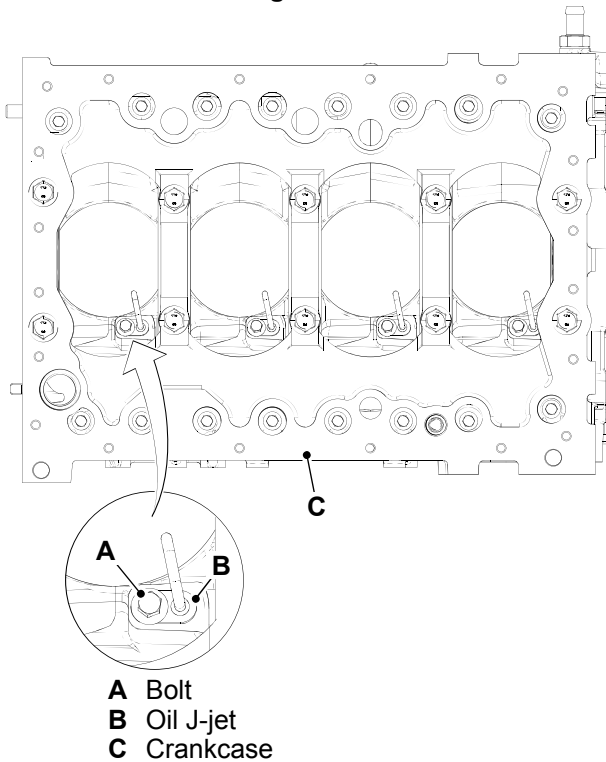
Before Removal

1. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.
2. Drain the engine oil.
[Refer to: PIL 15-00-00.](#)
3. Remove the oil sump.
[Refer to: PIL 15-45-00.](#)

Remove

1. Remove the bolt.
 - 1.1. If necessary rotate the crankshaft to gain access to the oil jet.
[Special Tool: Crankshaft Turning Tool \(95.25mm PCD\)- JCB 4 Cylinder Ecomax and Dieselmax \(Qty.: 1\)](#)

Figure 37.



2. Remove the oil jet from the crankcase.

Install

1. The installation procedure is the opposite of the removal procedure. Additionally do the following step.
2. Tighten the bolt to the correct torque value.

Table 37. Torque Values

Item	Nm
A	22–26

(For: SJ Engine)

Before Removal

This procedure requires service parts. Make sure you have obtained the correct parts before you start. Refer to the Parts Catalogue.

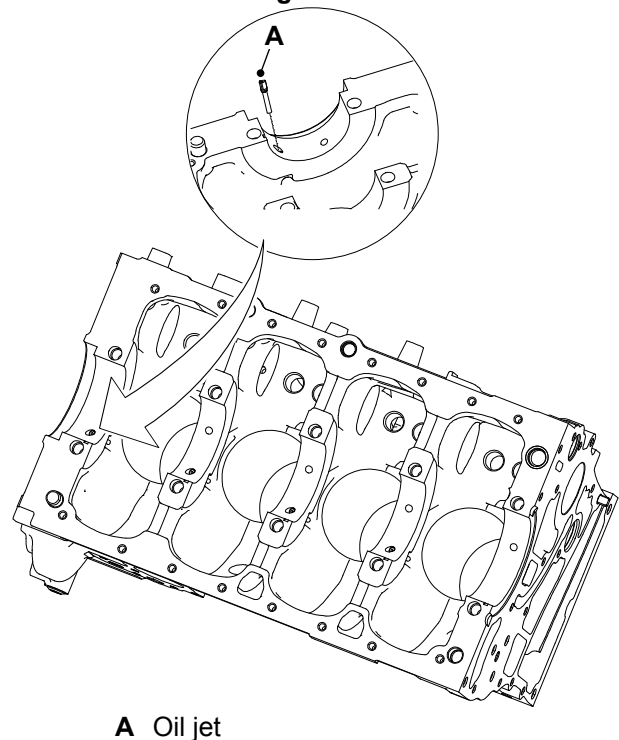
1. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.
2. Remove the engine.
[Refer to: PIL 15-00-00.](#)
3. Remove the cylinder head.
[Refer to: PIL 15-06-00.](#)

4. Remove the oil sump.
[Refer to: PIL 15-45-00.](#)
5. Remove the piston and connecting rod assemblies.
[Refer to: PIL 15-36-00.](#)
6. Remove the crankshaft and main bearings.
[Refer to: PIL 15-12-00.](#)

Remove

1. Use a suitable punch to press the oil jet out of the crankcase. The jet must not be reused. Discard the jet.
 - 1.1. Take care not to damage the cylinder bores.

Figure 38.



Install

1. Make sure the oil jet bore is clean and free from contamination or debris.
2. Insert the oil jet.
3. Use a suitable punch to fully seat the oil jet in the bore.
 - 3.1. Take care not to damage the machined surface of the crankshaft bore.

After installation

1. The after installation procedure is the opposite of the before removal procedure.



06 - Cylinder Head

Contents

Page No.

15-06-00 General 15-53



Notes:



00 - General

Introduction	15-53
Technical Data	15-54
Component Identification	15-55
Remove and Install	15-56

Introduction

The cylinder head is located above the cylinders on top of the crankcase. It closes in the top of the cylinder, forming the combustion chamber. This joint is sealed by a cylinder head gasket.

The cylinder head also provides the space for the passages that feed air and fuel to the cylinder and allow the exhaust to escape. The cylinder head is also used to mount the valves and fuel injectors.

Technical Data

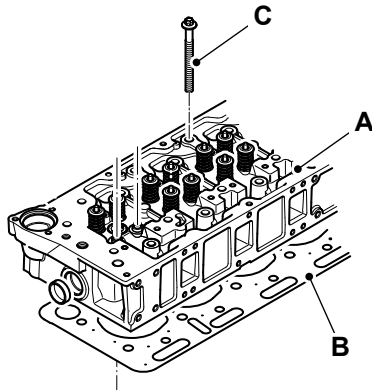
Table 38. Cylinder Head Data

Cylinder head distortion (maximum permissible) ⁽¹⁾	
- End to end	0.05mm
- Side to side	0.03mm
Valve recess depth	
- Inlet	0.85mm
- Exhaust	0.85mm
Valve seat angle	
- Inlet	120° (inclusive)
- Exhaust	90° (inclusive)
Surface finish for cylinder head joint	Rz < 15µm Rmax < 20µm
Permissible wave profile	wt < 10µm (2.5mm distance)

(1) The block to cylinder head surface may be skimmed and restored using the oversize gaskets (0.25mm and 0.5mm).

Component Identification

Figure 39.



- A Cylinder head
- B Cylinder head gasket
- C Cylinder head bolts

Remove and Install

Special Tools

Description	Part No.	Qty.
Torque Wrench (10-100Nm)	993/70111	1

Consumables

Description	Part No.	Size
Cleaner/Degreaser - General purpose solvent based parts cleaner	4104/1557	0.4 L

Before Removal

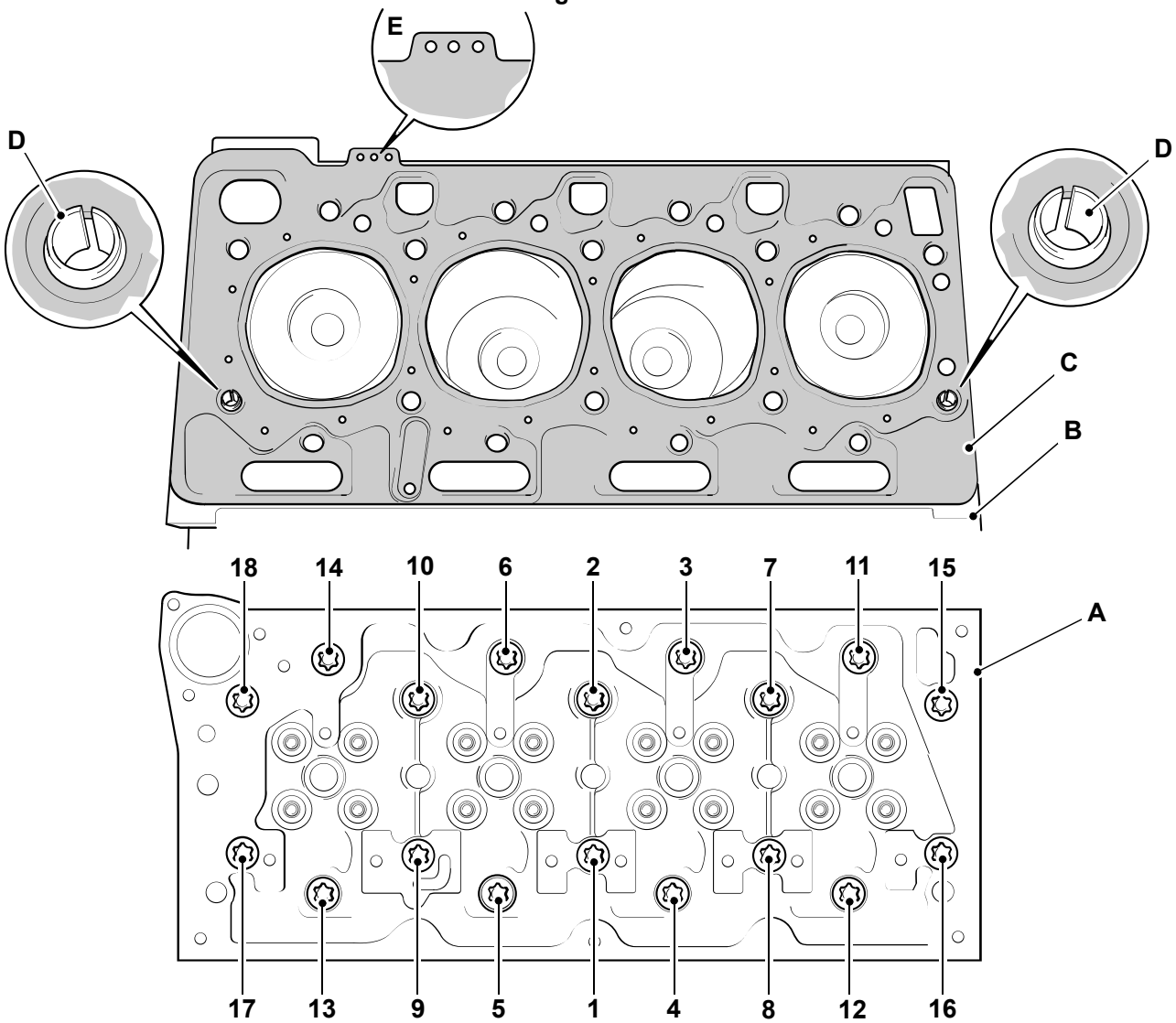
This procedure requires service parts. Make sure you have obtained the correct parts before you start, refer to Parts Catalogue.

1. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.
2. Get access to the engine.
3. Drain the coolant.

[Refer to: PIL 21-00-00.](#)

4. Remove the high pressure fuel pipes.
[Refer to: PIL 18-96-03.](#)
5. Remove the low pressure fuel pipes.
[Refer to: PIL 18-96-06.](#)
6. Remove the rocker cover.
[Refer to: PIL 15-42-06.](#)
7. Remove the fuel injectors.
[Refer to: PIL 18-18-03.](#)
8. Remove the rocker assembly.
[Refer to: PIL 15-42-00.](#)
9. Remove the exhaust manifold.
[Refer to: PIL 18-24-04.](#)
10. Remove the inlet manifold.
[Refer to: PIL 18-24-03.](#)

Figure 40.



- 1-18** Cylinder head fixing bolts (x18)
- B** Crankcase
- D** Location dowels (x2)

- A** Cylinder head
- C** Cylinder head gasket
- E** Cylinder head gasket identification holes

Remove

1. Progressively remove the cylinder head bolts in reverse order, starting at bolt 18. The bolts **MUST NOT** be re-used. Discard the bolts.
2. Carefully lift the cylinder head from the crankcase. If necessary use a soft face hammer. **DO NOT** use a lever to separate the cylinder head from the crankcase. Discard the head gasket.
3. Using a suitable cleaning agent, carefully remove all traces of the head gasket material from the cylinder head and crankcase mating faces.

Consumable: [Cleaner/Degreaser - General purpose solvent based parts cleaner](#)

4. Check the cylinder head and crankcase mating faces for signs of damage and distortion.

[Refer to: PIL 15-06-00.](#)

Before Install

1. Obtain the correct new cylinder head bolts. Note that the original bolts **MUST NOT** be re-used.
2. Obtain the correct replacement head gasket. Note the number of identification holes.
3. Make sure that all items are clean and free from damage and corrosion.

Install

1. Replacement is the reversal of the removal procedure.
2. Make sure that the location dowels are correctly installed into the crankcase. Use a dowel punch to install the dowels as required.
3. Position a new head gasket on to the crankcase mating face. Make sure that the gasket is installed the correct way around and correctly located over the dowels.
4. Lower the cylinder head on to the crankcase. Make sure that the cylinder head is correctly located on the dowels. Install new cylinder head bolts. Tighten the bolts in three stages, use the torque and angle method.

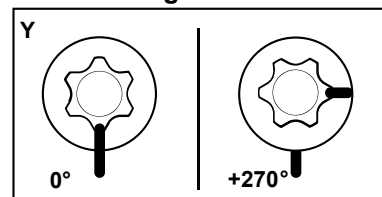
[Refer to: PIL 72-00-00.](#)

- 4.1. Tighten the bolts, starting with the middle pair and working outwards (in sequence 1-18) to the 1st stage torque.

Special Tool: [Torque Wrench \(10-100Nm\)](#) (Qty.: 1)

- 4.2. Then, further tighten the bolts, starting with the middle pair and working outwards (in sequence 1- 18) to the 2nd stage torque.
- 4.3. Use the angle gauge to angle tighten the bolts, starting with the middle pair and working outwards (in sequence 1-18) to the 3rd stage torque. As a visual check, matchmark the bolts to the cylinder head before you start. When the bolts have been angle tightened, the matchmarks will appear as shown at Y.

Figure 41.



Y Matchmark

After Install

1. The installation procedure is the opposite of the removal procedure. Additionally do the following steps.
2. Bleed the fuel system.

Table 39. Torques Table

Description	Torque Value
Cylinder head to crankcase bolts 1-18	
1st stage torque	40N·m
2nd stage torque	70N·m
3rd stage torque	270°



09 - Bedplate

Contents

Page No.

15-09-00 General	15-61
------------------------	-------



Notes:

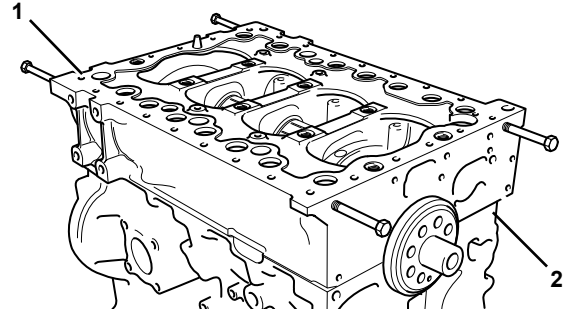
00 - General

[Introduction](#) 15-61
[Remove and Install](#) 15-62

Introduction

The bedplate acts as the main strength component of the engine. It maintains the correct alignment and supports the weight of the internal components.

Figure 42.



- 1 Bedplate
- 2 Crankcase



Remove and Install

Refer to: [PIL 15-12-00](#).



12 - Crankshaft

Contents	Page No.
15-12-00 General	15-65
15-12-03 Main Bearing	15-75
15-12-06 Front Oil Seal	15-77
15-12-09 Rear Oil Seal	15-80
15-12-12 Pulley	15-84



Notes:

00 - General

Technical Data

Technical Data 15-65
 Component Identification 15-66
 Operation 15-67
 Check (Condition) 15-68
 Remove and Install 15-69

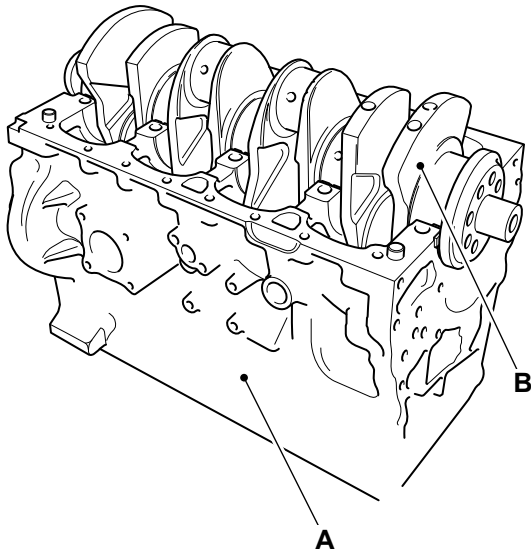
Table 40.

Main bearing journal diameter (x4)	
- min	87.98mm
- max	88mm
Main rear bearing journal diameter (x1)	
- min	99.98mm
- max	100mm
Connecting rod bearing journal diameter	
- min	72.98mm
- max	73mm
Maximum wear and ovality on journals ⁽¹⁾	
Crankshaft induction hardness	55 HRc min on surface
Thrust washer width	
- min	2.44mm
- max	2.5mm
Crankshaft end float	
- min	0.05mm
- max	0.28mm

(1) No visible damage/wear or marks

Component Identification

Figure 43.



- A** Crankcase
- B** Crankshaft

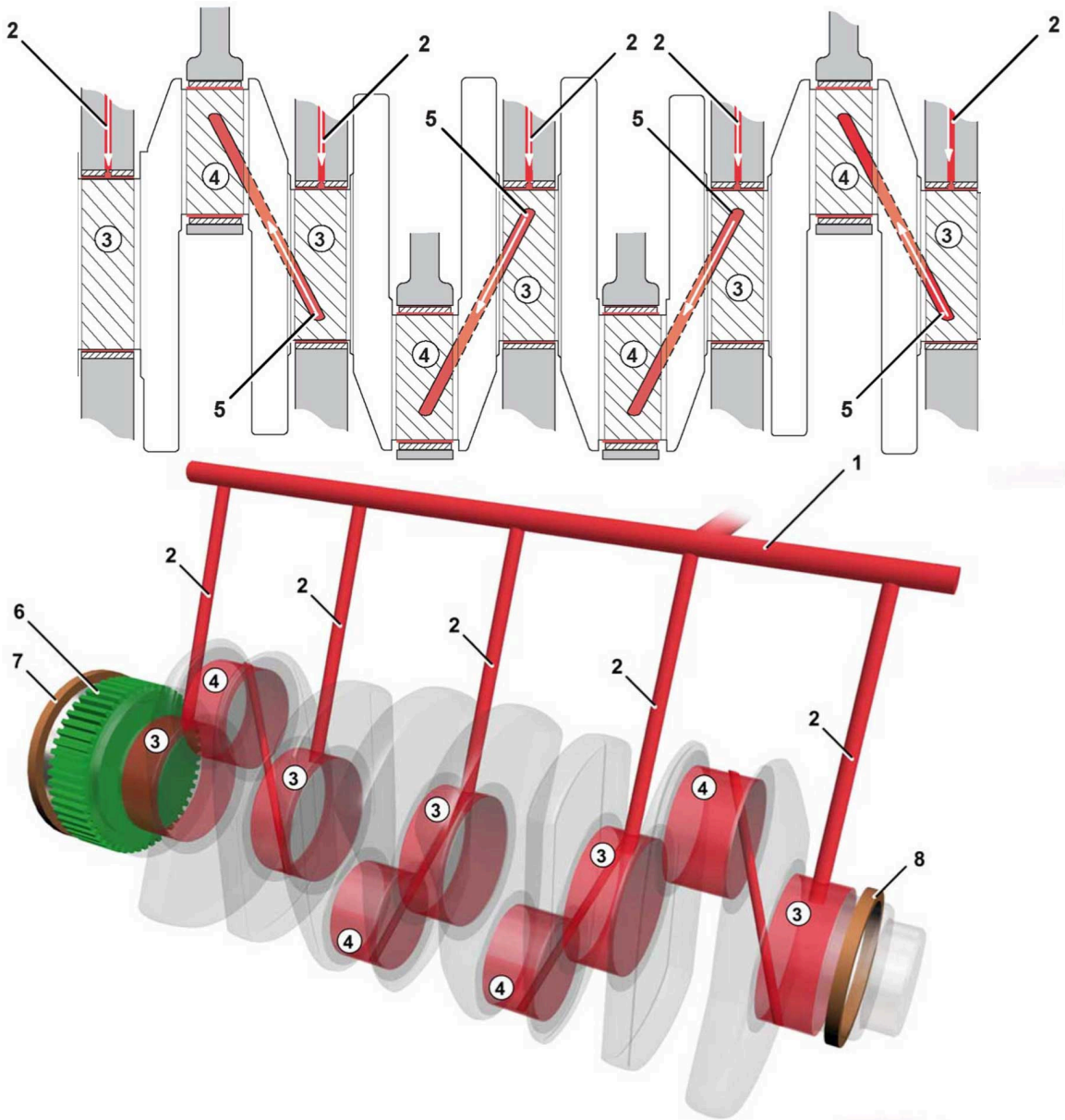
Operation

Lubrication

Oil is fed from the main gallery via five drillings, one to each of the main bearings. A groove around the diameter of the upper main bearing shell allows oil

transfer to cross drillings in the crankshaft to feed each of the big end bearings. Crankshaft gear is 'splash' lubricated. Front and rear crankshaft oil seals prevent oil leakage from, and dirt ingress to, the engine.

Figure 44.



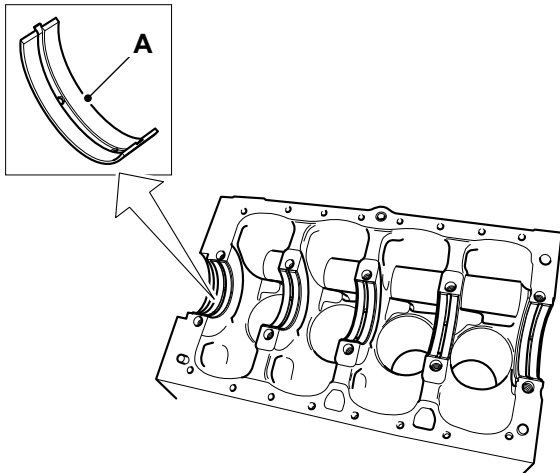
- 1 Main gallery
- 3 Main bearings
- 5 Cross drillings
- 7 Crankshaft oil seal

- 2 Drillings (x5)
- 4 Big end bearings
- 6 Crankshaft gear
- 8 Crankshaft oil seal

Check (Condition)

1. Check the main bearing surfaces for damage and excessive wear.

Figure 45.

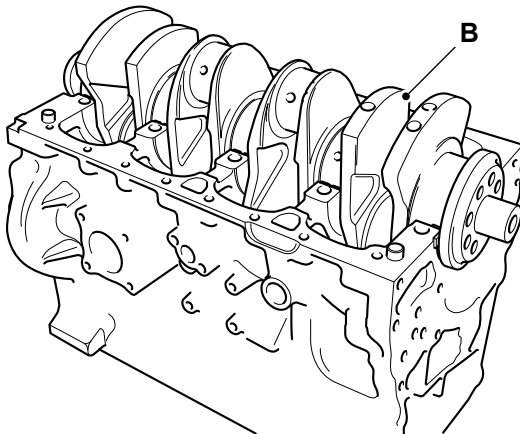


A Main bearing shells

2. Measure the crankshaft diameters to confirm they are within service limits.

Refer to: [PIL 15-12-00](#).

Figure 46.



B Crankshaft

3. Check that the oil-way cross drillings in the crankshaft are clear and free from debris. Blocked or restricted oil-ways will cause oil starvation at the big end bearings.
4. Check that the piston cooling jets are clear.

Refer to: [PIL 15-03-06](#).

Remove and Install

Special Tools

Description	Part No.	Qty.
Template for Sealant Bedplate to Crankcase (4 Cyl)	892/12356	1

Consumables

Description	Part No.	Size
Cleaner/Degreaser - General purpose solvent based parts cleaner	4104/1557	0.4 L

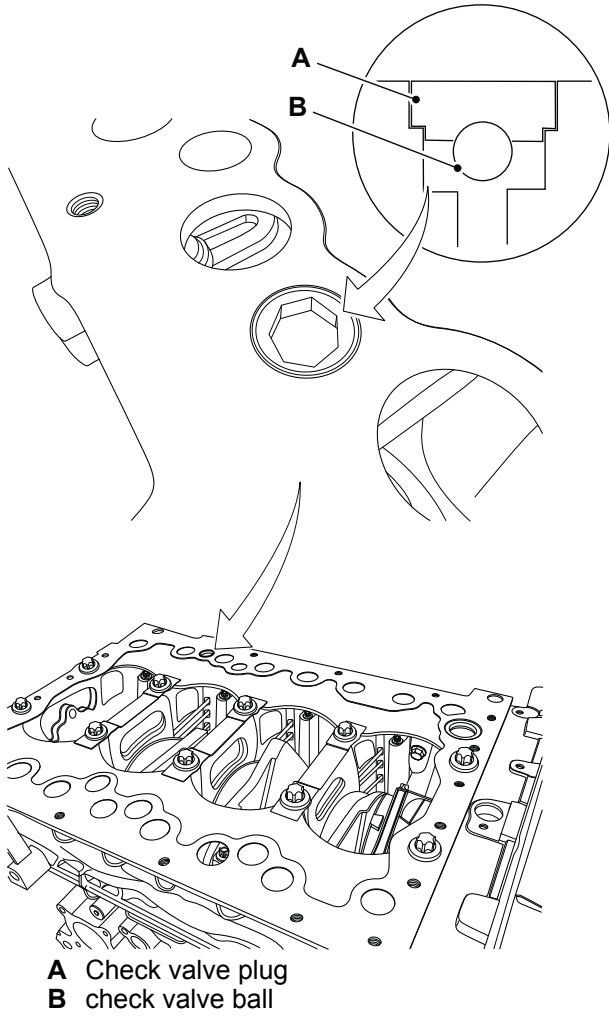
▲ CAUTION This component is heavy. It must only be removed or handled using a suitable lifting method and device.

Before Removal

This procedure requires service parts. Make sure you have obtained the correct service parts before you start, refer to Parts Catalogue.

- Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.
- Remove the engine.
[Refer to: PIL 15-00-00.](#)
- Remove the drive belt.
[Refer to: PIL 15-18-03.](#)
- Remove the crankshaft pulley.
[Refer to: PIL 15-12-12.](#)
- Remove the oil sump.
[Refer to: PIL 15-45-00.](#)
- Disconnect and remove the high pressure fuel pipes from the injectors.
[Refer to: PIL 18-96-03.](#)
- Disconnect and remove the low pressure fuel pipes from the injectors.
[Refer to: PIL 18-96-06.](#)
- Remove the rocker cover.
[Refer to: PIL 15-42-06.](#)
- Remove the fuel injectors.
[Refer to: PIL 18-18-03.](#)
- Remove the rocker assembly including the push rods.
[Refer to: PIL 15-42-00.](#)
- It is not necessary to remove the cylinder head assembly to remove the crankshaft. If however the cylinder head needs to be removed for other reasons (for piston and connecting rod removal for example) remove it now.
[Refer to: PIL 15-06-00.](#)
- Remove the fuel injection pump.
[Refer to: PIL 18-18-15.](#)
- Remove the starter motor.
[Refer to: PIL 15-75-00.](#)
- Remove the heavy duty PTO (Power Take-Off) device (if installed).
[Refer to: PIL 15-54-00.](#)
- Position the engine upside down in a suitable jig or fixture, supported at the front of the cylinder block.
[Refer to: PIL 15-54-03.](#)
- Remove the flywheel.
[Refer to: PIL 15-54-00.](#)
- Remove the flywheel housing
[Refer to: PIL 15-54-03.](#)
- Remove the fuel injection pump drive gear.
- Remove the oil pump.
[Refer to: PIL 15-60-00.](#)
- Remove the heavy duty PTO idler drive gear (if installed).
- Remove the crankshaft drive gear.
[Refer to: PIL 15-51-03.](#)
- Remove the camshaft.
[Refer to: PIL 15-15-00.](#)
- Remove the rear timing case.
[Refer to: PIL 15-51-22.](#)
- If the pistons and connecting rods have not been removed, undo and remove the main bearing caps.
[Refer to: PIL 15-36-00.](#)
- Remove the CCV (Crankcase Ventilation) check valve plug and ball.

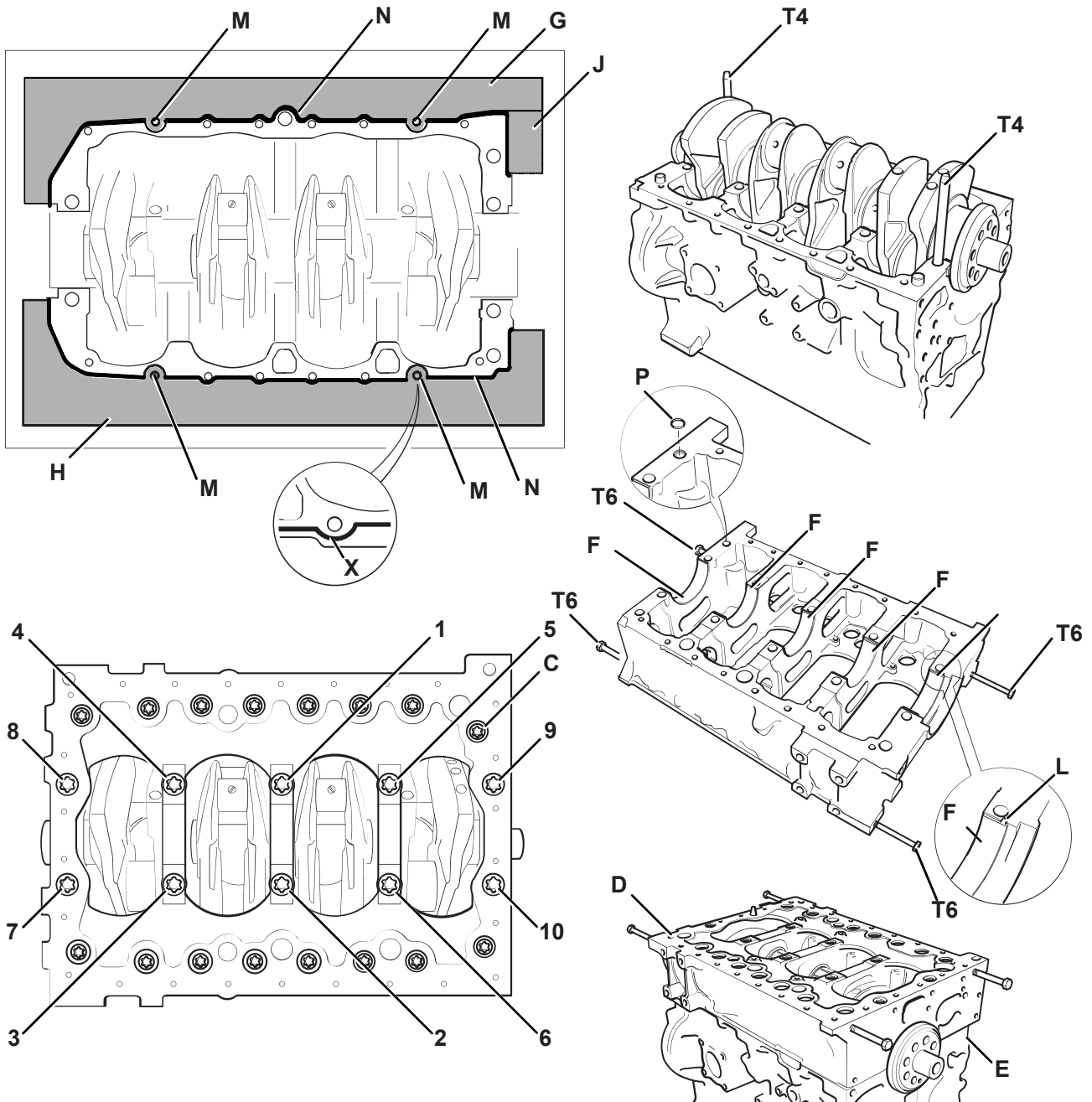
Figure 47.



Remove

1. Remove the bedplate peripheral bolts.

Figure 48.



- 1-10** Main bearing bolts
- D** Bedplate
- F** Lower main bearing shells (x5)
- H** Right side template
- K** Rear main bearing
- M** Sealant template locating holes
- P** O-ring
- T4** Guide pins (x2 obtain locally)
- T3** Angle Gauge (obtain locally)

- C** Bedplate peripheral bolts (x16)
- E** Crankcase
- G** Left side template
- J** Sealant template portion for removal
- L** Bearing tab
- N** Anaerobic sealant
- X** Sealant path
- T6** Lifting bolts (x4 obtain locally)

2. Progressively remove the main bearing bolts in reverse order starting at bolt 10. The bolts **MUST NOT** be re-used. Discard the bolts.

3. Install the four temporary lifting bolts. Carefully separate the bedplate from the crankcase. Use suitable lifting equipment (if the bedplate is lifted

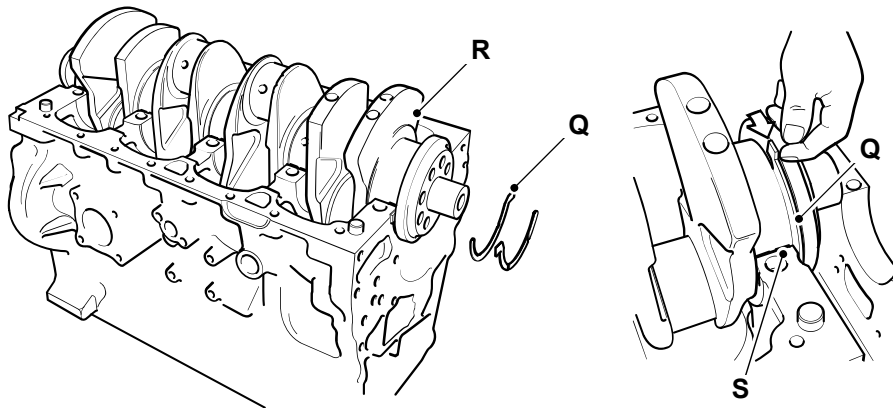
manually, two people will be required). DO NOT use a lever to separate the bedplate.

- Remove and discard the O-ring.

- Carefully remove the upper bearing shells from the bedplate, remove the bedplate.

- Remove the thrust washers between the crankshaft and crankcase rear main bearing.

Figure 49.



- Q** Thrust Washers
- S** Rear main bearing

- R** Crankshaft

- Put labels on the thrust washers to make sure that they are installed in the correct positions during assembly.
- Use suitable lifting equipment to carefully lift the crankshaft from the crankcase (if the crankshaft is lifted manually, two people will be required).
- Carefully lift out the bearing shells.

- Inspect the crankshaft and main bearings etc. for damage and excessive wear.

[Refer to: PIL 15-12-00.](#)

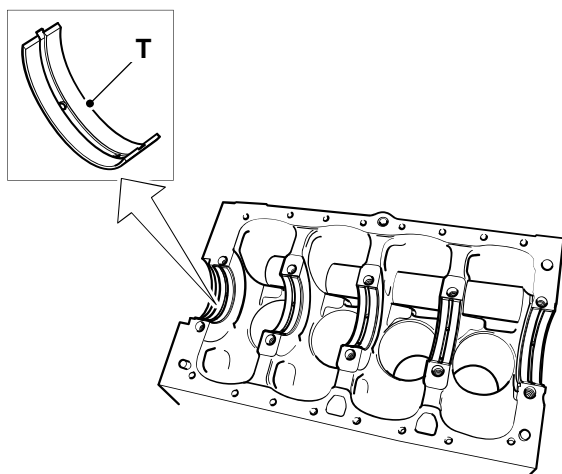
Before Installation

- Clean off all traces of the old sealant compound from the crankcase and bedplate mating faces.
- Use a suitable degreasing agent to carefully clean the main bearing saddles in the bedplate and crankcase. Take care not to block the oil ways or the piston cooling jets.

Consumable: [Cleaner/Degreaser - General purpose solvent based parts cleaner](#)

- 2.1. Cleanliness is of the utmost importance. Blocked oil-ways or oil jets will cause engine failure. Before you install the crankshaft make sure that ALL oil-ways and jets are clear and free from debris
- Make sure that all items are clean and free from damage and corrosion.

Figure 50.



- T** Upper Main bearing shells

- It is recommended that the bearing shells are replaced. If however they are to be used again, put label on the shells to make sure that they are installed in their original positions during assembly.

Install

Important: Anaerobic sealant will not start to cure whilst it is open to the atmosphere, however when air is excluded (for instance when the two parts are put together) it will immediately start to harden. Make sure that all the necessary tools, bolts etc. are readily available prior to assembling the components. The parts must be installed and

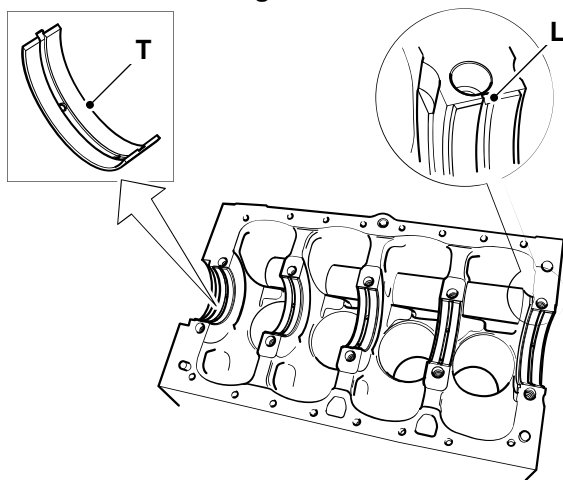
tightened to the correct torque value within 5min (with a maximum permissible time of 15min minutes).

1. The installation procedure is the opposite of the removal procedure. Additionally do the following steps.
2. Make sure that all items are clean and free from damage and corrosion.
3. If removed or if a new crankcase is being installed then install the piston cooling jets.

Refer to: PIL 15-03-06.

4. Install the upper bearing shells as follows:

Figure 51.



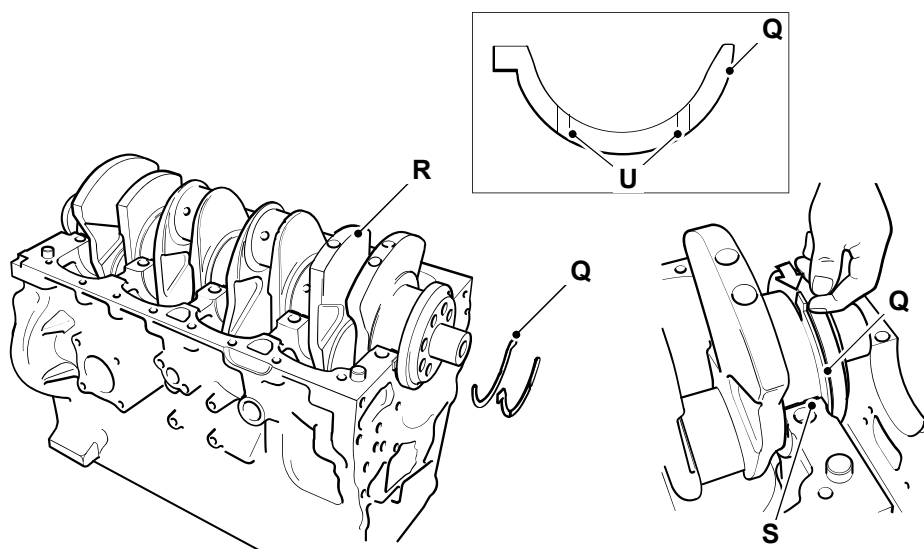
- T Upper main bearing shells
- L Bearing location tab

- 4.1. Use a suitable degreasing agent to make sure that the surface of the upper bearing shells are clean.

Consumable: Cleaner/Degreaser - General purpose solvent based parts cleaner

- 4.2. Assemble the bearing shells into the crankcase bearing saddles. Make sure that the location tab engages into the slot as shown.
- 4.3. Important: Make sure that the oil-way holes in the bearing saddles align with the holes in the bearing shell. If the holes are even partially misaligned the piston cooling oil jet will be restricted, causing the engine to fail.
- 4.4. Lubricate the upper bearing shells with clean engine oil.
5. Use suitable lifting equipment (if the crankshaft is lifted manually, two people will be required), to carefully lower the crankshaft into the crankcase. DO NOT rotate the crankshaft, the bearing shells can become dislodged.
6. Install the thrust washers as follows:

Figure 52.



- Q Thrust washers
- S Rear main bearing

- R Crankshaft
- U Oil slot - thrust washers

- 6.1. Slide the thrust washers between the crankshaft and the crankcase rear main bearing.
 - 6.2. Make sure that they are installed in the correct positions, with the two slots facing outwards from the bearing saddle.
 - 6.3. If necessary, push the crankshaft forward and then backwards to obtain clearance to install the thrust washers.
 - 6.4. DO NOT rotate the crankshaft, the bearing shells can become dislodged.
7. Check that the crankshaft end float is within service limits.
[Refer to: PIL 15-12-00.](#)
 8. Make sure that the upper main bearing shells are flush with the bottom face of the crankcase.
 9. Install the two guide pins T4 to the crankcase bedplate fixing holes as shown.
 10. Install the four lifting bolts T6 to the bedplate as shown.
 11. Install a new O-ring at the bedplate.
 12. Use a suitable degreasing agent to clean both sides of the lower bearing shells. Assemble the lower bearing shells into the bedplate. Lubricate the lower bearing shells with clean engine oil. Make sure that the location tab engages in the slot.
[Consumable: Cleaner/Degreaser - General purpose solvent based parts cleaner](#)
 13. Note: The sealant template T5 is used on the crankcase, NOT the bedplate. The sealant template T5 comprises of two pieces, G and H. Modify the template by removing portion J.
[Special Tool: Template for Sealant Bedplate to Crankcase \(4 Cyl\) \(Qty.: 1\)](#)
 14. Locate the holes in the templates using four fixing bolts at positions M. Use the templates as a guide apply beads of sealant around the crankcase/bedplate mating face as shown to the dimension specified.
 Length/Dimension/Distance: 1.5mm
 15. Remove the four fixing bolts at positions M. Remove the templates. Make sure you do not smudge the sealant. Discard the templates.
 16. Add beads of sealant around the four bolt holes at positions M, so as to join the sealant beads as shown at X.

17. Make sure that the location guide pins T4 are in position in the crankcase. Assemble the bedplate to the crankcase use the alignment guide pins.
18. Note: The bedplate is heavy. Two people will be required to lift and rotate the bedplate safely on to the crankcase. Install new main bearing bolts 1-10. Tighten the bolts to the correct torque value in pairs, starting in the centre and working outwards (in sequence 1-10) to the 1st stage pre-torque.
19. Install the bedplate peripheral bolts. Tighten the bolts to the correct torque value.
20. After installation and tightening the bedplate peripheral bolts, tighten the main bearing bolts in pairs, starting in the centre and working outwards (in sequence 1-10) to the 2nd stage torque.
21. Tighten the main bearing bolts in pairs, starting in the centre and working outwards (in sequence 1-10) for the final stage torque. Use the torque and angle method.
[Refer to: PIL 72-00-00.](#)

After Installation

1. Check that the crankshaft can be freely rotated by hand. Remove the bedplate lifting bolts T6.
2. Carry out the procedures listed, before removal in reverse order. Additionally do the following step.
3. Tighten the CCV check valve plug to the correct torque value.

Table 41. Torque Table

Item	Torque Value
1-10 (1st Stage)	50N·m
1-10 (2nd Stage)	115N·m
1-10 (Final Stage)	180°
A - CCV Check valve plug	45–55N·m
C - Bedplate peripheral bolts	24N·m

03 - Main Bearing

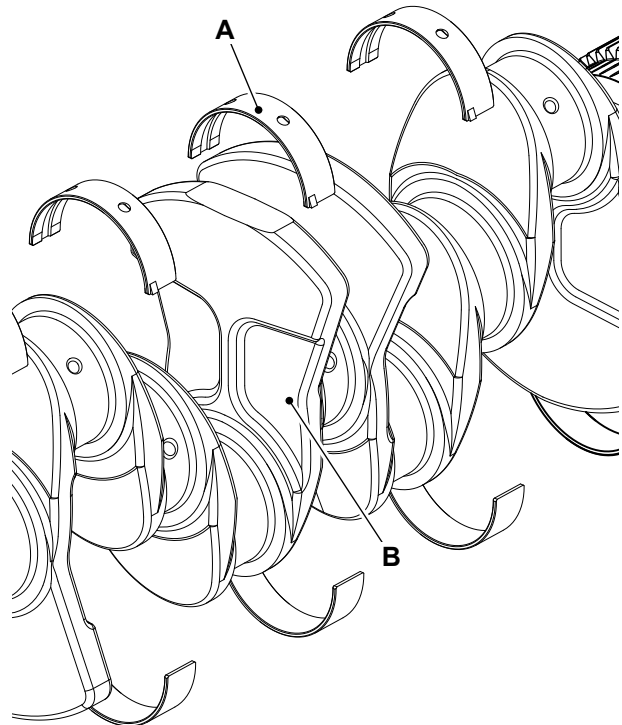
Introduction	15-75
Check (Condition)	15-76
Remove and Install	15-76

Introduction

In a piston engine, the main bearings are the bearings on which the crankshaft rotates.

The bearings hold the crankshaft in place and prevent the forces created by the piston and transmitted to the crankshaft by the connecting rods from dislodging the crankshaft, instead forcing the crank to convert the reciprocating movement into rotation.

Figure 53.



- A** Main bearing
- B** Crankshaft

Check (Condition)

1. Check the bearing shell surfaces for signs of damage and excessive wear.
2. Measure the crank pin diameters to confirm they are within service limits.
[Refer to: PIL 15-12-00.](#)
3. Renew any parts that are worn or not within the specified tolerances.

Remove and Install

[Refer to: PIL 15-12-00.](#)

06 - Front Oil Seal

Remove and Install

Special Tools

Description	Part No.	Qty.
Crankshaft Front Oil Seal Installation Tool	892/01157	1

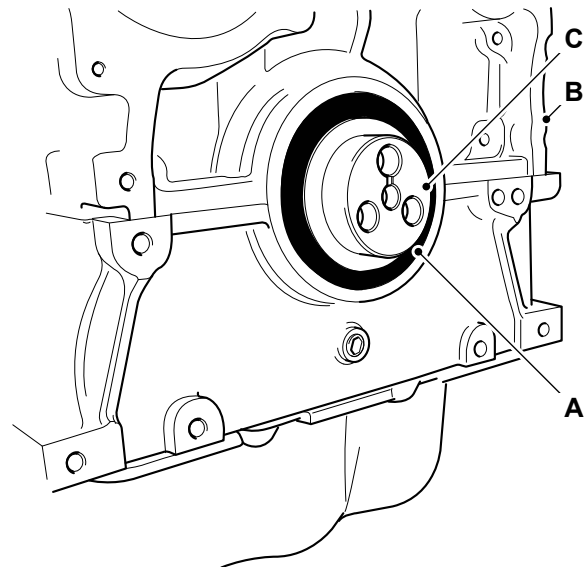
Before Removal

1. This procedure requires service parts. Make sure you have obtained the correct service parts before you start, refer to Parts Catalogue.
2. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.
3. Get access to the engine.
4. Remove the drive belt, refer to (PIL 15-18).
5. Remove the crankshaft pulley, refer to (PIL 15-12-12).

Remove

1. Use a suitable lever behind the lip of the seal, carefully prise out the oil seal from the counterbore in the crankcase. Take care not to scratch or damage the counterbore or the crankshaft hub. Damaged or dirty sealing faces will cause the oil seal to fail.

Figure 54.



- A Crankshaft oil seal
- B Crankcase
- C Crankshaft hub

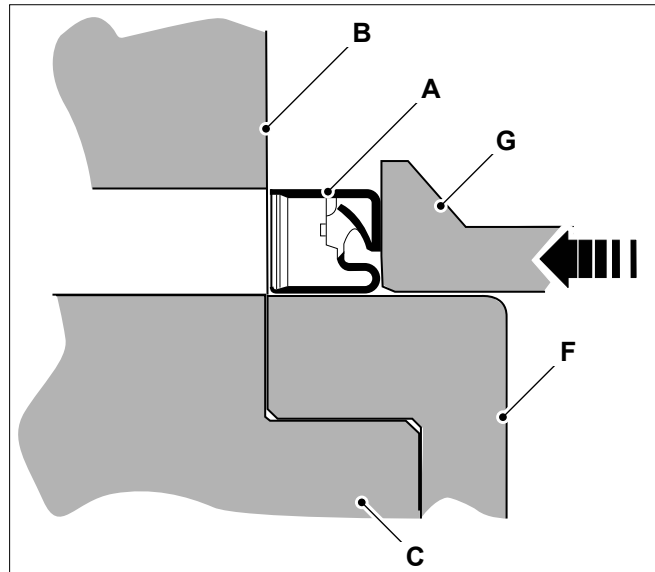
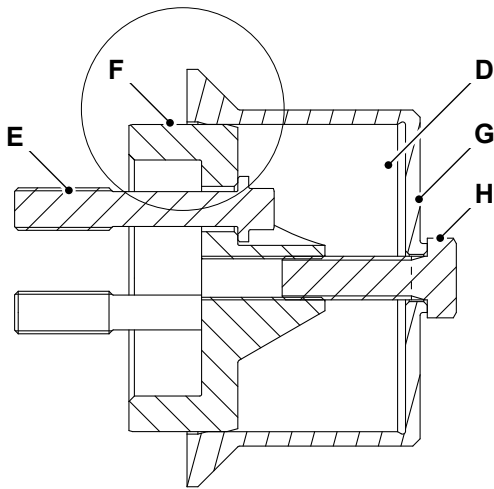
Install

1. Make sure that the counterbore and the crankshaft hub are clean and free from damage and corrosion. Use a suitable degreasing agent to clean all traces of oil and grease from the counterbore. Important: The oil seal has a special coating and MUST be installed dry without lubricant.
2. Dismantle the seal installation tool. Bolt the centre body to the crankshaft hub, using the bolts. Refer to Figure 55.

Special Tool: Crankshaft Front Oil Seal Installation Tool (Qty.: 1)

3. Install the oil seal on to the centre body. Make sure that the seal is installed the correct way around. Assemble the outer sleeve on to the centre body and install the screw. Refer to Figure 55.

Figure 55.



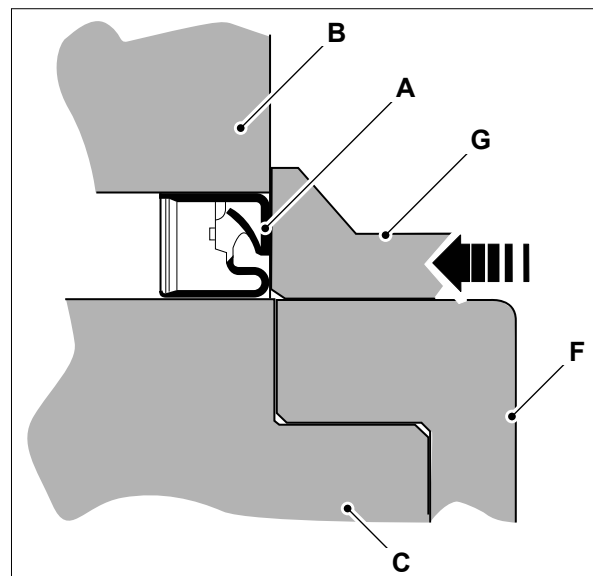
- A** Crankshaft oil seal
- C** Crankshaft hub
- E** Fixing bolts (x3)
- G** Outer sleeve

- B** Crankcase
- D** Seal installation tool
- F** Centre body
- H** Screw

4. Turn the screw to push the seal squarely into the counterbore until the outer sleeve comes up against the front edge of the counterbore. When correctly installed, the front face of the seal should be flush with the edge of the counterbore within the specified tolerance. Refer to Figure 56.

Dimension: $-0.5 -0/+0.5\text{mm}$

Figure 56.



- A** Crankshaft oil seal
- B** Crankcase
- C** Crankshaft hub
- F** Centre body
- G** Outer sleeve

5. Remove the seal installation tool.

After Installation

1. Install the crankshaft pulley, refer to (PIL 15-12-12).
2. Install the drive belt, refer to (PIL 15-18).

09 - Rear Oil Seal

Remove and Install

Special Tools

Description	Part No.	Qty.
Crankshaft Rear Oil Seal Installation Tool (new type)	320/B0656	1
Crankshaft Rear Oil Seal Installation Tool (old type)	892/01156	1
Crankshaft Rear Oil Seal Alignment Tool	892/01158	1

Note: The flywheel hub and crankshaft rear oil seal need to be replaced as a pair.

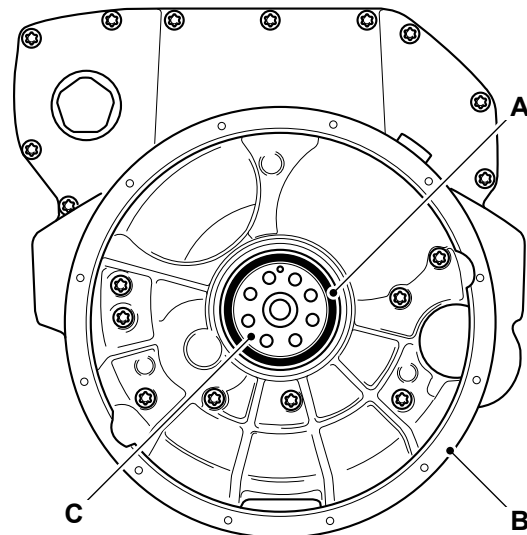
Before Removal

1. This procedure requires service parts. Make sure you have obtained the correct service parts before you start, refer to Parts Catalogue.
2. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.
3. Get access to the engine.
4. Remove the flywheel, refer to (PIL 15-54).

Remove

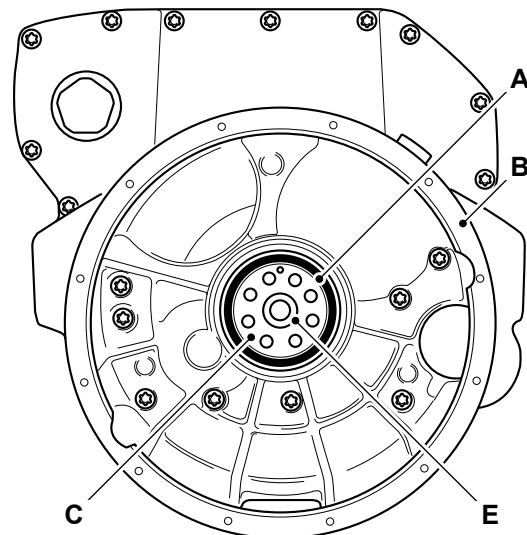
1. Use a suitable lever behind the lip of the seal to carefully prise out the rear oil seal from the counterbore in the flywheel housing. Take care not to scratch or damage the counterbore or the flywheel hub. Damaged or dirty sealing faces will cause the oil seal to fail.

Figure 57. 24mm Hub



- A Crankshaft rear oil seal
- B Flywheel housing
- C Flywheel hub

Figure 58. 15mm Hub

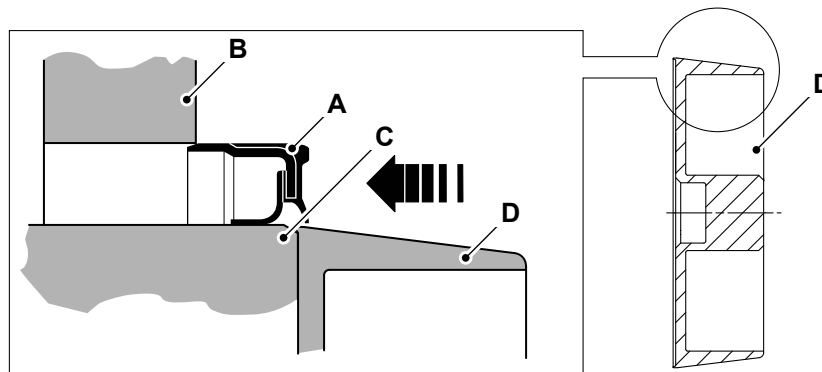


- A Crankshaft rear oil seal
- B Flywheel housing
- C Flywheel hub
- E Fixing bolt

Install (24mm Hub)

1. Make sure that the counterbore and the flywheel hub are clean and free from damage and corrosion.

Figure 59.



- A** Crankshaft rear oil seal
- C** Flywheel hub

- B** Flywheel housing
- D** Oil seal alignment tool

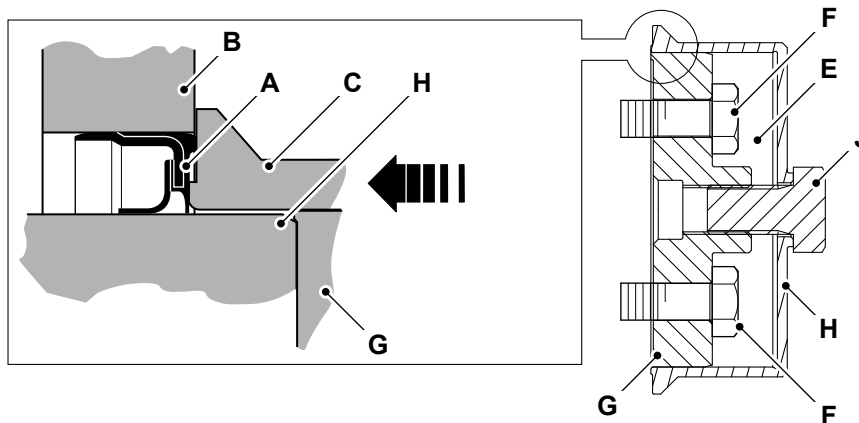
2. To prevent the seal lip rolling over and becoming damaged, make sure that you use the oil seal alignment tool to initially install the oil seal on to the flywheel hub. Locate the alignment tool over the end of the hub, then carefully push the oil seal over the alignment tool and on to the crankshaft diameter. Make sure that the oil seal is installed the correct way around.

[Special Tool: Crankshaft Rear Oil Seal Installation Tool \(new type\) \(Qty.: 1\)](#)

[Special Tool: Crankshaft Rear Oil Seal Installation Tool \(old type\) \(Qty.: 1\)](#)
[Special Tool: Crankshaft Rear Oil Seal Alignment Tool \(Qty.: 1\)](#)

- 3. Apply lubricant P80 around the seal outer rubber diameter.
- 4. Dismantle the oil seal installation tool. Bolt the centre body to the flywheel hub, using the two flywheel bolts. Assemble the outer sleeve on to the centre body and install the screw.

Figure 60.



- A** Crankshaft rear oil seal
- C** Outer sleeve
- F** Flywheel bolts
- H** Flywheel hub

- B** Flywheel housing
- E** Oil seal installation tool
- G** Centre body
- J** Screw

5. Turn the screw to push the seal squarely into the counterbore until the outer sleeve comes up against the front edge of the counterbore. When correctly installed, the front face of the seal

should be flush with the edge of the counterbore within the tolerance specified.

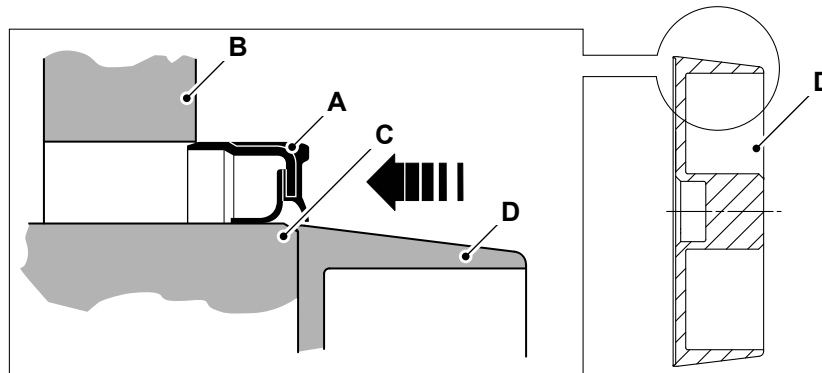
Length/Dimension/Distance: 0.5mm

- 6. Remove the oil seal installation tool.

Install (15mm Hub)

1. Make sure that the counterbore and the hub are clean and free from damage.

Figure 61.



- A Crankshaft rear oil seal
- C Flywheel hub

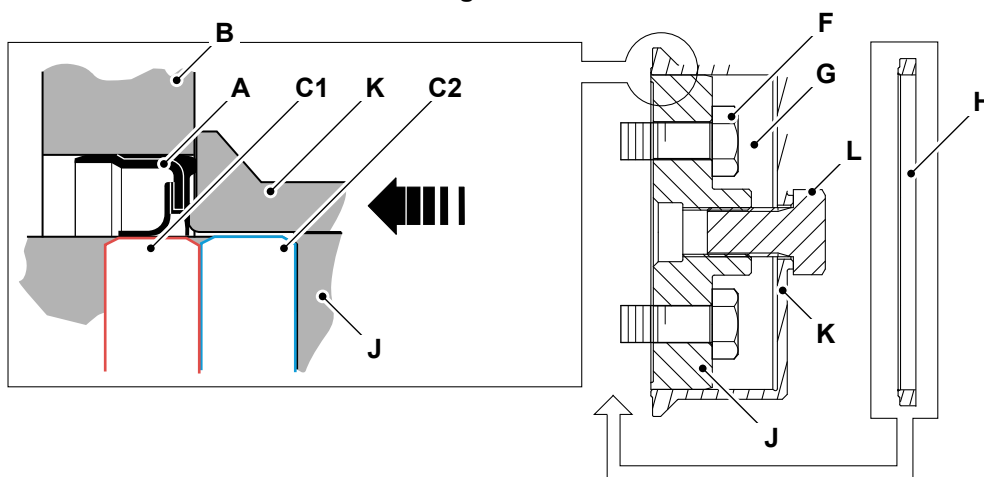
- B Flywheel housing
- D Oil seal alignment tool

2. Install the new hub on to the crankshaft gear and install the old hub on the outside of the new hub to create a double thickness flywheel hub, install the fixing bolt as shown at A. Do not touch the PTFE seal lips of the crankshaft oil seal.
3. Make sure that you use the oil seal alignment tool to initially install the oil seal on to the flywheel hub to prevent damage to the seal lip. Locate the alignment tool over the end of the hub, carefully push the oil seal over the alignment tool as far on to the crankshaft hub as possible. Make sure that the seal is installed the correct way around.

Special Tool: Crankshaft Rear Oil Seal Installation Tool (old type) (Qty.: 1)
 Special Tool: Crankshaft Rear Oil Seal Alignment Tool (Qty.: 1)

4. Apply the lubricant P80 around the seal outer rubber diameter.
5. Dismantle the oil seal installation tool. Use the two flywheel bolts to attach the centre body on to the flywheel hub. Assemble the outer sleeve on to the centre body include the extension ring and install the screw.

Figure 62.



- A Crankshaft rear oil seal
- C1 New hub
- F Flywheel bolts
- H Extension ring

- B Flywheel housing
- C2 Old hub
- G Oil seal installation tool
- J Centre body

K Outer sleeve

L Screw

6. Turn the screw to push the seal into position in the counterbore so that the screw will not turn.
7. Remove the oil seal installation tool, remove the old hub and install the fixing bolt. Repeat steps 5 and 6 to fully install the rear oil seal.
8. Remove the oil seal installation tool.

After Installation

1. Install the flywheel, refer to (PIL 15-54).

Table 42. Torque Values

Item	Nm
E	47

12 - Pulley

Remove and Install

Before Removal

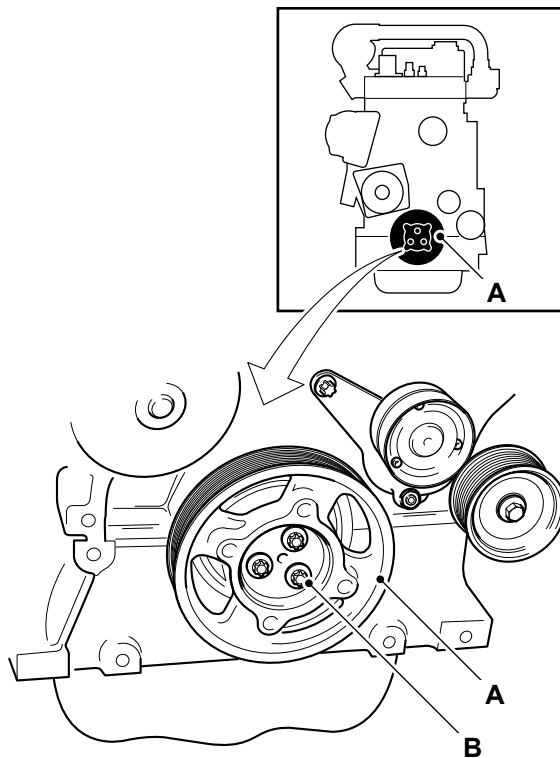
This procedure requires service parts. Make sure you have obtained the correct service parts before you start, refer to Parts Catalogue.

1. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.
2. Get access to the engine.
3. Remove the drive belt.
[Refer to: PIL 15-18-03.](#)

Remove

1. Remove the fixing bolts and withdraw the pulley from the crankshaft.

Figure 63.



- A** Crankshaft pulley
- B** Fixing bolts (x3)

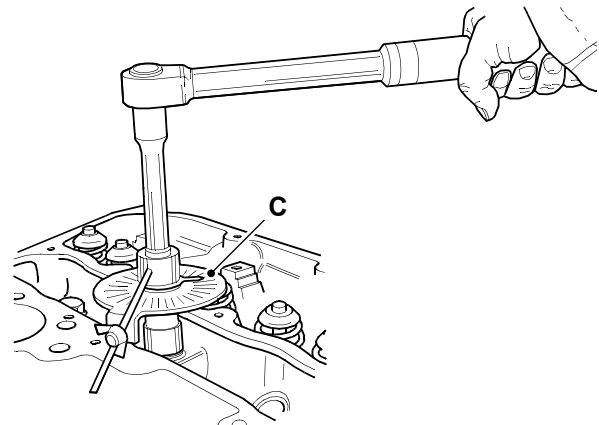
2. The bolts must not be reused. Discard the bolts.

Install

1. The installation procedure is the opposite of the removal procedure. Additionally do the following steps.
2. Make sure that all items are clean and free from damage and corrosion.
3. Install the new fixing bolts.
4. Tighten the new bolts in three stages to the correct torque value.
 - 4.1. The bolts are tightened using a torque and angle method.

[Refer to: PIL 72-00-00.](#)

Figure 64.



C Angle gauge (obtain locally)

After Replacement

1. Install the drive belt.
[Refer to: PIL 15-18-03.](#)

Table 43.

Item	Torque Value (Nm)	Torque Angle (Degrees)
B (1st stage)	30N·m	
B (2nd stage)	75N·m	
B (Final stage)		180°



15 - Camshaft

Contents

Page No.

15-15-00 General 15-87



Notes:

00 - General

Introduction	15-87
Technical Data	15-88
Component Identification	15-89
Operation	15-90
Check (Condition)	15-91
Remove and Install	15-91

Introduction

When the engine runs the crankshaft drives the camshaft via gears. The camshaft opens and closes the inlet and exhaust valves via push rods in time with the four stroke cycle. [Refer to: PIL 15-00-00.](#)

The relationship between the rotation of the camshaft and the rotation of the crankshaft is of critical importance. Since the valves control the flow of the air/fuel mixture intake and exhaust gases, they must be opened and closed at the appropriate time during the stroke of the piston. For this reason, the camshaft is connected to the crankshaft directly, via a gear mechanism.

Technical Data

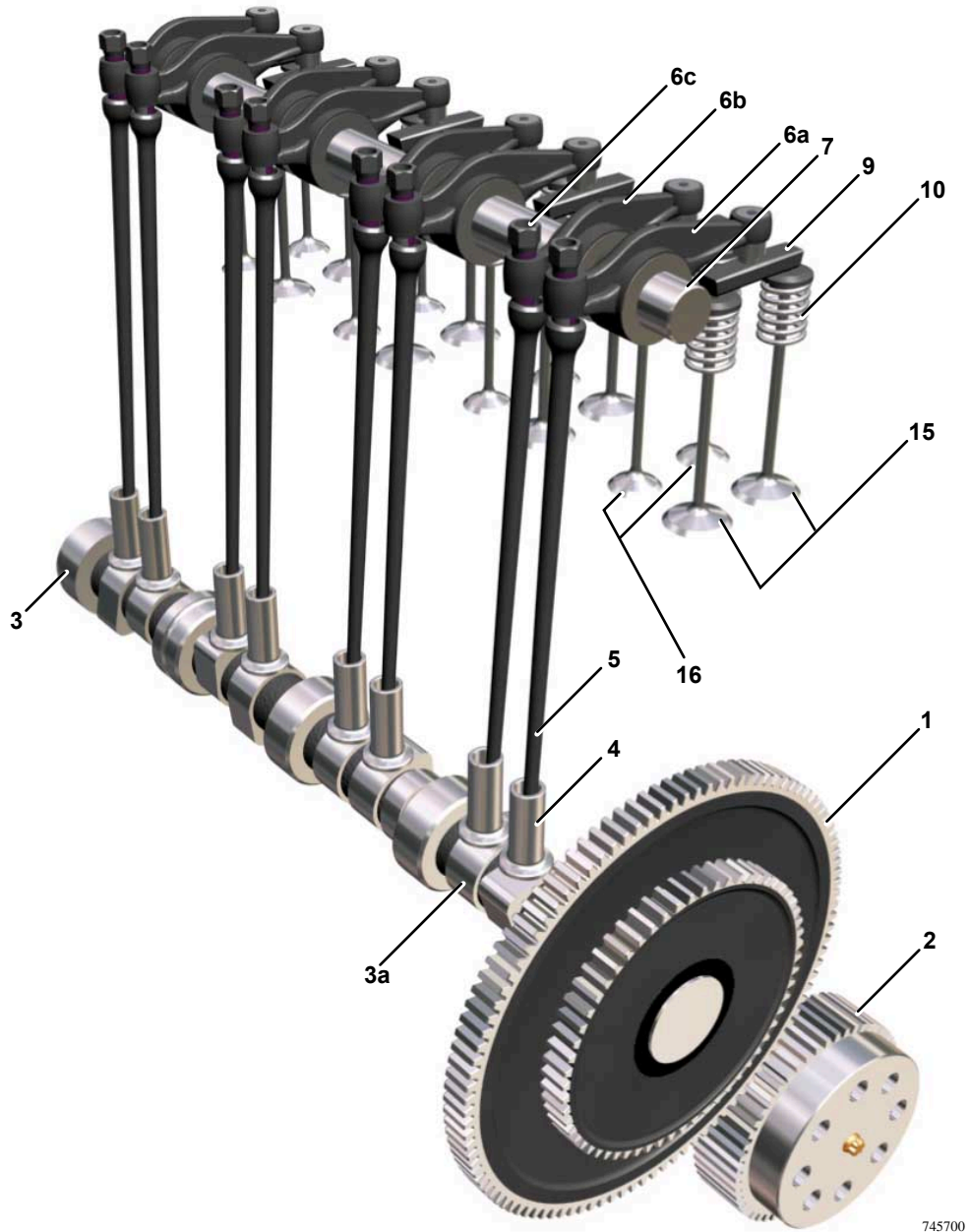
Table 44. Camshaft Data

Camshaft journal diameter	
- 4 off	59.99–59.97mm
- 1 off	60.25–60.22mm
Camshaft lobe wear limits	
Inlet lift	7.161–7.271mm
Exhaust lift	7.2–7.31mm
Camshaft bore diameter	
- 4 off	60.07–60.04mm
- 1 off	60.32–60.29mm
Camshaft gear ⁽¹⁾	104 teeth

(1) The camshaft gear is not available as a separate item. The gear must be heated on to the camshaft in the correct timed position. Specialist fixtures are used during the production process to achieve the correct timing.

Component Identification

Figure 65.



745700

- 1 Camshaft drive gear
- 3 Camshaft
- 4 Tappets
- 15 Inlet valves

- 2 Crankshaft gear
- 3a Camshaft lobes
- 5 Push rods
- 16 Exhaust valves

Operation

As the crankshaft rotates the camshaft also rotates, driven by a gear on the crankshaft. The inlet and exhaust valves are opened by lobes on the camshaft in time with the cycle.

The diagrams show the position of the camshaft at each part of the four stroke cycle, refer to Engine-General, Operation. Refer to: [PIL 15-00-00](#).

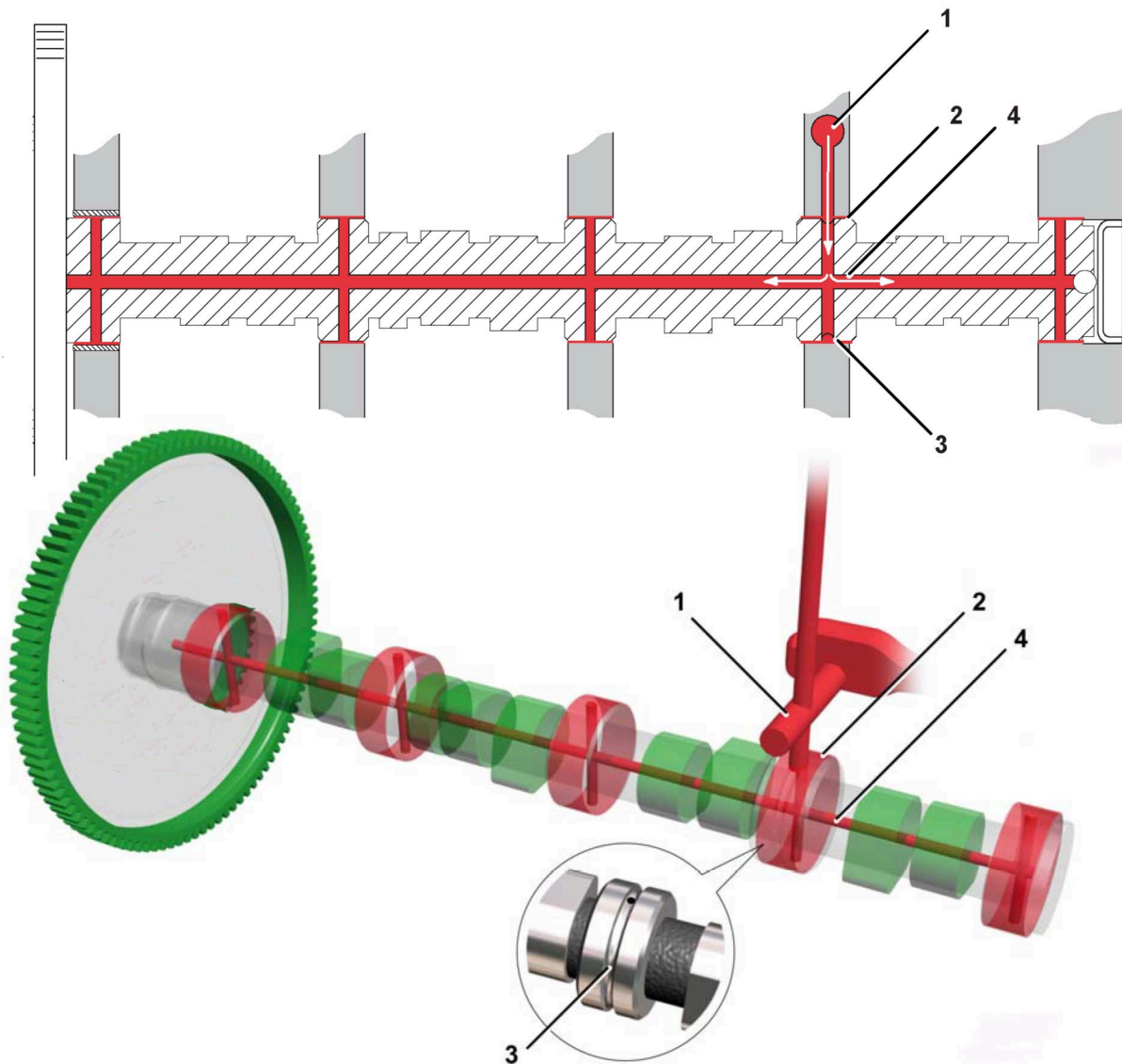
It can be seen that for a complete cycle the camshaft revolves once. Since the crankshaft revolves twice

during the cycle it follows that the camshaft is driven at half crankshaft (engine) speed.

Lubrication

Oil is fed from the main gallery via a drilling to the camshaft bearing. A groove around the diameter of the bearing and connecting the cross drilling ensures that oil is always fed to the centre drilling. Oil is then transferred to the remaining camshaft bearings by further cross drillings in the shaft. The cam lobes and tappets are 'splash' lubricated.

Figure 66.



1 Main gallery
 3 Groove

2 Camshaft bearing
 4 Centre drilling

Check (Condition)

1. Inspect the camshaft gear teeth for signs of damage or excessive wear.
2. Inspect the cam lobes for signs of excessive wear, scoring or pitting.
3. Inspect the cam bearing surfaces for signs of excessive wear, or scoring. Check that the dimensions are within service limits.
4. Inspect the cam bearing surfaces inside the crankcase for signs of excessive wear, or scoring. Check that the dimensions are within service limits.
5. Inspect the bearing surfaces of the tappets for signs of excessive wear or damage. Check that the dimensions are within service limits.
6. Inspect the tappet bores inside the crankcase for signs of excessive wear or damage. Check that the dimensions are within service limits.
7. If any of the camshaft bearings or lobes are worn or damaged then the relative oil feed galleries in the crankcase and camshaft may be blocked. Make sure all oil ways are clear and free from debris.

Remove and Install

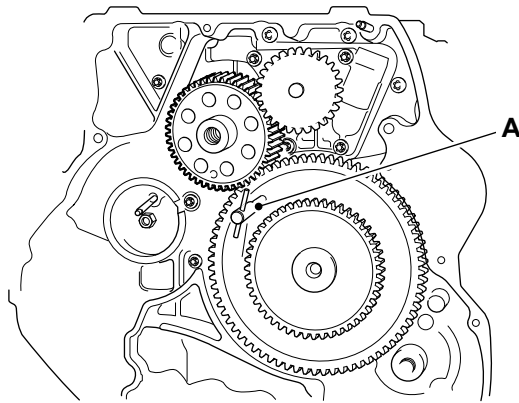
Special Tools

Description	Part No.	Qty.
Crankshaft / Camshaft Timing Pin (444/448/672 Engine)	892/01148	1

Before Removal

1. Drain the oil from the engine.
[Refer to: PIL 15-00-00.](#)
2. Disconnect and remove the fuel pipes from the injectors.
[Refer to: PIL 18-96-03.](#)
3. Remove the rocker cover.
[Refer to: PIL 15-42-06.](#)
4. Remove the rocker assembly and push rods.
[Refer to: PIL 15-42-00.](#)
5. Remove the starter motor.
[Refer to: PIL 15-75-00.](#)
6. Remove the fuel injection pump.
[Refer to: PIL 18-18-15.](#)
7. Remove the oil sump.
[Refer to: PIL 15-45-00.](#)
8. Remove the flywheel.
[Refer to: PIL 15-54-00.](#)
9. Remove the flywheel housing.
[Refer to: PIL 15-54-03.](#)
10. Rotate the crankshaft until the camshaft timing pin can be inserted through the gear and into the aligning hole in the rear gear case.
[Special Tool: Crankshaft / Camshaft Timing Pin \(444/448/672 Engine\) \(Qty.: 1\)](#)

Figure 67.

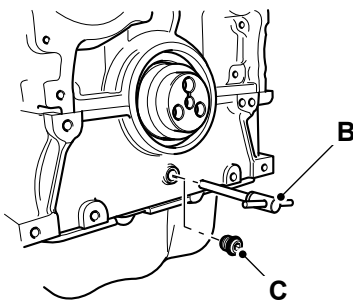


A Timing pin - camshaft

11. Remove the taper blanking plug and insert crankshaft locking pin. The camshaft and crankshaft locking pins must be in position to lock the crankshaft and camshaft before removing the camshaft assembly.

Special Tool: Crankshaft / Camshaft Timing Pin (444/448/672 Engine) (Qty.: 1)

Figure 68.



B Timing pin - crankshaft
C Blanking plug

12. Remove the fuel injection pump drive gear.

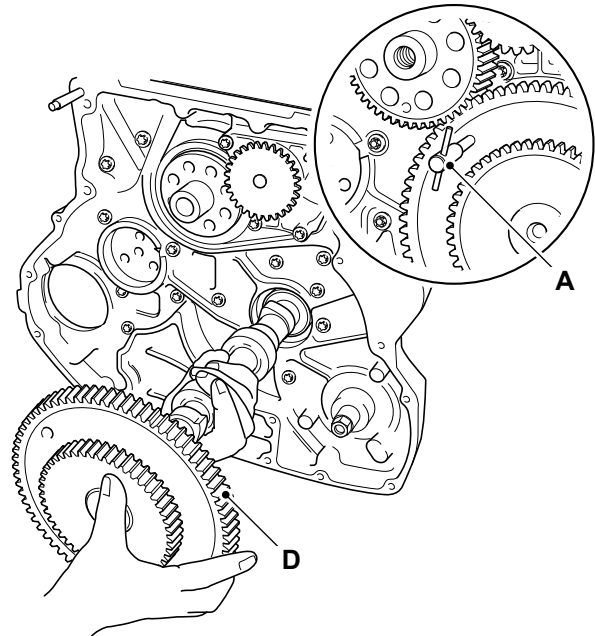
Refer to: PIL 15-51-09.

Remove

The engine must be inverted. Do not attempt to remove the camshaft and its drive gears with the engine upright. The tappets and push rods will fall into the engine and further dismantling will be required to retrieve them.

1. Remove the camshaft timing pin.
2. Carefully withdraw the camshaft and gear assembly from the crankcase. Make sure that you fully support the camshaft to prevent the lobes contacting the bearing surfaces in the crankcase. The bearing surfaces can easily be damaged by the sharp hard edges on the cam lobes.

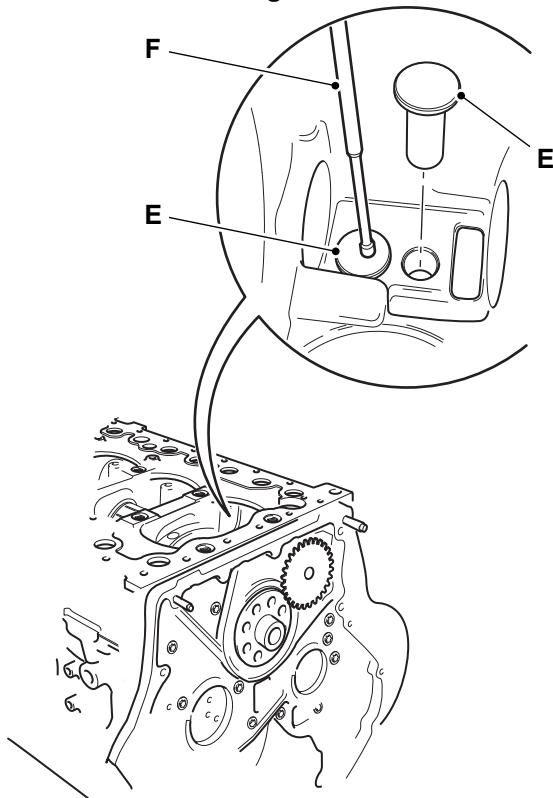
Figure 69.



A Timing pin - camshaft
D Camshaft and drive gear

3. Access the tappets through the apertures in the crankcase bedplate next to the crankshaft. Lift out the tappets from the crankcase using a suitable magnetic probe. Label the tappets to ensure replacement in their original positions.

Figure 70.



E Tappet
 F Magnetic probe

After Installation

1. Note that the fuel injection pump drive gear fixing nut is torque tightened as part of the fuel injection pump replacement procedure.

[Refer to: PIL 18-18-15.](#)

2. Do the procedures in Before Removal in reverse order.

Inspection

[Refer to: PIL 15-15-00.](#)

Install

1. Lubricate the tappets and tappet bores inside the crankcase with clean engine oil.
2. Insert the tappets in their original positions in the crankcase using a suitable magnetic probe.
3. Lubricate the camshaft bearing journals inside the crankcase with clean engine oil.
4. Carefully insert the camshaft assembly into the crankcase as shown. Support the camshaft preventing the lobes contacting the bearing surfaces in the crankcase. Before meshing the camshaft gear with the crankshaft gear, rotate the camshaft until the timing hole in the gear aligns with the dowel hole in the gear casing. Insert the timing pin to lock the camshaft in this position.

[Special Tool: Crankshaft / Camshaft Timing Pin \(444/448/672 Engine\) \(Qty.: 1\)](#)



18 - Engine Belt

Contents	Page No.
15-18-00 General	15-95
15-18-03 Front End Accessory Drive (FEAD) Belt	15-98
15-18-21 Tensioner	15-102



00 - General

Introduction	15-95
Health and Safety	15-96
Component Identification	15-96

Introduction

A crankshaft pulley is used to drive a FEAD (Front End Accessory Drive) belt. The belt drives the coolant pump. Depending on the machine application, the belt is configured to drive engine mounted accessories, such as the alternator and cooling fan.

Some applications have a second pulley on the crankshaft which drives a dedicated fan belt. The belt drives an engine mounted cooling fan.

Health and Safety

Turning the Engine

Do not try to turn the engine by pulling the fan or fan belt. This could cause injury or premature component failure.

WARNING! The engine has exposed rotating parts. Switch off the engine before working in the engine compartment. Do not use the machine with the engine cover open.

Notice: A drive belt that is loose can cause damage to itself and/or other engine parts.

Component Identification

Figure 71. A - With air conditioning compressor, no cooling fan

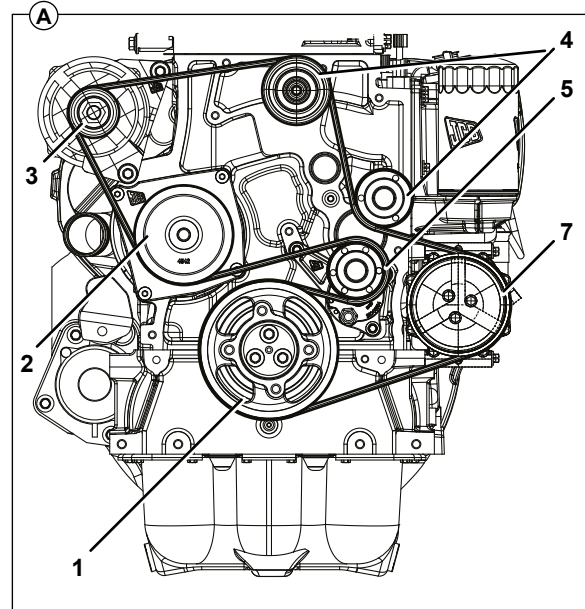
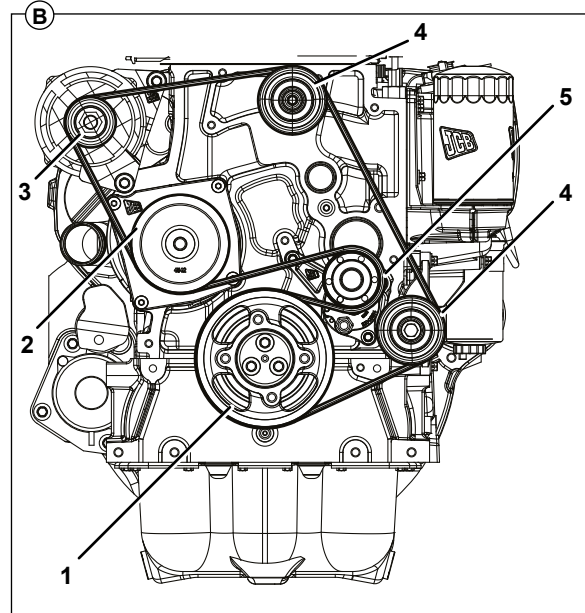


Figure 72. B - Without air conditioning compressor, no cooling fan



- 1 Crankshaft drive pulley
- 2 Coolant pump drive pulley
- 3 Alternator drive pulley
- 4 Idler pulley
- 5 Tensioner pulley
- 7 Air conditioning compressor drive pulley

Figure 73. C - With air conditioning compressor, cooling fan pulley installed

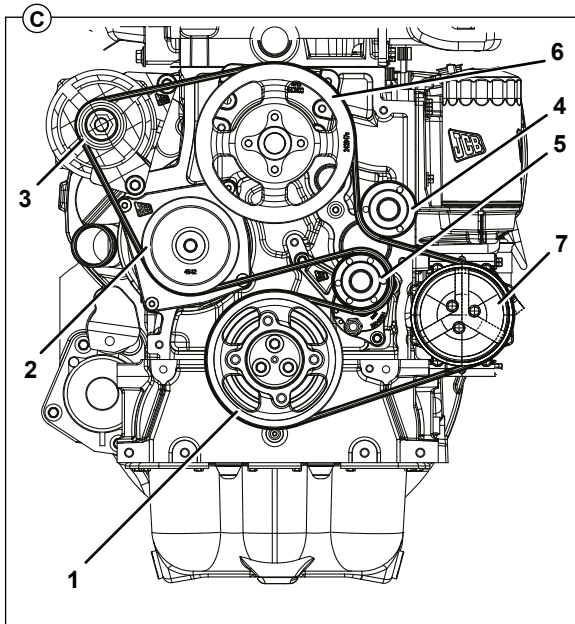
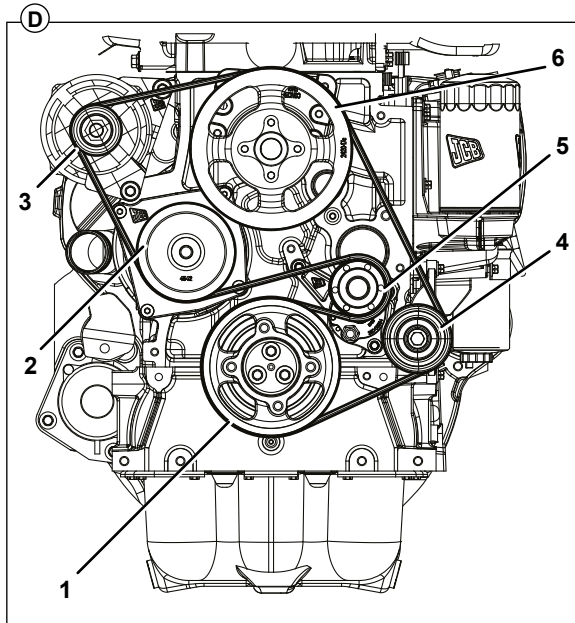


Figure 74. D - Without air conditioning compressor, cooling fan pulley installed



- 1 Crankshaft drive pulley
- 2 Coolant pump drive pulley
- 3 Alternator drive pulley
- 4 Idler pulley
- 5 Tensioner pulley
- 6 Cooling fan drive pulley
- 7 Air conditioning compressor drive pulley



03 - Front End Accessory Drive (FEAD) Belt

Introduction	15-98
Health and Safety	15-99
Check (Condition)	15-99
Adjust	15-100
Remove and Install	15-100

Introduction

The crankshaft pulley is used to drive the coolant pump via a FEAD (Front End Accessory Drive) belt. In addition to the coolant pump the drive belt can also be configured to drive the engine mounted accessories.

The belt is maintained at a constant tension by a spring loaded tensioner. To achieve the necessary belt/pulley contact area the belt is routed around idler wheels as required. The configuration varies depending on the accessories installed.

Health and Safety

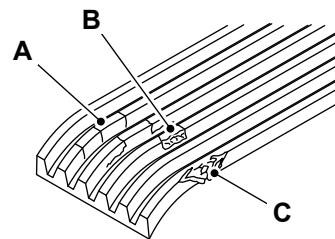
▲ **Notice:** A drive belt that is loose can cause damage to itself and/or other engine parts.

Check (Condition)

At the recommended service interval, visually inspect the drive belt for damage.

1. Make the machine safe.
[Refer to: PIL 01-03.](#)
2. Stop the engine and let it cool down.
3. Renew the drive belt if it has cracks or if it is frayed or has pieces of material missing.

Figure 75.



- A** Crack in belt
- B** Missing piece of belt
- C** Frayed belt

Adjust

Adjustment is not possible with this drive belt. A spring loaded tensioning unit ensures that the FEAD (Front End Accessory Drive) belt is kept at the correct tension.

Remove and Install

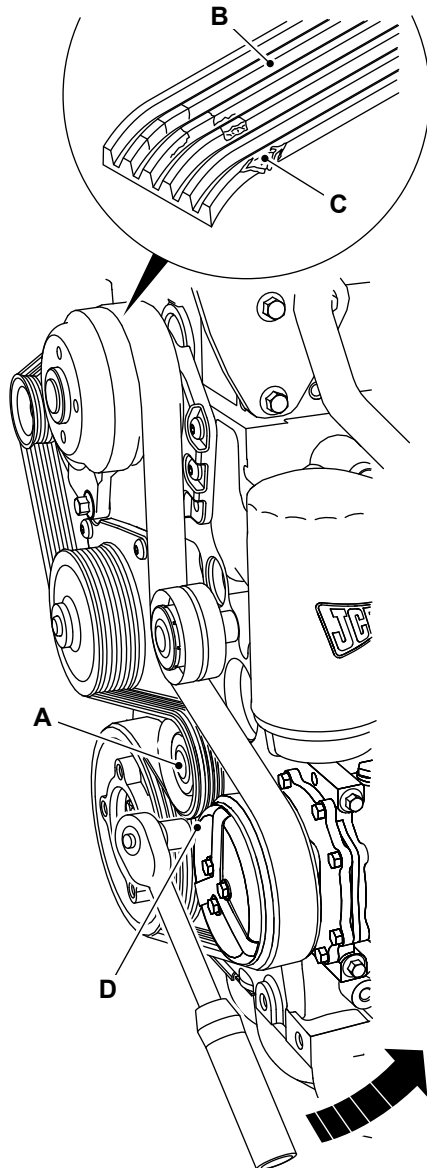
Remove

1. Make the machine safe. Refer to (PIL 01-03).
2. Stop the engine and let it cool down.
3. Use a socket of the specified size to locate on to the hexagon spigot nut, carefully rotate the tensioner against the spring force in the direction shown. Do not use excessive force or the tensioner will be damaged.

Dimension: 16mm

4. Keep holding the tensioner against the spring force and lift the belt off the drive tensioner pulley.
5. Slowly release the spring force by rotating the tensioner unit in the opposite direction.

Figure 76.



- A** Spring loaded tensioner
- B** Drive belt
- C** Example of frayed drive belt (refer to Check Condition)
- D** Spigot nut

Install

1. The installation procedure is the opposite of the removal procedure. Additionally do the following step.
2. Before you install the new belt, check that the tensioner roller and the fan pulley rotate smoothly and that there is no play in the bearings.

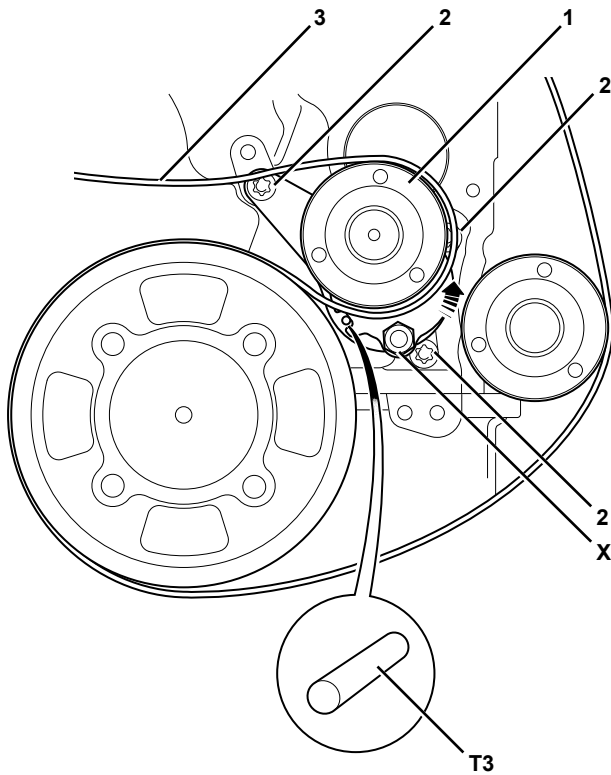
21 - Tensioner

Remove and Install

Before Removal

1. Make the machine safe. Refer to (PIL 01-03).
2. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.
3. Get access to the engine.
4. Remove the drive belt, refer to (PIL 15-18).

Figure 77.



- 1 Drive belt tensioner pulley
- 2 Fixing bolts (x3)
- 3 Drive belt
- T3 Locking pin
- X Spigot nut

Remove

The drive belt tensioner is a non-serviceable item. If the drive belt tensioner or the idler wheel is faulty or damaged it must be renewed as a complete assembly.

1. To remove the tensioner assembly, remove the bolts and lift the tensioner pulley from the cylinder block.

Install

1. The installation procedure is the opposite of the removal procedure. Additionally do the following steps.
2. Tighten the bolts to the correct torque value.
3. Install the drive belt, refer to (PIL 15-18).
4. Make sure that the drive belt is under tension and the locking pin is removed before starting the engine. Refer to Drive Belt - Adjust (PIL 15-18).

Table 45. Torque Values

Item	Nm
2	24



21 - Oil Filter

Contents

Page No.

15-21-00 General 15-105



Notes:



00 - General

Introduction	15-105
Health and Safety	15-106
Component Identification	15-107
Check (Level)	15-109
Remove and Install	15-110

Introduction

The oil filter is a spin on type which screws on and off the oil filter head.

Health and Safety

Oil

Oil is toxic. If you swallow any oil, do not induce vomiting, seek medical advice. Used engine oil contains harmful contaminants which can cause skin cancer. Do not handle used engine oil more than necessary. Always use barrier cream or wear gloves to prevent skin contact. Wash skin contaminated with oil thoroughly in warm soapy water. Do not use petrol, diesel fuel or paraffin to clean your skin.

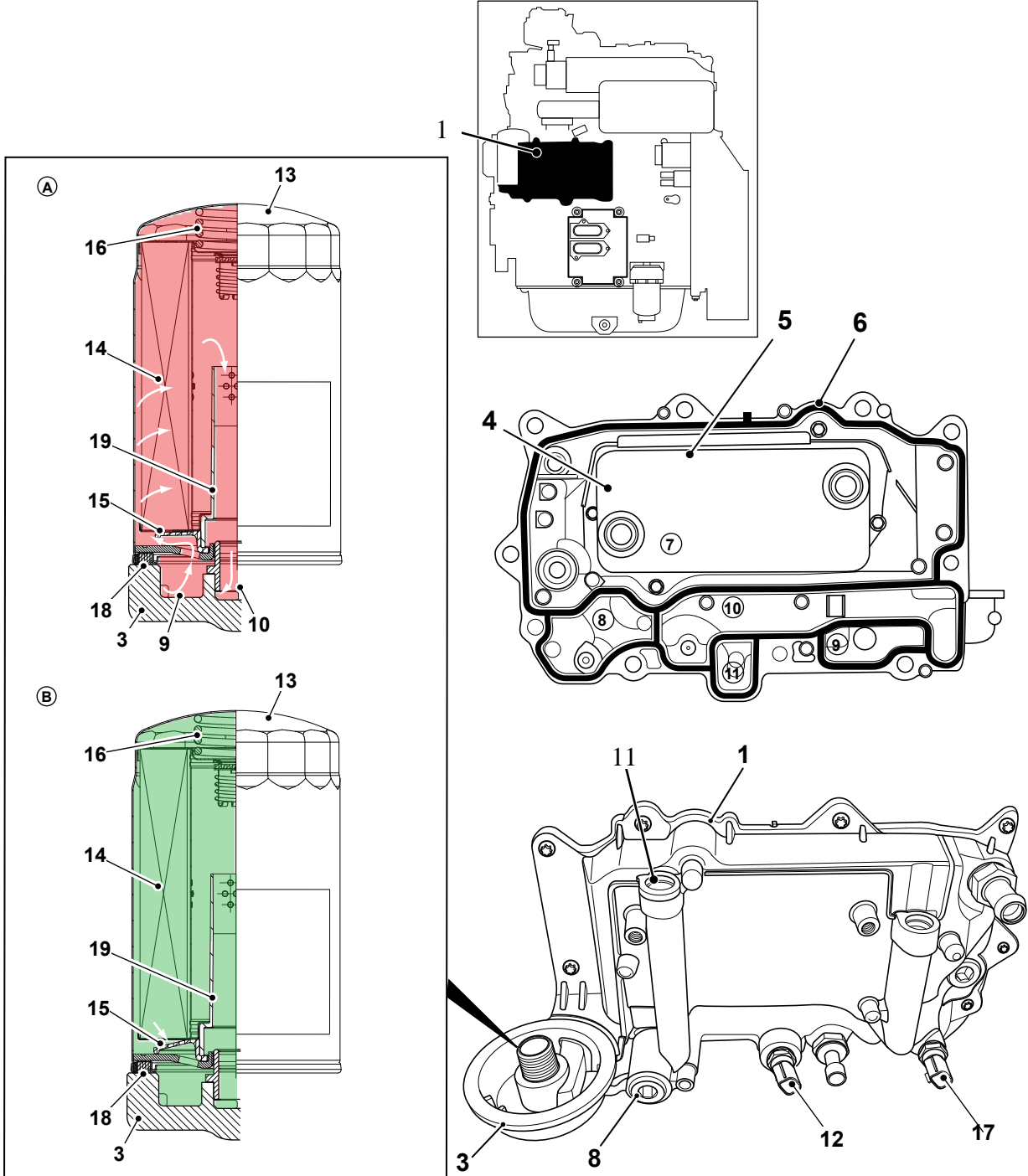
CAUTION! *It is illegal to pollute drains, sewers or the ground. Clean up all spilt fluids and/or lubricants. Used fluids and/or lubricants, filters and contaminated materials must be disposed of in accordance with local regulations. Use authorised waste disposal sites.*

CAUTION! *Oil will gush from the hole when the drain plug is removed. Keep to one side when you remove the plug.*

CAUTION! *The oil filter canister will contain some oil which could spill out when you remove the canister.*

Component Identification

Figure 78.



- 1 Oil cooler and filter housing
- 3 Oil filter head
- 5 Oil cooler matrix
- 7 Coolant gallery
- 9 Oil gallery - from cooler to filter head

- 2 Oil filler cap (not shown)
- 4 Oil gallery - from pump to cooler
- 6 Sealing gasket - housing to crankcase
- 8 Oil filter drain down plug
- 10 Oil gallery - from filter head to main oil gallery

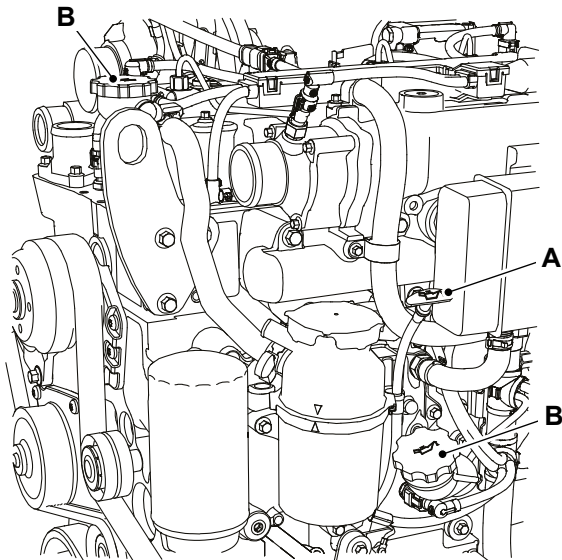
- | | | | |
|-----------|-----------------------------------|-----------|-----------------------------------|
| 11 | Oil filler port | 12 | Oil pressure switch |
| 13 | Oil filter | 14 | Filter element |
| 15 | Anti-drain seal | 16 | Spring |
| 17 | Oil Temperature Sensor | 18 | O-ring |
| 19 | Anti-drain pipe | A | Oil filter state - engine running |
| B | Oil filter state - engine stopped | | |

Check (Level)

Engine oil and oil filter replacement must be completed in accordance with the service schedules. Failure to replace the oil and filter at the recommended interval could cause serious engine failure.

1. Make the machine safe, refer to (PIL 01-03).
2. Get access to the engine.
3. Check that the oil level is between the two marks on the dipstick.
4. If necessary, add recommended oil through one of the filler points.

Figure 79.



- A** Dipstick
B Oil filler point

Remove and Install

Special Tools

Description	Part No.	Qty.
Oil Filter Removal Tool	892/00292	1
Data Link Adaptor (DLA) Kit Data Link Adaptor (DLA 2.0) Kit	892/01174 728/H5409	1*

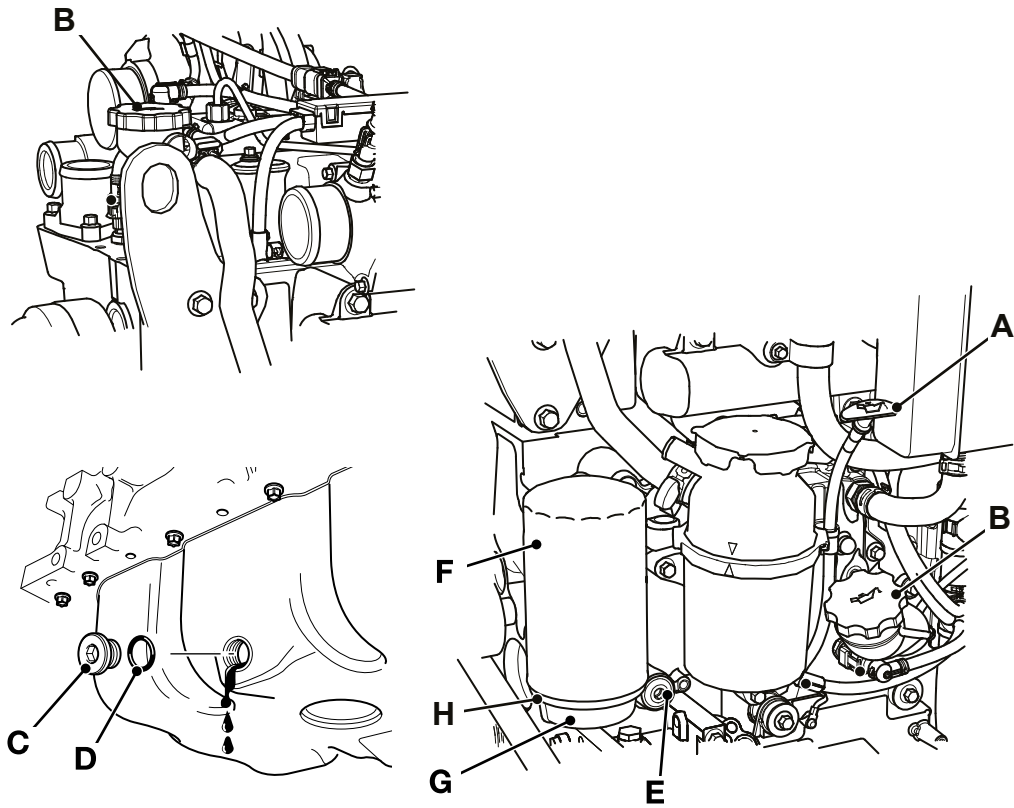
*Unless otherwise stated, you can use any of the tools shown.

Drain the oil when the engine is warm as contaminants held in suspension will then be drained with the oil.

CAUTION! Oil will gush from the hole when the drain plug is removed. Keep to one side when you remove the plug.

1. Place a container of suitable size beneath the drain plug.
2. Remove the oil sump drain plug and 'O' ring. Let the oil drain out, then clean and install the drain plug with a new 'O' ring. Tighten the plug to the correct torque value.
3. Loosen and remove the filter housing drain plug. Let the oil fully drain. Install the plug. Tighten the plug to the correct torque value.
4. Unscrew the filter canister, use special tool if necessary.
Special Tool: Oil Filter Removal Tool (Qty.: 1)
5. Clean the seal face of the filter head.
6. Smear the seal on the new filter canister with clean engine oil.
7. Screw in the new filter canister and tighten it to the correct torque value.
 - 7.1. The filter canister can also be tightened by hand. Screw the filter until it contacts the filter housing and then tighten it an additional 3/4 of a turn.
8. Through one of the filler points, fill the engine with the recommended oil to the MAX mark on the dipstick. Wipe off any spilt oil, install the filler cap and make sure it is secure.
9. If the engine has a dead crank feature, carry out the following procedure.
 - 9.1. Turn the ignition key to the on position.
 - 9.2. Turn the ignition key to the off position.
 - 9.3. Repeat steps 9.1 and 9.2 5 times.
 - 9.4. Wait for the ECU (Electronic Control Unit) to shutdown.
 Duration: 30s
 - 9.5. Turn the ignition key to the start position. The engine will crank for an extended time period before starting.
 Duration: 10s
10. If the engine does not have a dead crank feature, carry out the following procedure.
 - 10.1. Connect a laptop to the engine with a data link adaptor and open Servicemaster.
Special Tool: Data Link Adaptor (DLA) Kit / Data Link Adaptor (DLA 2.0) Kit (Qty.: 1)
 - 10.2. Perform the IMV (Inlet Metering Valve) Override test.
 - 10.3. The IMV Override test will allow the engine to be cranked for a set time period without starting allowing sufficient time to prime the oil pressure.
 Duration: 10s
11. Operate the engine at idle, make sure that the oil pressure low warning light is extinguished immediately after the engine starts. If it does not extinguish, stop the engine and investigate the cause.
12. Check for oil leakage. When the oil has cooled, check the oil level again, and if necessary top up with clean engine oil.

Figure 80.



- | | |
|--|---|
| <p>A Dipstick
 C Oil sump drain plug
 E Filter housing drain plug
 G Filter head</p> | <p>B Oil filler points
 D 'O' ring
 F Filter canister
 H Seal</p> |
|--|---|

Table 46. Torque Values

Item	Description	Nm
C	Oil sump drain plug	40
E	Filter housing drain plug	40
F	Oil filter canister	15



24 - Air Filter

Contents	Page No.
15-24-00 General	15-113
15-24-09 Dust Valve	15-116

00 - General

Introduction	15-113
Health and Safety	15-114
Check (Condition)	15-114
Remove and Install	15-115

Introduction

Engine performance and durability will be severely affected if the quality of the air intake is poor.

A dirty and blocked air cleaner element will reduce the amount of air entering the combustion chamber which can cause engine mis-firing, black smoke and low output power.

A dirty and blocked air filter can also lead to abrasion of the cylinder bores and valves (referred to as dusting). This will cause excessive oil consumption, black smoke, low output power and a reduced engine life.

In hostile environments, change the air filter elements more frequently.

In some applications, an air filter pre-cleaner can be installed.

Health and Safety

▲ **Notice:** Do not run the engine when the element has been removed.

Notice: The outer element must be renewed immediately if the warning light on the instrument panel illuminates.

Check (Condition)

The air filter element (s) should be changed at the recommended service interval, refer to the Maintenance Schedules. [Refer to: PIL 78-24.](#)

Check all the hose connections for loose installations and damaged hose clamps, look specifically for splits or cracks in the hoses. Pay particular attention to the connections on the air intake to turbo compressor and on the crossover tube.

Renew any damaged components.

The air filter elbow is installed with a vacuum switch. The switch will detect if there is a restriction on the air intake and this will activate a warning within the engine ECU (Electronic Control Unit), which will be viewed as a fault code on the controller.

Remove and Install

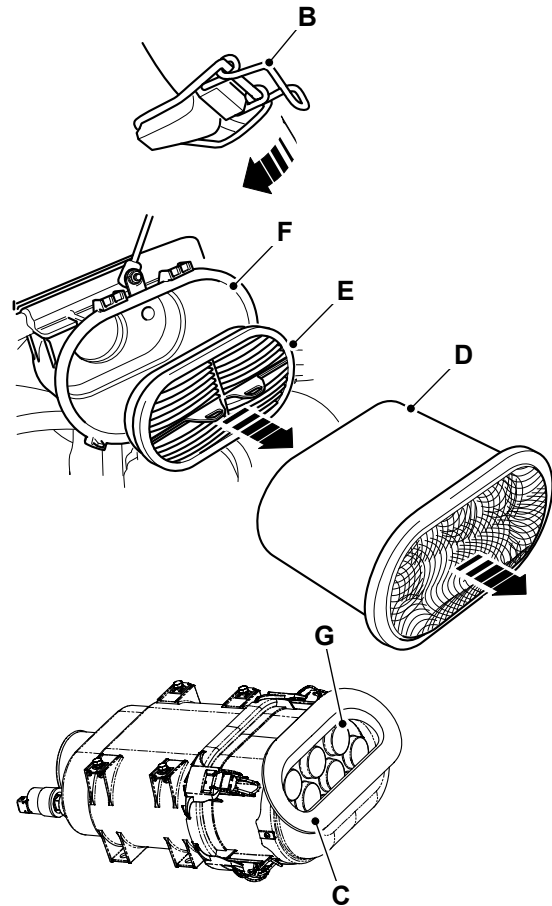
Do not attempt to wash or clean the elements, they must only be renewed.

A new inner element must be installed at least every other time the outer element is changed. As a reminder, mark the inner element with marker pen each time the outer element is changed.

Remove

1. Make the machine safe. Refer to (PIL 01-03).
2. Get access to the engine.
3. Depress the clips and lift off the cover.
4. Remove the outer element. Take care not to tap or knock the element.
5. If the inner element is to be changed, lift up pulls and remove the inner element.

Figure 81.



- B** Clips
- C** Cover
- D** Outer element
- E** Inner element
- F** Housing
- G** Air holes

Install

1. The installation procedure is the opposite of the removal procedure. Additionally do the following steps.
2. Clean inside the housing, and cover, make sure that the air holes are clear.
3. Install the cover and fasten the latch. Make sure that dust valve is at the bottom.

09 - Dust Valve

Check (Condition)

- Check the dust valve for rips/tears.
- Check there are no obstructions.
- Check that the dust valve is free of dirt and dust.
- Check that the dust valve securely attached to the air filter housing.



27 - Crankcase Ventilation Filter

Contents	Page No.
15-27-00 General	15-119



Notes:



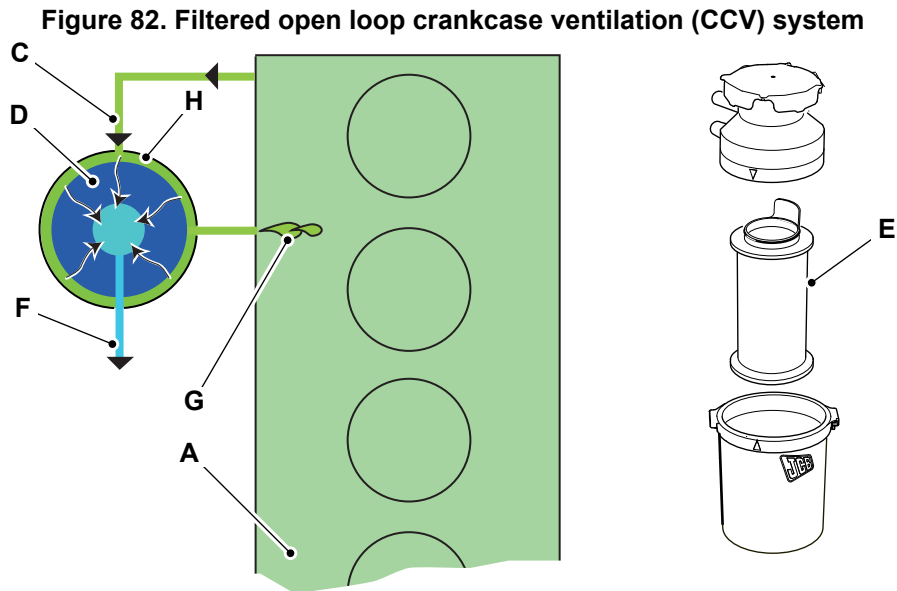
00 - General

Introduction	15-119
Component Identification	15-120
Operation	15-121
Remove and Install	15-121

Introduction

Depending on the specification, the engine may be installed with open loop, filtered open loop or a closed loop CCV (Crankcase Ventilation) system.

Component Identification



- A Crankcase vapour
- C Transfer hose
- E Filter element - first stage
- G Oil droplets - return to sump

- B Pressure relief valve
- D Filter element - second stage
- F Filtered vapour vent to atmosphere
- H Crankcase ventilation filter assembly

Operation

Filtered open loop crankcase ventilation (CCV) system

Crankcase emissions are created during the combustion process. These emissions include unburned fuel and 'blow by gases' which contain hydrocarbon and engine oil contaminants. A large proportion of these emissions are prevented from entering the atmosphere by the CCV (Crankcase Ventilation) filter assembly.

A series of ports in the crankcase, cylinder head and rocker cover allow pressure to vent from the crankcase. The vapour from the crankcase flows from the rocker cover to the filter assembly. Combined two stage filter elements remove around 90% of contaminants as the vapour passes from the inside to the outside of the filter elements. Trapped oil is allowed to drain back to the sump via a non return valve. The filtered vapour vents to the atmosphere.

If the pressure inside the filter assembly rises due to a blocked filter non return valve in the oil drain line prevents vapour being forced back into the crankcase.

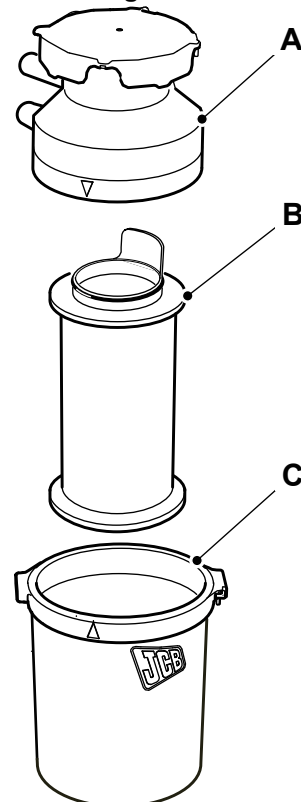
The ventilation circuit incorporates a pressure relief valve. If the filter element becomes blocked the valve opens bypassing the filter and preventing a build up of pressure in the crankcase. Although this prevents serious engine damage it must be remembered that the filtration system does not function when bypassed. The filter element must be replaced at the intervals specified to ensure a bypass condition is avoided.

Remove and Install

The filter element must be changed at the recommended maintenance interval. Refer to (PIL 78-24).

1. Make the machine safe. Refer to (PIL 01-03).
2. Get access to the engine. Refer to (PIL 06-06).
3. Rotate the filter cover anti-clockwise and remove.
4. Lift out the filter element and discard it.
5. Clean the inside of the filter housing. Remove all oil and sludge contamination.
6. Make sure that the oil drain in the bottom of the filter housing is not blocked with sludge.
7. Install a new filter element. Make sure that the correct type of filter element is installed.
8. Align the arrows on both parts to install the filter cover.

Figure 83.



- A** Filter cover
- B** Filter element
- C** Filter housing



30 - Valve

Contents	Page No.
15-30-00 General	15-123
15-30-12 Valve Spring	15-132
15-30-24 Stem Seal	15-133

00 - General

Introduction	15-123
Technical Data	15-124
Component Identification	15-125
Operation	15-127
Adjust	15-127
Remove and Install	15-130

Introduction

The valve train system opens and closes the valves with correct timing in relation to the piston movements.

Each push rod has one end in a valve tappet and the other end under a rocker arm, or as applicable. The adjusting screw has a ball shaped end that locates in the push rod. The adjusting screw is used for setting the valve clearance.

The valves extend through the cylinder head. There are no sleeves or valve guides in the cylinder head. The valves are made from a special metal to provide a long service life. Damaged or worn valves cannot be lapped or reground and must be replaced with new ones. Each valve stem has an oil seal.

The Valve seat inserts are pressed into the cylinder head. The seat inserts are also made from a special metal to provide for a long service life. Damaged or worn seat inserts can be removed and replaced with new ones.

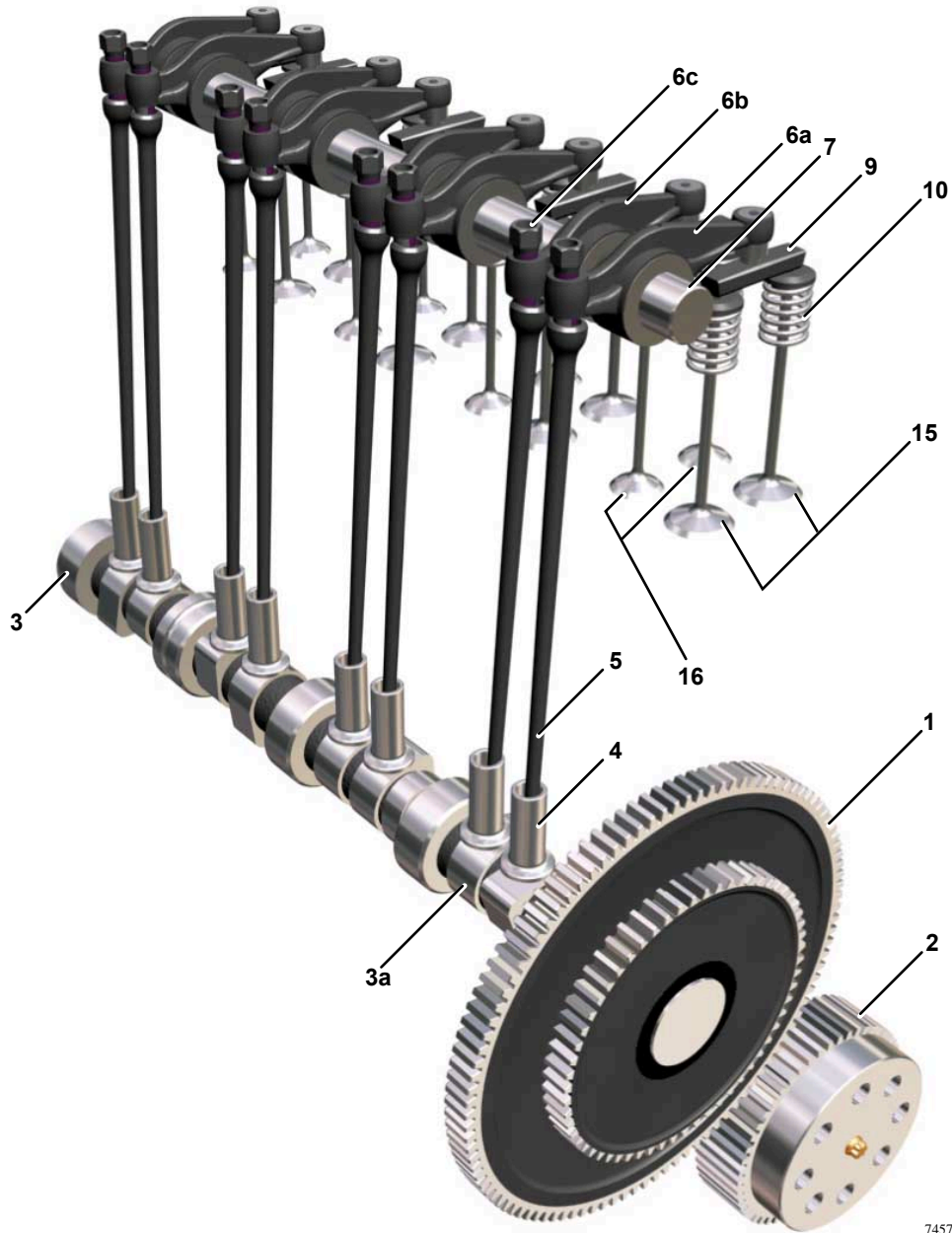
Technical Data

Table 47. Inlet and Exhaust Valve Data

Max lift Inlet	9.64mm @ 101° ATDC
Max lift Exhaust	9.84mm @ 115° BTDC
Inlet opens (top of ramp)	6° BTDC
Inlet closes	28° ATDC
Exhaust opens	41° BTDC
Exhaust closes	6° ATDC
Valve stem diameter	
- Inlet	6.928–6.943mm
- Exhaust	6.918–6.933mm
Valve spring free length	51.1mm
Valve guide bore diameter	
- min	6.958mm
- max	6.973mm
Valve face angle	
- Inlet	60.5°
- Exhaust	45.17°
Valve length	131.9–132.4mm
Valve sealing	Stem seal with sealing washer
Valve head depth (below cylinder head surface)	
- Inlet	0.89–1.39mm
- Exhaust	0.95–1.45mm
Valve rim thickness	2.98–3.38mm
Valve Clearances - tappet adjuster end of the valve rockers (engine cold)	
- Inlet	0.15–0.21mm
- Exhaust	0.43–0.49mm
Valve Clearances - valve end of the rocker (engine cold)	
- Inlet	0.19–0.27mm
- Exhaust	0.56–0.64mm

Component Identification

Figure 84.



745700

- 1 Camshaft drive gear
- 3 Camshaft
- 4 Tappets (x8)
- 6a Rockers - inlet (x4)
- 6c Adjusting screws (x8)
- 7 Rocker shaft
- 9 Bridge pieces (x8)
- 11 Retainer (x16)
- 13 Oil seal - valve stems (x16)

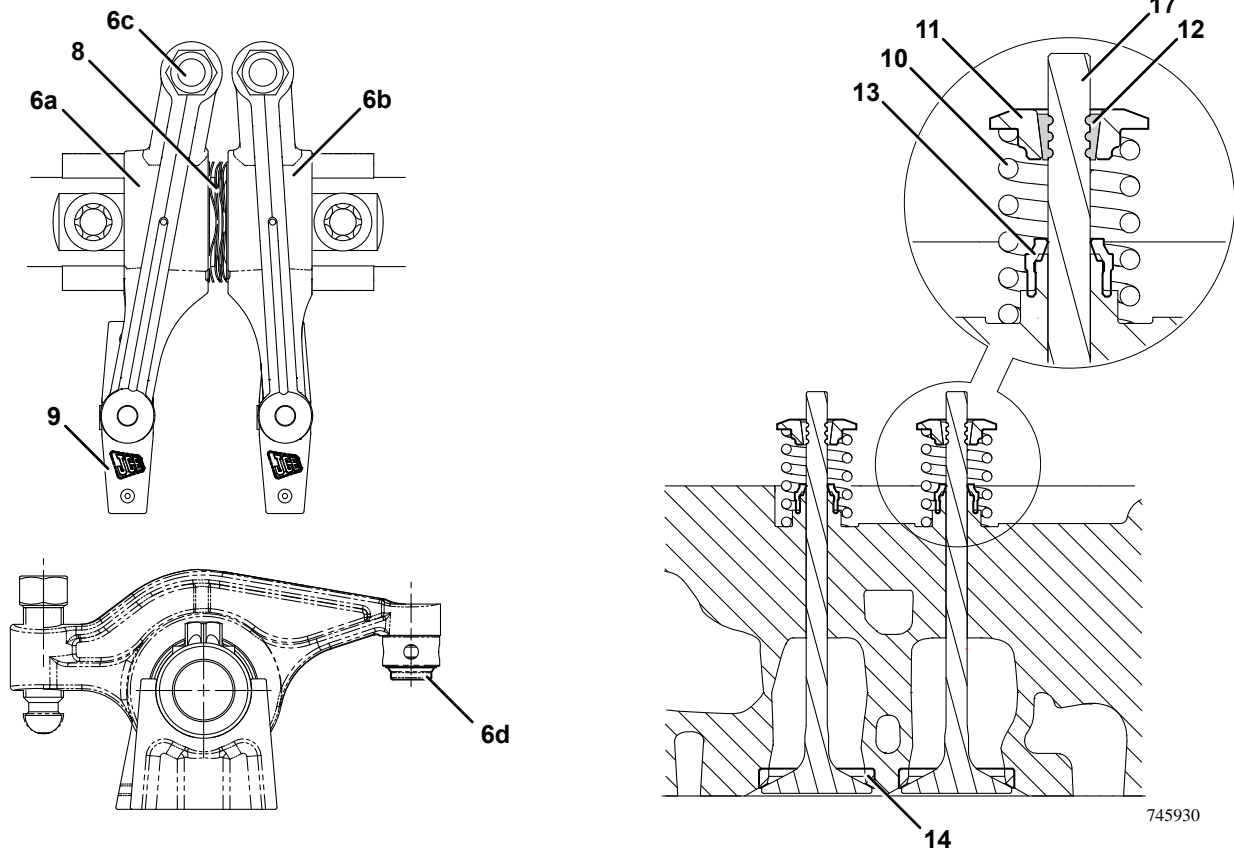
- 2 Crankshaft gear
- 3a Lobes
- 5 Push rods (x8)
- 6b Rockers - exhaust (x4)
- 6d Swivel tip - rockers
- 8 Wave washers (x8)
- 10 Valve springs (x16)
- 12 Collets (x32)
- 14 Valve seat inserts (x16)

- 15 Inlet valves (x8)
 17 Valve stem

- 16 Exhaust valves (x8)

Cross Sectional View

Figure 85.



- 6a Rockers - inlet (x4)
 6c Adjusting screws (x8)
 8 Wave washers (x8)
 10 Valve springs (x16)
 12 Collets (x32)
 14 Valve seat inserts (x16)

- 6b Rockers - exhaust (x4)
 6d Swivel tip - rockers
 9 Bridge pieces (x8)
 11 Retainer (x16)
 13 Oil seal - valve stems (x16)
 17 Valve stem

Operation

The camshaft drive gear is driven by the crankshaft gear at half the speed of the crankshaft. Camshaft lobes, two for each cylinder, (operating exhaust and inlet valves) actuate the valve tappets.

When the camshaft rotates the cam lobes act on the tappets. The push rods act on the rockers which pivot on the camshaft, depressing two valves at the same time via the bridge piece.

The screw is self locking in the rocker by means of a tapered thread. Wave washers act like springs to keep the rockers in their correct positions along the camshaft and prevent them contacting one another. The rockers incorporate a swivel tip to ensure alignment with the bridge piece. This prevents excessive wear.

Each valve has a compression spring. The function of the spring is to close the valve and at the same time return the rocker arm and push rod to ensure that the tappets follow the camshaft lobes. The spring is located on the valve stem by a retainer and split collets.

Adjust

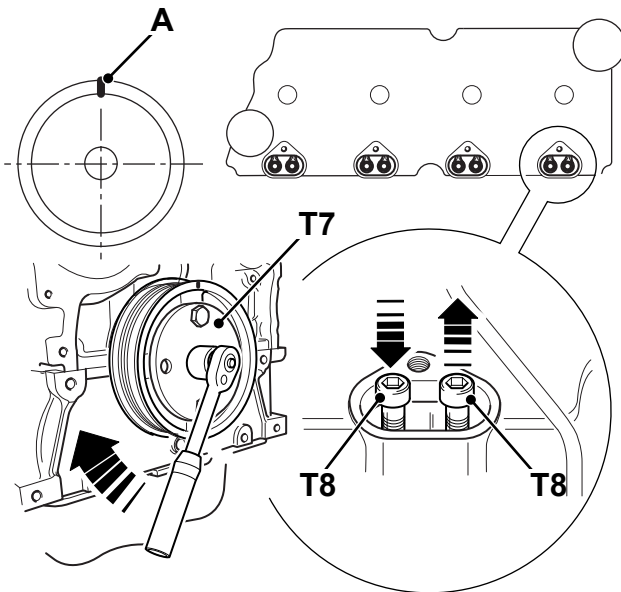
Special Tools

Description	Part No.	Qty.
Crankshaft Turning Tool (95.25mm PCD)- JCB 4 Cylinder Ecomax and Dieselmex	892/01147	1
Valve Clearance Service Kit	892/01380	1

Engine Position

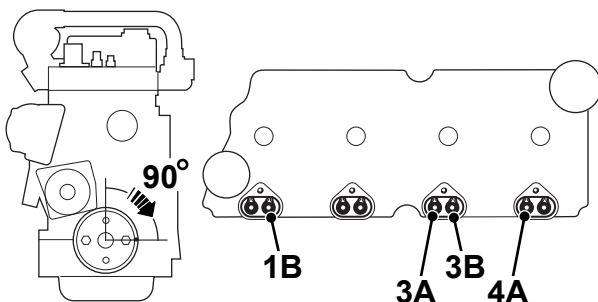
The engine needs to be set to two different positions to measure and adjust all of the valves. The graphics show which valves are applicable at which engine position.

1. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.
2. Get access to the engine.
3. Remove the tappet covers. Refer to (PIL 15-42).
4. Put the indicator pins into the holes inside the tappet adjusters for cylinder number 4. Make sure that the pins do not fall into the engine.
5. Use the crankshaft turning tool to turn the engine crankshaft clockwise. Stop turning the crankshaft when one indicator pin starts to move up after the other pin has moved down. This is the position where the exhaust valve is almost closed and the inlet valve is just starting to open.
[Special Tool: Crankshaft Turning Tool \(95.25mm PCD\)- JCB 4 Cylinder Ecomax and Dieselmex \(Qty.: 1\)](#)
[Special Tool: Valve Clearance Service Kit \(Qty.: 1\)](#)
6. Put a mark on the crankshaft pulley at the 12 o'clock position.

Figure 86.


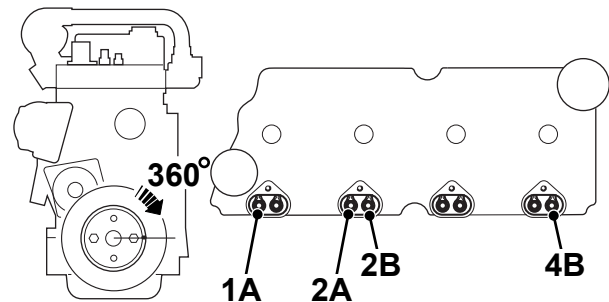
- A** 12 o'clock position
T7 Crankshaft turning tool
T8 Indicator pins (obtain locally)

7. Turn the engine crankshaft 90 degrees clockwise.
8. Measure and, if necessary, adjust the clearances for the correct valves.

Figure 87. 90 Degree Position


- 1B** Inlet valve-Cylinder 1
3A Exhaust valve-Cylinder 3
3B Inlet valve-Cylinder 3
4A Exhaust valve-Cylinder 4

9. Remove the valve clearance service tools. Turn the engine crankshaft 360 degrees clockwise. Use the mark on the crankshaft pulley as a reference.
10. Measure and, if necessary, adjust the clearances for the correct valves.

Figure 88. 360 Degree Position


- 1A** Exhaust valve-Cylinder 1
2A Exhaust valve-Cylinder 2
2B Inlet valve-Cylinder 2
4B Inlet valve-Cylinder 4

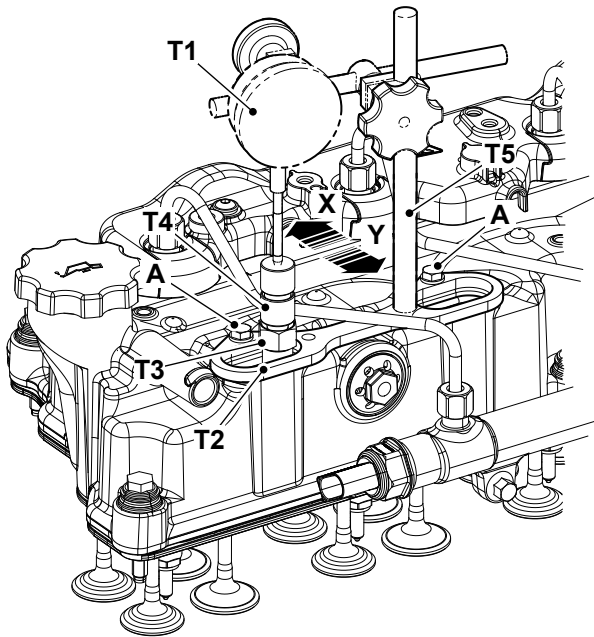
Valve Clearances

The procedure describes how to measure and, if necessary, adjust one valve clearance. The procedure for all the valves is the same. Do the procedure for the correct valves at each of the two engine positions. Remember you must remove the valve clearance service tools before you turn the engine crankshaft.

Important: The engine must be cold before you measure or adjust the valve clearances.

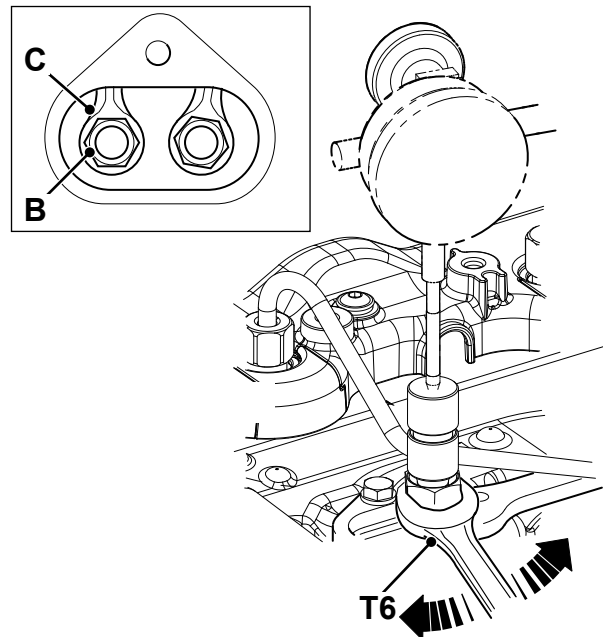
1. Install the adaptor plate in the correct position on the rocker cover using the screws A.
2. Make sure that the crankshaft is in the correct position.
3. Put the adaptor sleeve on the correct valve tappet adjuster screw.
4. Push the lock bar into the correct valve tappet adjuster screw.
5. Tighten the lock bar by turning it with your hand.
6. Assemble the DTI support and DTI.
7. Push and then pull the lock bar in the direction of the arrows X and Y. Do this until you are sure that the lock bar is correctly installed and oil is moved away from the cam follower and push rod.
8. **Important:** Apply a side force on the lock bar at the same time as pushing and pulling. This prevents the rocker moving along the rocker shaft and giving a false reading on the DTI. Apply a force to the left on the exhaust valve tappets and to the right on the inlet valve tappets.

Figure 89.



- A** Screws
- T1** Dial Test Indicator (DTI)(obtain locally)
- T2** Adaptor plate (part of valve clearance service kit)
- T3** Adaptor sleeve (part of valve clearance service kit)
- T4** Lock bar (part of valve clearance service kit)
- T5** DTI Support (obtain locally)

Figure 90.



- B** Tappet adjusters
- C** Rockers
- T6** Spanner open ended (obtain locally)

9. Pull the lock bar in the direction of arrow Y and turn the DTI to zero.
10. Push the lock bar in the direction of arrow X and record the DTI indication.
11. Compare the valve clearance measurement with the correct clearances. If an adjustment is necessary:
 - 11.1. Turn the tappet adjuster using an open ended spanner on the adaptor sleeve. Turn the sleeve clockwise to reduce the clearance and counterclockwise to increase the clearance.
 - 11.2. Important: The tappet adjusters are set in position by thread friction with the rockers. Make sure that the torque to turn the tappet adjusters is more than the minimum necessary. If any of the adjusters show a lower torque value then the adjuster and its related rocker must be replaced.

Remove and Install

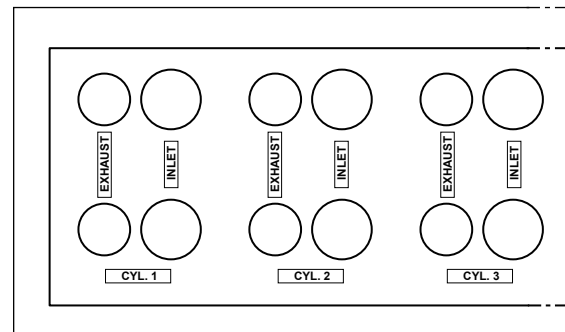
Special Tools

Description	Part No.	Qty.
Valve Stem Seal Installation Tool (444/448/672 Engine)	892/01152	1

Before Removal

1. This procedure requires service parts. Make sure you have obtained the correct service parts before you start, refer to Parts Catalogue.
2. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.
3. Get access to the engine.
4. Remove the thermostat, refer to (PIL 21-12).
5. Remove all of the fuel injector pipes, refer to (PIL 18-96).
6. Remove the rocker cover, refer to (PIL 15-42).
7. Remove the fuel injectors, refer to (PIL 18-18).
8. Remove the rocker assembly, refer to (PIL 15-42).
9. Remove the exhaust manifold, refer to (PIL 18-24).
10. Remove the inlet manifold, refer to (PIL 18-24).
11. Remove the cylinder head assembly from the cylinder block, refer to (PIL 15-06).
12. Measure the valve recession with a suitable DTI (Dial Test Indicator). Clean the carbon deposits from a small area of the valve heads for location of the DTI probe. If the valve recession is outside the serviceable limits, it is advisable to obtain a new or reconditioned cylinder head assembly, refer to Technical Data (PIL 15-06).
13. To aid removal and replacement, use a wooden valve stand to retain the valves after removal. Add labels to make sure that the valves are correctly replaced.

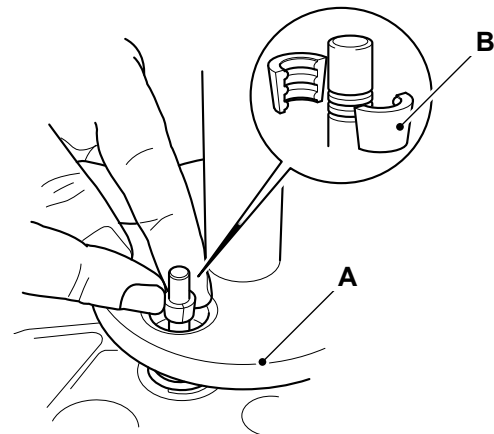
Figure 91. Valve Stand



Remove

1. Use a spring compressor tool to compress each valve spring and remove the collets. Make sure that the springs are compressed squarely.

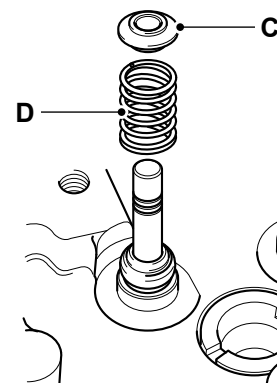
Figure 92.



- A** Spring compressor tool
- B** Collets

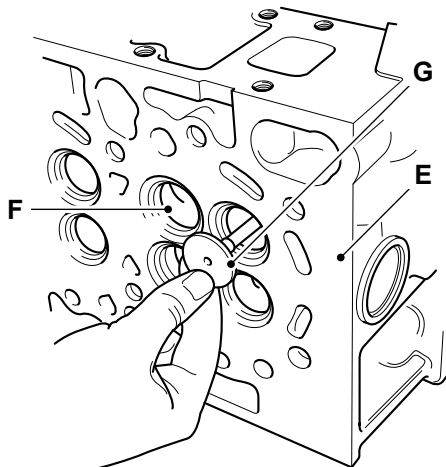
2. Remove the spring compressor tool and lift off the retainer and valve spring.

Figure 93.



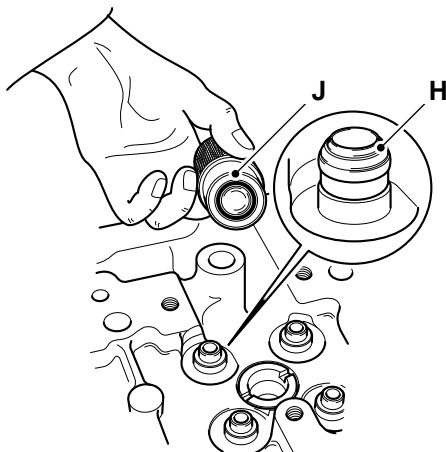
- C** Retainer
- D** Valve spring

3. Turn the cylinder head on its side and withdraw the inlet valves and exhaust valves as shown.

Figure 94.


E Cylinder head
F Inlet valves
G Exhaust valves

4. When removing, note the respective position of each valve. Use a suitable valve stand to keep the valves together and identify them with their respective cylinder. Note: The exhaust valves have smaller diameter heads.
5. Remove the valve stem seals. Discard the seals.

Figure 95.


H Valve stem seals
J Punch tool

Inspection

1. Carefully clean the carbon deposits from the valves, take care not to damage the valve seats.
2. Check that the valves and valve seats are not cracked, burnt or damaged.
3. Check the valve stems and valve guides for wear, refer to Technical Data (PIL 15-30).

If there is evidence of wear or damage to the valves, guides or seats, it is advisable to obtain a new or reconditioned cylinder head assembly.

Before Installation

1. Position the cylinder head upside down in a suitable jig or fixture.
2. Make sure that all items are clean and free from damage and corrosion.
3. Install the injectors into the cylinder head to do a trial check of the nozzle protrusion. Note the relative positions for the injectors, and then remove the injectors for installation at a later stage.

Installation

1. The installation procedure is the opposite of the removal procedure. Additionally do the following steps.
2. Install the new valve stem seals as shown. Use the installation tool to avoid damaging the seals. Pre-assemble the seal into the tool. Locate the tool over the valve guide and gently press the seal into place. Lubricate the seal with P80 fluid.
[Special Tool: Valve Stem Seal Installation Tool \(444/448/672 Engine\) \(Qty.: 1\)](#)
3. With the cylinder head on its side, insert the inlet valves and exhaust valves as shown. Make sure that the valves are installed in the correct positions. Lubricate the valve stems with clean engine oil before assembly. Carefully push the end of the valve stem through the stem seals.
4. Install the valve springs on to the valve stems, together with a retainer. Use the spring compressor tool to compress each valve spring and insert the collets. Make sure that the collets are correctly seated in the valve stem grooves, before you remove the spring compressor tool.

After Installation

1. Tap the valve stems in turn using a rubber mallet top fully seat the valves.



12 - Valve Spring

Remove and Install

Refer to: [PIL 15-30-00](#).



24 - Stem Seal

Remove and Install

Refer to: [PIL 15-30-00](#).



33 - Connecting Rod

Contents	Page No.
15-33-00 General	15-135
15-33-06 Big-End Bearing	15-139

00 - General

Introduction	15-135
Technical Data	15-136
Component Identification	15-136
Check (Condition)	15-137
Remove and Install	15-137
Disassemble and Assemble	15-138

Introduction

The connecting rod connects the piston to the crankshaft. They form a simple mechanism that converts reciprocating motion into rotating motion.

Connecting rods are usually made of high strength steel. They are not rigidly fixed at either end, so that the angle between the connecting rod and the piston can change as the rod moves up and down and rotates around the crankshaft.

The small end of the connecting rod attaches to the piston pin which is a press fit into the connecting rod.

The big end of the connecting rod connects to the bearing journal on the crank throw, they run on replaceable bearing shells that are accessible via the connecting rod bolts which hold the bearing cap on to the big end.

There is a pinhole bored through the bearing and the big end of the connecting rod so that pressurised lubricating engine oil squirts out on to the thrust side of the cylinder wall to lubricate the travel of the pistons and piston rings.

Technical Data

Table 48. Connecting Rods Data

Connecting rod type ⁽¹⁾	Split fracture
Connecting rod bore diameter	77–77.01mm
Connecting rod side clearance	
min	0.05mm
max	0.4mm
Big end bearings	
Width	32.5–33mm
Thickness (at centre)	1.99–1.981mm
Small end bearings	
Inside diameter	40.034–40.02mm

(1) Split fracture type connecting rods MUST NOT be dot punched or etched in anyway during disassembly - refer to relevant service procedures.

Component Identification

Refer to Piston- Component Identification. [Refer to: PIL 15-36-00.](#)

Check (Condition)

1. Check the connecting rods for signs of bending. In the event of sufficient liquid entering the engine, a hydraulic lock can occur. This may result in bending of one or more of the connecting rods. Bending of a connecting rod(s) can occur even when the engine is cranked by the starter motor. Bending of the connecting rod may be very slight and can be checked prior to a full engine strip down.

[Refer to: PIL 15-36-00.](#)

2. Check the connecting rod for signs of damage and excessive wear.

The connecting rod small end bearing bush is not renewable. If the small end bearing bush is damaged or worn the connecting rod must be renewed as a complete assembly.

Remove and Install

The removal and installation procedure for one piston and connecting rod assembly is exactly the same. Refer to Piston - Remove and Install. [Refer to: PIL 15-36-00.](#)



Disassemble and Assemble

Refer to: [PIL 15-36-00](#).



06 - Big-End Bearing

Introduction	15-139
Check (Condition)	15-140
Remove and Install	15-140

Introduction

In a piston engine, the big-end bearings are the bearings at the big-end of the connecting rod.

Check (Condition)

1. Check the bearing shell surfaces for signs of damage and excessive wear.
[Refer to: PIL 15-33-00.](#)
2. Measure the crank pin diameters to confirm they are within service limits.
[Refer to: PIL 15-12-00.](#)
3. Renew any parts that are worn or not within the specified tolerances.

Remove and Install

Special Tools

Description	Part No.	Qty.
Torque Wrench (10-100Nm)	993/70111	1

Before Removal

This procedure requires service parts. Make sure you have obtained the correct service parts before you start. Refer to Parts Catalogue.

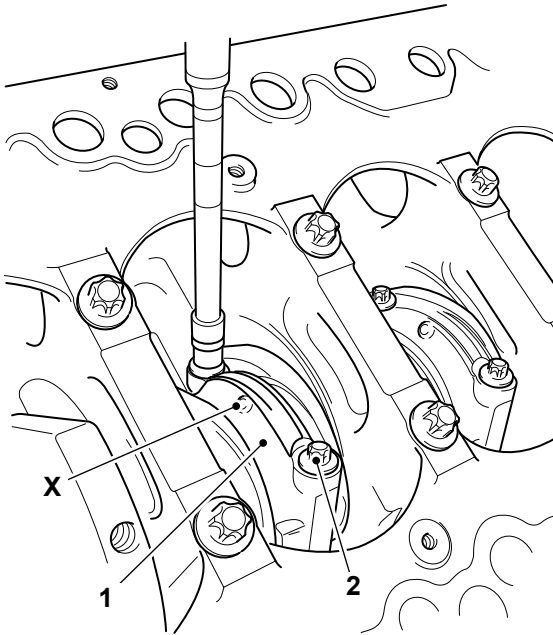
1. Make the machine safe.
[Refer to: PIL 01-03.](#)
2. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.
3. Remove the engine from the machine.
[Refer to: PIL 15-00-00.](#)
4. Disconnect and remove the fuel pipes from the injectors.
[Refer to: PIL 18-96-00.](#)
5. Remove the rocker cover.
[Refer to: PIL 15-42-06.](#)
6. Remove the fuel injectors.
[Refer to: PIL 18-18-03.](#)
7. Drain the oil from the engine.
[Refer to: PIL 15-21-00.](#)
8. Remove the oil sump.
[Refer to: PIL 15-45-00.](#)
9. Position the engine upside down in a suitable jig or fixture, supported at the front of the crankcase.

The connecting rod and the big-end bearing cap have been fracture split and must be kept together as a set. Care must be taken to avoid contamination and or damage to the fracture split surfaces.

Remove

1. It is recommended that the big-end bearing caps are removed in pairs, cylinders 1 and 4 and cylinders 2 and 3. Rotate the crankshaft so that the big-end bearing caps on cylinders 2 and 3 are positioned as shown.
2. Remove the bolts and lift off the big-end bearing caps from the connecting rods. The bolts must not be re-used, discard the bolts.

Figure 96.

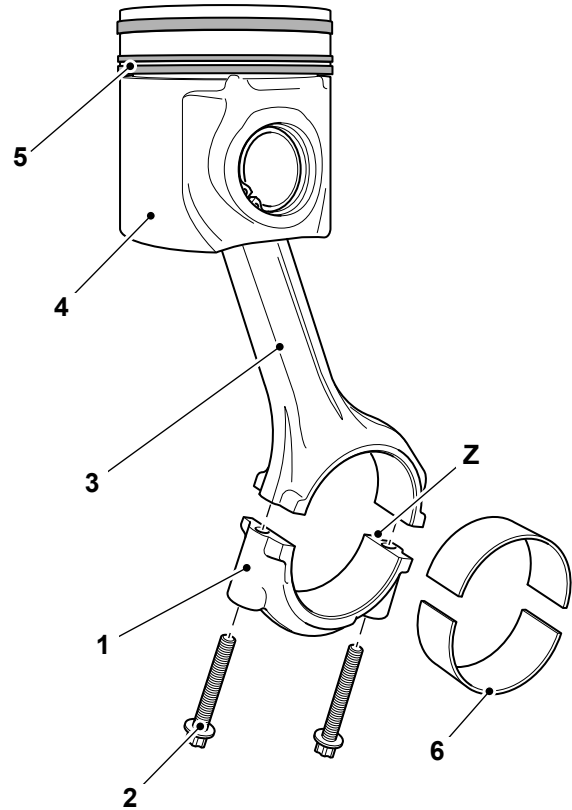


- 1 Big-end bearing caps
- 2 Big-end bearing cap bolts
- X Cast notch

2.1. Make sure that the tool is kept in inline with the bolt to avoid damaging the screw thread.

3. Lift out the bearing shells from the bearing caps. Carefully rotate the crank to disengage from the connecting rods and get access to the upper bearing shells. Lift out the upper bearing shells. It is recommended that the bearing shells are renewed. If they are to be reused, label the bearing shells to make sure that they are installed in their original positions on assembly.

Figure 97.



- 1 Big-end bearing cap
- 2 Bolts
- 3 Connecting rod
- 4 Piston
- 5 Piston rings
- 6 Big end bearing shells
- Z Fracture split surfaces

4. Carefully rotate the crankshaft to position the big-end bearing caps of cylinders 1 and 4. Make sure that the crank does not foul the connecting rods of cylinders 2 and 3. Remove the bearing caps and bearing shells as described in previous steps.
5. Inspect the big-end bearings for signs of damage and excessive wear.

Install

1. The installation procedure is the opposite of the removal procedure. Additionally do the following steps.
2. Make sure that all items are clean and free from damage and corrosion.
3. Install the upper bearing shell to the connecting rod. Lubricate the bearing shell with clean engine oil.
4. Install the lower bearing shell to the big-end bearing cap. Lubricate the bearing shell with

clean engine oil. Install the big-end bearing cap to the connecting rod. Make sure that the cast notch on the bearing cap faces to the front of the engine. Use compressed air to clean the fracture surfaces before assembly.

5. Install new big end bearing cap bolts. Tighten the new bolts in three stages to the correct torque value.

Special Tool: Torque Wrench (10-100Nm) (Qty.: 1)

- 5.1. Make sure that the tool is kept in inline with the bolt to avoid damaging the screw thread.
- 5.2. The bolts are tightened using a torque and angle method.

Refer to: PIL 72-00-00.

Figure 98.

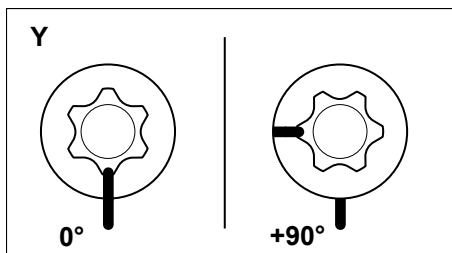
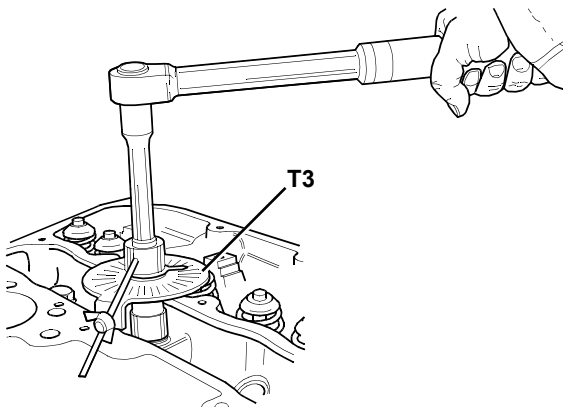


Figure 99.



T3 Angle gauge (obtain locally)

After Installation

1. The after installation procedure is the opposite of the before removal procedure.

Table 49. Torque Table

Item	Torque Value (Nm)	Angle (degrees)
2 (1st Stage)	35	
2 (2nd Stage)	65	
2 (Final Stage)		90



36 - Piston

Contents

Page No.

15-36-00 General 15-145



Notes:

00 - General
Technical Data

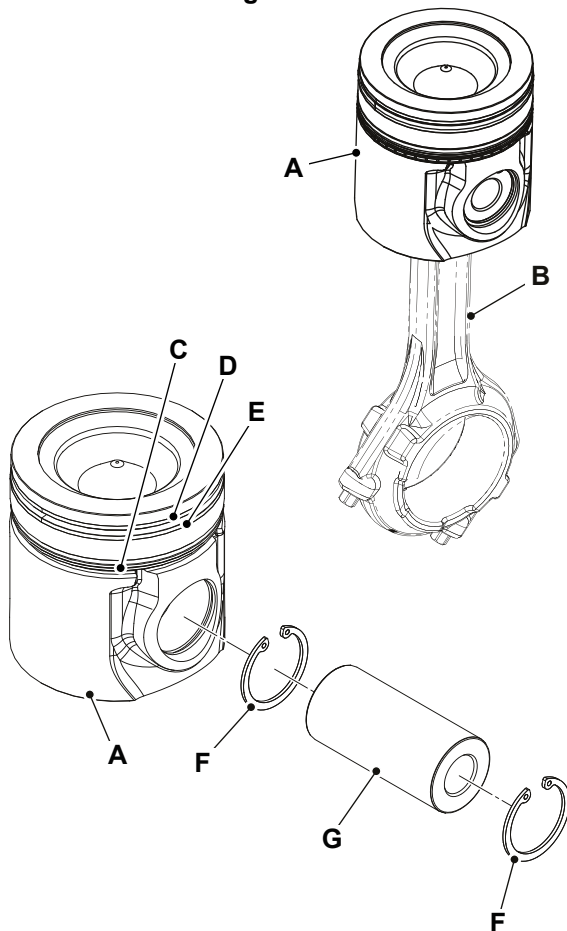
Technical Data	15-145
Component Identification	15-146
Check (Condition)	15-146
Calibrate	15-147
Remove and Install	15-149
Disassemble and Assemble	15-152

Table 50.

Engine	444
Gudgeon pin bore diameter	
- min.	40.01mm
- max.	40.015mm
Piston ring clearance	
- Top ring	Full keystone ring
- Middle ring	0.125–0.08mm
- Bottom (oil) ring	0.09–0.05mm
Piston ring gap	
- Top ring	0.3–0.4mm
- Middle ring	0.55–0.8mm
- Bottom (oil) ring	0.25–0.5mm
Piston height above crankcase (cold)	0.00025–0.36825mm ⁽¹⁾
Piston groove width	
- Top ring	3.114–3.134mm
- Middle ring	2.575–2.595mm
- Bottom (oil) ring	4.04–4.06mm
Piston skirt	102.853–102.871mm
Piston pin	39.994–40mm

(1) Nominal measurement is 0.03325mm

Component Identification

Figure 100.


- A** Piston
- B** Connecting rod
- C** Oil control ring
- D** Piston ring - compression No.1
- E** Piston ring - compression No.2
- F** Retaining circlips
- G** Piston pin

Check (Condition)

1. Check the piston for signs of damage and excessive wear. Measure the piston skirt diameter, piston pin bore and the clearance in the piston ring grooves to confirm they are within service limits.

Refer to: PIL 15-36-00.

2. Check the piston pin for signs of damage and excessive wear. Measure the pin diameter to confirm it is within service limits. Refer to Piston.

Refer to: PIL 15-36-00.

The connecting rod small end bearing bush is not renewable. If the small end bearing bush is damaged or worn the connecting rod must be renewed as a complete assembly.

Calibrate

Piston Height Measurement Above Cylinder Block- DTI Method

In the event of sufficient liquid entering the engine, a hydraulic lock can occur. This may result in bending of one or more of the connecting rods. Bending of the connecting rod(s) can occur even when the engine is cranked by the starter motor.

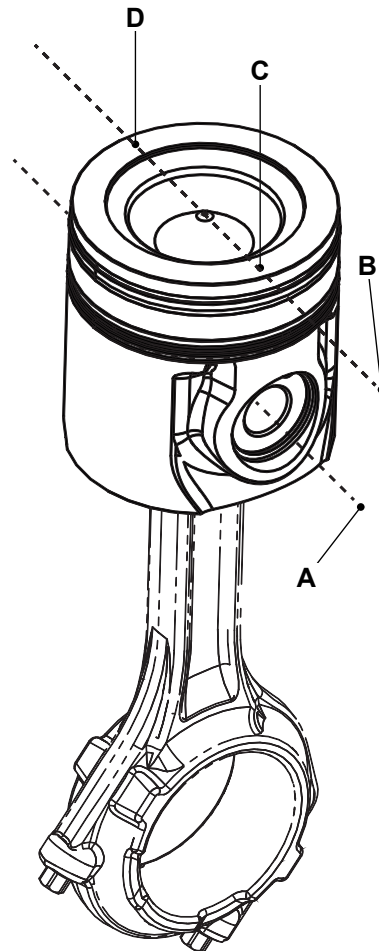
Bending of the connecting rod may be very slight and can be checked by carrying out this procedure prior to a full strip down:

1. With the cylinder head removed, make sure the surface of the engine block and piston are clean.
2. Zero a DTI (Dial Test Indicator) on the top face of the cylinder block adjacent to the area on the piston to be measured. The aim of the procedure is to use the DTI to take a measurement across 2 locations on the piston that are on the axis of the gudgeon pin. This will be towards the front and rear of the engine.
3. Rotate the engine and bring the piston up until it is 3mm below the engine block face. Carefully reposition the zeroed DTI above the area of the piston to be measured.
4. Rotate the engine to bring the piston up to exactly TDC (Top Dead Centre) and record the measurement at position 1.
5. Repeat steps 2 to 4 for position 2.
6. Calculate the average of the 2 readings to give a figure of the piston height above the cylinder block.
7. Compare the reading obtained to the technical data.

[Refer to: PIL 15-36-00.](#)

 - 7.1. If the reading obtained is lower than zero, the connecting rod may be bent.
 - 7.2. If the reading obtained is equal to the range stated in technical data, the connecting rod is not bent.
8. Repeat steps 2 to 7 to check all connecting rods/pistons.
9. If any connecting rods are bent, strip the engine and check for further damage.
10. If the engine is serviceable, any connecting rod that is bent must be replaced.

Figure 101. DTI Measurement



- A Gudgeon pin axis
- B Line of measurement above gudgeon pin axis
- C Piston measurement point 1
- D Piston measurement point 2

Piston Height Measurement Above Cylinder Block- Straight Edge Method

If a DTI is not available, a calibrated straight edge may be used to take a measurement. The measurement will be less accurate.

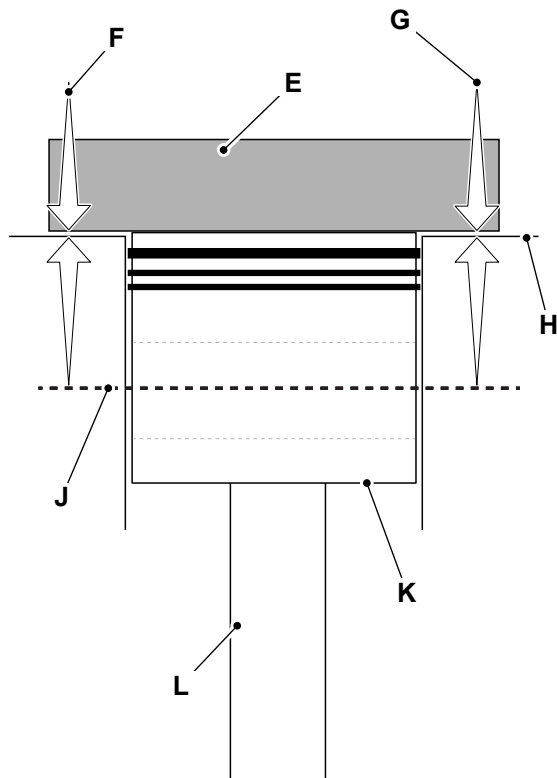
1. With the cylinder head removed, make sure the surface of the engine block and piston are clean.
2. Rotate the engine until the piston to be measured is at TDC.
3. Position the straight edge on top of the piston along the axis of the gudgeon pin.
4. Use feeler gauges to measure the gap between the cylinder block face and underside of the straight edge on both sides, position 1 and position 2.

5. Calculate the average of the 2 readings to give a figure of the piston height above the cylinder block.
 - 5.1. If the reading obtained is lower than zero, the connecting rod may be bent.
 - 5.2. If the reading obtained is equal to the range stated in technical data, the connecting rod is not bent.

Refer to: [PIL 15-36-00](#).

6. Repeat steps 1 to 5.2 to check all connecting rods/pistons.

Figure 102. Straight Edge Measurement



- E Straight edge
- F Measurement position 1
- G Measurement position 2
- H Cylinder block- top face
- J Gudgeon pin axis
- K Piston
- L Connecting rod

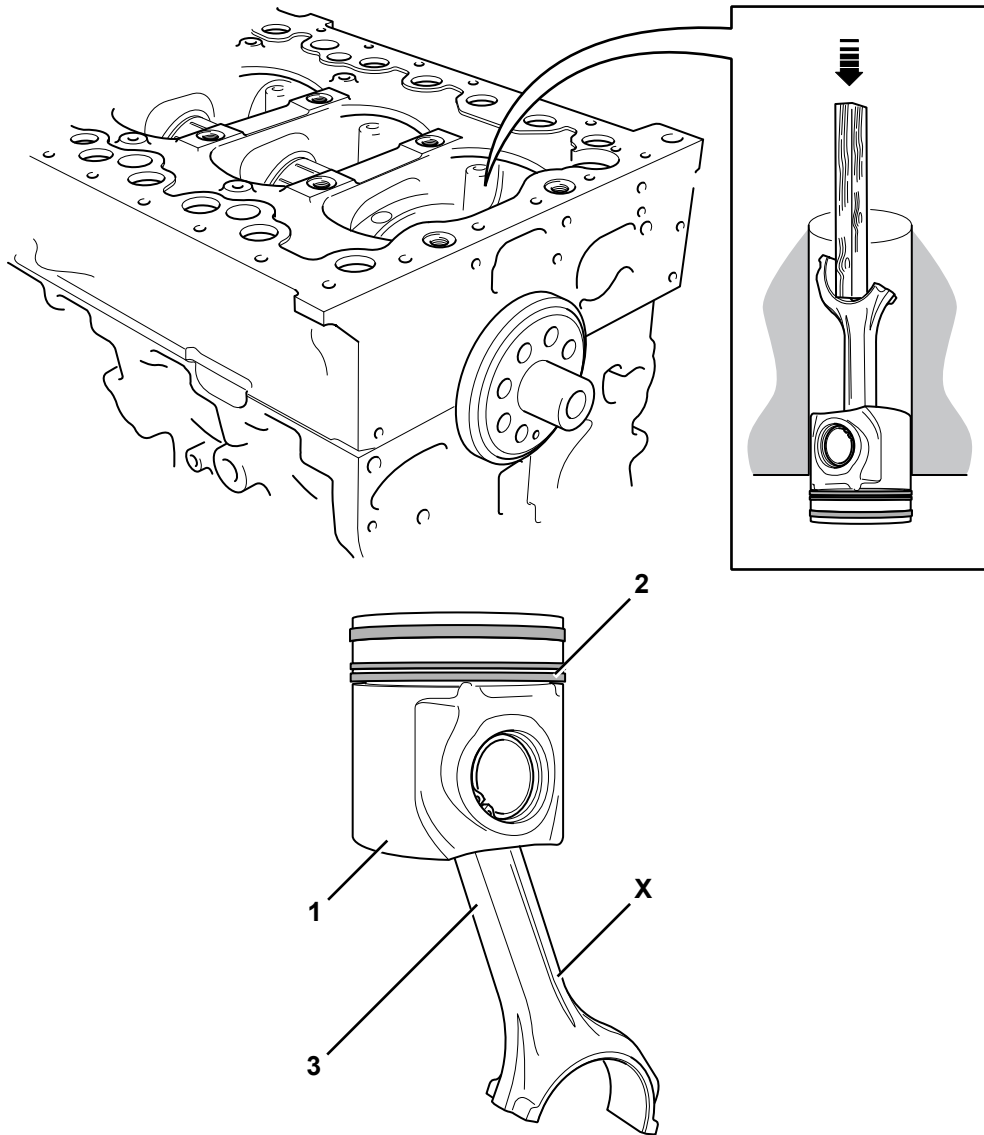
Remove and Install

Before Removal

The following procedure is for one piston and connecting rod assembly. Note that each assembly must be replaced in the same cylinder bore. Label each piston and connecting rod assembly to make sure it is installed in the correct position on assembly.

1. This procedure requires service parts. Make sure that you have obtained the correct service parts before you start. Refer to Parts Catalogue.
2. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.
3. Get access to the engine.
4. Disconnect and remove the fuel pipes from the injectors. Refer to (PIL 18-96).
5. Remove the rocker cover. Refer to (PIL 15-42).
6. Remove the fuel injectors. Refer to (PIL 18-18).
7. Remove the cylinder head assembly. Refer to (PIL 15-06).
8. Remove the oil sump. Refer to (PIL 15-45).
9. Remove the big end bearing caps. Refer to (PIL 15-33-06).

Figure 103.



- 1 Piston
- 3 Connecting rod

- 2 Piston ring
- X Longest side of connecting rod

Remove

The piston and connecting rod assemblies are removed through the top of the crankcase.

1. Use a suitable scraper and wire wool to clean off the carbon deposits from around the top of the cylinder bore. Take care not to scratch or damage the cylinder bore.
2. Use a hammer and a short length of wood to tap the piston from the connecting rod side. Take care not to scratch or damage the cylinder bore or the connecting rod bearing surface.

Install

1. The installation procedure is the opposite of the removal procedure. Additionally do the following steps.
2. Make sure that all items are clean and free from damage and corrosion.
3. If the upper big end bearing shell has been removed replace it. Refer to (PIL 15-33-06).
4. Lubricate the cylinder bore with clean engine oil.
5. Use a suitable compressor tool to compress the piston rings.
6. Insert the piston and connecting rod assembly into the cylinder bore, make sure that the longest side of the connecting rod is on the exhaust side of the crankcase. Take care not to damage the cooling jets when you guide the connecting rod down the cylinder bore and over the crank pin diameter.

After Installation

1. Install the big end bearing caps. Refer to (PIL 15-33-06).
2. Carry out the procedures listed under Before removal in reverse order.

Disassemble and Assemble

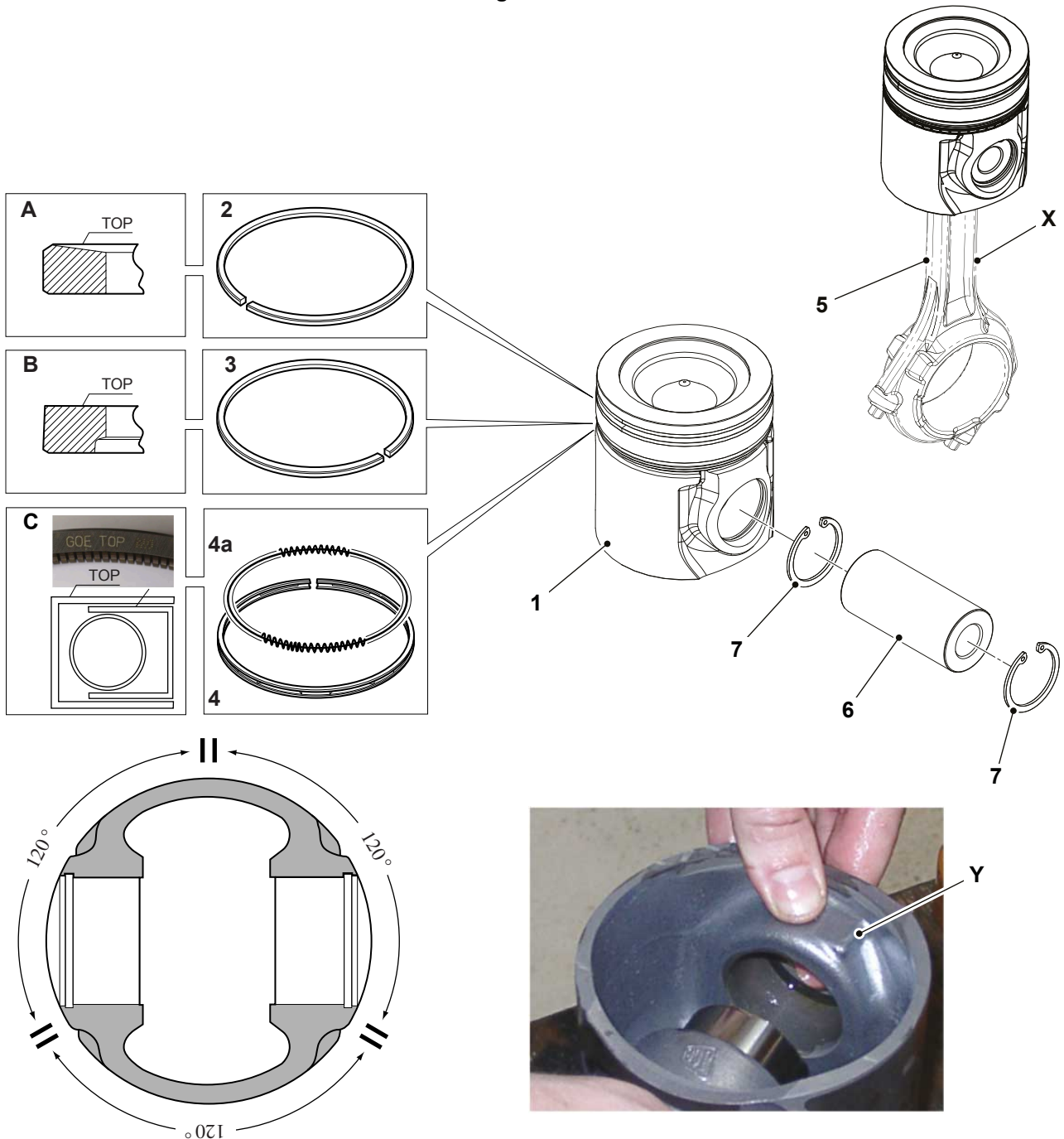
Dismantle

1. Clamp the connecting rod in a vice. Take care not to damage the connecting rod.
2. It is recommended that the piston rings are renewed. If they are to be reused, label the rings to ensure they are installed in the correct positions and the correct way up on assembly. Carefully remove the piston rings from the piston.

To avoid damage or distortion to the rings, use a suitable piston ring expander tool. Note that the oil control ring is installed with a spiral wire. Pull the wire apart and remove it.

3. Remove the circlips and push out the piston pin.
4. Use a suitable cleaning agent, clean the carbon deposits from the piston.

Figure 104.



- | | |
|---|---|
| <p>1 Piston
 3 Piston ring - compression No.2
 4a Spiral wire - oil control ring
 6 Piston pin
 X Connecting rod - longest side</p> | <p>2 Piston ring - compression No.1
 4 Piston ring - oil control ring
 5 Connecting rod
 7 Retaining circlip (x2)
 Y Cast boss - piston</p> |
|---|---|

Inspect

1. Inspect the pistons for signs of wear or damage.
 Refer to Check (Condition) (PIL 15-36-00).

Assemble

1. The assembly procedure is the opposite of the disassemble procedure. Additionally do the following steps.
2. Make sure that all items are clean and free from damage and corrosion.
3. Lubricate the piston pin with clean engine oil. Assemble the connecting rod to the piston and insert the piston pin. Make sure that the long side of the connecting rod is on the same side as the internal cast boss in the piston.
4. Install new circlips. Make sure that they are installed correctly in the groove in the piston.
5. Lubricate the piston with clean engine oil. Install the piston rings to the piston in sequence as follows:
 - 5.1. Install the spiral wire for the oil control ring in the bottom groove and locate the locking wire inside both ends of the spiral as shown. Using a piston ring expander tool to install the oil control ring in the bottom groove and locate the locking wire inside both ends of the spiral as shown. Ensure that the ring gap is positioned 180° to the locking wire. Note: The correct ring orientation can also be determined from the profile shape of the ring as shown at C.
 - 5.2. Install the No.2 compression ring into the middle groove. Note that new rings have a reference number etched on one face. Make sure that this face is installed uppermost in the piston groove. Note: The correct ring orientation can also be determined from the profile shape of the ring as shown at B.
 - 5.3. Install the No.1 compression ring into the top groove. Note that new rings have a reference number etched on one face. Make sure that this face is installed uppermost in the piston groove. Note: The correct ring orientation can also be determined from the profile shape of the ring as shown at A.
6. Rotate the piston rings so that the ring gaps are 120° apart as shown.



42 - Rocker and Fittings

Contents	Page No.
15-42-00 General	15-157
15-42-06 Rocker Cover	15-168
15-42-21 Tappet	15-169
15-42-24 Tappet Cover	15-171



Notes:



00 - General

Introduction	15-157
Technical Data	15-158
Component Identification	15-159
Operation	15-160
Check (Condition)	15-161
Remove and Install	15-162
Disassemble and Assemble	15-166

Introduction

The rocker assembly is an indirect valve actuating system consisting of rocker arms and a shaft.

The rocker arm is an oscillating lever that conveys radial movement from the cam lobe into linear movement at the poppet valve to open it. One end is raised and lowered by a rotating lobe of the camshaft via a tappet and push rod while the other end acts on the bridge piece which is connected to the valve stem.

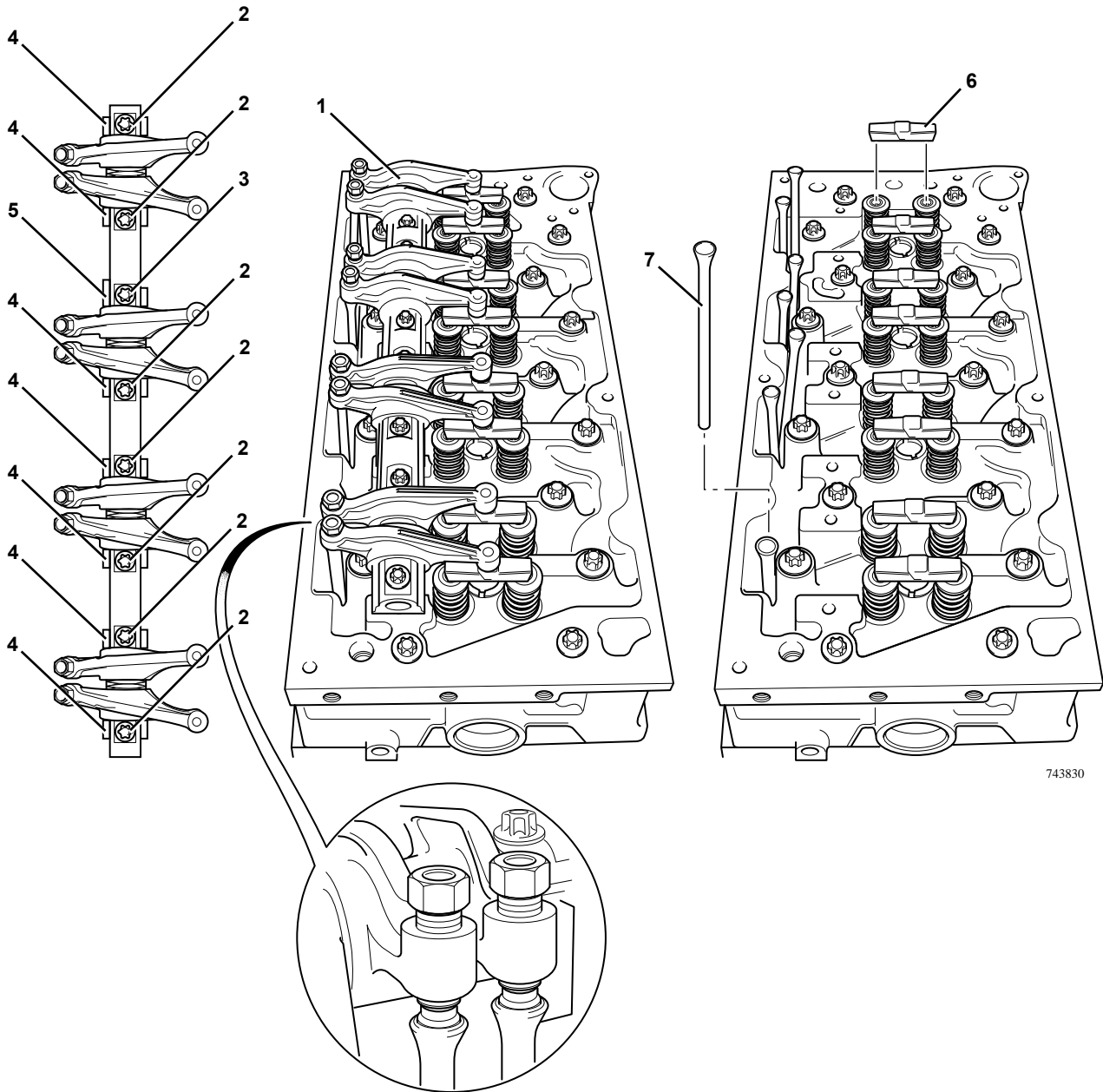
Technical Data

Table 51. Rocker Levers, Rocker Shafts and Tappets Data

Rocker lever bore diameter	
- min	26.058mm
- max	26.092mm
Rocker shaft diameter	
- min	26.003mm
- max	26.021mm
Tappets stem diameter	
- min	19.975mm
- max	19.985mm
Tappet bore diameter	
- min	20mm
- max	20.021mm
Tappet height (maximum)	55.25mm

Component Identification

Figure 105.



743830

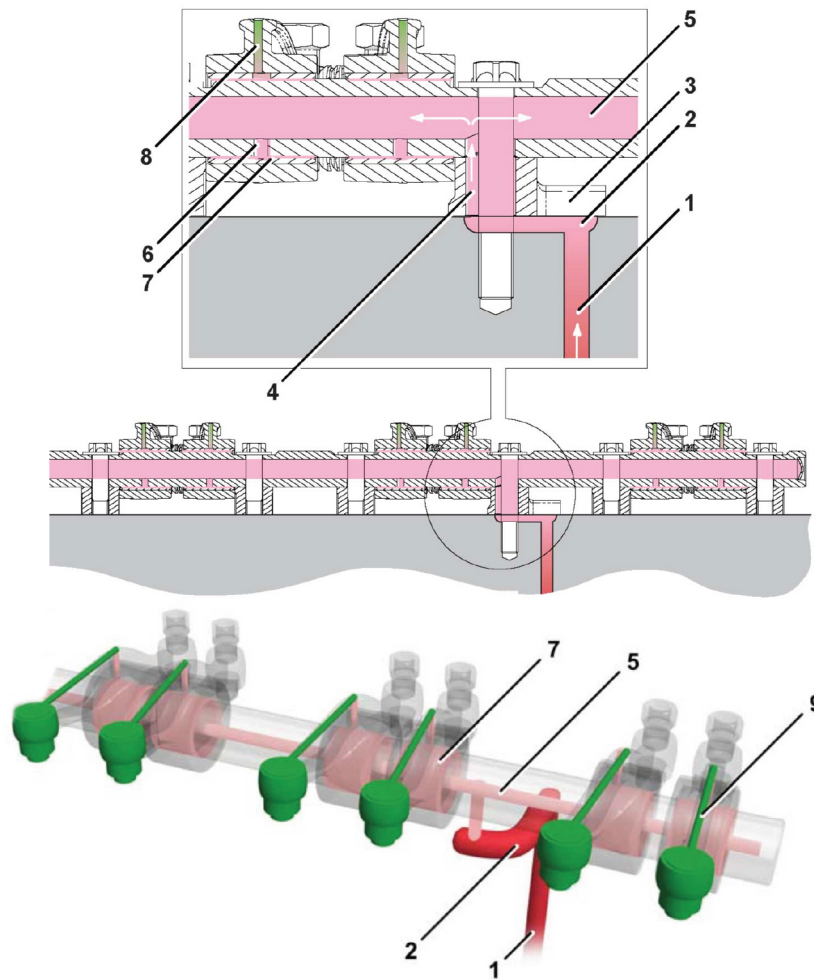
- | | | | |
|---|---|---|--------------------------------|
| 1 | Rocker shaft assembly | 2 | Rocker shaft fixing bolts (x7) |
| 3 | Rocker shaft - oil feed pedestal fixing bolt (x1) | 4 | Pedestals (x7) |
| 5 | Oil feed pedestal (x1) | 6 | Bridge pieces (x8) |
| 7 | Push rods (x8) | | |

Operation

When the camshaft lobe raises the outside of the rocker arm, the inside presses down on the valve stem to open the valve. When the outside of the

rocker arm is permitted to return due to the camshaft's rotation, the inside rises to allow the valve spring to close the valve.

Figure 106.



- 1 Oil feed from main gallery
- 3 Shaft pedestal
- 5 Centre rocker shaft drilling
- 7 Rocker pivot bushes
- 9 Groove

- 2 Small transfer gallery
- 4 Rocker shaft fixing bolt hole
- 6 Cross drillings
- 8 Cross drilling

Lubrication

Oil is fed from the main gallery via a drilling which passes up through the crankcase and the cylinder head to a small transfer gallery under the rocker shaft pedestal. The oversized rocker shaft fixing bolt hole allows oil to pass into a drilling in the centre of the rocker shaft. Further cross drillings transfer oil to each of the rocker pivot bushes. A cross drilling

in each rocker transfers oil to the top of the rocker where it flows by gravity along a groove to the rocker tip.

Check (Condition)

1. Check the rocker shaft and rocker bushings for signs of damage and excessive wear. Measure the rocker shaft diameter and rocker bearing bushes to confirm they are within service limits. Refer to Technical Data. Note: The rocker bearing bushes are not renewable. If a rocker bearing bush is damaged or worn the rocker must be renewed as a complete assembly.

[Refer to: PIL 15-42.](#)

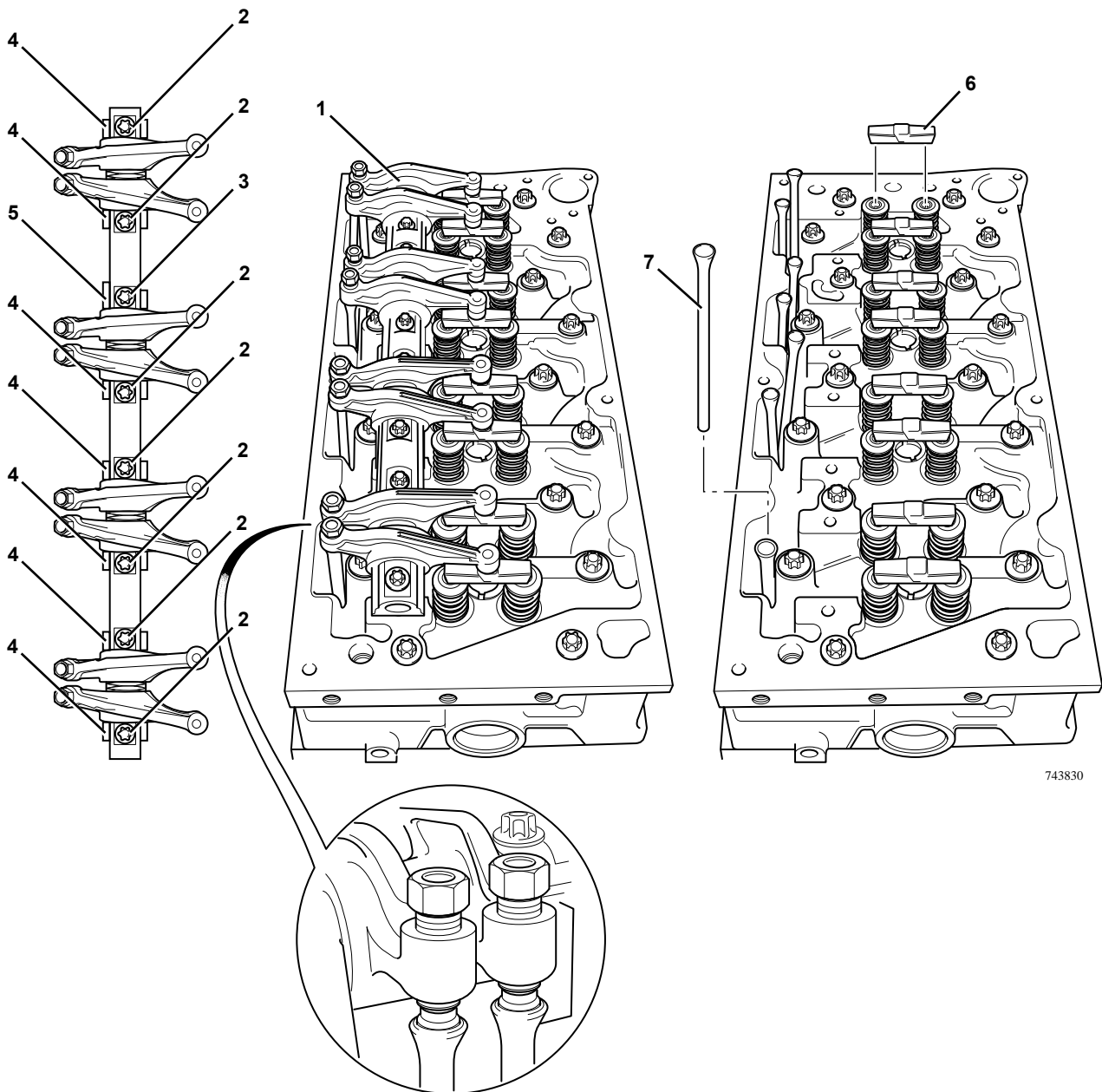
2. Make sure that all oil-ways and cross drillings in the rocker shaft, rocker arms and pedestals are clear and free from debris. Use an air line to blow through cross drillings.

Remove and Install

Before Removal

1. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.
2. Get access to the engine.
3. Disconnect and remove the fuel pipes from the fuel injectors.
[Refer to: PIL 18-96-03.](#)
4. Remove the rocker cover.
[Refer to: PIL 15-42-06.](#)

Figure 107.



743830

- | | |
|---|----------------------------------|
| 1 Rocker shaft assembly | 2 Rocker shaft fixing bolts (x7) |
| 3 Rocker shaft - oil feed pedestal fixing bolt (x1) | 4 Pedestals (x7) |
| 5 Oil feed pedestal (x1) | 6 Bridge pieces (x8) |



7 Push rods (x8)

Remove

1. Remove the rocker shaft fixing bolts. DO NOT withdraw the bolts. Lift the rocker shaft assembly from the cylinder head complete with pedestals still attached. Important: Keep all pedestals and fixing bolts in their original positions.
2. Lift off the bridge pieces from the pairs of inlet and exhaust valves.
3. Withdraw the push rods from the cylinder block.

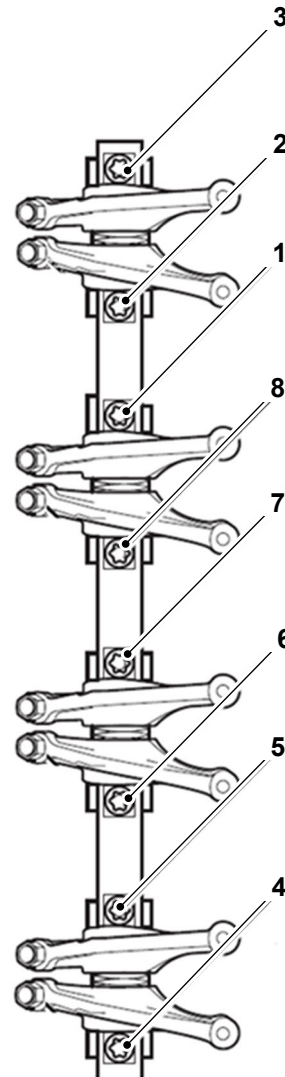
Before Installation

1. Make sure that all items are clean and free from damage and corrosion.
2. Make sure that all oil-ways and cross drillings in the cylinder head, rocker shaft and pedestals are clear and free from debris. Use an air line to blow through the cross drillings.

Install

1. Use a suitable degreasing agent to clean the top of the cylinder head.
2. Install the bridge pieces on to the pairs of inlet and exhaust valves in the cylinder head.
3. Insert the push rods into the cylinder block. Make sure that they engage with the camshaft tappets.
4. Install the rocker shaft assembly into the cylinder head. Make sure that the pedestals are located in their original positions. Note the position of the oil feed pedestal and the longer bolt. Make sure that the push rods engage with the tappet adjusters and that the rockers are located over the bridge pieces.
5. Tighten the bolts to the first stage torque value in the correct sequence. Refer to Figure 108.

Figure 108.



1-8 Rocker shaft fixing bolts tightening sequence

6. Tighten the bolts to the second stage torque value in the correct sequence. Refer to Figure 108.
7. Lubricate the rocker shaft, rocker arm inserts and bridge pieces with clean engine oil.

Figure 109.



8. Adjust the valve clearances.
 Refer to: [PIL 15-30-00](#).

After Installation

1. The after installation procedure is the opposite of the before removal procedure.

Table 52. Torque Values

Item	Description	Nm
2	Stage 1	5
2	Stage 2	24
3	-	24

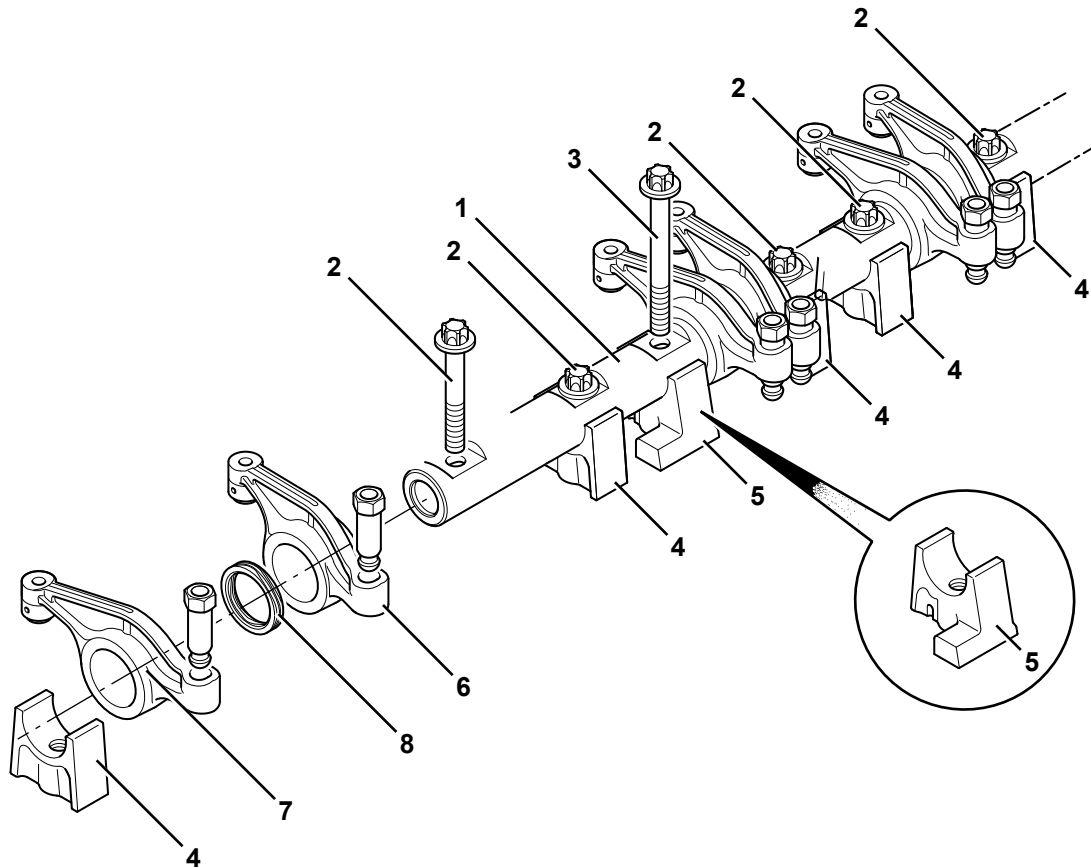
Disassemble and Assemble

Before Disassembly

1. Remove the rocker cover. Refer to (PIL 15-42).

2. Remove the rocker assembly. Refer to (PIL 15-42).

Figure 110.



- 1 Rocker shaft
- 3 Rocker shaft - Oil feed pedestal fixing bolt (x1)
- 5 Oil feed pedestal (x1)
- 7 Rockers - exhaust (x4)

- 2 Rocker shaft fixing bolts (x7)
- 4 Pedestals (x7)
- 6 Rockers - inlet (x4)
- 8 Wave washers (x8)

Disassemble

1. Lift out the rocker shaft fixing bolts, then slide the pedestals, rockers and wave washers off the rocker shaft as shown. Label the pedestals and rockers to make sure that they are installed in the correct positions on assembly.
2. Check the rocker shaft and rocker bushings for signs of damage and excessive wear. Refer to Check (Condition) (PIL 15-42).

Assemble

1. The assembly procedure is the opposite of the disassemble procedure. Additionally do the following steps.
2. Lubricate the rocker shaft and rocker bearing bushes with clean engine oil.
3. Make sure that the rockers and pedestals are installed in their original positions along the rocker shaft. Note the position of the oil feed pedestal.
4. Insert the rocker shaft fixing bolts to hold the rockers and pedestals loosely in position before fitting the assembly into the cylinder head. Note the position of the longer bolt.

After Assembly

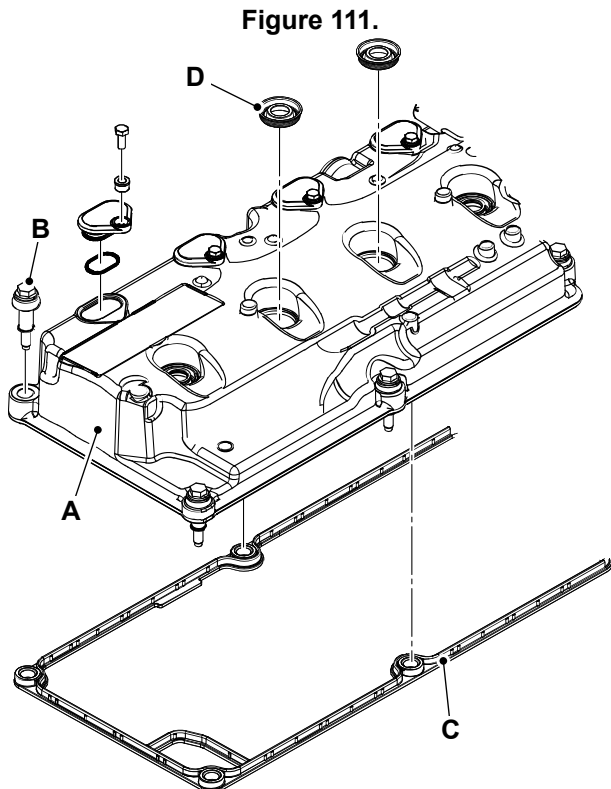
1. Install the rocker assembly. Refer to (PIL 15-42).
2. Install the rocker cover. Refer to (PIL 15-42).

06 - Rocker Cover

Remove and Install

Before Removal

1. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.
2. Clean the engine. Refer to Engine - Clean (PIL 15-00).



- A** Rocker cover
- B** Bolts
- C** Gasket
- D** Injector seals

Remove

1. Get access to the engine.
2. Remove the high pressure fuel pipes. Refer to Fuel Pipes (PIL 18-96).
3. Remove the fuel bleed off fuel pipes. Refer to Fuel Pipes (PIL 18-96).
4. Disconnect the electrical connectors at the fuel injectors. Refer to Fuel Injection (PIL 18-18).
5. Disconnect the electrical connector at the coolant temperature sensor. Refer to Engine Sensors (PIL 15-84).

6. Move the electrical harness away from the rocker cover.
7. Remove the bolts and lift the rocker cover from the cylinder head.
8. Discard the gasket.
9. The rocker cover injector seals must be replaced. Refer to Injector seals (PIL 18-18).

Install

1. The installation procedure is the opposite of the removal procedure. Additionally do the following steps.
2. Remove all oil and sludge contamination from inside the rocker chamber.
3. Renew the injector seals. Refer to Injector seals (PIL 18-18).
4. Renew the rocker cover gasket.
5. Prevent damage to the seals. Put sleeves/covers on the four injectors. Apply a rubber lubricant to the seals and then install the rocker cover.
6. Tighten the bolts to the correct torque value.
7. Remove the sleeves/covers.

After Installation

1. The high pressure fuel pipes must be replaced with new parts. Refer to Fuel Pipes (PIL 18-96).
2. Start the engine and check for oil and fuel leaks.

Table 53. Torque Values

Item	Nm
B	24

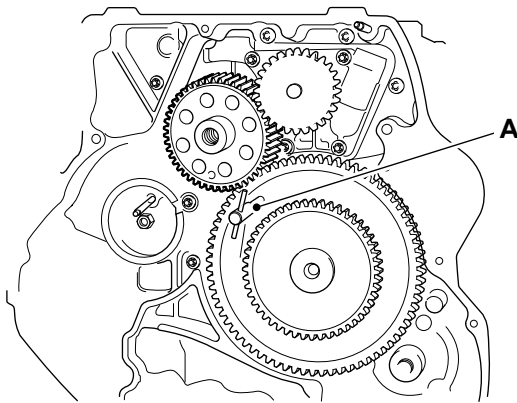
21 - Tappet

Remove and Install

Before Removal

1. Drain the oil from the engine.
2. Disconnect and remove the fuel pipes from the injectors. Refer to (PIL 18-96).
3. Remove the rocker cover. Refer to (PIL 15-42).
4. Remove the fuel injection pump. Refer to (PIL 18-18).
5. Remove the rocker assembly and push rods. Refer to (PIL 15-42).
6. Remove the starter motor. Refer to (PIL 15-75).
7. Remove the oil sump. Refer to (PIL 15-45).
8. Remove the flywheel. Refer to (PIL 15-54).
9. Remove the flywheel housing. Refer to (PIL 15-54).
10. Rotate the crankshaft until the camshaft timing pin can be inserted through the gear and into the aligning hole in the rear gear case.

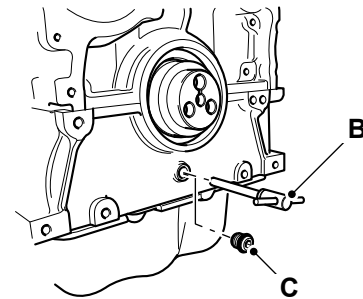
Figure 112.



A Timing pin - camshaft

11. Remove the taper blanking plug and insert the crankshaft locking pin. The camshaft and crankshaft locking pins must be in position to lock the crankshaft and camshaft before removing the camshaft assembly.

Figure 113.



B Timing pin - crankshaft
C Blanking plug

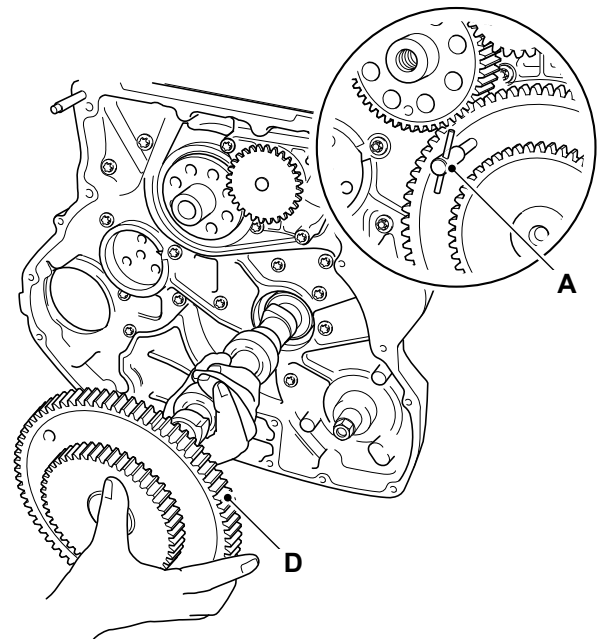
12. Remove the fuel injection pump drive gear. Refer to (PIL 15-51).

Removal

The engine must be inverted. DO NOT attempt to remove the camshaft and its drive gears with the engine upright. The tappets and push rods will fall into the engine and further dismantling will be required to retrieve them.

1. Remove the camshaft timing pin.
2. Carefully withdraw the camshaft and gear assembly from the crankcase. Make sure you fully support the camshaft to prevent the lobes contacting the bearing surfaces in the crankcase. The bearing surfaces can easily be damaged by the sharp hard edges on the cam lobes.

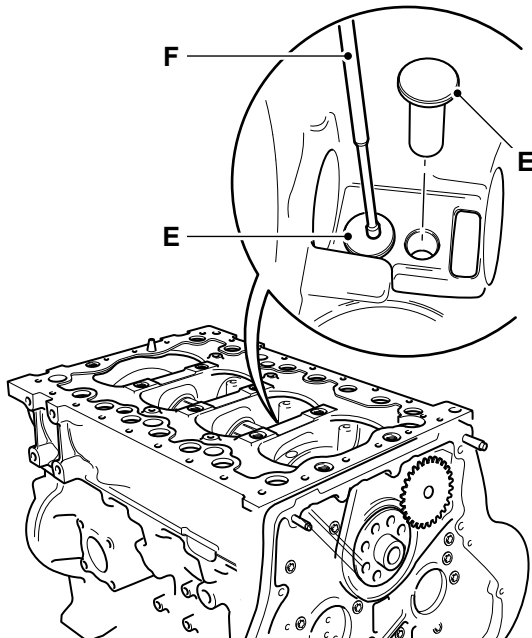
Figure 114.



A Timing pin - camshaft
D Camshaft and drive gear

3. Access the tappets through the apertures in the crankcase bedplate next to the crankshaft. Lift out the tappets from the crankcase using a suitable magnetic probe. Label the tappets to ensure replacement in their original positions.

Figure 115.



E Tappet (8 off)
F Magnetic probe

Inspection

1. Inspect the camshaft gear teeth for signs of damage or excessive wear.
2. Inspect the cam lobes for signs of excessive wear, scoring or pitting.
3. Inspect the cam bearing surfaces for signs of excessive wear, or scoring. Check that the dimensions are within service limits.
4. Inspect the cam bearing surfaces inside the crankcase for signs of excessive wear, or scoring. Check that the dimensions are within service limits.
5. Inspect the bearing surfaces of the tappets for signs of excessive wear or damage. Check that the dimensions are within service limits.
6. Inspect the tappet bores inside the crankcase for signs of excessive wear or damage. Check that the dimensions are within service limits.
7. If any of the camshaft bearings or lobes are worn or damaged then the relative oil feed galleries in the crankcase and camshaft may be blocked. Make sure all oil ways are clear and free from debris.

Installation

1. Lubricate the tappets and tappet bores inside the crankcase with clean engine oil.
2. Insert the tappets in their original positions in the crankcase using a suitable magnetic probe.
3. Lubricate the camshaft bearing journals inside the crankcase with clean engine oil.
4. Carefully insert the camshaft assembly into the crankcase as shown. Support the camshaft preventing the lobes contacting the bearing surfaces in the crankcase. Before meshing the camshaft gear with the crankshaft gear, rotate the camshaft until the timing hole in the gear aligns with the dowel hole in the gear casing. Insert the timing pin to lock the camshaft in this position.

After Installation

1. Note that the fuel injection pump drive gear fixing nut is torque tightened as part of the fuel injection pump replacement procedure. Refer to (PIL 18-18).
2. Do the procedures in Before Removal in reverse order.

24 - Tappet Cover

Remove and Install

It is not necessary to remove the tappet covers unless a new rocker cover is to be installed. It is necessary to remove the tappet covers to measure and adjust the valve clearances. Refer to Valve-Adjust, Valve Clearances (PIL 15-30).

Remove

1. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.
2. Get access to the engine.
3. Clean the tappet covers and the adjacent areas of the rocker cover. Refer to Engine - Clean. Important: Make sure that the screws do not fall into the engine.
4. Remove the tappet cover screws.
5. Keep the screws away from the engine.
6. Use a screwdriver in the slot to remove the tappet covers. Make sure that dirt or debris does not fall into the engine.

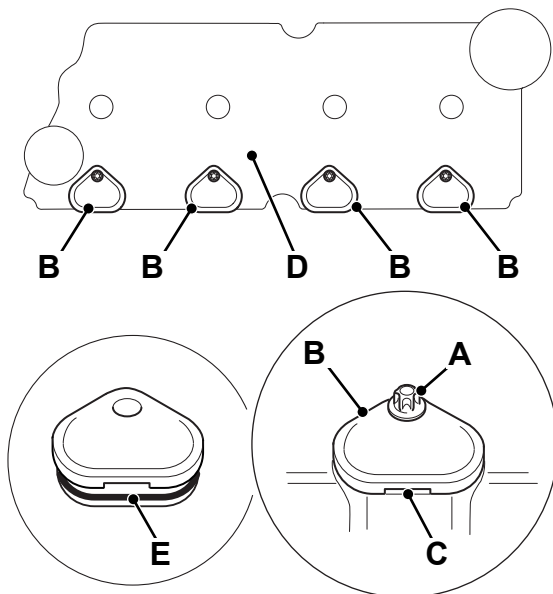
Install

1. The installation procedure is the opposite of the removal procedure. Additionally do the following steps.
2. Inspect the tappet cover seals for signs of damage. Replace any damaged seals.
3. Install the tappet covers. Tighten the screws to the correct torque value.

Table 54. Torque Values

Item	Nm
A	9

Figure 116.



- A** Screws
- B** Tappet covers
- C** Slot
- D** Rocker cover
- E** Tappet cover seals



45 - Oil Sump

Contents

Page No.

15-45-00 General	15-173
------------------------	--------

00 - General

Introduction	15-173
Component Identification	15-174
Remove and Install	15-175

Introduction

The lubrication system distributes oil around the engine by a system of galleries and drillings in the crankcase and cylinder head. The oil lubricates and seals the moving parts of the engine, reducing friction and wear. In addition the oil plays an important role in cooling the engine by carrying heat from the engine to the cooler. A piston cooling jet sprays oil onto the underside of the pistons to keep them cool, refer to (PIL 15-36).

Oil is drawn from the oil sump by the integral oil pump via the suction strainer. The strainer prevents any large particles of debris passing through, which may damage the pump.

The oil passes from the outlet side of the pump through a relief valve which limits the maximum oil pressure by venting oil back to the inlet side of the pump, refer to (PIL 15-36).

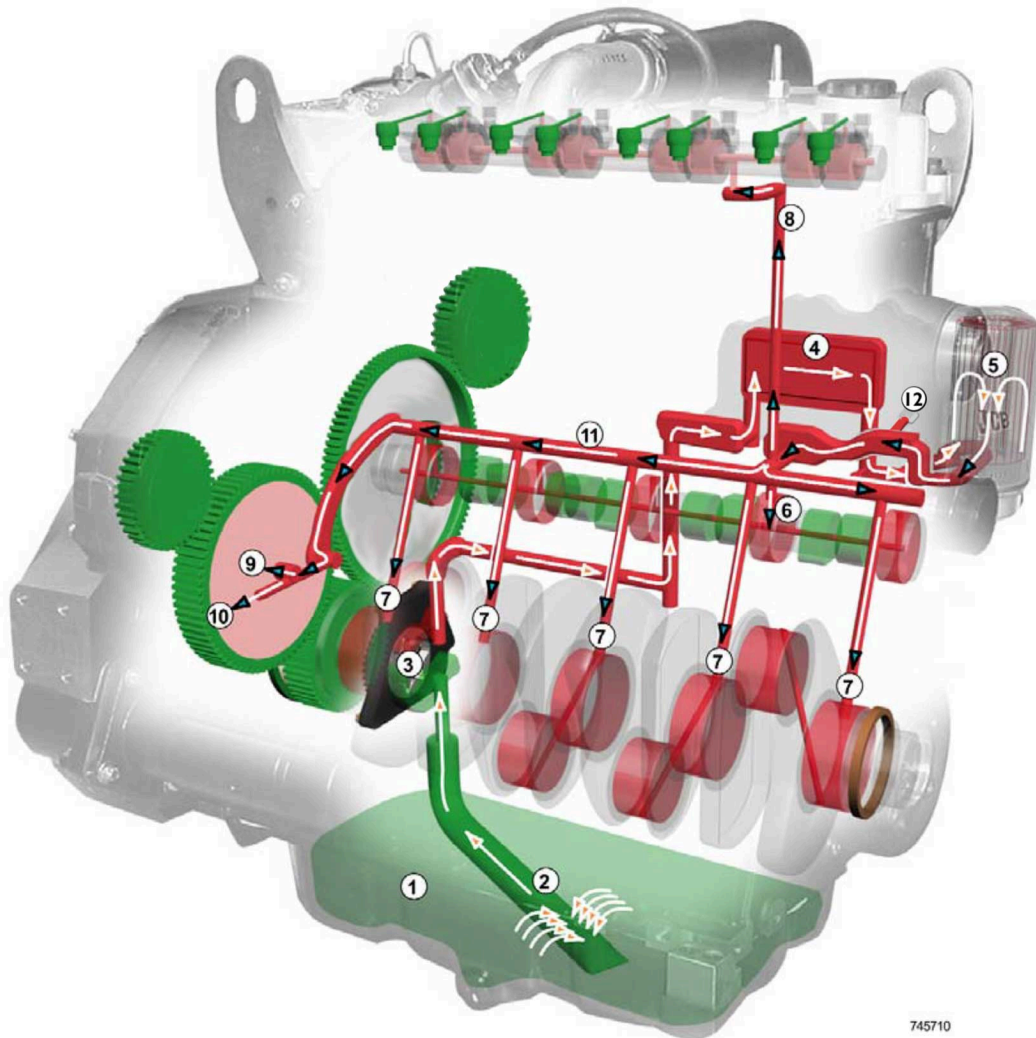
From the pump the oil passes through the oil cooler and filter, refer to (PIL 15-69 and PIL 15-21).

After cooling and filtering, the oil passes into the main oil gallery. An oil pressure switch senses the oil pressure. From the main gallery oil is delivered, via drillings, to the crankshaft main bearings, rocker assembly, camshaft and timing gears. Note that drillings are through the crankcase and cylinder head.

When the high pressure oil has passed through the bearings it reverts to sump pressure and splash lubricates the internal components such as rocker tips, cam lobes and timing gear teeth. Gravity drains the oil via drains into the cylinder head and crankcase, back into the oil sump. A drain slot allows the oil to drain from the timing case back to the oil sump.

Component Identification

Figure 117.



- | | | | |
|----|--|----|--|
| 1 | Oil sump | 2 | Suction strainer |
| 3 | Oil pump | 4 | Oil cooler |
| 5 | Filter | 6 | Camshaft - high pressure oil feed |
| 7 | Crankshaft main bearings - high pressure oil feed | 8 | Rocker assembly - high pressure oil feed |
| 9 | PTO (Power Take-Off) idler gear bearing/timing case - high pressure oil feed | 10 | External high pressure oil feed connection (crankcase) - Turbocharger (if installed) |
| 11 | Main high pressure oil feed gallery (crankcase) | 12 | Oil pressure switch |
- Green- Oil at sump pressure
 Pink- Oil at lower pressure but higher than sump pressure
 Red- Oil at high pressure

Remove and Install

Special Tools

Description	Part No.	Qty.
Template for Sealant Oil Sump - Pressed	892/01149	1
Oil Sump Location Dowel	892/01150	2
Template for Sealant Oil Sump (Cast)	892/12354	1

Consumables

Description	Part No.	Size
Clear Silicone Sealant	4102/0901	0.31 L

Before Removal

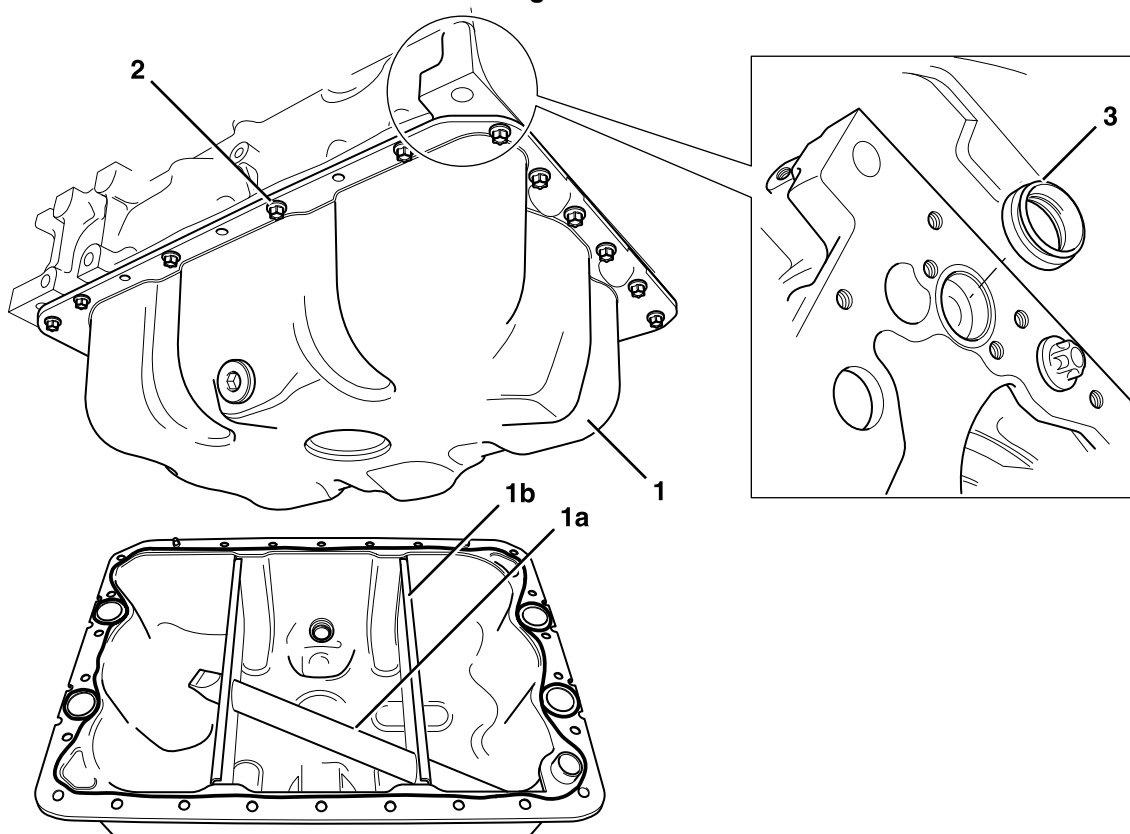
1. Make sure that the engine is safe to work on. If the engine has been running, make sure the engine has cooled sufficiently before you start.

2. Drain the engine oil.

Removal

1. Remove the fixing bolts and remove the oil sump from the engine. The oil sump may be difficult to remove due to adhesion of sealing compound. If necessary, carefully lever the mating flanges apart. Do not use excessive force, the oil sump could be damaged. Be sure to retrieve the oil pick up seal.
2. Use a gasket removal compound, carefully remove all traces of sealing compound from the oil sump and engine mating faces. Do not allow the sealing compound to enter the engine.
3. Use a suitable degreasing agent to thoroughly clean the oil sump.

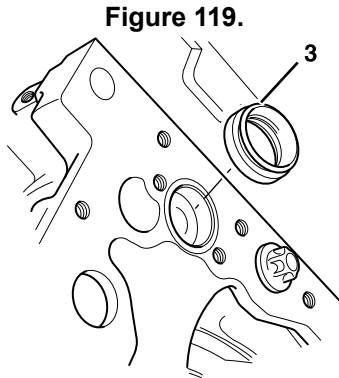
Figure 118.



- | | |
|----------------------------------|--------------------------------------|
| 1 Oil sump | 1a Integral suction tube |
| 1b Integral baffle plates | 2 Oil sump fixing bolts (x20) |
| 3 Oil pick up seal | |

Installation

1. Lightly smear the new oil pick up seal with oil and install into the bedplate as shown.



3 Oil pick up seal

2. Install the two guide pins at the oil sump screw holes in the engine.

Special Tool: Oil Sump Location Dowel (Qty.: 2)

3. Use the fixing bolts to locate the template to the oil sump mating face. Make sure that the template is the correct way round (note that holes are on different centres).

Special Tool: Template for Sealant Oil Sump (Cast) (Qty.: 1)

Special Tool: Template for Sealant Oil Sump - Pressed (Qty.: 1)

4. Apply a bead of sealing compound around the oil sump flange using the inside edge of the template as a guide as shown. Note the beads around holes.

Length/Dimension/Distance: 4mm

Consumable: Clear Silicone Sealant

5. Carefully remove the template without smudging the sealant beads.

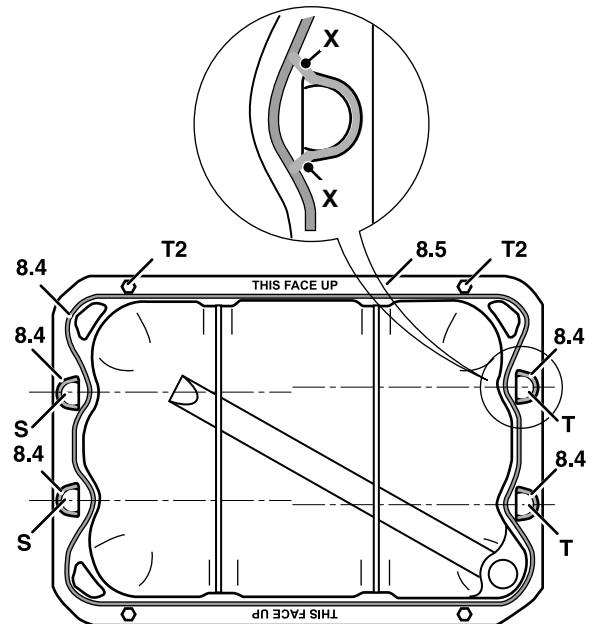
6. Apply a bead of sealant so as to join the sealant beads around holes with the bead around the oil sump flange.

Length/Dimension/Distance: 4mm

7. After applying the sealing compound, the oil sump must be installed and the bolts torque tightened within

Duration: 5min

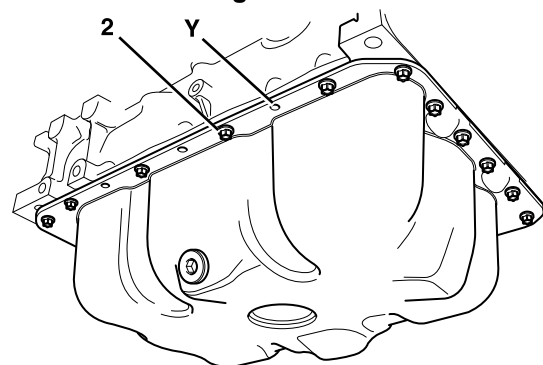
Figure 120.



S Hole
T Hole
T2 Guide pins
X 4mm Bead of sealant

8. Position the oil sump with the suction tube outlet aligned with the oil pump inlet port on the engine. Take care not to damage the oil pick up seal when you install the oil sump. Damage to the seal could cause a drop in oil pressure and subsequently damage to the engine.
9. Locate the oil sump on the guide pins on the engine. Avoid smudging the sealant beads. **DO NOT** remove the guide pins until sufficient bolts have been installed to secure the oil sump.
10. Install the bolts and tighten the bolts to the correct torque value. Note that the bolts are not installed at 6 positions.

Figure 121.



2 Bolts
Y No bolts to be installed at this position (x6)

After Replacing

1. Allow the sealant to cure for
Duration: 20min
2. Refill the engine with the recommended engine oil. Refer to (PIL 75-00).
3. Start the engine and check for oil leaks.

Table 55. Torque Values

Item	Nm
2	24



51 - Timing Gear

Contents	Page No.
15-51-00 General	15-179
15-51-03 Crankshaft Gear	15-182
15-51-06 Camshaft Gear	15-185
15-51-09 Fuel Injection Pump Gear	15-186
15-51-15 Heavy Duty PTO Gear	15-189
15-51-22 Rear Case	15-192

00 - General

Introduction	15-179
Component Identification	15-180
Operation	15-181
Check (Condition)	15-181

Introduction

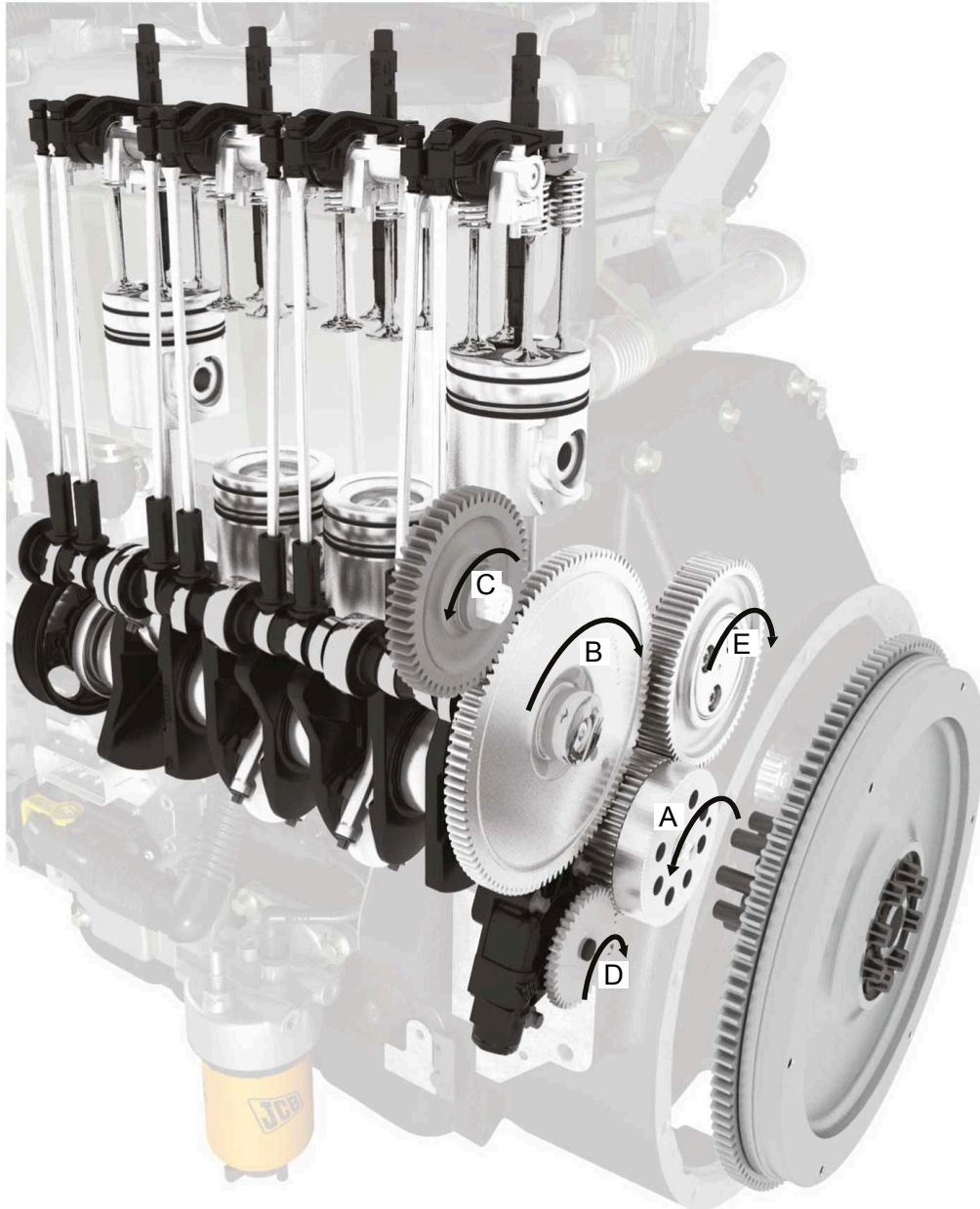
The timing gears are located inside a case at the flywheel end of the engine.

The engine must be timed so that the camshaft operates the valves at the correct times relative to the crankshaft position.

Valve timing is achieved by ensuring that the camshaft drive gear is meshed to the crankshaft gear at their correct angular positions, refer to Engine-General, Operation, The Four Stroke Cycle (PIL 15-00) for more information about valve timing.

Component Identification

Figure 122.



- A Crankshaft gear
- C High pressure fuel pump gear
- E Heavy duty PTO device gear (if installed)
- G Low duty PTO device gear (if installed)

- B Camshaft gear
- D Oil pump gear
- F Heavy duty PTO device gear (if installed)

Operation

All the gears are driven via the crankshaft gear as follows.

- Camshaft gear-The camshaft is driven at half crankshaft speed.
- High pressure fuel pump gear-The high pressure fuel pump is driven via the camshaft gear installed to the camshaft.
- Oil pump gear-The lubrication oil pump is driven directly by the crankshaft gear.
- Power Take-Off (PTO)-driven by the crankshaft gear via idler gear.
- Low Duty Power Take-Off (PTO) Gear (if installed)-driven by the camshaft gear.

Check (Condition)

1. Inspect the gears for wear or damage. If one or more of the gears are worn or damaged, replace them.

03 - Crankshaft Gear

Remove and Install

Special Tools

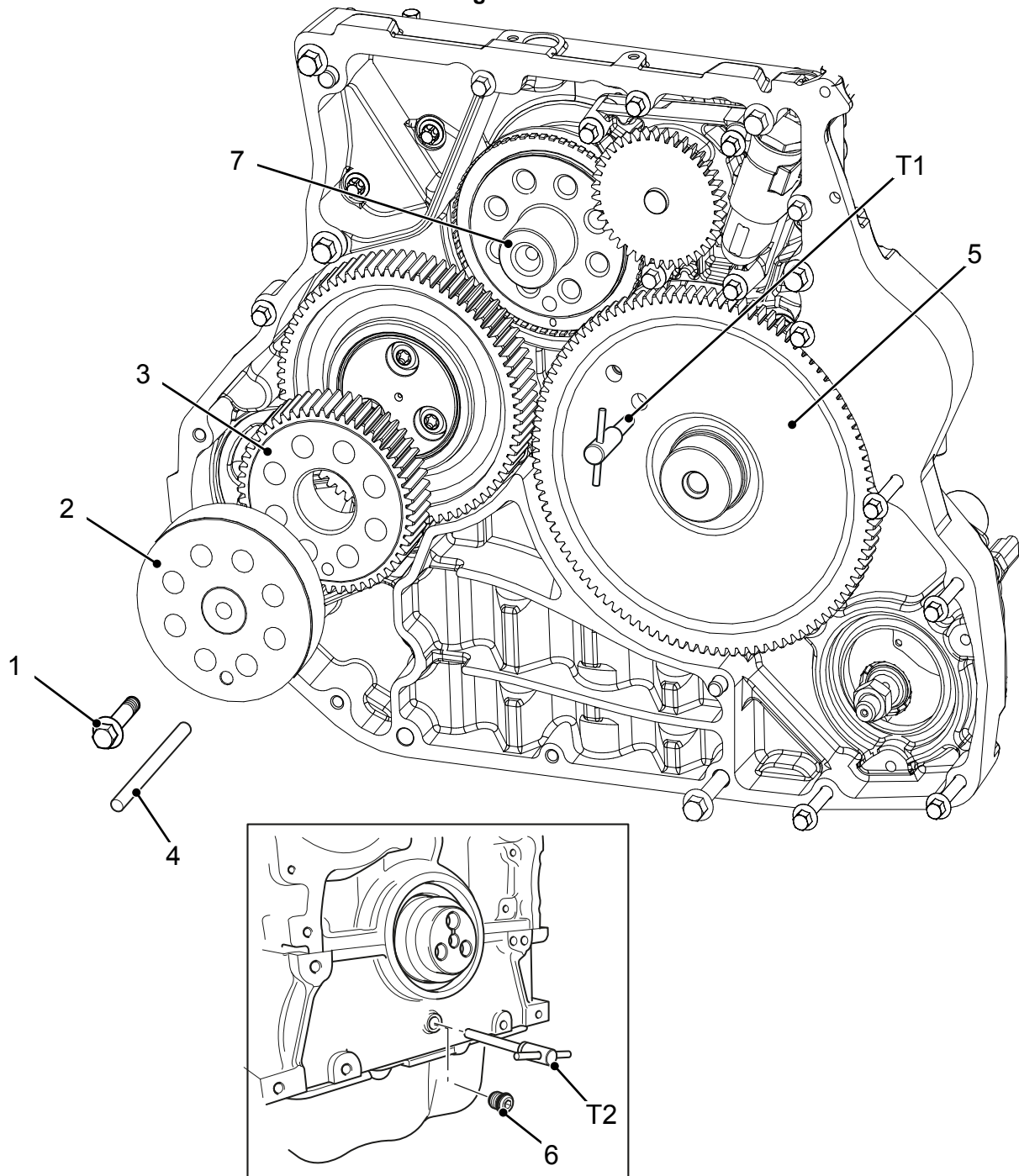
Description	Part No.	Qty.
Crankshaft / Camshaft Timing Pin (444/448/672 Engine)	892/01148	2

Note: The illustrations show the engine inverted. If the drive gear components are being removed prior to crankshaft or camshaft removal the engine must be inverted. If the gear components only are being removed (for inspection/renewal) then the engine need not be inverted.

Before Removal

1. Remove the starter motor. Refer to (PIL 15-75).
2. Remove the flywheel. Refer to (PIL 15-54).
3. Remove the flywheel housing. Refer to (PIL 15-54).
4. Rotate the crankshaft until the camshaft locking pin can be inserted through the gear and into the aligning hole in the rear gear case. Note: The camshaft and crankshaft locking pins must be in position to lock the crankshaft and camshaft before removing the crankshaft gear.
[Special Tool: Crankshaft / Camshaft Timing Pin \(444/448/672 Engine\) \(Qty.: 2\)](#)
5. Remove the taper blanking plug and insert the crankshaft locking pin.

Figure 123.



- 1 Drive gear and flywheel hub fixing bolt
- 2 Flywheel hub
- 3 Crankshaft gear
- 4 Location dowel
- 5 Camshaft drive gear
- 6 Blanking plug - crankcase
- 7 Crankshaft - gear location spigot
- T1 Timing pin - camshaft
- T2 Timing pin - crankshaft

Remove

1. Remove the flywheel hub fixing bolt and remove the flywheel hub.
2. Remove the crankshaft gear from the crankshaft. Make sure you retrieve the location dowel.

Inspect

1. Carefully inspect the outer diameter of the flywheel hub for signs of wear or damage. Wear or damage will cause the crankshaft rear oil seal to fail. If in doubt renew the hub.

Install

1. Apply some clean engine oil to the location spigot on the end of the crankshaft.
2. Make sure that the dowel is located in the crankshaft gear and locate the gear and dowel on to the crankshaft spigot.
3. Install the flywheel hub to the gear, locate on the dowel. Fix the hub with fixing bolt. Tighten the bolt to the correct torque value.

Table 56. Torque Values

Item	Nm
1	47
6	11

06 - Camshaft Gear

Remove and Install

The camshaft drive gear is an interference fit on the end of the camshaft and cannot be removed individually. If the gear is damaged or worn the complete camshaft and gear assembly must be replaced. Refer to Camshaft- Remove and Install (PIL 15-15).

09 - Fuel Injection Pump Gear

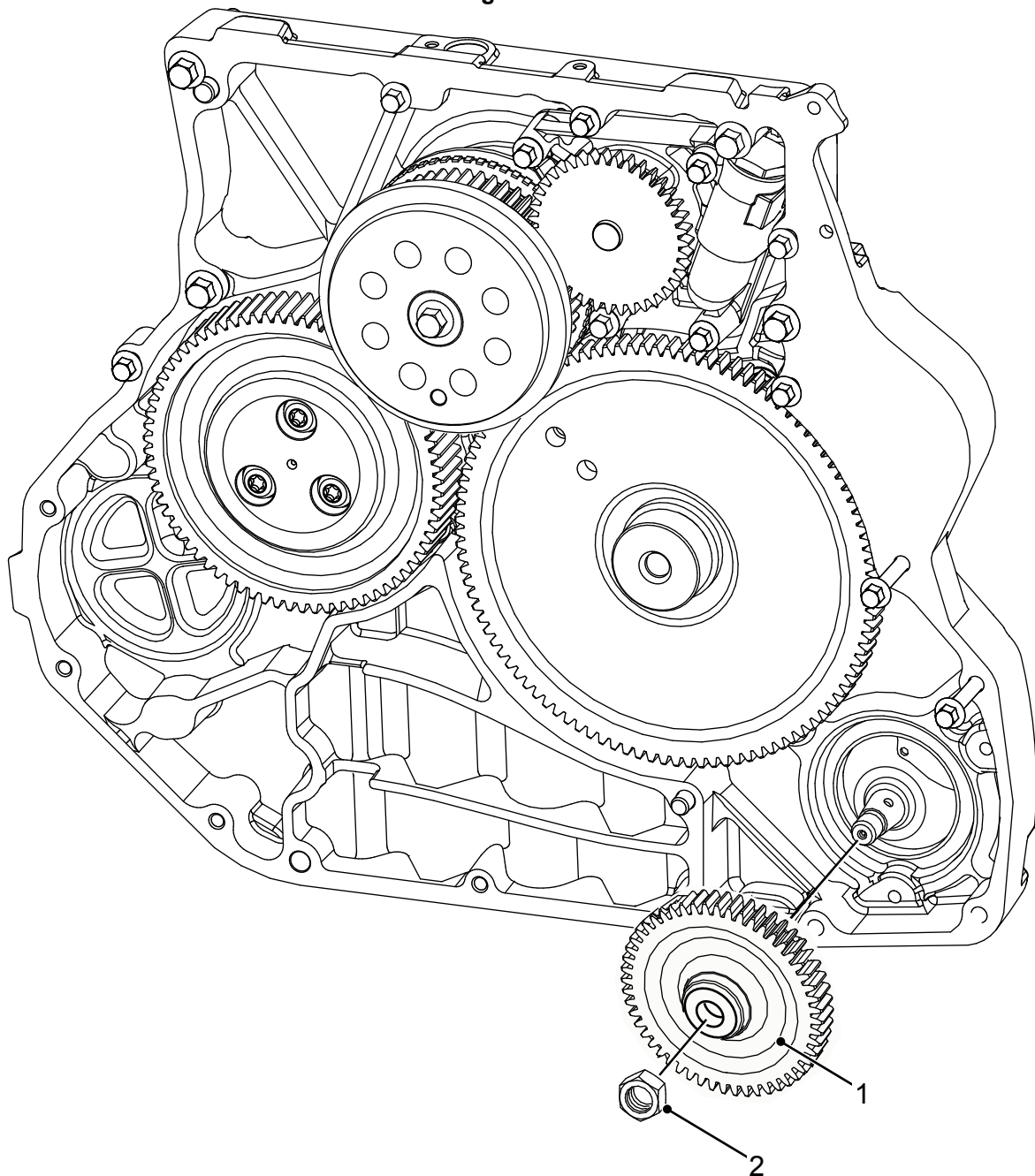
Remove and Install

Note: The illustrations show the engine inverted. If the drive gear components are being removed prior to crankshaft or camshaft removal the engine must be inverted. If the gear components only are being removed (for inspection/renewal) then the engine need not be inverted.

Before Removal

1. Remove the high pressure fuel injection pump. Refer to (PIL 18-18).
2. Loosely install the high pressure fuel pump and fixing nut, retain the gear.
3. Remove the starter motor. Refer to (PIL 15-75).
4. Remove the flywheel. Refer to (PIL 15-54).
5. Remove the flywheel housing. Refer to (PIL 15-54).

Figure 124.



1 Drive gear - high pressure fuel pump

2 Fixing nut - drive gear - high pressure fuel pump

Remove

1. Remove the fixing nut and lift out the gear.
2. If the rear timing case is to be removed, remove the high pressure fuel pump.

Install

1. Use the fixing nut to loosely install the high pressure fuel pump and the drive gear. DO NOT lock the gear to the taper on the fuel pump drive shaft.
2. Follow the procedures listed under Before Removal in reverse order. Note that the gear fixing nut is torque tightened as part of the



high pressure fuel pump replacement procedure.
Refer to (PIL 18-18).

15 - Heavy Duty PTO Gear

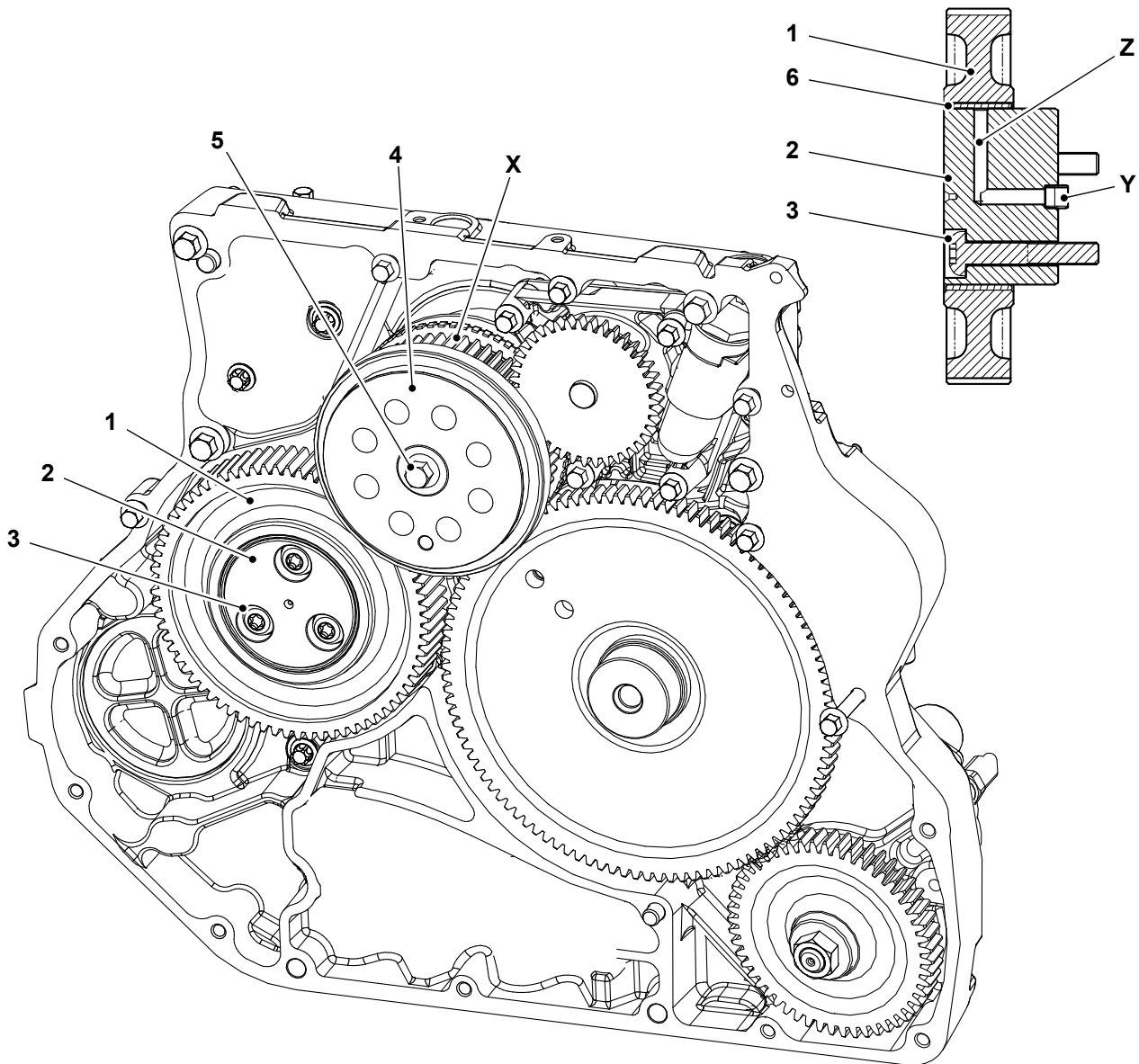
Remove and Install

The illustrations show the engine inverted. If the drive gear components are being removed prior to crankshaft or camshaft removal the engine must be inverted. If the gear components only are being removed (for inspection / renewal) then the engine need not be inverted.

Before Removal

1. This procedure requires service parts. Make sure you have obtained the correct service parts before you start, refer to Parts Catalogue.
2. Remove the starter motor. Refer to (PIL 15-75).
3. Remove the flywheel. Refer to (PIL 15-54).
4. Remove the flywheel housing. Refer to (PIL 15-54-03).

Figure 125.



- | | |
|--|---------------------------------|
| 1 High duty PTO idler gear | 2 Idler gear hub |
| 3 Idler gear hub retaining screws (x3) | 4 Flywheel hub |
| 5 Flywheel hub fixing bolt | 6 Idler gear bearing bush |
| X Crankshaft gear | Y Idler gear hub location dowel |
| Z Oil feed drilling | |

Remove

1. Remove the flywheel hub fixing bolt and remove the flywheel hub. DO NOT remove the crankshaft gear.
2. Lift the High duty PTO (Power Take-Off) idler gear from the hub.
3. If required, remove the idler gear hub retaining screws and lift out the hub.

Inspect

1. Check the idler gear teeth and idler gear bearing bush for signs of damage or excessive wear.
2. Measure the bearing bush inside diameter to confirm it is within service limits, refer to Technical Data.



Install

1. The installation procedure is the opposite of the removal procedure. Additionally do the following steps.
2. Make sure that all items are clean and free from damage and corrosion.
3. Make sure the oil way in the idler gear hub is clear and free from debris. Use an air line to blow through the oil feed drilling.
4. When you install the idler gear hub, make sure the Idler gear hub location dowel locates into the hole in the crankcase.
5. Lubricate the idler gear bearing bush with clean engine oil.
6. Install the flywheel hub to the crankshaft gear, locate on the dowel. Tighten the bolt to the correct torque value.

After Installation

1. Install the flywheel housing. Refer to (PIL 15-54-03)
2. Install the flywheel to the crankshaft hub. Refer to (PIL 15-54)
3. Install the starter motor. Refer to (PIL 15-75).

Table 57. Torque Values

Item	Nm
3	65
5	47

22 - Rear Case

Remove and Install

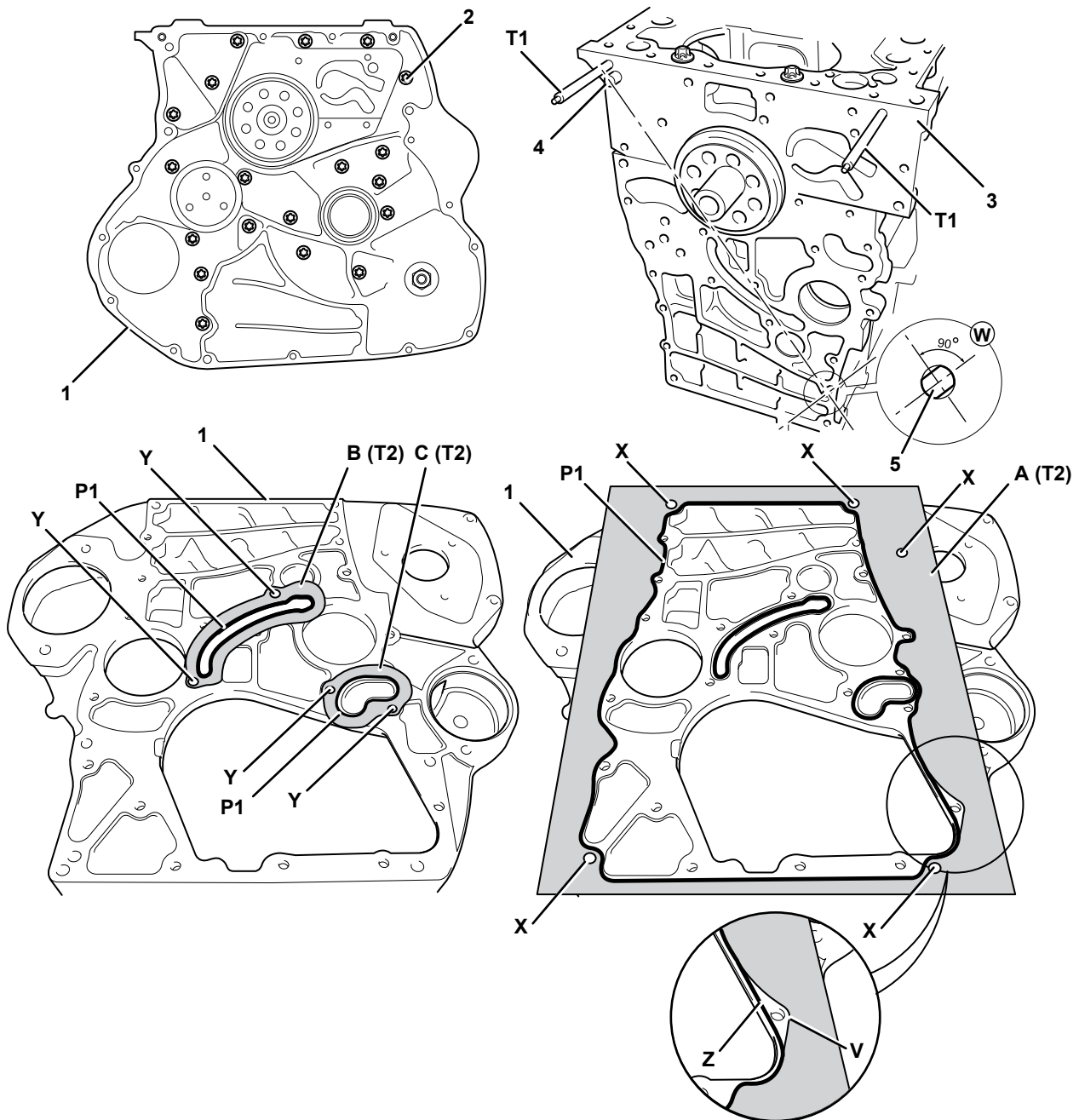
Special Tools

Description	Part No.	Qty.
Template for Sealant Gear Case to Cylinder Block (4 Cyl and 6 Cyl Elec)	892/01176	1

Before Removal

1. Drain the oil from the engine. Refer to (PIL 15-21).
2. Disconnect and remove the fuel pipes from the injectors. Refer to (PIL 18-96).
3. Remove the fuel injection pump. Refer to (PIL 18-18).
4. Remove the fuel lift pump. Refer to (PIL 18-21).
5. Remove the starter motor. Refer to (PIL 15-75).
6. Remove the high duty PTO (Power Take-Off) device (if installed).
7. Remove the low duty PTO device (if installed).
8. Remove the flywheel. Refer to (PIL 15-54).
9. Remove the flywheel housing. Refer to (PIL 15-54).
10. Remove the fuel injection pump drive gear. Refer to (PIL 15-51).
11. Remove the oil pump. Refer to (PIL 15-60).
12. Remove the high duty PTO idler drive gear (if installed). Refer to (PIL 15-51).
13. Remove the crankshaft drive gear. Refer to (PIL 15-51).
14. Remove the camshaft. Refer to (PIL 15-15).

Figure 126.



- 1** Timing gear case - rear
- 3** Crankcase/bedplate assembly
- 5** Dowel - with flats
- T1** Alignment pins (Locally manufacture)

- 2** Timing case fixing bolts (x19)
- 4** Dowel
- P1** Anaerobic sealant
- T2** Sealant template (comprises: Main template - A, Long gallery template - B, Short gallery template - C)

Remove

1. Remove the timing case fixing bolts and then separate the timing case from the crankcase/bedplate assembly. Do not use a lever to separate the timing case from the crankcase/bedplate assembly.

Important: Anaerobic sealant will not start to cure whilst it is open to the atmosphere, however when air is excluded (for instance when the two parts are put together) it will immediately start to harden. Make sure that all the necessary tools, bolts etc. are readily available prior to assembling the components. The parts must be installed and torque tightened within 5 minutes (with a maximum permissible time of 15 minutes).

Install

1. Carefully remove all traces of the old sealing compound from the timing case and crankcase/bedplate assembly mating faces. Make sure that the mating faces are clean and free from damage. Clean the inside of the timing case using a suitable degreaser.
2. Install two alignment pins T1 to the crankcase/bedplate assembly.
3. Make sure that dowels are correctly located in the crankcase. Note: Dowel 5 has flats which must be positioned relative to dowel 4, as shown at W. This ensures correct alignment of the timing cover.
4. The sealant template T2 comprises three pieces. Locate parts B and C using the holes in the templates and fixing bolts at positions Y as shown.

Special Tool: Template for Sealant Gear Case to Cylinder Block (4 Cyl and 6 Cyl Elec) (Qty.: 1)
5. Use the templates B and C as a guide apply a continuous 1.5 mm (0.060 in.) bead of sealant P1 to the case. Remove the bolts from positions Y. Remove the templates make sure you do not smudge the sealant. Discard the templates.
6. Locate part A of the template T2 using the holes in the template and bolts at positions X as shown.
7. Use the template A as a guide apply a continuous 1.5 mm (0.060 in.) bead of sealant P1 to the case. Do not follow the template at V, instead apply a continuous bead Z (inboard of the fixing hole). Remove the bolts from positions X. Remove the template make sure you do not smudge the sealant. Discard the template.
8. Locate the timing case on the alignment pins T1 and install the timing case fixing bolts (remove

pins T1 to install the final two bolts). Tighten the bolts to the correct torque value.

Important: If the parts have not been torque tightened within the maximum 15 minute time period, then the parts must be separated, thoroughly cleaned and fresh sealant applied

After Installation

1. Replace all the components listed under Before removal in reverse order.

Table 58. Torque Values

Item	Nm
2	37

54 - Flywheel

Contents	Page No.
15-54-00 General	15-197
15-54-03 Housing	15-201
15-54-09 Gear Ring	15-205



Notes:

00 - General

Introduction	15-197
Component Identification	15-198
Remove and Install	15-199

Introduction

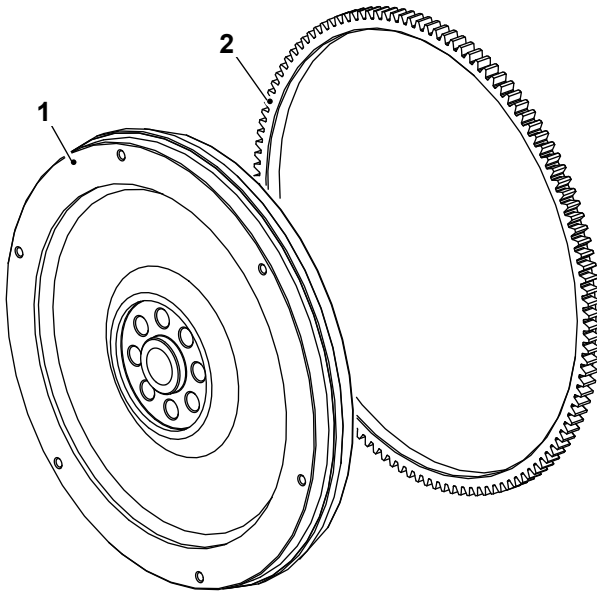
Flywheels are used to provide continuous energy in systems, where the energy source is not continuous. In such cases, the flywheel stores energy when torque is applied by the energy source, and it releases stored energy when the energy source is not applying torque to it.

In a reciprocating engine, a flywheel is used to maintain constant angular velocity of the crankshaft.

The flywheel, which is mounted on the crankshaft, stores energy when torque is exerted on it by a firing piston, and it releases energy to its mechanical loads when no piston is exerting torque on it.

Component Identification

Figure 127.



- 1 Flywheel
- 2 Flywheel gear ring

Remove and Install

Before Removal

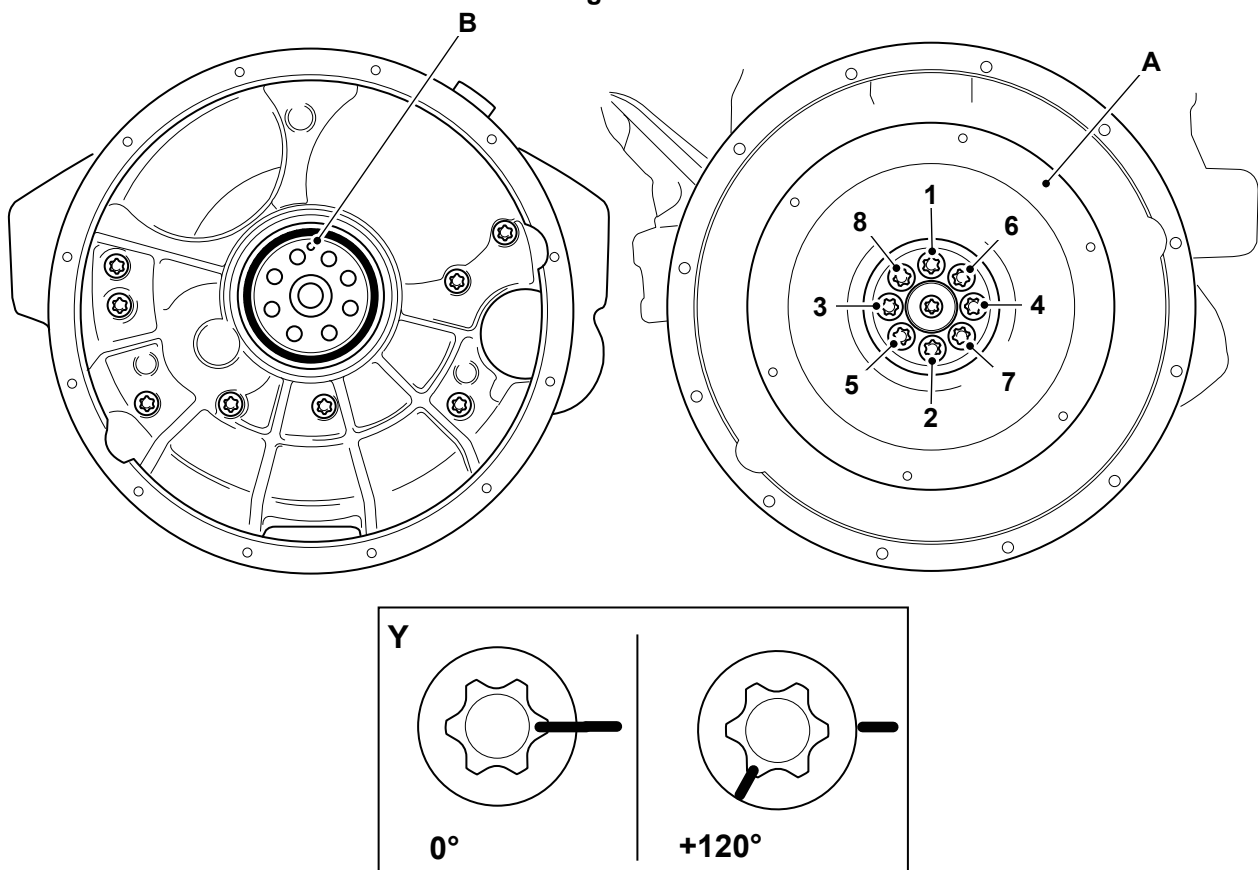
1. This procedure requires service parts. Make sure you have obtained the correct service parts before you start. The flywheel is installed with a crankshaft position sensor target disc. **DO NOT** remove the target disc. If the disc is defective the flywheel must be replaced.

2. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.
3. Get access to the engine.

Removal

1. Remove the bolts and withdraw the flywheel from the crankshaft hub. The bolts **MUST NOT** be reused. Discard the bolts.

Figure 128.



- 1-8** Flywheel bolts (x8)
B Flywheel location dowel

- A** Flywheel
Y Angle tightening mark

Installation

1. Make sure that all items are clean and free from damage and corrosion.
2. Align the flywheel location dowel and install the flywheel onto the crankshaft hub.
3. Install new flywheel bolts. Tighten the bolts in three stages using the torque and angle method.

Refer to: [PIL 72-00-00](#).

- 3.1. Tighten the bolts to the first stage torque in sequence in diagonally opposing pairs. Refer to Figure 128.
- 3.2. Tighten the bolts to the first stage torque in sequence in diagonally opposing pairs. Refer to Figure 128.
- 3.3. Use an angle gauge to tighten the bolts final stage torque in sequence in diagonally opposite pairs. As a visual check, matchmark the bolts to the flywheel before you start. When the bolts have been angle tightened, the matchmarks will appear as shown at Y. Refer to Figure 128.

Table 59. Torque Values

Item	Torque Value	Angle
1-8 (1st Stage)	40N·m	
1-8 (2nd Stage)	120N·m	
1-8 (Final Stage)		120°

03 - Housing

Remove and Install

Special Tools

Description	Part No.	Qty.
Template for Sealant Flywheel Housing to Gear Case (4 Cyl Elec)	892/12349	1

Before Removal

The flywheel housing is integral with the drive gears front case. When the housing is removed the drive gears will be exposed. DO NOT attempt to remove the camshaft and the drive gears. Removing the camshaft with the engine in the upright position will cause the tappets to dislodge, requiring the engine block to be dismantled.

1. This procedure requires service parts. Make sure you have obtained the correct service parts before you start.

2. Remove the starter motor.

[Refer to: PIL 15-75-00.](#)

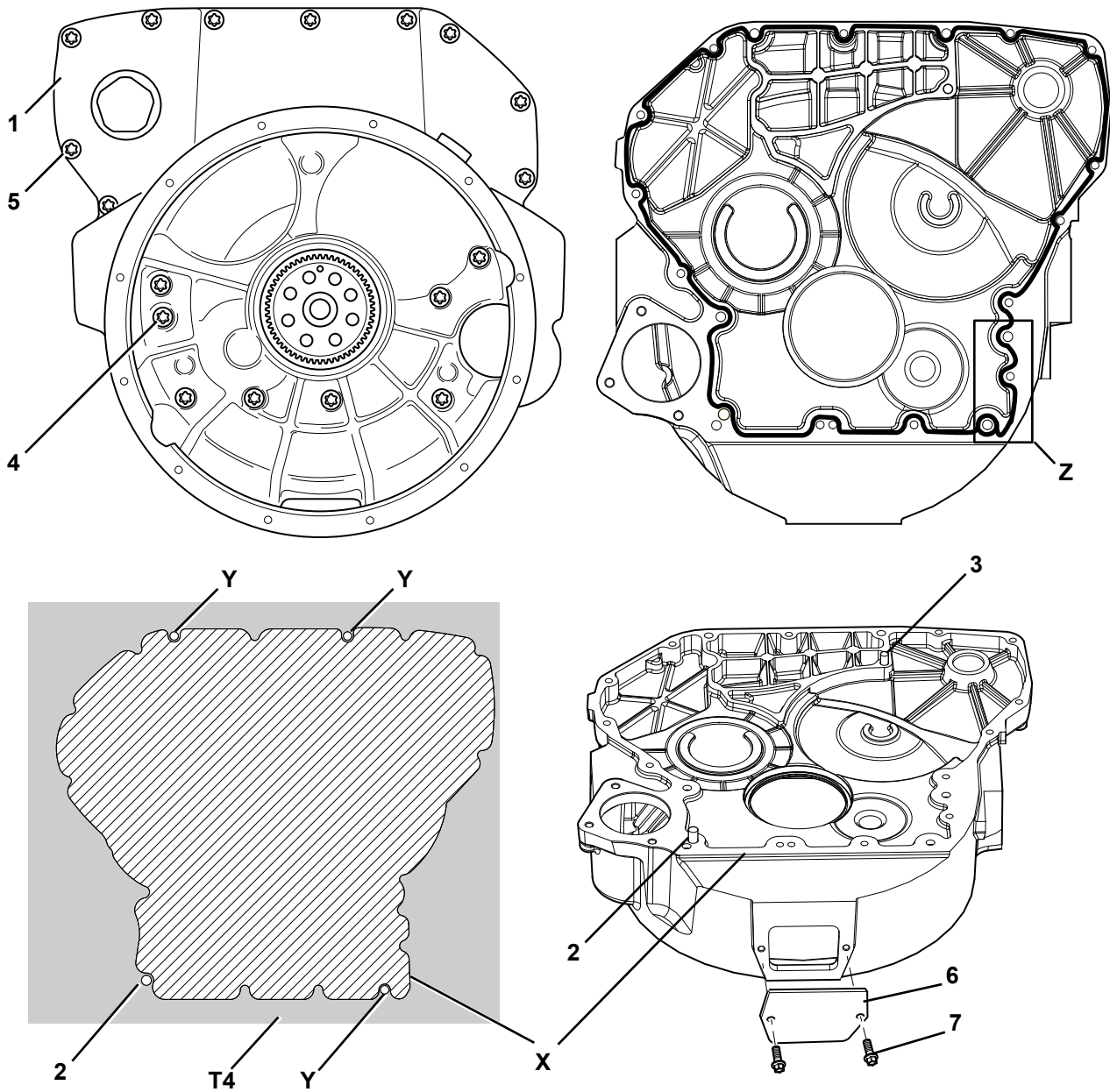
3. Remove the flywheel.

[Refer to: PIL 15-54-00.](#)

Removal

1. Remove the flywheel housing fixing bolts and then separate the flywheel housing from the gear case.
2. If required, undo the bolts and remove the access cover.
3. Remove and discard the crankshaft rear oil seal. Take care not to damage the seal bore in the housing.

Figure 129.



- | | |
|---|---|
| <p>1 Flywheel housing
 3 Dowel - 10 mm
 5 Flywheel housing fixing bolts (x12) M8
 7 Access cover fixing bolts (x2)
 Y Fixing point
 T3 Alignment pins</p> | <p>2 Dowel - 12 mm
 4 Flywheel housing fixing bolts (x6) M10
 6 Access cover
 X Flywheel housing mating face
 Z Alternative fixing holes
 T4 Sealant template</p> |
|---|---|

Before Installation

1. Carefully remove all traces of the old sealant compound from the flywheel housing mating faces.

2. Use a suitable degreasing agent to clean the inside of the flywheel housing.
3. Carefully inspect all gears, bearings and shafts for signs of excessive wear or damage. If wear or damage is evident, the components must be renewed.

Installation

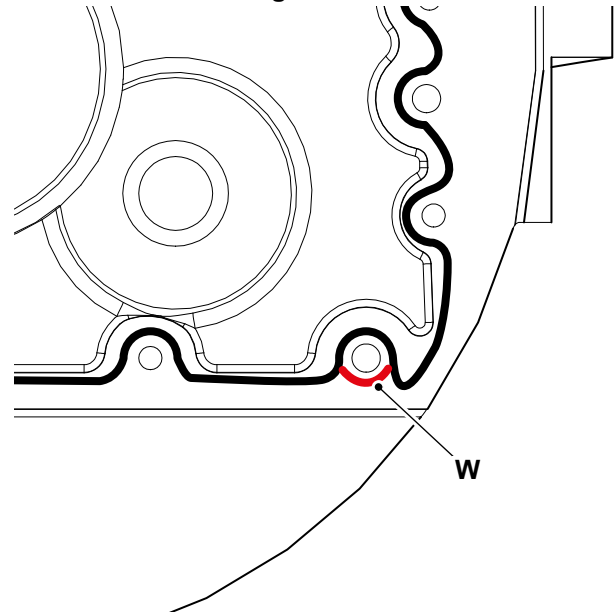
Anaerobic sealant will not start to cure whilst it is open to the atmosphere, however when air is excluded (for instance when the two parts are put together) it will immediately start to harden. Make sure that all the necessary tools, bolts etc. are readily available prior to assembling the components. The parts must be installed and torque tightened within 5min with a maximum permissible time of 15min

1. The installation procedure is the opposite of the removal procedure. Additionally do the following steps.
2. Make sure that all items are clean and free from damage and corrosion.
3. Make sure that the dowels are installed to the mating face of the flywheel housing.
4. Install the sealant template T4 on the housing. Locate the holes in the template, use the dowel and three fixing bolts in the fixing points.

Special Tool: Template for Sealant Flywheel Housing to Gear Case (4 Cyl Elec) (Qty.: 1)

5. Use the template T4 as a guide, apply a continuous bead of sealant around the flywheel housing mating face
Length/Dimension/Distance: 1.5mm
 - 5.1. Some engines feature a flywheel housing with a different fixing hole pattern. Use the template to apply the sealant but apply sealant manually in the position shown at Z.
6. Remove the three fixing bolts at positions. Remove the template T4, make sure not to smudge the sealant. Discard the template.
7. Apply sealant manually to complete the sealant path around the hole at position W.

Figure 130.



W Sealant path

8. Locate the flywheel housing on the alignment pins T3 on the crankcase and install the fixing bolts. Progressively tighten the bolts to the correct torque value.
 - 8.1. Remove the alignment pins to install the last two M10 fixing bolts.
 - 8.2. The parts must be separated, thoroughly cleaned and fresh sealant applied if the parts have not been torque tightened within the maximum time period.
Duration: 15min
9. Install the access cover and use the bolts to secure. Tighten the bolts to the correct torque value.

After Installation

1. Install a new crankshaft rear oil seal.
[Refer to: PIL 15-12-09.](#)
2. Install the flywheel.
[Refer to: PIL 15-54-00.](#)
3. Install the starter motor.
[Refer to: PIL 15-75-00.](#)
4. Allow the sealant to cure for the specified duration before starting the engine. The curing times vary depending on the ambient temperature. Refer to Table 60.

Table 60. Sealant Curing Times

Ambient temperature	Curing time
40°C (103.9°F)	20min
22°C (71.6°F)	1h
5°C (41.0°F)	24h

Table 61. Torque Values

Item	Nm
4	47
5	24
7	24

09 - Gear Ring

Remove and Install

- ▲ CAUTION** Wear eye protection when you drive the gear ring off the flywheel.

If the flywheel gear teeth are damaged or excessively worn, the gear ring can be replaced with a new one.

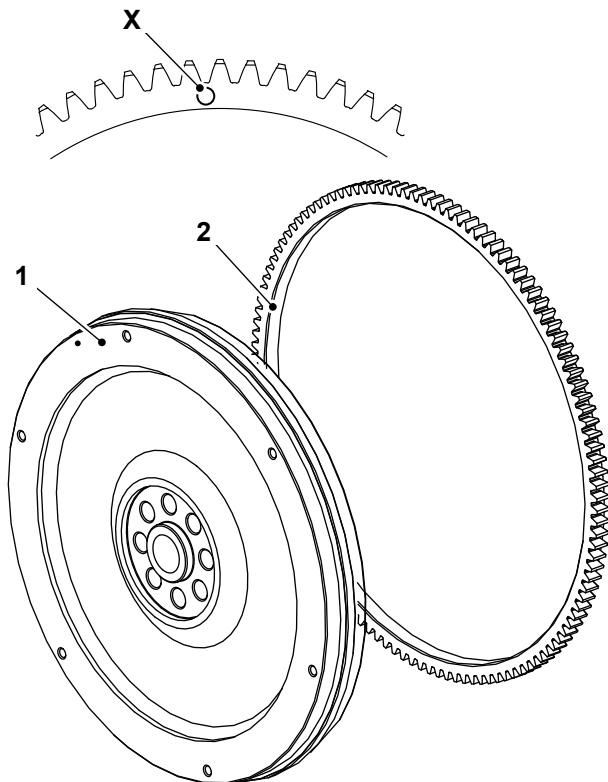
Before Removal

This procedure requires service parts. Make sure you have obtained the correct service parts before you start. Refer to the Parts Catalogue.

1. Remove the flywheel from the engine.

[Refer to: PIL 15-54-00.](#)

Figure 131.



- 1 Flywheel
- 2 Gear ring
- x Position of hole

Removal

1. Note that the gear teeth have a lead-in chamfer on one side to assist the starter motor pinion to engage. Note which way around the gear ring is installed to make sure that the new gear ring is installed the same way on assembly.

2. Place the flywheel flat on a firm surface. Drill a hole through the gear ring below the root of one of the gear teeth as shown. Drive a chisel into the adjacent tooth to spread the gear ring apart. Take care not to damage the flywheel or the position sensor target disc.

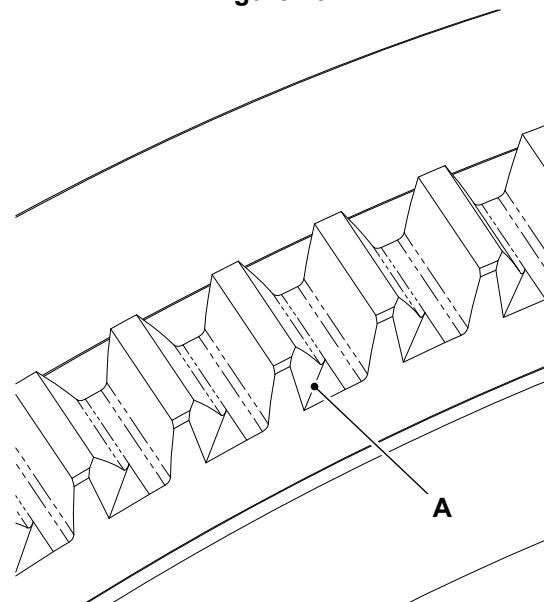
Installation

1. Make sure that all items are clean and free from damage and corrosion.
2. Heat up the new gear ring, preferably in an oven to make sure that the heat is applied evenly around the circumference, to the specified temperature.

Temperature: 280°C (535.6°F)

3. When the gear ring is sufficiently heated, install the gear ring into position over the flywheel. Make sure that the gear ring is installed the correct way around with the chamfer on the engine side of the flywheel.

Figure 132.



A Gear teeth chamfer

4. Allow the gear ring to cool and shrink into position.

After Installation

1. Install the flywheel.

[Refer to: PIL 15-54-00.](#)



60 - Oil Pump

Contents

Page No.

15-60-00 General 15-207

00 - General

Introduction	15-207
Component Identification	15-208
Check (Condition)	15-209
Remove and Install	15-210

Introduction

The oil pump is a rotor type pump located inside the timing gear case. The pump is driven by gears via the crankshaft.

The pump consists of two rotors, one running inside the other. The outer rotor has one more lobe than the inner rotor and turns on a different axis.

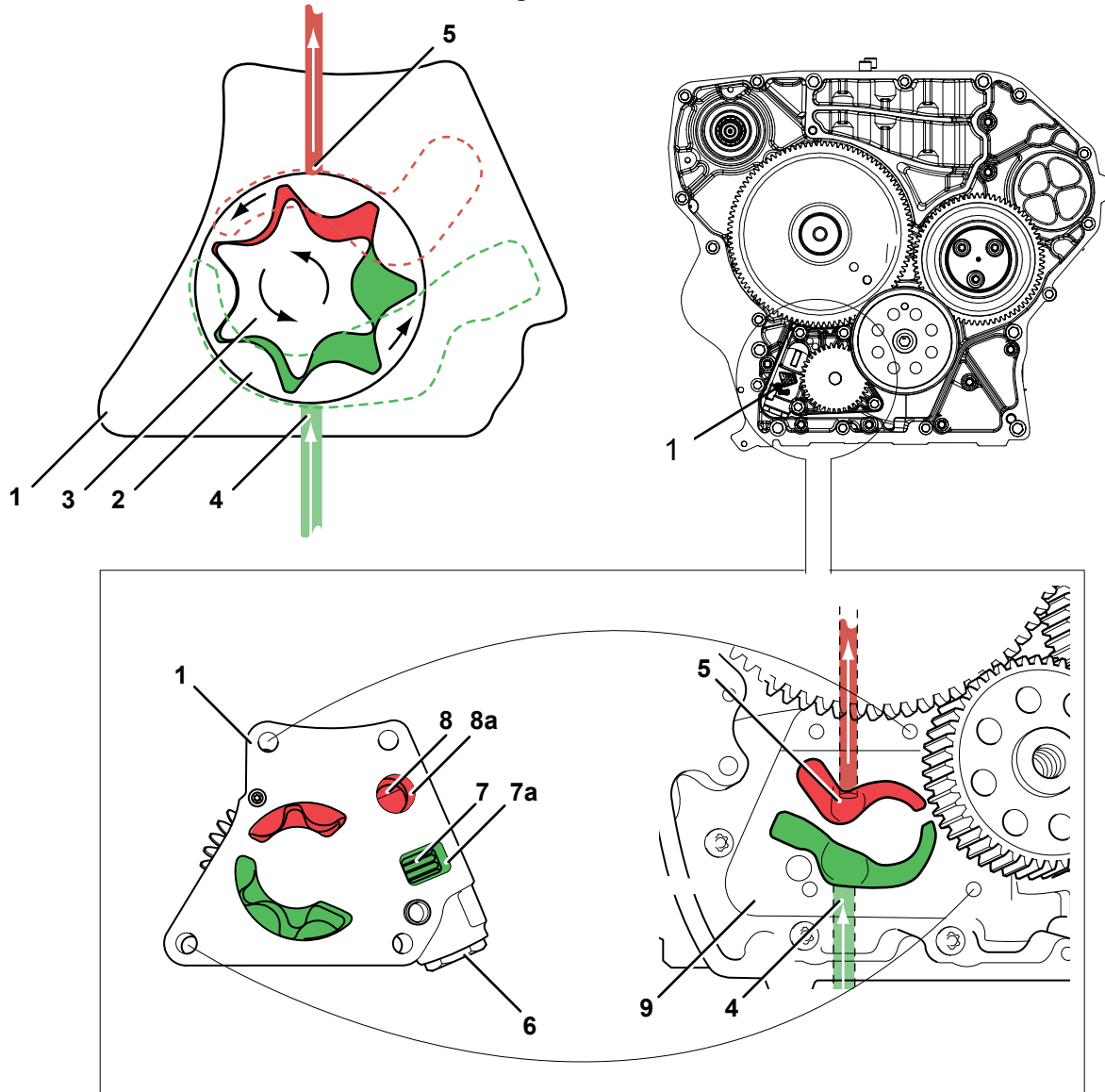
When rotated the gap between the inner and outer rotor lobes increases, drawing oil in through the inlet port. After a half rotation the gap reaches a maximum, the inlet port is closed and the outlet port opens.

Further rotation causes the gap between the lobes to diminish, forcing the oil out through the outlet port.

A pressure relief valve assembly is integral with the pump body. As oil pressure increases it acts on a spool to overcome the pressure of the spring. As the spool moves it uncovers a port allowing pressurised oil directly back to the inlet port. In practice the spool is continually opening and closing to maintain the correct oil pressure value. The valve is not adjustable.

Component Identification

Figure 133.



- 1 Oil pump
- 3 Inner rotor
- 5 Outlet port
- 7 Relief valve spring
- 8 Relief valve spool
- 9 Oil pump connecting ports (engine bed plate)

- 2 Outer rotor
- 4 Inlet port
- 6 Relief valve assembly
- 7a Relief valve port (return to inlet port 4)
- 8a Relief valve pressure port (connected to port 5)

Check (Condition)

1. Check the oil pump internal parts for signs of damage and excessive wear.
2. Check that the engine oil pressure is within the specified tolerance.

[Refer to: PIL 15-00-00.](#)

Remove and Install

Special Tools

Description	Part No.	Qty.
Torque Wrench (10-100Nm)	993/70111	1

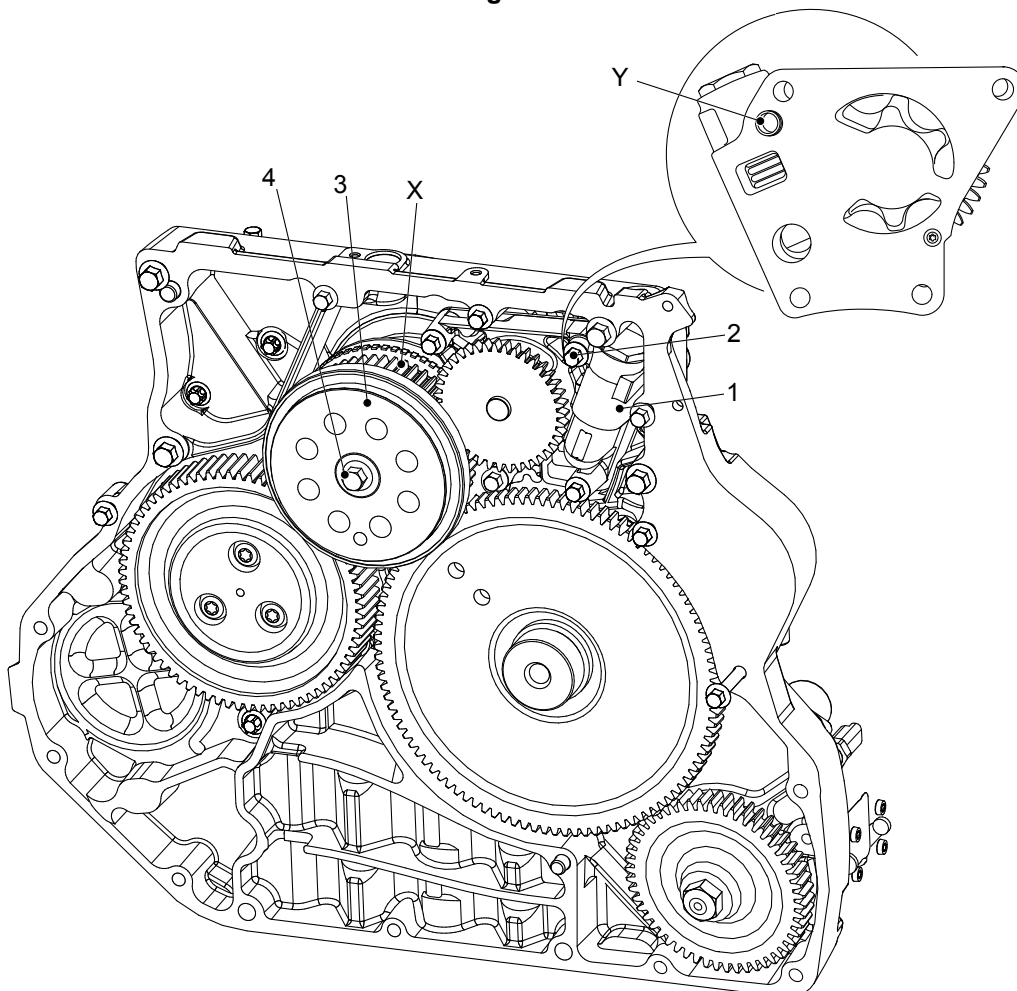
The illustrations show the engine inverted. If the oil pump is being removed prior to crankshaft or camshaft removal, the engine must be inverted. If the oil pump only is being removed (for inspection or renewal) then the engine need not be inverted.

This procedure requires service parts. Make sure you have obtained the correct service parts before you start, refer to Parts Catalogue.

Before Removal

1. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.
2. Drain the oil from the engine, refer to (PIL 15-21).
3. Remove the starter motor, refer to (PIL 15-75).
4. Remove the flywheel, refer to (PIL 15-54).
5. Remove the flywheel housing, refer to (PIL 15-54).

Figure 134.



- 1 Oil pump
- 3 Flywheel hub
- X Crankshaft gear

- 2 Oil pump fixing bolts (x4)
- 4 Flywheel hub fixing bolt
- Y Oil pump location dowel

Remove

1. Remove the flywheel hub fixing bolt.
2. Remove the flywheel hub. DO NOT remove the crankshaft gear.
3. Remove the oil pump fixing bolts and lift the oil pump away from the timing gear case.

The oil pump is a non-serviceable item. If the oil pump is damaged or worn it must be renewed as a complete assembly.

Install

1. The installation procedure is the opposite of the removal procedure. Additionally do the following steps.
2. Make sure that all parts are clean and free from damage and corrosion.
3. Lubricate the pump rotor with clean engine oil.
4. Make sure that the oil pump location dowel locates into the hole in the gear timing case.
5. Install the flywheel hub into the crankshaft gear, locating on the dowel. Tighten the bolts to the correct torque value.

Special Tool: Torque Wrench (10-100Nm) (Qty.: 1)

After Replacement

1. Install the flywheel housing, refer to (PIL 15-54).
2. Install the flywheel to the crankshaft hub, refer to (PIL 15-54).
3. Install the starter motor, refer to (PIL 15-75).
4. Fill the engine with engine oil, refer to (PIL 15-21).

Table 62. Torque Values

Item	Nm
2	24
4	47



63 - Mount

Contents

Page No.

15-63-00 General 15-213



00 - General

Introduction	15-213
Check (Condition)	15-214
Remove and Install	15-214

Introduction

Engine mounts support the engine, they dampen noise and vibration. The mounts isolate the engine from the chassis or framework so that vibrations and noise are not transmitted to the rest of the machine.

Most engine mounts consist of metal attachment plates and large rubber insulator blocks. The rubber portions of the mount are flexible and provide the cushioning that dampens the engine vibrations. The metal bracket part of the mount provides the mechanical support and attachment points for the engine mounts.

Check (Condition)

1. Make the machine safe.
[Refer to: PIL 01-03.](#)
2. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.
3. Check the condition of the engine mounts for wear and damage.
4. Check the condition of the engine mounts for correct tightness.
5. If necessary, tighten the engine mounts to the correct torque value.

Table 63. Torque Values

Item	Description	Nm
A	Engine Mounting bolts	83

Remove and Install

Do the below procedure for each AVM that requires replacement.

Remove

1. Make the machine safe.
[Refer to: PIL 01-03-27.](#)
2. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.
3. Remove the engine compartment cover.
4. Remove the fan cowl.
5. Remove the mounting bolts on the engine feet and alternator.
6. Make sure that you work on one mount at a time.
7. Use suitable lifting equipment to lift the engine up until the AVM can slid out and choke the engine.
8. Remove the AVM.

Install

1. The installation procedure is the opposite of the removal procedure. Additionally do the following steps.
2. Replace the AVM with new.
3. Make sure that the AVM is installed in correct installation position.
4. Remove the choke and lower the engine.
5. Install the mounting bolts to the engine feet and alternator.
6. Tighten the mounting bolts to the correct torque value.
[Refer to: PIL 72-00-00.](#)
7. Install the fan cowl.



69 - Oil Cooler

Contents

Page No.

15-69-00 General 15-217



Notes:

00 - General

Introduction	15-217
Component Identification	15-218
Operation	15-218
Check (Condition)	15-219
Remove and Install	15-219
Disassemble and Assemble	15-221

Introduction

Oil Cooler Assembly

The oil cooler and filter are incorporated in a housing that is bolted to the side of the crankcase. The housing allows transfer of lubricating oil from the crankcase to the oil cooler and filter head.

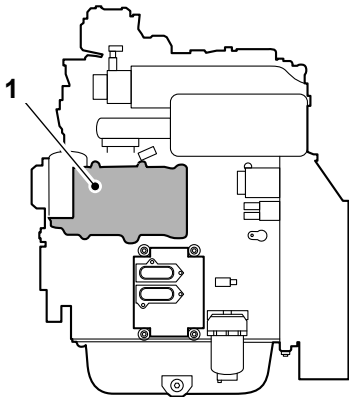
Some installations have a remote oil filter head. The oil cooler housing incorporates feed and return ports for hose connections to the filter head. A remote oil filter head is used when access to the engine is restricted.

Oil Cooler Matrix

The oil cooler matrix is a non-serviceable part and must not be removed from the housing. The housing/cooler assembly is leak tested during manufacture to minimise the risk of cross contamination of coolant and lubricating oil.

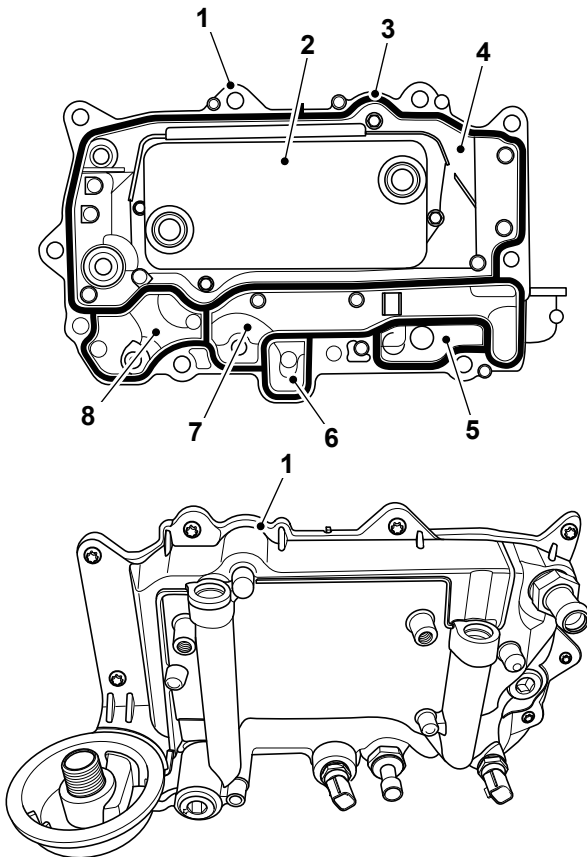
Component Identification

Figure 135.



- 1 Oil cooler housing

Figure 136.



- 1 Oil cooler housing
- 2 Oil cooler matrix
- 3 Sealing gasket (housing to crankcase)
- 4 Coolant gallery
- 5 Oil gallery (from cooler to filter head)
- 6 Oil fill port
- 7 Oil gallery (from filter head to main oil gallery)
- 8 Oil gallery (from pump to cooler)

Operation

The oil cooler housing allows transfer of lubricating oil from the crankcase to the oil cooler and filter head. The coolant also transfers to the housing and passes over the oil cooler matrix causing heat to exchange from the oil to the coolant.

The cooled and filtered oil then passes back into the main oil gallery into the crankcase.

An engine oil filler point is also included via cap and port which aligns with a port in the crankcase.

Check (Condition)

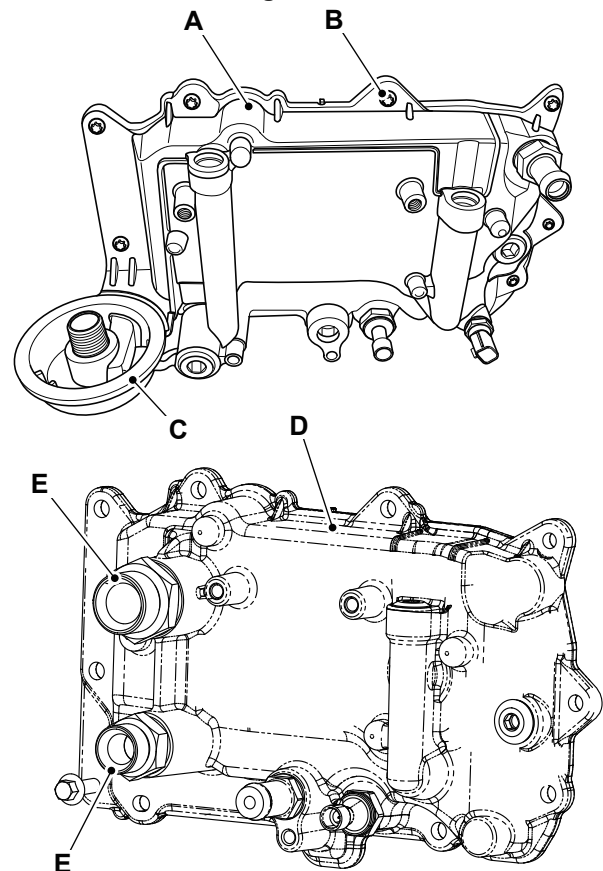
1. Inspect the sealing faces on the oil cooler matrix, oil cooler housing and the crankcase. Make sure that the faces are clean and free from scale or damage.
2. Inspect the sealing gasket and o-rings for signs of damage. If in doubt, renew the gasket or O-rings.

Remove and Install

Before Removal

1. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.
2. Drain the coolant, refer to (PIL 21-00).
3. Remove the oil filter, refer to (PIL 15-21).

Figure 137.



- A** Oil cooler housing (integral oil filter head)
- B** Oil cooler housing fixing bolts (x10)
- C** Oil filter head
- D** Oil cooler housing (remote oil filter head)
- E** Remote oil filter head hose ports

Remove

1. Get access to the engine.
2. If applicable, disconnect the electrical connectors at the oil pressure switch and the oil temperature sensor.
3. If applicable, label and disconnect the electrical connectors at the ECM (Engine Control Module). Do not touch the electrical pins on the ECM. Cap the connectors on the harnesses and the

ECM to prevent ingress of oil and coolant. Tie the harnesses away from the oil cooler housing.

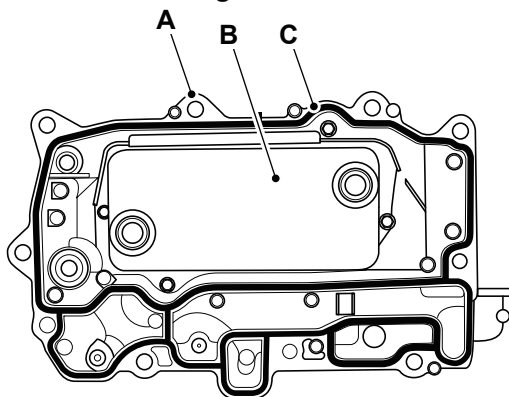
4. If applicable disconnect the remote oil filter head hoses from the ports on the oil cooler.
5. Remove the bolts and lift the oil cooler housing away from the crankcase. DO NOT attempt to remove the oil cooler matrix from the oil cooler housing.

If there is cross contamination of coolant and lubricating oil, the oil cooler matrix may be faulty. If a faulty matrix is suspected renew the matrix and the seals.

Table 64. Torque Values

Item	Description	Nm
B	Bolts	24

Figure 138.



- A** Oil cooler housing
- B** Oil cooler matrix
- C** Sealing gasket

Install

1. The installation procedure is the opposite of the removal procedure. Additionally do the following steps.
2. Make sure that sealing gasket is undamaged and correctly located in its groove. A faulty gasket will cause cross contamination of the lubricating oil and coolant. If in doubt install a new gasket.
3. Tighten the bolts to the correct torque value.

After Installation

1. If applicable, install the oil filter, refer to (PIL 15-21).
2. Refill the cooling system with the recommended coolant mixture, refer to (PIL 21-00).
3. If applicable, make sure that the harness connectors are connected to the correct connectors on the ECM.
4. Start the engine and check for oil and coolant leaks.

Disassemble and Assemble

Dismantling of the oil cooler and oil filter head assembly is not necessary unless the oil cooler matrix or the seals are faulty.

Disassemble

1. Remove the four fixing bolts and lift off the oil cooler matrix.
2. Remove and discard the two sealing O-rings.
3. Remove the sealing gasket.

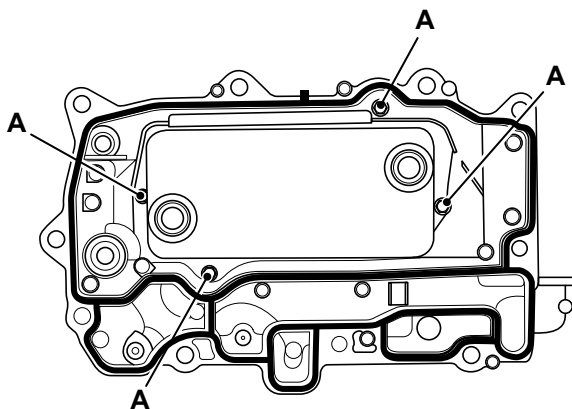
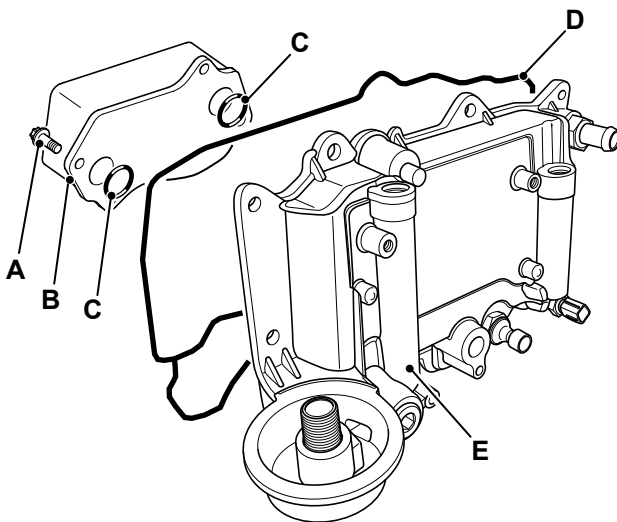
Assemble

1. Locate the new O-rings. Install the oil cooler matrix. Tighten the bolts to the correct torque value.
2. Install the sealing gasket to the oil cooler housing.

Table 65. Torque Values

Item	Nm
A	23

Figure 139.



- A Fixing bolts
- B Oil cooler matrix
- C O-rings
- D Sealing gasket
- E Oil cooler housing

Inspect

1. Refer to Oil Cooler - Check Condition.



72 - Alternator

Contents	Page No.
15-72-00 General	15-223
15-72-03 Pulley	15-229
15-72-06 Voltage Regulator	15-230



00 - General

Introduction	15-223
Health and Safety	15-224
Technical Data	15-224
Component Identification	15-225
Check (Condition)	15-225
Remove and Install	15-227
Disassemble and Assemble	15-228

Introduction

When the generator is running, the current from the battery flows by way of the No Charge warning light to the field winding. This creates a magnetic field which supplements the residual magnetism in the rotor poles. As the engine is started, the FEAD (Front End Accessory Drive) belt drives the rotor and the alternating current is generated in the power windings as they are cut by the rotating magnetic field. Output is controlled by a solid state regulator which varies the field current in accordance with electrical demand.

Health and Safety

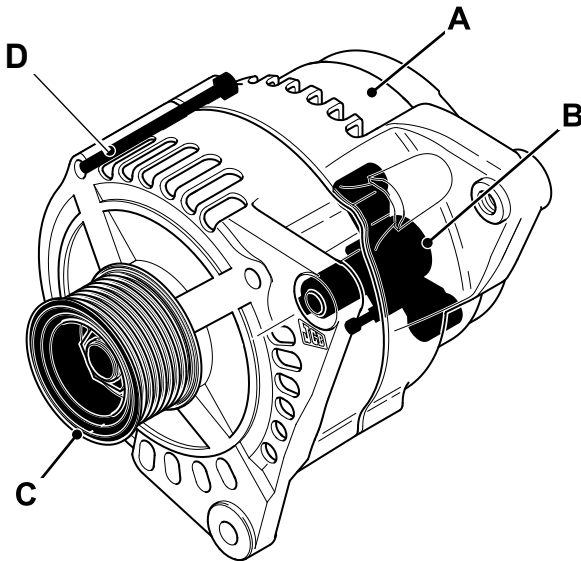
- Ensure that the battery negative terminal is connected to the earthing cable.
- Never make or break connections to the battery or alternator, or any part of the charging circuit whilst the engine is running. Disregarding this instruction will result in damage to the regulator or rectifying diodes.
- Main output cables are 'live' even when the engine is not running. Take care not to earth connectors in the moulded plug if it is removed from the alternator.
- During arc welding on the machine, protect the alternator by removing the moulded plug (or if separate output cables installed, remove the cables).
- If slave starting is necessary, connect the second battery in parallel without disconnecting the vehicle battery from the charging circuit. The slave battery may then be safely removed after a start has been obtained. Take care to connect batteries positive to positive, negative to negative.

Technical Data

Technical data may differ between machine variants and installations. For full data relating to the alternator refer to the applicable parts information.

Component Identification

Figure 140.



- A Alternator
- B Regulator and brush assembly
- C Drive pulley
- D Tie bolts

Check (Condition)

Charging Circuit Test

1. Make sure that all the battery and alternator connections are in place, secure and making good metal - to - metal contact, especially the earth connections to chassis and engine.
2. Adjust the alternator drive belt tension if necessary and make sure that the battery is well charged.
3. Turn the ignition switch to the ON position. Oil pressure and "No Charge" warning lights should glow. If any light fails, re-check the connections.
4. Start the engine; all warning lights should extinguish rapidly. If the "No Charge" warning light remains ON, re-check the alternator drive belt tension and that the battery is charged. If the oil pressure warning remains on stop the engine immediately and investigate the engine lubrication system.

Check 1

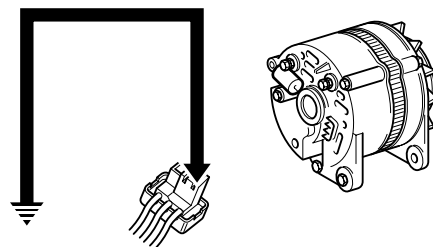
With the ignition switch ON, check that the heater motor and screen wiper will operate.

If they operate normally, check the warning light bulb for a blown filament.

Simultaneous failure of all items indicates a fault at the ignition switch. Check for cable disconnection before condemning the switch itself.

If the 'No Charge' warning bulb is in good order, withdraw the triple plug from the back of the alternator. Make a temporary connection between the small terminal in the plug and earth as shown below. If the 'No Charge' warning bulb still fails to light, check the cable for continuity. If the bulb now lights, check the alternator for a defective regulator.

Figure 141.

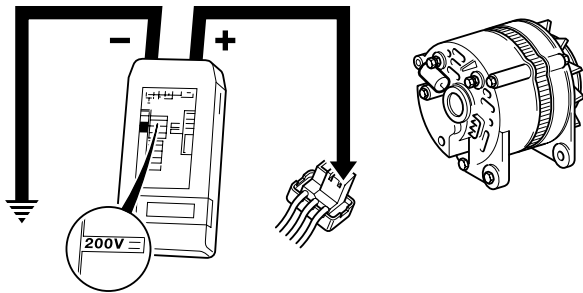


Check 2

The following checks should be made using an analogue (moving pointer) type Multimeter.

1. Stop the engine and turn the ignition switch to OFF.
2. Withdraw the alternator plug and connect the Multimeter between the large terminals and earth. With the Multimeter set to measure, Voltage: 12V

Figure 142.

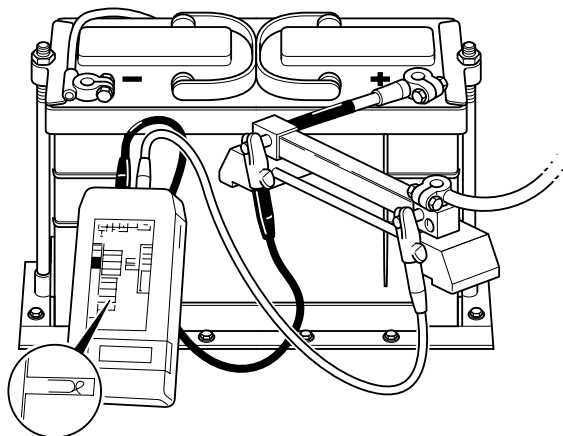


- 2.1. The Multimeter should show battery voltage.
- 2.2. If the reading is zero, check the cables for continuity, particularly at the starter terminals.

3. If the voltage is correct, check the alternator.

Alternator Charging Test

Figure 143.



1. Make sure that all battery and alternator connections are in place, secure and making good metal to metal contact, especially the earth connections to chassis and engine.
2. Make sure that the alternator drive belt tension is correctly adjusted.
3. If the battery is in a fully charged condition, before commencing the test switch on the working lights for
Duration: 3min

4. Alternatively, operate the starter for a few moments with the ESOS (Engine Shut-Off Solenoid) fuse removed.
5. Install an open type shunt between the battery positive lead and the battery positive terminal.
Current: 100A

6. Connect a Multimeter positive lead to machine side of the shunt and negative lead to battery side of the shunt.
7. Connect the leads to the Multimeter and set the Multimeter to the relevant range as follows.

8. AVO 2002
 - 8.1. Red lead to volts (middle) socket on Multimeter.
 - 8.2. Black lead to negative on Multimeter.
 - 8.3. Right side slider to DC (Direct Current) voltage.
 - 8.4. Left side slider, Refer to Figure 143.

9. AVO 2003
 - 9.1. Red lead to amps socket (A) on the Multimeter.
 - 9.2. Black lead to negative on Multimeter.
 - 9.3. Right side slider to DC voltage
 - 9.4. Left side slider to 200 Shunt

10. FLUKE 85
 - 10.1. Red lead to volts socket (V) on Multimeter.
 - 10.2. Black lead to COM socket on Multimeter.
 - 10.3. Set dial to mV.

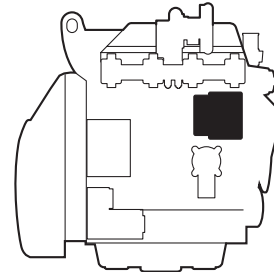
11. Start the engine and run at maximum speed (see Technical Data). Multimeter should show maximum alternator output in Amps (see Technical Data). The Multimeter reading should be taken as soon as possible after starting the engine, as the charging current will fall rapidly.

12. A zero reading indicates failure of the alternator and may be caused by one of the following conditions. These are listed in the order of probability.
 - 12.1. Defective suppression capacitor.
 - 12.2. Dirty slip rings or worn brushes.
 - 12.3. Defective regulator.
 - 12.4. Defective rectifier.
 - 12.5. Open or short circuited field (rotor) windings.

- 12.6. Open or short circuited power (stator) windings.
13. To check for a fault, disconnect the capacitor and repeat the charging test. Renew the capacitor if necessary.
14. To check for faults with the slip rings, bushes or regulator, remove the regulator and brush box assembly. Check the condition of the brushes and, if necessary, clean the slip rings using extra-fine glass paper. The regulator may only be renewed.
15. Faults with the rectifier, rotor and stator may be checked only by removing and dismantling the alternator for further testing.

Remove and Install

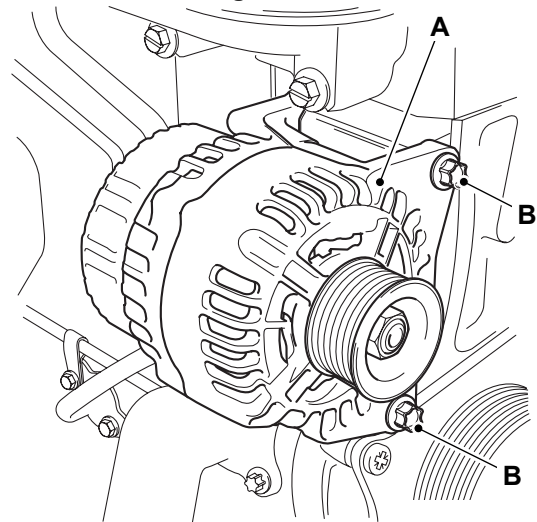
Figure 144. Alternator location



Remove

1. Disconnect the negative (-) lead followed by the positive (+) lead from the battery terminals.
2. Remove the alternator (accessory) drive belt.
3. Disconnect the electrical leads from the alternator terminals. Label the leads to make sure that they are installed in the correct positions on assembly.
4. Undo the alternator securing bolts and lift the alternator away from the cylinder block mounting.

Figure 145.



- A** Alternator
- B** Securing bolts

Inspect

1. Check the brushes for wear. Renew the brushes if the length is less than
 Length/Dimension/Distance: 8mm

Install

1. The installation procedure is the opposite of the removal procedure. Additionally do the following steps.
2. It is not necessary to adjust the position of the alternator in order to tension the drive belt, as the accessory drive belt arrangement is self-tensioning.
3. Tighten the alternator securing bolts to the correct torque value.
4. Make sure you reconnect the electrical leads to the alternator in the correct positions and tighten to the correct torque.

Table 66. Alternator securing bolt torque

Item	Torque Value
A	47N·m
B	47N·m

Figure 146.

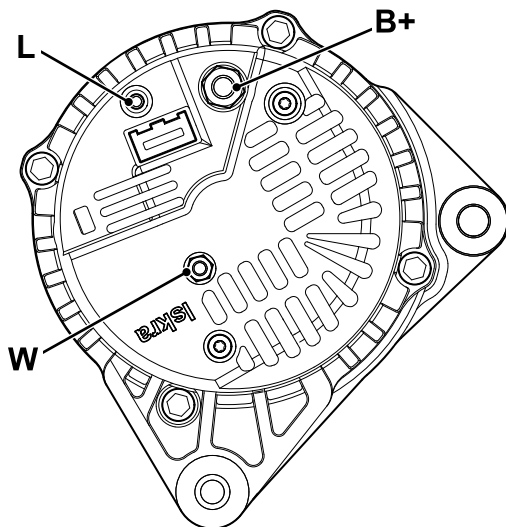


Table 67. Alternator electrical connection torque

Item	Torque Value
B+	9–13N·m
L	2.7–3.8N·m
W	2.7–3.8N·m

Disassemble and Assemble

Voltage Regulator and Brushes

1. The voltage regulator and brush set is a combined assembly. Refer to (PIL 15-72-06).

Drive Pulley

1. Refer to (PIL 15-72-03).

03 - Pulley

Remove and Install

This part is non-serviceable. If it fails, replace the complete alternator. [Refer to: PIL 15-72-00.](#)



06 - Voltage Regulator

Remove and Install

The voltage regulator is an integral part of the alternator, it is designed to automatically maintain a constant voltage level.

This part is non-serviceable. If it fails, replace the complete alternator. Refer to: [PIL 15-72-00](#).



75 - Starter Motor

Contents	Page No.
15-75-00 General	15-233
15-75-03 Solenoid	15-240
15-75-06 Brush Gear	15-241



Notes:

00 - General

Introduction	15-233
Health and Safety	15-234
Component Identification	15-234
Check (Condition)	15-235
Remove and Install	15-237
Disassemble and Assemble	15-238

Introduction

The starter motor is a DC (Direct Current) motor with combined starter solenoid. When the current from the battery is applied to the solenoid, the solenoid engages a lever that pushes out the drive pinion on the starter driveshaft and meshes the pinion with the starter ring gear on the flywheel of the engine.

The solenoid also closes high current contacts for the starter motor, which begins to turn. Once the engine starts and is above cranking speed the controller will remove the crank signal and a spring in the solenoid assembly pulls the pinion gear away from the ring gear, and the starter motor stops. The starter motor pinion is clutched to the drive shaft through an overrunning clutch which permits the pinion to transmit drive in only one direction. Drive is then transmitted through the pinion to the flywheel ring gear, but if the pinion remains engaged (as for example because the controller fails to remove the crank signal as the engine starts, or if there is a short and the solenoid remains engaged), the pinion will spin independently of the drive shaft, this prevents the engine driving the starter.

The starter motor is only designed for intermittent use, the electrical components are designed only to operate for a time period of 20s before overheating.

Health and Safety

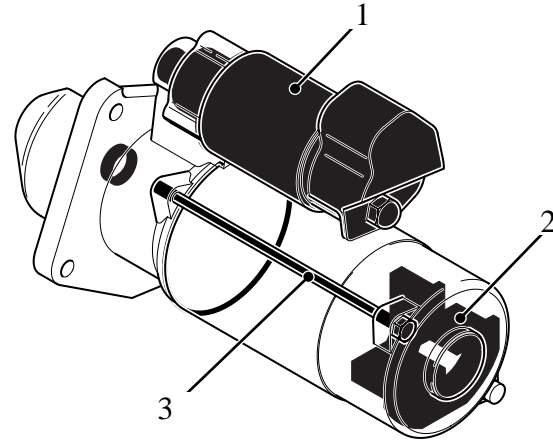
▲ **Notice:** Before carrying out arc welding on the machine, disconnect the battery and alternator to protect the circuits and components. The battery must still be disconnected even if a battery isolator is installed.

WARNING Do not attempt to disconnect the batteries while the generator is running.

WARNING Ensure that the generator is isolated and made safe, by switching off the battery charger and disconnecting the starter batteries.

Component Identification

Figure 147.



- 1 Solenoid
- 2 Brush gear
- 3 Tie bolts

Check (Condition)

Before carrying out the multimeter tests, check the battery condition and make sure that all the applicable electrical connections are clean and tight. Make sure that the starter motor fixing bolts are tightened to the correct torque.

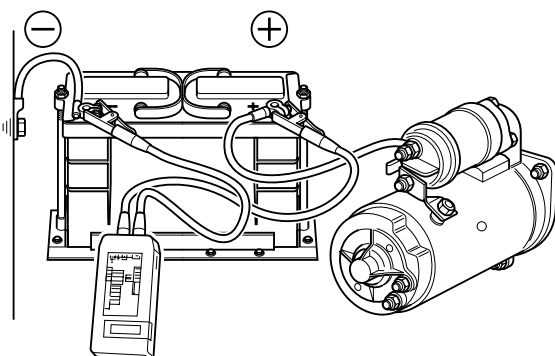
To prevent the engine starting during the tests make sure that the applicable engine stop fuse is removed.

Check the readings in the following sequence using a multimeter. Unless otherwise stated, the readings must be taken with the ignition switch held in the start position (HS) and the controls set to enable the starter motor. The readings are shown for both 12V and 24V systems. The highest values are for machines with 24V systems. Identify the applicable system before carrying out the tests.

Do not operate the starter motor for more than 20s at one time. Let the starter motor cool for at least 2min between starts.

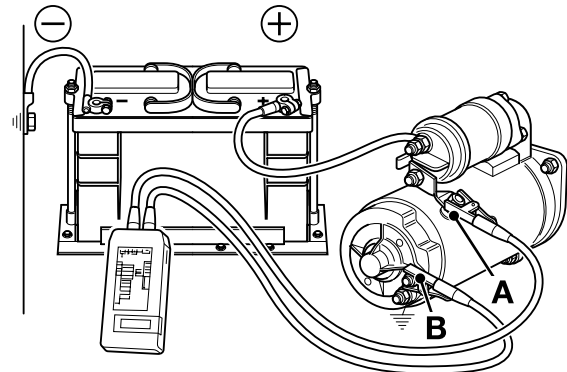
1. Connect the multimeter across the battery terminals.

Figure 148.



- 1.1. Reading in start position approximately
 Voltage: 10V
 Voltage: 20V
- 1.2. Minimum permissible reading in start position
 Voltage: 9.5V
 Voltage: 18V
- 1.3. A low reading probably indicates a fault in the starter motor.
2. Connect the multimeter between the starter main terminal and the commutator end bracket. In the start position, the reading should not be below the reading obtained in 1 by any more than
 Voltage: 0.5V
 Voltage: 1V

Figure 149.

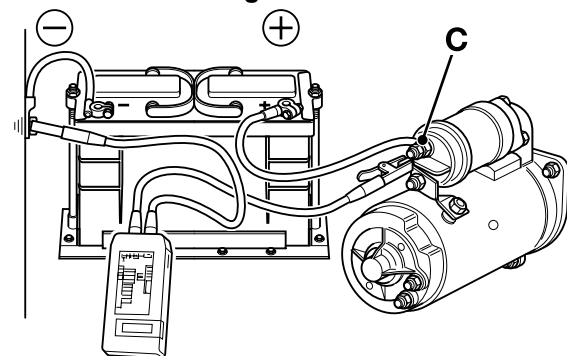


- A** Starter main terminal
- B** Commutator end bracket (Starter earth connection)

- 2.1. Minimum permissible reading in start position
 Voltage: 9V
 Voltage: 17V
- 2.2. If the reading is within this limit, continue to 3. If the reading is outside the limit, proceed to 4.

3. Connect the multimeter between the solenoid terminal and a good earth. Minimum permissible reading in start position
 Voltage: 8V
 Voltage: 16V

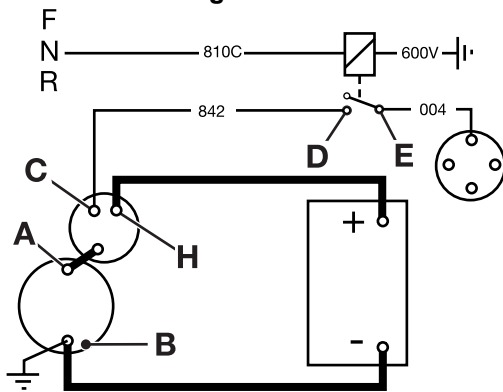
Figure 150.



- C** Solenoid terminal

4. If the reading is less than specified, connect the multimeter between the start relay switched output and earth. A fault is indicated with the wiring from the start relay to the solenoid if the reading increases to
 Voltage: 8V
 Voltage: 16V

Figure 151.



- A** Starter main terminal
- B** Starter earth connection
- C** Solenoid terminal
- D** Start relay feed
- E** Start relay switched output
- H** Battery positive and solenoid connection

4.1. If the reading is less than specified, connect the multimeter between the start relay feed and earth.

4.2. A faulty start relay or a fault in the feed to the relay solenoid is indicated if the voltage increases to

Voltage: 8V
 Voltage: 16V

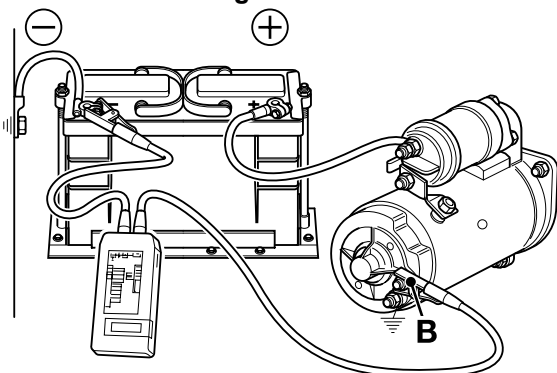
4.3. Check also the solenoid earth connection. The fault must be in either the starter switch or in the wiring between the solenoid, starter switch, and the start relay, if the reading between terminal and earth is less than

Voltage: 8V
 Voltage: 16V

5. Connect the multimeter between battery negative and starter earth connection. The reading in the start position should be practically zero, maximum permissible reading

Voltage: 0.25V

Figure 152.



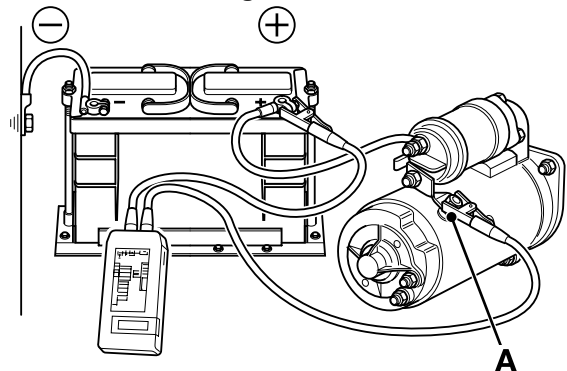
- B** Starter earth connection

5.1. If the reading is above the maximum permissible voltage, a high resistance in the earth lead or connections is indicated.

6. Connect the voltmeter between battery positive and the starter main terminal. With the starter switch off, the voltmeter should indicate battery voltage, but it should fall to practically zero when the switch is turned to the on position, maximum permissible reading

Voltage: 0.25V

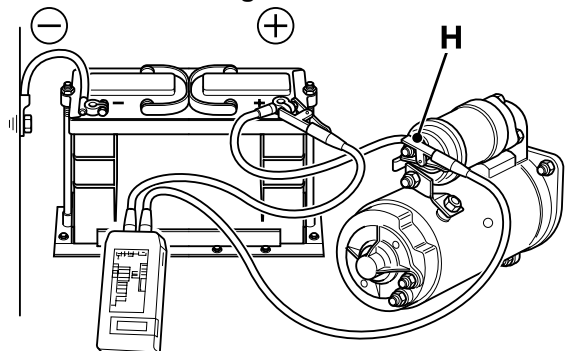
Figure 153.



- A** Starter main terminal

7. If the reading is above the maximum permissible voltage, a high resistance is present in the insulated lead or in the solenoid. Connect the multimeter between the battery positive and solenoid connection. If the multimeter now reads zero with the switch closed, the fault is in the solenoid.

Figure 154.

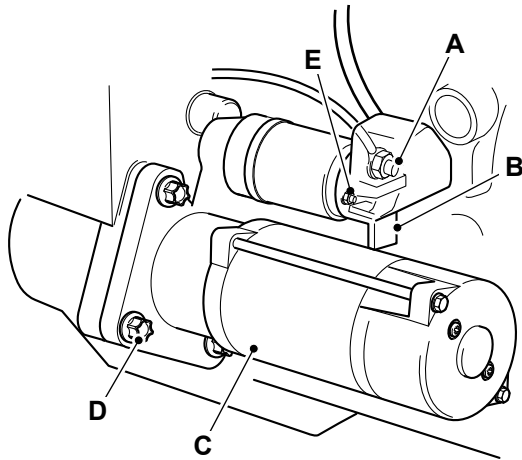


- H** Battery positive and solenoid connection

8. Finally install the engine stop fuse.

Remove and Install

Figure 155.



- A** Electrical lead (Terminal 30)
- B** Security cover
- C** Starter motor
- D** Bolt (x3)
- E** Electrical lead (Terminal 50)

Remove

1. Make the machine safe.
[Refer to: PIL 01-03.](#)
2. Make sure the engine is safe to work on. If the engine has been running, make sure that the engine has cooled sufficiently before you start work.
3. Disconnect the battery negative lead followed by the positive lead from the battery terminals.
4. Remove the security nut and bolt, remove the security cover (if installed).
5. Disconnect the electrical leads from the starter motor terminals. Label the leads to make sure they are installed in the correct positions on assembly.
6. Undo the bolts (x3) and withdraw the starter motor from the flywheel housing.

Inspection

1. Check the drive pinion splines for damage and excessive wear.
2. Check the brushes for wear. Renew the brushes if the length is less than
 Length/Dimension/Distance: 8mm

Install

1. The installation procedure is the opposite of the removal procedure. Additionally do the following steps.
2. Make sure that the flywheel housing and starter motor mating faces are clean.
3. Tighten the bolts to the correct torque value.
4. Make sure you reconnect the electrical leads to the starter motor in the correct positions.
5. Install the security cover (if installed).

Table 68. Torque Values

Item	Nm
A	15 ± 3
D	47 ± 4
E	3.6 ± .6

Disassemble and Assemble

These parts are non-serviceable if any part fails, replace the complete starter motor. For cleaning and checking purposes only, dismantle the motor as follows:

Brush Gear

1. Check the brush gear as follows:
 - 1.1. Remove the tie bolts and carefully separate the commutator end cover.
 - 1.2. Remove the screws. Remove the brush holder and brushes.
 - 1.3. Check the brushes for wear. Install or renew the brush set as required. Renew the brushes if they are less than
Length/Dimension/Distance: 8mm
 - 1.4. Clean the commutator.
 - 1.5. Before installing the commutator end cover, make sure that the sealing ring is undamaged and correctly installed. Make

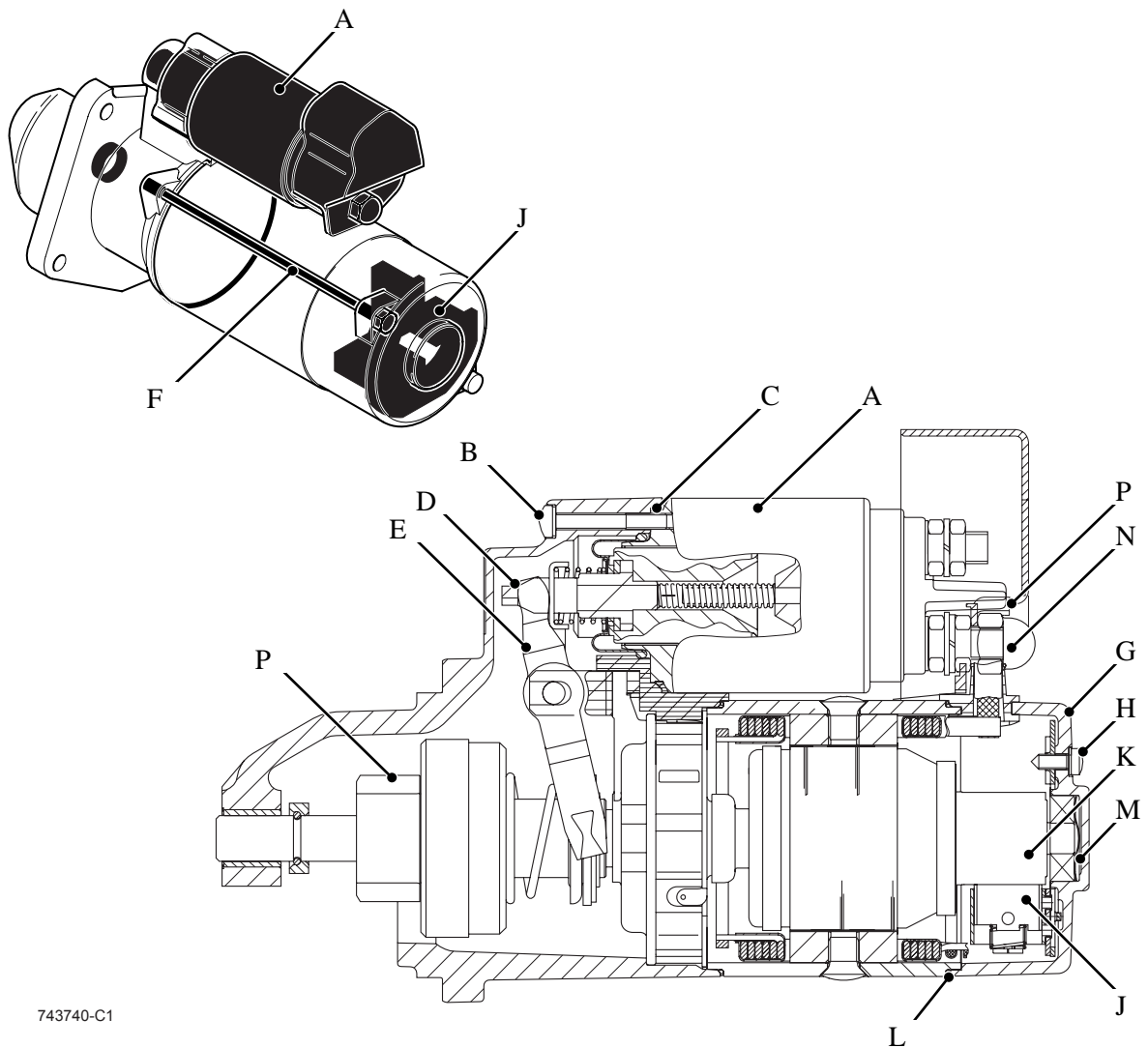
sure the wave washer is installed inside the cover.

- 1.6. Carefully install the commutator end cover, then tighten the tie bolts.

Starter Solenoid

1. Check the starter solenoid as follows:
 - 1.1. Disconnect the starter motor cable from the solenoid connector post.
 - 1.2. Remove the screws and carefully withdraw the solenoid assembly.
 - 1.3. Make sure that the sealing ring is undamaged and correctly installed.
 - 1.4. Before you install the solenoid make sure you engage the pinion lever arm through the hole in the solenoid actuator rod, then tighten the screws.
 - 1.5. Reconnect the starter motor cable to the solenoid connector post.

Figure 156.



743740-C1

- | | |
|--|--|
| A Starter solenoid | B Screws - starter solenoid (3 off) |
| C Sealing ring - solenoid | D Solenoid actuator rod |
| E Pinion lever arm | F Tie bolts (2 off) |
| G Commutator end cover | H Screws - commutator end cover (2 off) |
| J Brush set | K Commutator |
| L Sealing ring - commutator end cover | M Wave washer |
| N Cable connector post | P Pinion gear |

03 - Solenoid

Remove and Install

The solenoid is an integral part of the starter motor, it is designed to relay a large electric current to the starter motor, which in turn sets the engine in motion. The solenoid also engages the starter pinion with the ring gear of the engine.

This part is a non-serviceable part if it fails, replace the complete starter motor.



06 - Brush Gear

Remove and Install

The starter motor brushes are an integral part of the starter motor.

This part is a non-serviceable part if it fails, replace the complete starter motor.

84 - Sensor

Contents	Page No.
15-84-00 General	15-243
15-84-03 Crankshaft Position	15-254
15-84-06 Camshaft Position	15-258
15-84-09 Knock	15-262
15-84-14 Exhaust Manifold Temperature	15-265
15-84-16 Exhaust Manifold Pressure	15-267
15-84-17 Temperature and Manifold Air Pressure (TMAP)	15-270
15-84-18 Temperature and Mass Air Flow (TMAF)	15-273
15-84-19 Exhaust Temperature	15-276
15-84-24 Fuel Temperature	15-279
15-84-27 Fuel Rail Pressure	15-282
15-84-33 Coolant Temperature	15-284
15-84-42 Engine Oil Temperature	15-287
15-84-43 Engine Oil Level	15-290
15-84-48 Intercooler Outlet Temperature	15-293

00 - General

Introduction	15-243
Technical Data	15-244
Component Identification	15-246
Fault-Finding	15-248
Check (Operation)	15-253

Introduction

The engine sensors continually send signals to the ECM (Engine Control Module) to help the ECM to control the smooth running of the engine and related components.

The ECM processes signals from the sensors continually and its response will be based on an evaluation of the combination of sensor signals.

After removal from the engine, protect the sensors from knocks, dust and water ingress and any high temperature sources.

The sensors are not serviceable, therefore they must be replaced in the event of damage.

Technical Data
Table 69.

Crankshaft Position Sensor	
Type	Hall effect.

Table 70.

Camshaft Position Sensor	
Type	Hall effect.

Table 71.

Coolant Temperature Sensor		
Type	Temperature dependant resistance.	
Tightening torque	22N·m max	
Thread diameter	M12 x 1.5.	
Temperature v Resistance Table		
Temperature °C (°F)	Resistance Ω	+/- %
25 (77.0)	2,062	5.7
50 (121.9)	833	4.3
100 (211.9)	187	2
110 (229.8)	144	2.4

Table 72.

Inlet Manifold Air Pressure and Temperature Sensor (TMAP)		
Fixing screw tightening torque	22N·m max	
Fixing screw thread diameter	M6	
Supply voltage	5V	
Temperature Sensor		
Type	Temperature dependant resistor.	
Temperature v Resistance Table		
Temperature °C (°F)	Resistance Ω	+/- %
5 (41.0)	4,707	4.66
10 (50.0)	3,791	4.55
15 (59.0)	3,075	4.44
20 (68.0)	2,510	4.33
25 (77.0)	2,062	4.22
30 (86.0)	1,715	4.12
Pressure Sensor		
Type	Piezo-resistive	
Atmospheric Pressure v Voltage		

Inlet Manifold Air Pressure and Temperature Sensor (TMAP)

Atmospheric pressure bar (psi)	Output voltage V	+/- V
0.98 -0.025/+0.025 (14.2 -0.4/+0.4)	1.84	0.05

Table 73.

Knock Sensor	
Type	Piezo crystal.
Fixing screw tightening torque	24N·m
Fixing screw thread diameter	M8

Table 74.

Throttle Position Sensor (TPS)⁽¹⁾	
Type	Two channel ratio metric voltage output sensor.
Supply voltage	5V
Rotational range	75°
Output range	Linear output voltage over the rotational range.

(1) The throttle position sensor is not supplied as part of the engine assembly. The technical data given is compatible with the specification required.

Table 75.

Rail Pressure Sensor	
Type	The rail pressure sensor is integral with the common rail.

Table 76.

High Pressure Rail Fuel Valve	
Type	The HPV (High Pressure Valve) is integral with the common rail.

Table 77.

Fuel Temperature Sensor	
Type	The fuel temperature sensor is integral with the high pressure fuel pump.

Table 78.

Oil Pressure Switch	
Set pressure	0.6bar (8.7psi) falling.
Switch mode	Normally open.
Max pressure	27.5bar (398.5psi)

Oil Pressure Switch	
Max working pressure	13.8bar (200.0psi)
Tightening torque	23N·m max.
Thread diameter	M12 x 1.5.

Table 79.

TMAF (Temperature and Mass Air Flow) Sensor	
Air temperature	Expected resistance
0°C (32.0°F)	5,370–5,935Ω
25°C (77.0°F)	1,900–2,100Ω

Table 80.

Exhaust Manifold Pressure Sensor	
Pressure (Absolute)	Expected output ⁽¹⁾
0bar (0.0psi)	0.5V
5bar (72.5psi)	4.5

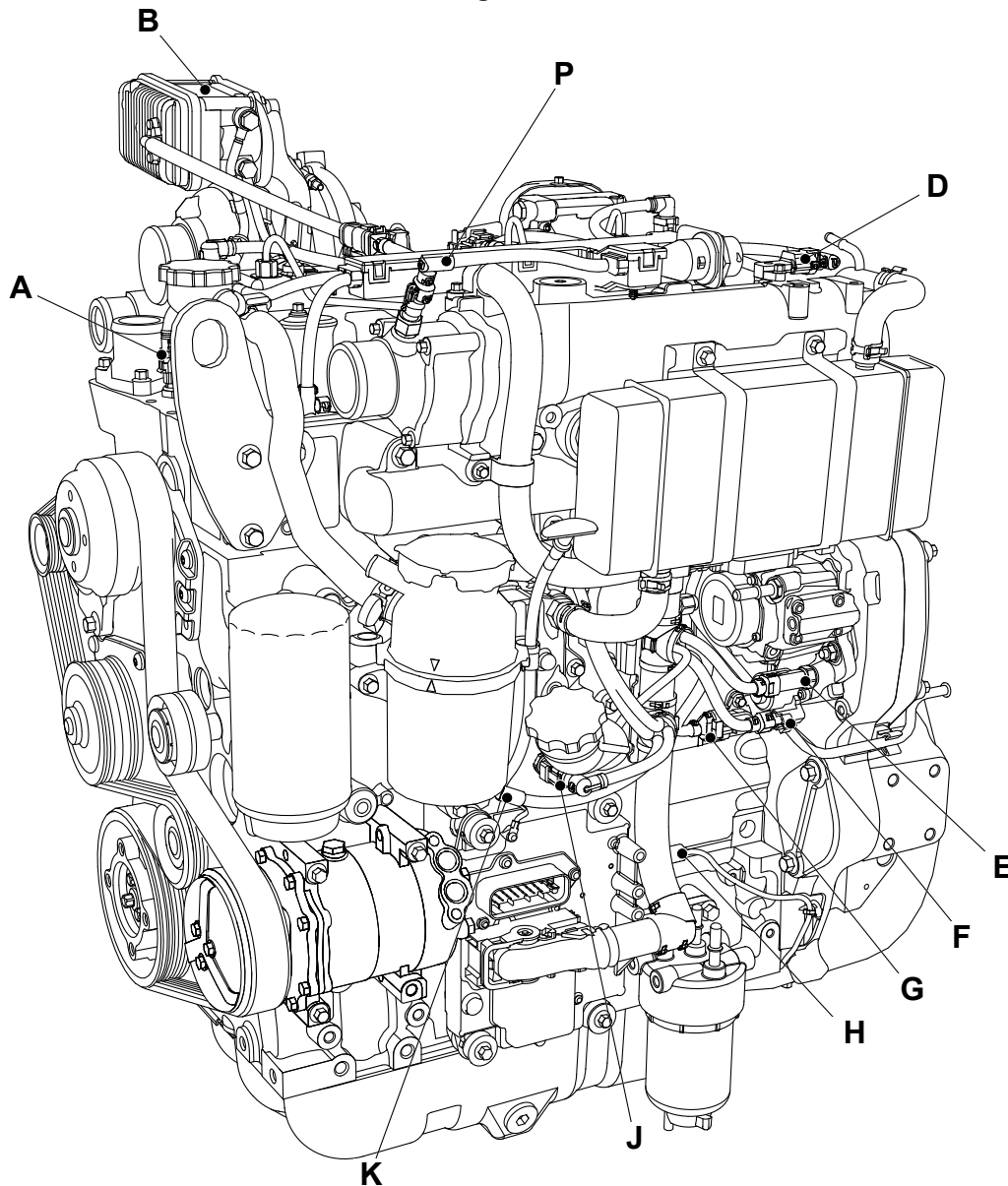
(1) With a 5V supply

Table 81.

Intercooler Outlet Temperature Sensor	
Temperature	Expected resistance
0°C (32.0°F)	8,600–10,000Ω
10°C (50.0°F)	5,200–6,000Ω
20°C (68.0°F)	3,250–3,700Ω
40°C (103.9°F)	1,370–15,210Ω
80°C (175.9°F)	319–340Ω

Component Identification

Engine Sensors and Actuators

Figure 157.


A Coolant temperature sensor (PIL 15-84)

D TMAP (Temperature Manifold Absolute Pressure) (PIL 15-84)

F Fuel inlet metering valve (PIL 18-18)

H Crankshaft position sensor (PIL 15-84)

K Oil pressure switch (PIL 15-84)

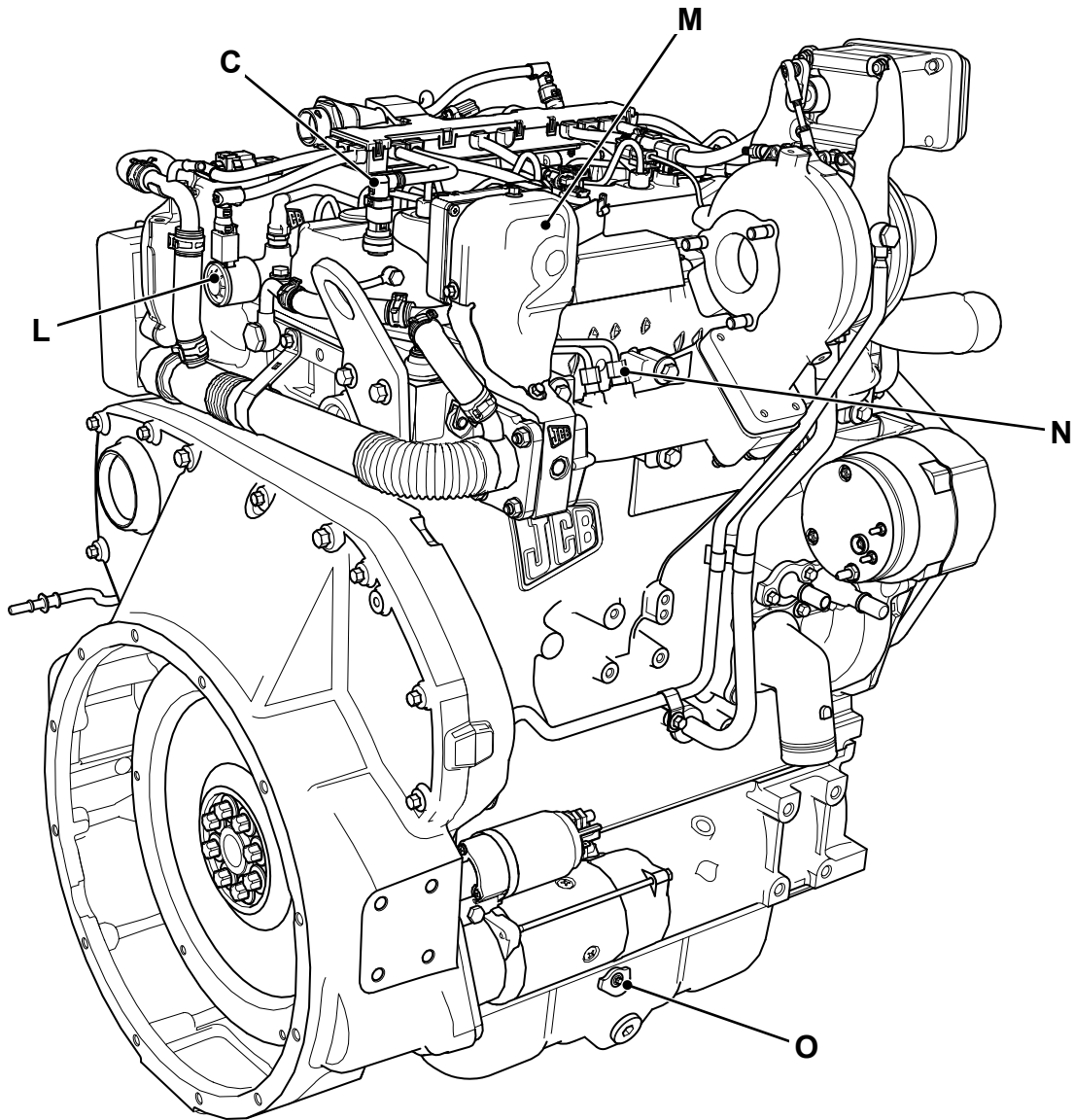
B Turbocharger actuator (not installed on 55Kw engines) (PIL 18-36)

E Fuel temperature sensor (PIL 15-84)

G Camshaft position sensor (PIL 15-84)

J Oil temperature sensor (PIL 15-84)

P Inter cooler outlet temperature sensor (PIL 15-84)

Figure 158.


- C** Exhaust manifold pressure sensor (PIL 15-84)
- M** EGR (Exhaust Gas Recirculation) actuator (PIL 18-27)
- O** Oil level switch (optional) (PIL 15-84)

- L** Fuel pressure relief valve (HPV) (PIL 15-84)
- N** Exhaust manifold temperature sensor (PIL 15-84)

Fault-Finding

Fault

General Sensor Fault	Table 82.	Page 15-248
Water in Fuel Sensor Fault	Table 83.	Page 15-248
Knock Sensors	Table 84.	Page 15-249
TMAP (Temperature Manifold Absolute Pressure) Sensor Fault (Boost Pressure)	Table 85.	Page 15-250
Crankshaft Position Sensor	Table 86.	Page 15-250
Camshaft Position Sensor	Table 87.	Page 15-251
TMAF (Temperature and Mass Air Flow) Sensor	Table 88.	Page 15-252

Table 82. General Sensor Fault

Cause	Remedy
Sensor supply voltage fault	<p>Disconnect the sensor, check sensor voltage supply at the harness connector (see relevant sensor help file for pin numbers or refer to engine electrical schematic). If voltage supply is faulty, disconnect all other sensors in turn until voltage supply returns.</p> <p>If sensor supply voltage is OK, proceed to 'Sensor connection faulty'.</p>
Sensor connection faulty	<p>Check the condition of sensor to harness connection, make sure the seals are in place, check for signs of corrosion or contamination. Repair/replace as necessary.</p> <p>If no fault is found, proceed to 'Sensor failure'.</p>
Sensor failure	<p>Check the sensor resistance (see relevant help file page). If sensor is out of specification replace.</p> <p>If no faults is found, proceed to ECM (Engine Control Module) connection fault'.</p>
ECM connection fault	<p>Disconnect the harness from engine ECM and inspect. Check seals are in place, check for signs of corrosion or contamination.</p> <p>If ECM pins are damaged, replace ECM and re-flash appropriate calibration (see Re-flashing an ECM).</p> <p>If harness is damaged, repair or replace as necessary.</p> <p>If no fault is found proceed to 'Wiring fault'.</p>
Wiring fault	<p>Check the harness continuity. Check the machine and engine earth contacts. Repair/ replace as necessary.</p> <p>If no fault is found, raise Techweb Helpdesk call.</p>

Table 83. Water in Fuel Sensor Fault

Cause	Remedy
Sensor supply voltage fault	<p>Check the presence of electrical supply on water sensor.</p> <p>If sensor supply voltage is OK, proceed to 'Sensor connection faulty'.</p>
Sensor connection faulty	<p>Check the condition of sensor to harness connection, make sure the seals are in place, check for signs of corrosion or contamination. Repair/replace as necessary.</p> <p>If no fault is found, proceed to 'Sensor failure'.</p>

Cause	Remedy
Sensor failure	<p>Check the sensor resistance (see relevant help file page). If sensor is out of specification replace.</p> <p>If no faults is found, proceed to ECM connection fault'.</p>
ECM connection fault	<p>Disconnect the harness from engine ECM and inspect. Check seals are in place, check for signs of corrosion or contamination.</p> <p>If ECM pins are damaged, replace ECM and re-flash appropriate calibration (see Re-flashing an ECM.</p> <p>If harness is damaged, repair or replace as necessary.</p> <p>If no fault is found proceed to 'Wiring fault'.</p>
Wiring fault	<p>Check the harness continuity and machine and engine earth contacts. Repair/ replace as necessary.</p> <p>If no fault is found, raise Techweb Helpdesk call.</p>

Table 84. Knock Sensors

Cause	Remedy
Sensor connection fault	<p>Check the following sensors and make sure they work correctly. – Knock sensors – Water temperature sensor – Air temperature sensor – Fuel temperature sensor – Barometric pressure sensor (built inside the ECM).</p> <p>Check the knock sensors connection and screw torque (Check particularly the ground shield connection). Repair as necessary and re-enter all injector calibration codes (read then write) in correct position to reset learned parameters.</p> <p>If no fault is found proceed to 'Knock sensors ground fault'.</p>
Knock sensors ground fault	<p>Check the grounding of knock sensors, repair as necessary.</p> <p>If no fault is found proceed to ECM connection fault'.</p>
ECM connection fault	<p>Disconnect ECM and inspect. Check seals are in place, check for signs of corrosion or contamination.</p> <p>If ECM pins are damaged, replace ECM and re-flash appropriate calibration (see Re-flashing an ECM.</p> <p>If harness is damaged, repair or replace as necessary.</p> <p>If no fault is found proceed to 'Wiring fault'.</p>
Wiring fault	<p>Check the harness continuity and electrical installation, repair/replace as necessary.</p> <p>If no fault is found proceed to 'Injector calibration codes fault'.</p>
Injector calibration codes fault	<p>Check the injector calibration codes recorded in ECM, if found fault re-enter all injector calibration codes (read then write) in correct position to reset learned parameters.</p> <p>If the injector calibration codes are OK, test the vehicle on road and check the DTC (Diagnostic Trouble Code) again with the diagnostic tool. If the problem is still present, replace the knock sensors.</p>

Table 85. TMAP (Temperature Manifold Absolute Pressure) Sensor Fault (Boost Pressure)

Cause	Remedy
Sensor supply voltage or calibration fault	<p>Disconnect the sensor, check sensor voltage supply at the harness connector (see relevant sensor help file for pin numbers or refer to engine electrical schematic). If voltage supply is faulty, disconnect all other sensor in turn until voltage supply returns. Replace the faulty sensor. If no sensor is faulty replace the ECM.</p> <p>If sensor supply voltage is OK, proceed to 'Air inlet circuit fault'.</p>
Air inlet circuit fault	<p>Check the consistency of barometric pressure reading. Verify the conformity of air inlet circuit:– VGT (Variable Geometry Turbocharger) / Turbo – Leakage before VGT / Turbo – Air filter – Valve position using ServiceMaster – Vane state.</p> <p>Check all the hose connections for air leaks, repair as necessary.</p> <p>If no fault is found, raise Techweb Helpdesk call.</p>
Sensor connection faulty	<p>Check the condition of sensor to harness connection, make sure the seals are in place, check for signs of corrosion or contamination. Repair/replace as necessary.</p> <p>If no fault is found, proceed to 'Sensor failure'.</p>
Sensor failure	<p>Check the sensor resistance (see relevant help file page). If sensor is out of specification replace.</p> <p>If no faults is found, proceed to ECM connection fault'.</p>
ECM connection fault	<p>Disconnect the harness from engine ECM and inspect. Check seals are in place, check for signs of corrosion or contamination.</p> <p>If ECM pins are damaged, replaceECM and re-flash appropriate calibration (see Re-flashing an ECM</p> <p>If harness is damaged, repair or replace as necessary.</p> <p>If no fault is found proceed to 'Wiring fault'.</p>
Wiring fault	<p>Check the harness continuity and machine and engine earth contacts. Repair/ replace as necessary.</p> <p>If no fault found, raise Techweb Helpdesk call.</p>

Table 86. Crankshaft Position Sensor

Cause	Remedy
Sensor supply voltage fault	<p>Disconnect the sensor, check sensor voltage supply at the harness connector (see relevant sensor help file for pin numbers or refer to engine electrical schematic). If voltage supply is faulty, replace the sensor.</p> <p>If sensor supply voltage is OK, proceed to 'Sensor connection faulty'.</p>
Sensor connection faulty	<p>Check the condition of sensor to harness connection, make sure the seals are in place, check for signs of corrosion or contamination. Repair as necessary.</p> <p>If no fault is found, proceed to ECM connection fault'.</p>

Cause	Remedy
ECM connection fault	Disconnect the harness from engine ECM and inspect. Check seals are in place, check for signs of corrosion or contamination.
	If ECM pins are damaged, replace ECM and re-flash appropriate calibration (see Re-flashing an ECM).
	If harness is damaged, repair or replace as necessary.
	If no fault is found proceed to 'Sensor signals faulty'.
Sensor signals faulty	Check the sensor signals. If scope available, display Cam and crank signals on the scope. Change the sensor as necessary.
	If no fault is found, proceed to 'Sensor failure'.
Sensor failure	Check the sensor resistance (see relevant help file page). If sensor is out of specification replace.
	If no fault is found, proceed to 'Sensor target wheel fault'.
Sensor target wheel fault	Check the crankshaft position sensor target wheel if damaged, replace with a new crankshaft.
	If no fault is found raise Techweb Helpdesk call.

Table 87. Camshaft Position Sensor

Cause	Remedy
Sensor supply voltage fault	Disconnect the sensor, check sensor voltage supply at the harness connector (see relevant sensor help file for pin numbers or refer to engine electrical schematic). If voltage supply is faulty, replace the sensor.
	If sensor supply voltage is OK, proceed to 'Sensor connection faulty'.
Sensor connection faulty	Check the condition of sensor to harness connection, make sure the seals are in place, check for signs of corrosion or contamination. Repair as necessary.
	If no fault is found, proceed to 'Sensor failure'.
Sensor failure	Check the sensor resistance (see relevant help file page). If sensor is out of specification replace.
	If no fault is found, proceed to Step 4.
ECM connection fault	Disconnect the harness from engine ECM and inspect. Check seals are in place, check for signs of corrosion or contamination.
	If ECM pins are damaged, replace ECM and re-flash appropriate calibration (see Re-flashing an ECM).
	If harness is damaged, repair or replace as necessary.
	If no fault is found proceed to 'Sensor signals faulty'.
Sensor signals faulty	Check the sensor signals. If scope available, display Cam and crank signals on the scope. Change the sensor as necessary.
	If no fault is found, proceed to 'Sensor target wheel fault'.
Sensor target wheel fault	Check the Cam target wheel if damaged, replace with new camshaft.
	If no fault is found raise Techweb Helpdesk call.

Table 88. TMAF (Temperature and Mass Air Flow) Sensor

Cause	Remedy
Sensor supply voltage or calibration fault	Disconnect the sensor, check sensor voltage supply at the harness connector (see relevant sensor help file for pin numbers or refer to engine electrical schematic). If voltage supply is faulty, disconnect all other sensor in turn until voltage supply returns. Replace the faulty sensor. If no sensor is faulty replace the ECM If sensor supply voltage is OK, proceed to 'Air inlet fault'.
Air inlet fault	Check all the hose connections for air leaks, repair as necessary. If no fault is found proceed to 'Sensor connection faulty'.
Sensor connection faulty	Check the condition of sensor to harness connection, make sure the seals are in place, check for signs of corrosion or contamination. Repair/replace as necessary. If no fault is found, proceed to 'Sensor failure'.
Sensor failure	If sensor is out of specification replace. If no faults is found, proceed to Step 5.
ECM connection fault	Disconnect the harness from engine ECM and inspect. Check seals are in place, check for signs of corrosion or contamination. If ECM pins are damaged, replace ECM and re-flash appropriate calibration (see Re-flashing an ECM). If harness is damaged, repair or replace as necessary. If no fault is found proceed to Step 6.
Wiring fault	Check the harness continuity and machine and engine earth contacts. Repair/ replace as necessary. If no fault found, raise Techweb Helpdesk call.

Check (Operation)

1. Check the applicable fuse.
2. Check the display for related fault codes.
3. Using Servicemaster perform the required diagnostic tests.
4. Check the sensor condition, make sure the sensor or housing is not damaged, broken, contaminated or subjected to excess heat. If necessary replace sensor and make sure the damage can not reoccur.
5. Check the condition of sensor to harness connection, make sure the seals are in place, check for signs of corrosion or contamination. Repair/replace as necessary.
6. Check the sensor location and make sure it is mounted correctly. Where applicable check the sensor is tightened to the correct torque. Refer to the applicable sensor procedure for details.
7. Check the sensor is of the correct type and specification. If incorrect replace with correct sensor. Refer to the applicable sensor procedure for details.
8. Disconnect the sensor, check sensor voltage supply at the harness connector (Refer to the applicable sensor Technical Data and Component Identification procedures. Alternatively refer to engine electrical schematic). If the voltage supply is faulty, disconnect all other sensors in turn until voltage supply returns. Trace the supply fault and rectify.
9. Check the sensor characteristics. Refer to the applicable sensor Technical Data. If sensor is out of specification replace.
10. Disconnect the harness from the engine ECM (Engine Control Module) and inspect. Check seals are in place, check for signs of corrosion or contamination.
11. Check the harness continuity. Check the machine and engine earth contacts. Repair / replace as necessary.



03 - Crankshaft Position

Introduction	15-254
Operation	15-255
Check (Operation)	15-256
Remove and Install	15-256

Introduction

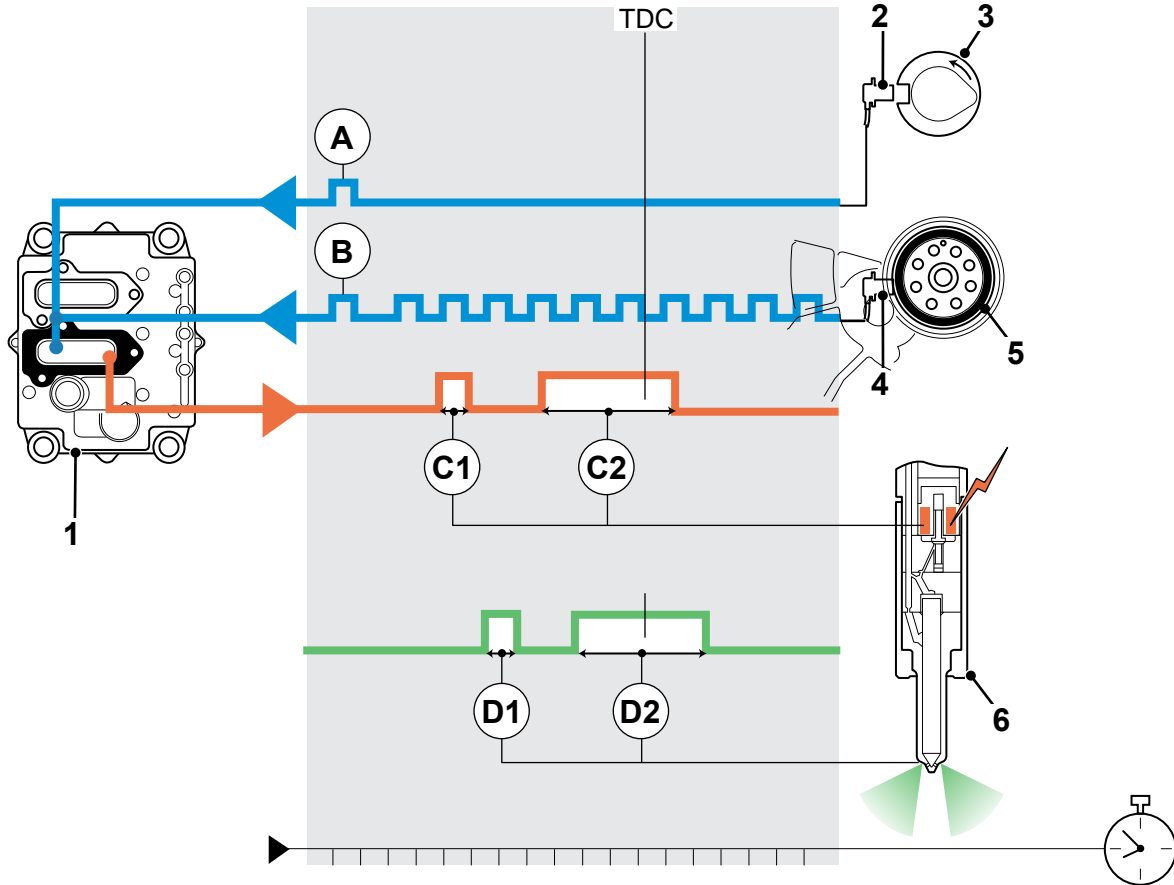
The crankshaft position sensor is a device used to monitor the position or rotational speed of the crankshaft. This information is used by the ECM (Engine Control Module) to control the ignition system timing and other engine parameters.

Operation

A signal is generated by the crankshaft mounted target wheel and crankshaft position sensor. It is

processed by the ECM (Engine Control Module) to determine the timing of fuel injection.

Figure 159.



- 1** ECM
- 3** Camshaft target wheel
- 5** Crankshaft mounted target wheel
- A** Camshaft sensor signal
- C1-C2** Current pulse-injector solenoid coil
- TDC** TDC (Top Dead Centre)

- 2** Camshaft position sensor
- 4** Crankshaft position sensor
- 6** Fuel injector
- D1-D2** Fuel Injection

Check (Operation)

1. Carefully inspect the sensor. If it is found to be defective, replace the sensor.
2. Inspect the sealing O-ring. If it is defective, replace the sensor. The O-ring is integral to the sensor and cannot be replaced.

Remove and Install

Before Removal

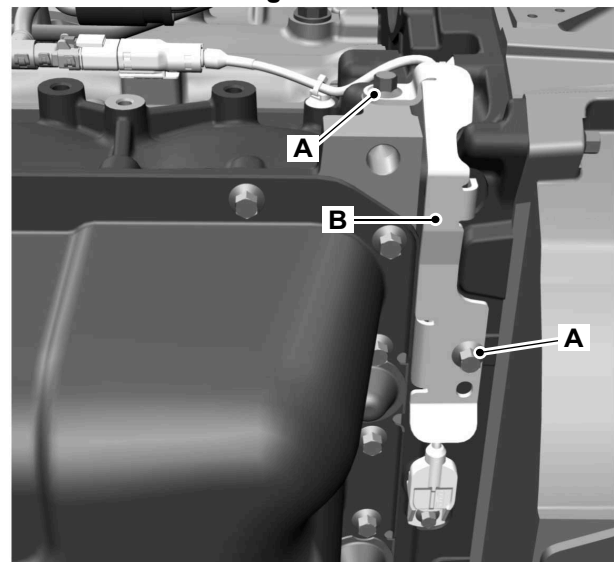
1. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.
2. Clean the sensor and the adjacent area of the flywheel housing.

Refer to: [PIL 15-00-00](#).

Remove

1. Get access to the engine.
2. Remove bolts 1 (x2) and remove the guard.

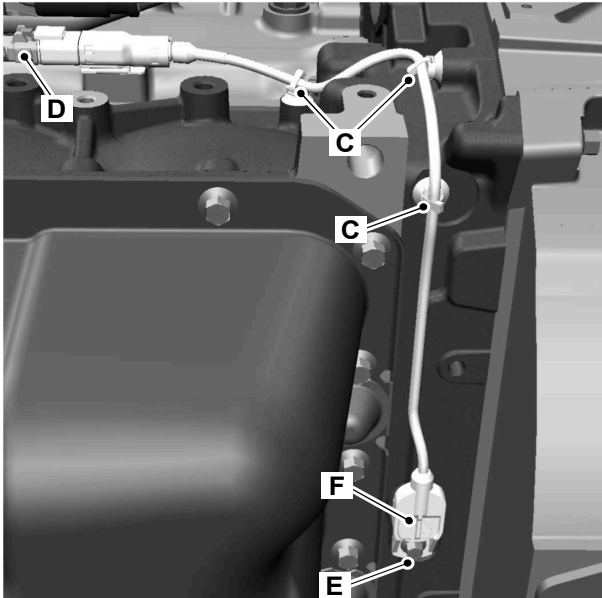
Figure 160.



- A** Bolts 1 (x2)
- B** Crankshaft position sensor guard

3. Remove the cable ties.

Figure 161.



- C** Cable ties
- D** Electrical connector
- E** Bolt 2 (x1)
- F** Crankshaft position sensor

4. Disconnect the electrical connector.
5. Remove the electrical connector from the retaining clip on the crankcase.
6. Remove the bolt 2 (x1).
7. Remove the crankshaft position sensor.

The crankshaft position sensor **F** is a non-serviceable item. If the sensor is defective it must be replaced.

Install

1. The installation procedure is the opposite of the removal procedure. Additionally do the following steps.
2. Tighten the bolt to the correct torque value.
3. Replace the cable ties.
4. Make sure that the wire is not trapped under the crankshaft position sensor guard.

Table 89. Torque Values

Item	Nm
E	7.7 ± .5



06 - Camshaft Position

Introduction	15-258
Operation	15-259
Check (Operation)	15-260
Remove and Install	15-260

Introduction

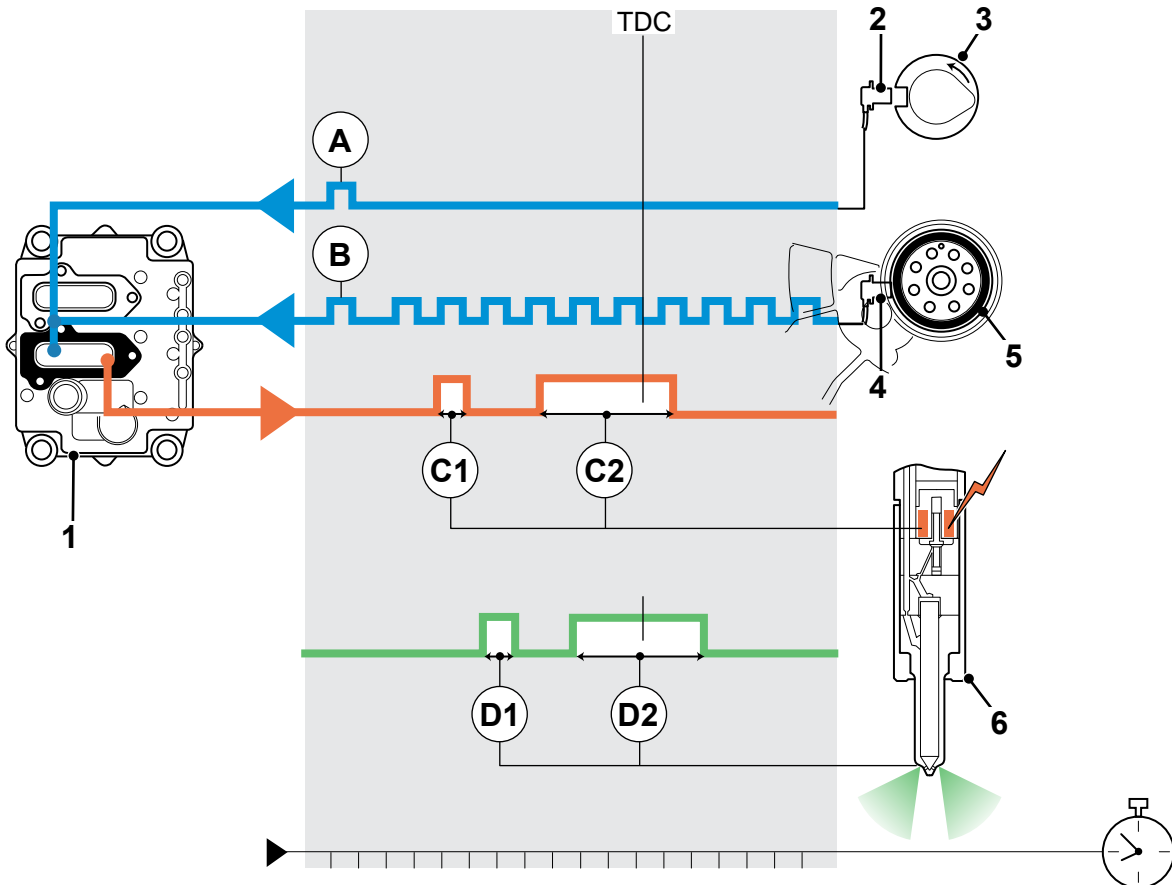
The camshaft position sensor is a device that detects the passing of a gap on a camshaft target wheel. It sends a signal to the ECM (Engine Control Module) which stroke number piston is on so that the ECM knows which cylinder to inject the fuel into.

Operation

A signal is generated by the camshaft mounted target wheel and camshaft position sensor. This information is used by the ECM (Engine Control Module) to process the signal to determine the engine phase (which cylinder is firing).

The ECM will select the correct cylinder for fuel injection.

Figure 162.



- | | | | |
|--------------|--|--------------|-----------------------------------|
| 1 | ECM | 2 | Camshaft position sensor |
| 3 | Camshaft target wheel | 4 | Crankshaft position sensor |
| 5 | Crankshaft mounted target wheel | 6 | Fuel injector |
| A | Camshaft sensor signal | B | Crankshaft position sensor signal |
| C1-C2 | Current pulse - injector solenoid coil | D1-D2 | Fuel Injection |
| TDC | TDC (Top Dead Centre) | | |

Check (Operation)

1. Carefully inspect the sensor. If it is found to be defective, replace the sensor.
2. Inspect the sealing O-ring. If it is defective, replace the sensor. The O-ring is integral to the sensor and cannot be replaced.

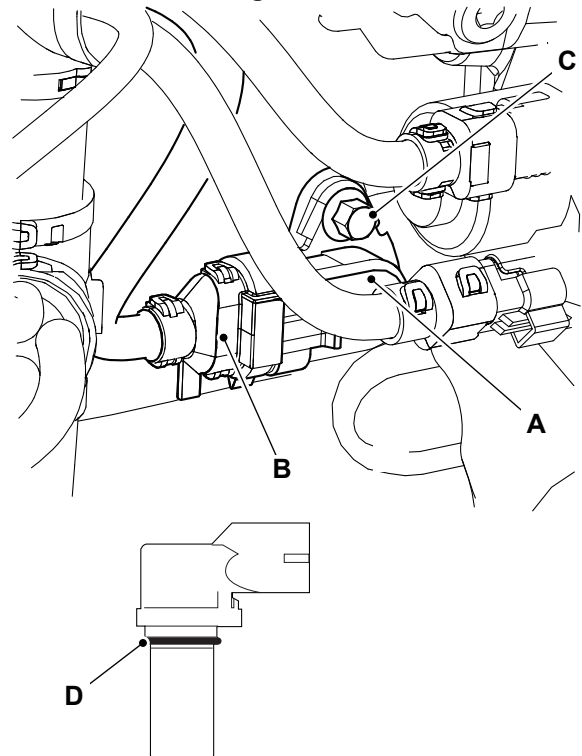
Remove and Install

Before Removal

1. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.
2. Clean the sensor and the adjacent area of the crankcase.

Refer to: [PIL 15-00-00](#).

Figure 163.



- A** Camshaft position sensor
- B** Electrical connector
- C** Bolt
- D** O-ring seal

Remove

1. Get access to the engine.
2. Disconnect the electrical connector at the sensor.
3. Remove the bolt.
4. Remove the sensor from the crankcase together with the O-ring.

The camshaft position sensor is a non-serviceable item. If the sensor is defective it must be replaced.

Install

1. The installation procedure is the opposite of the removal procedure. Additionally do the following steps.
2. Make sure that the sealing O-ring is correctly installed.
3. Apply a small amount of grease to the O-ring.
4. Carefully push the sensor into the location bore in the crankcase. Do not use excessive force.
5. Tighten the bolt to the correct torque value.

Table 90. Torque Values

Item	Nm
C	7.7 ± .5

09 - Knock

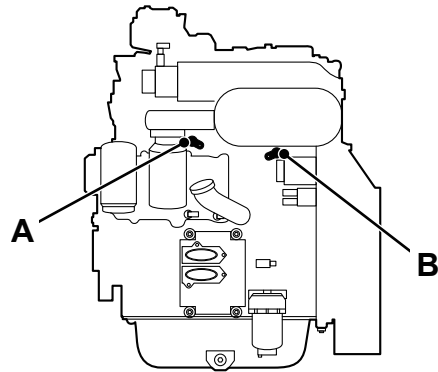
Introduction	15-262
Operation	15-263
Check (Operation)	15-263
Remove and Install	15-264

Introduction

There are two knock sensors fixed to the side of the crankcase with a centre mounted bolt. One sensor is situated between cylinders 1 and 2, and the second is situated between cylinders 3 and 4.

A knock sensor is a device that measures engine noise and transmits a signal to the ECM (Engine Control Module) when there is detonation. It allows the engine to run with the ignition timing as far advanced as possible.

The ECM will continue to advance the timing until the knock sensor detects pinging. At that point the ECM retards the ignition timing just enough for the pinging to stop. The knock sensor ensures that you are getting as much power and fuel economy as possible from your engine.

Figure 164. Knock sensor locations

- A** Knock sensor - cylinders 1 and 2
- B** Knock sensor - cylinders 3 and 4

Operation

The knock sensors detect pre-ignition (knock) by means of sensing engine vibration. The vibration signal is sent to the engine ECM (Engine Control Module) where the ECM will adjust the fuel timing to give optimum performance, economy and driveability and prevent engine damage. The voltage signal is proportional to engine vibration/acceleration.

Check (Operation)

1. For the full inspection and testing procedure, refer to the help files in ServiceMaster.

Remove and Install

The following procedure is for one knock sensor. The procedure for both sensors is identical.

Before Removal

1. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.

Remove

1. Get access to the engine.
2. Disconnect the electrical connector at the knock sensor.
3. Remove the bolt and remove the knock sensor from the crankcase.

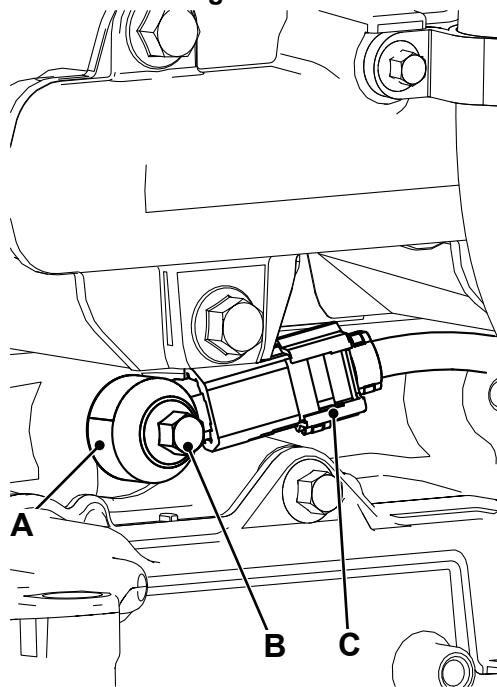
The knock sensor is a non-serviceable item. If the sensor is defective it must be replaced.

3. Tighten the bolt to the correct torque value.

Table 91. Torque Values

Item	Nm
C	22–26

Figure 165.



- A** Knock sensor
- B** Electrical connector
- C** Bolt

Install

1. The installation procedure is the opposite of the removal procedure. Additionally do the following steps.
2. Make sure that the sensor mates fully with the adjacent face on the crankcase.

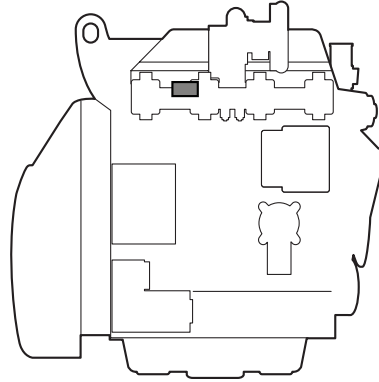
14 - Exhaust Manifold Temperature

Introduction	15-265
Operation	15-266
Remove and Install	15-266

Introduction

The exhaust manifold temperature sensor is screwed directly into the top of the exhaust manifold between cylinder 3 and 4 exhaust outlet ports.

Figure 166. Exhaust manifold temperature sensor location



Operation

The exhaust manifold temperature sensor measures the exhaust gas temperature from the engine, before it reaches the turbocharger. The analogue voltage signal is 1–4.5V.

Remove and Install

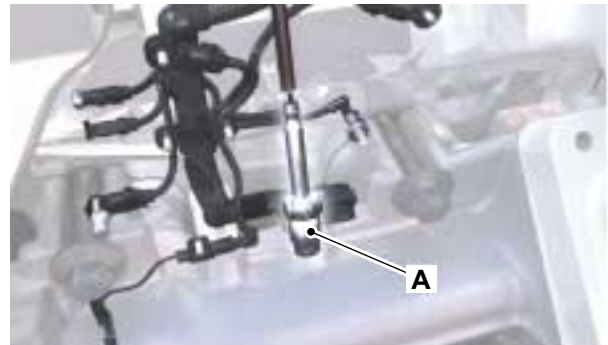
Special Tools

Description	Part No.	Qty.
Deep Socket	892/12351	1

Before Removal

1. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.

Figure 167.



A Exhaust manifold temperature sensor

Remove

1. Get access to the engine.
2. Disconnect the electrical connector at the exhaust manifold temperature sensor.
3. Use the special tool to remove the sensor from the exhaust manifold.

Special Tool: Deep Socket (Qty.: 1)

4. Discard the sealing washer.

The exhaust manifold temperature sensor is a non-serviceable item. If the sensor is faulty or damaged it must be renewed.

Install

1. The installation procedure is the opposite of the removal procedure. Additionally do the following steps.
2. Renew the sealing washer.
3. Tighten the exhaust manifold temperature sensor to the correct torque value.

Table 92. Torque Values

Item	Nm
N	45

16 - Exhaust Manifold Pressure

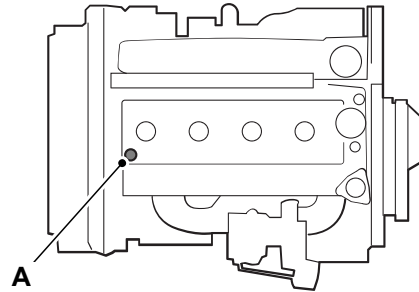
Introduction	15-267
Operation	15-268
Check (Operation)	15-268
Remove and Install	15-269

Introduction

The exhaust manifold pressure sensor measured the pressure in the exhaust manifold. This information is then used by the ECM (Engine Control Module) to optimise fuel injection and turbo boost pressure for maximum power and fuel economy.

To obtain an accurate and stable reading, the sensor is mounted in to a sample chamber in the corner of the rocker cover. This is fed exhaust manifold pressure by a take off pipe that is connected to the exhaust manifold.

Figure 168.



A Exhaust manifold pressure sensor



Operation

The exhaust manifold pressure sensor measures the exhaust pressure from the engine. To attain an accurate and stable reading, the take-off point is piped from the exhaust manifold between cylinders 3 and 4. This is fed to a sample chamber where the sensor is screwed directly into the pressure path. The analogue voltage signal is 0.5–4.5V.

Check (Operation)

For the full inspection and testing procedure, refer to the help files in ServiceMaster.

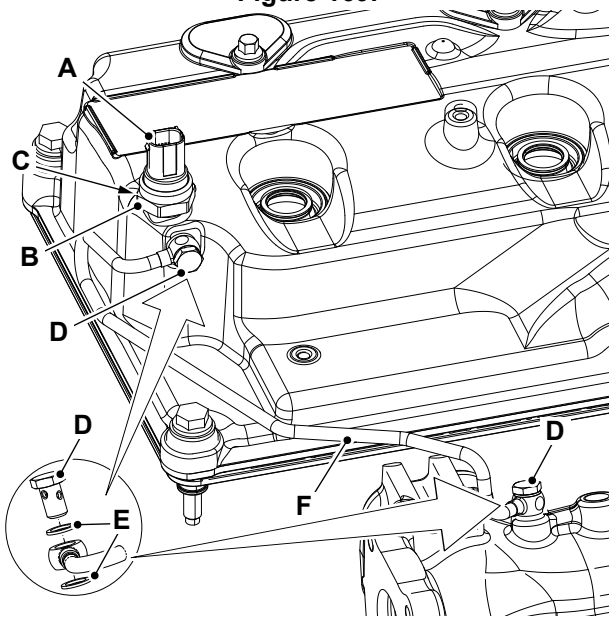
Remove and Install

Exhaust manifold pressure sensor

Remove

1. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.
2. Get access to the engine.
3. Disconnect the electrical connector at the exhaust manifold pressure sensor.

Figure 169.



- A** Electrical connector
- B** Exhaust manifold pressure sensor
- C** Sealing washer
- D** Banjo bolt
- E** Banjo bolt sealing washers
- F** Exhaust manifold pressure sensor feed pipe

4. Use a suitable deep socket to remove the sensor from the exhaust manifold.
5. Discard the sealing washer.

The exhaust manifold pressure sensor is a non-serviceable item. If the sensor is faulty or damaged it must be renewed.

Install

1. The installation procedure is the opposite of the removal procedure. Additionally do the following steps.
2. Replace the sealing washer.

3. Tighten the exhaust manifold pressure sensor to the correct torque value.

Exhaust manifold pressure sensor feed pipe

Remove

1. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.
2. Get access to the engine.
3. Remove the banjo bolts.
 - 3.1. Make sure you recover the sealing washers. The sealing washers must not be reused. Discard the sealing washers.

4. Remove the exhaust gas feed pipe

Install

1. Replace the sealing washers.
2. Install the exhaust gas feed pipe.
3. Loosely install both banjo bolts.
4. Tighten the banjo bolts to the correct torque value.

Table 93. Torque Values

Item	Nm
B	16.5 ± 1.5
D	8 ± 1



17 - Temperature and Manifold Air Pressure (TMAP)

Introduction	15-270
Operation	15-271
Check (Operation)	15-271
Remove and Install	15-272

Introduction

The TMAP (Temperature Manifold Absolute Pressure) sensor is mounted in a port on top of the inlet manifold. It measures the inlet manifold boost air pressure and temperature. The sensor incorporates a piezo-resistive element and resistor.

Operation

The TMAP (Temperature Manifold Absolute Pressure) sensor measures the inlet manifold boost air pressure and temperature. The sensor produces an analogue signal voltage proportional to air pressure.

Check (Operation)

1. Remove oil and sludge contamination from the sensor.
2. Carefully inspect the sensor. If it is defective, replace it.
3. Inspect the sealing O-ring. If it is defective, replace the sensor. The O-ring is integral to the sensor and cannot be replaced.

Remove and Install

Before Removal

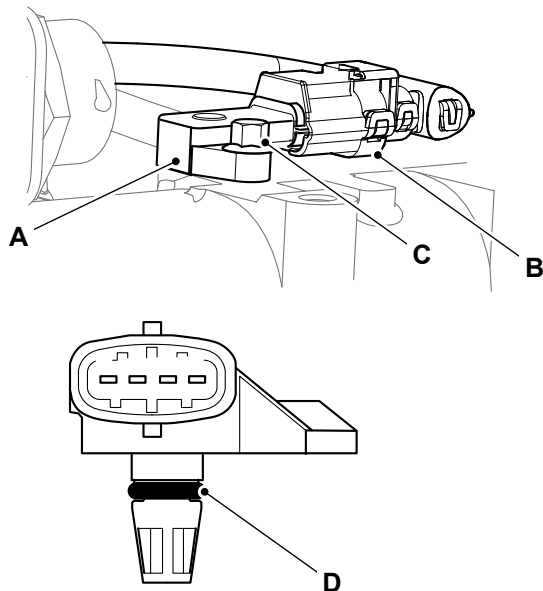
1. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.
2. Clean the sensor and the adjacent area of the inlet manifold.

Refer to: PIL 15-00-00.

Remove

1. Get access to the engine.
2. Disconnect the electrical connector at the sensor.

Figure 170.



- A** TMAP (Temperature Manifold Absolute Pressure)
- B** Electrical connector
- C** Bolt
- D** O-ring seal

3. Remove the bolt.
4. Remove the sensor from the inlet manifold together with O-ring.

The TMAP sensor is a non-serviceable item. If the sensor is defective, it must be replaced.

Install

1. The installation procedure is the opposite of the removal procedure. Additionally do the following steps.

2. Make sure that the sealing O-ring is correctly installed.
3. Carefully push the sensor into its location bore in the inlet manifold. Do not use excessive force.
4. Tighten the bolt to the correct torque value.

Table 94. Torque Values

Item	Nm
C	7.7 ± .5

18 - Temperature and Mass Air Flow (TMAF)

Introduction	15-273
Operation	15-274
Check (Operation)	15-274
Remove and Install	15-275

Introduction

The TMAF (Temperature and Mass Air Flow) sensor measures the amount of air coming in to the engine and the air temperature. It is mounted between the air filter and turbo charger.

Figure 171.



Operation

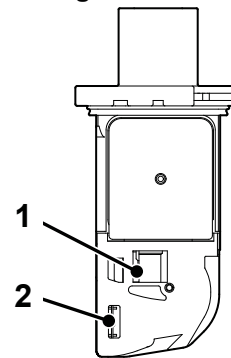
The TMAF (Temperature and Mass Air Flow) sensor produces a digital signal measuring air flow, and an analogue signal measuring inlet air temperature.

Check (Operation)

Faults relating to the TMAF (Temperature and Mass Air Flow) will normally be reported by the fault codes.

1. Remove contamination from the sensor. Do not touch the air flow sensor area or temperature sensor area.
2. Carefully inspect the sensor. If it is defective, replace it.
3. Inspect the sealing O-ring. If it is defective, replace it.

Figure 172.



- 1 Air flow sensor area
- 2 Temperature sensor area

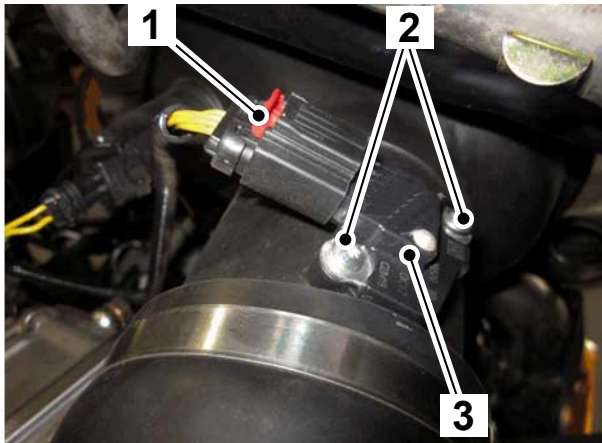
Remove and Install

Before Removal

1. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.
2. Get access to the TMAF (Temperature and Mass Air Flow) sensor
3. Clean the area around the sensor to prevent contamination entering the engine.

Remove

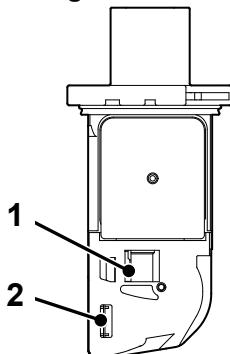
Figure 173.



- 1 Electrical connector
- 2 Screws (x2)
- 3 TMAF sensor

1. Disconnect the electrical connector. Do not touch the connector pins.
2. Remove the screws (x2) which secure the TMAF sensor to the air intake hose.
3. Remove the TMAF sensor together with the O-ring from the air intake hose. Do not touch the air flow sensor area or temperature sensor area.

Figure 174.



- 1 Air flow temperature sensor area
- 2 Temperature sensor area

Install

Do not install a TMAF sensor which has been dropped or damaged. Replace it with a new one.

1. The installation procedure is the opposite of the removal procedure. Additionally do the following step.
2. Tighten the screws to the correct torque value.

Table 95. Torque Values

Item	Nm
2	5



19 - Exhaust Temperature

Introduction	15-276
Operation	15-277
Check (Operation)	15-277
Remove and Install	15-278

Introduction

The exhaust temperature sensor is located in the exhaust system just before the SCR (Selective Catalytic Reduction) catalyst.

Operation

The exhaust temperature sensor measures the exhaust gas temperature just before it reaches the SCR (Selective Catalytic Reduction) catalyst. The analogue voltage signal is 0 - 5V

Check (Operation)

Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.

The resistance values specified are correct at 20°C (68.0°F).

1. Disconnect the electrical connector from the exhaust temperature sensor.
2. Switch the ignition on.
3. Connect the multimeter across the harness pins.
 - 3.1. Measure the voltage, the reading should be:
Voltage: 5V
 - 3.2. If the reading is correct, proceed to 4
 - 3.3. If the reading is not correct, check the harness between the sensor and the DCU (Dosing Control Unit) for continuity.
 - 3.4. Check the electrical connectors for integrity and contamination.
4. Connect the multimeter across the sensor pins.
 - 4.1. Measure the resistance, the reading should be:
Resistance: $24,560 \pm 1,228\Omega$
 - 4.2. If the resistance is not within tolerance, the sensor is faulty and must be replaced.
5. Connect the electrical connector to the exhaust temperature sensor.

Remove and Install

Consumables

Description	Part No.	Size
Graphite/Calcium Fluoride Based Metal Free Anti-Seize Compound	4004/7545	-

Before Removal

1. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.
2. Get access to the exhaust temperature sensor.

Remove

Figure 175.



- A** Electrical connector
- B** Exhaust temperature sensor
- C** Retaining nut

1. Disconnect the electrical connector.
2. Undo the retaining screw.

3. Remove the sensor from the exhaust, take care not to damage the sensor probe.

The exhaust temperature sensor is a non-serviceable item. If the sensor is faulty or damaged it must be replaced.

Install

1. The installation procedure is the opposite of the removal procedure. Additionally do the following steps.
2. Apply anti-seize compound to the threads of the retaining nut. Make sure the correct anti-seize compound is used to prevent damage to the SCR (Selective Catalytic Reduction) system.
[Consumable: Graphite/Calcium Fluoride Based Metal Free Anti-Seize Compound](#)
3. Tighten the retaining screw to the correct torque value.

Table 96. Torque Values

Item	Nm
C	44

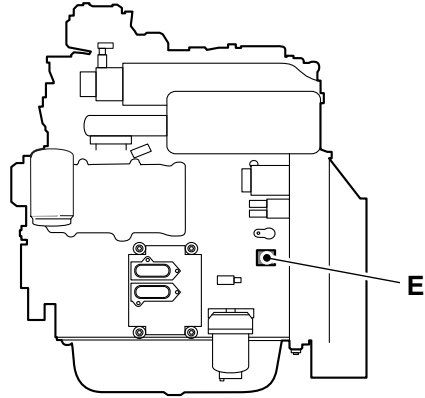
24 - Fuel Temperature

Introduction	15-279
Operation	15-280
Check (Operation)	15-280
Remove and Install	15-281

Introduction

The fuel temperature sensor is an integral part of the fuel injection high pressure pump.

Figure 176.



E Fuel temperature sensor



Operation

The fuel temperature sensor detects the fuel temperature as it enters the high pressure fuel injection pump.

Check (Operation)

For the full inspection and testing procedure, refer to the help files in ServiceMaster.



Remove and Install

This part is a non-serviceable component, if it is defective, replace the fuel injection high pressure pump.

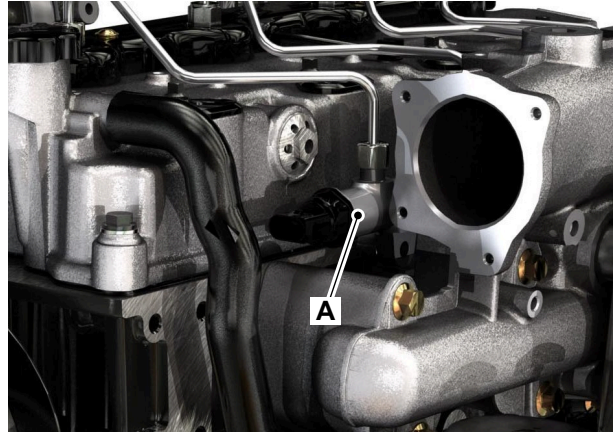
27 - Fuel Rail Pressure

Introduction	15-282
Operation	15-283
Remove and Install	15-283

Introduction

The fuel rail pressure sensor measures the fuel pressure in the common rail.

Figure 177.



A Fuel rail pressure sensor

Operation

The fuel rail pressure sensor measures the fuel pressure in the fuel rail. This allows the ECM (Engine Control Module) to control the IMV (Inlet Metering Valve) to deliver the correct amount of fuel to the high pressure fuel pump. This keeps the fuel pressure in the fuel rail constant at all engine RPM (Revolutions Per Minute).

Remove and Install

This part is a non-serviceable component, if it is defective, replace the complete common rail assembly.

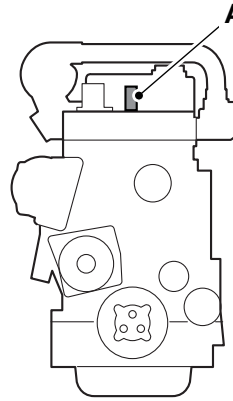
33 - Coolant Temperature

Introduction	15-284
Operation	15-285
Check (Operation)	15-285
Remove and Install	15-286

Introduction

The coolant temperature sensor is located on the cylinder head at the drive belt end.

Figure 178.



A Coolant temperature sensor

Operation

The coolant temperature sensor detects the temperature of the coolant in the cylinder head.

The signal from the sensor is used to drive the coolant temperature status display on the instrument panel.

On engines with electronically controlled fuel injection the ECM (Engine Control Module) processes the signal to determine the engine operating temperature. The ECM adjusts the injection timing and the amount of fuel injected, this can facilitate cold starting.

Check (Operation)

1. For the full inspection and testing procedure, refer to the help files in ServiceMaster.

Remove and Install

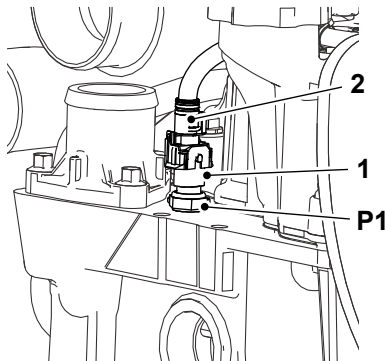
Table 97. Torque Values

Item	Nm
1	22 ± 4

Before Removal

1. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.
2. Drain the coolant.
[Refer to: PIL 21-00-00.](#)

Figure 179.



- 1** Coolant temperature sensor
- 2** Electrical connector
- P1** Encapsulated washer

Remove

1. Get access to the engine.
2. Disconnect the electrical connector at the sensor.
3. Remove the sensor from the cylinder head.
4. Cap the open port to prevent loss of fluid and ingress of dirt.

The coolant temperature sensor unit is a non-serviceable item. If the sensor is faulty or damaged it must be renewed.

Install

1. The installation procedure is the opposite of the removal procedure. Additionally do the following steps.
2. Tighten the coolant temperature sensor to the correct torque value.
3. Fill the cooling system.
[Refer to: PIL 21-00-00.](#)
 - 3.1. Make sure that you use the correct coolant mixture.
[Refer to: PIL 75-09-03.](#)
4. Start the engine and check for coolant leaks.

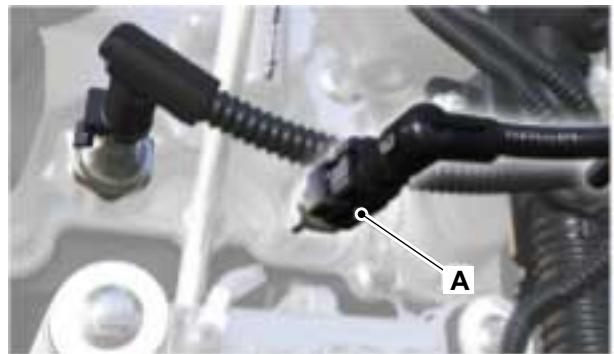
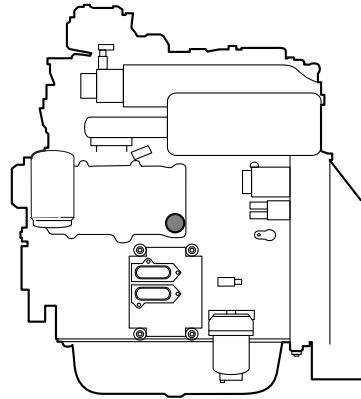
42 - Engine Oil Temperature

Introduction	15-287
Operation	15-288
Check (Operation)	15-288
Remove and Install	15-289

Introduction

The engine oil temperature sensor is mounted in a port on the oil cooler housing adjacent to the engine oil dipstick.

Figure 180. Engine oil temperature sensor location



A Engine oil temperature sensor



Operation

The oil temperature sensor informs the ECM (Engine Control Module) of the engine oil temperature. The ECM processes the signal to determine the oil temperature. The ECM adjusts the fuel delivery.

Check (Operation)

1. For the full inspection and testing procedure, refer to the help files in ServiceMaster.

Remove and Install

Special Tools

Description	Part No.	Qty.
Deep Socket	892/12351	1

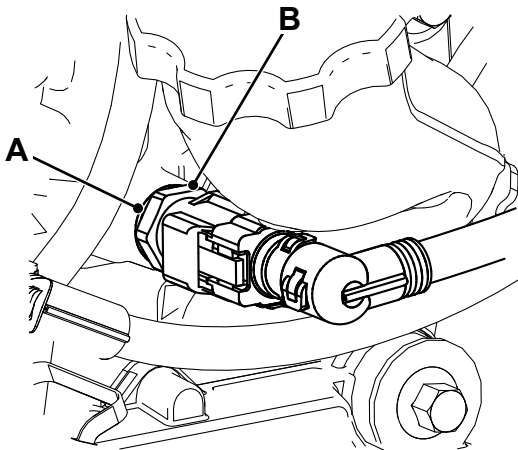
Table 98. Torque Values

Item	Nm
1	21

Before Removal

1. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.

Figure 181.



- A** Sealing washer
- B** Engine oil temperature sensor

Remove

1. Get access to the engine.
2. Disconnect the electrical connector at the engine oil temperature sensor.
3. Use the special tool to remove the sensor from the oil cooler housing.

Special Tool: Deep Socket (Qty.: 1)

4. Discard the sealing washer. Cap the open port with a blanking cap to prevent loss of fluid and ingress of dirt.

The engine oil temperature sensor is a non-serviceable item. If the sensor is faulty or damaged it must be renewed.

Install

1. The installation procedure is the opposite of the removal procedure. Additionally do the following steps.
2. Renew the sealing washer.
3. Use the special tool to tighten the engine oil temperature sensor to the correct torque value.



43 - Engine Oil Level

Introduction	15-290
Operation	15-291
Check (Operation)	15-291
Remove and Install	15-292

Introduction

The engine oil level sensor is used to warn the operator that the engine oil level is low and damage may be caused if it is not topped up immediately. It is mounted on the engine oil sump.

Operation

The engine oil level sensor is a normally closed switch. When the oil level drops below a certain point the switch will open and the low oil warning light will be illuminated.

Check (Operation)

1. For the full inspection and testing procedure refer to the help files in ServiceMaster.

Remove and Install

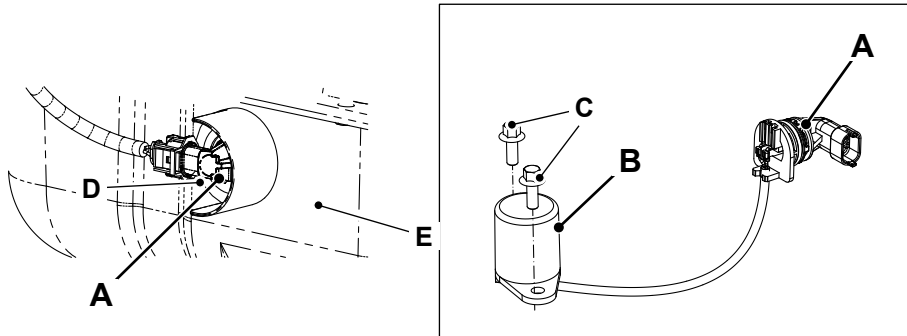
Before Removal

1. Make the machine safe.

Refer to: PIL 01-03.

2. Make sure that the engine is safe to work on. If the engine has been running, make sure the engine has cooled sufficiently before you start.

Figure 182.



A Engine oil level sensor
C Bolts (x2)
E Oil Sump

B Oil level sensor float
D Clip

Remove

1. Get access to the engine.
2. Drain the engine oil.
Refer to: PIL 15-21-00.
3. Disconnect the electrical connector.
4. Remove the oil sump.
Refer to: PIL 15-45-00.
5. Remove the bolts (x2) securing the oil level sensor float to the oil sump.
6. Remove the clip.
7. Remove the oil level sensor.

The engine oil level sensor is a non-serviceable item. If the sensor is faulty or damaged it must be replaced.

Install

1. The installation procedure is the opposite of the removal procedure. Additionally do the following steps.
2. Tighten the bolts to the correct torque value.

Table 99. Torque Values

Item	Nm
C	10 ± 1

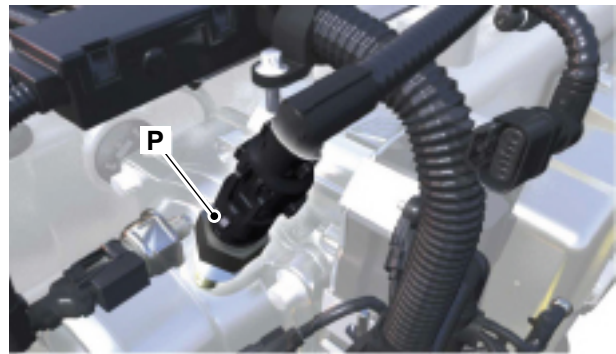
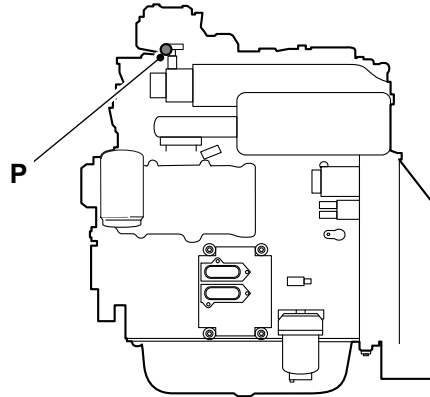
48 - Intercooler Outlet Temperature

Introduction	15-293
Operation	15-294
Check (Operation)	15-294
Remove and Install	15-295

Introduction

The intercooler outlet sensor is located in the air intake on the inlet manifold.

Figure 183.



P Intercooler outlet sensor



Operation

The intercooler outlet sensor measures the temperature of the air coming from the intercooler into the inlet manifold. The sensor sends an analogue voltage signal to the ECM (Engine Control Module).

Check (Operation)

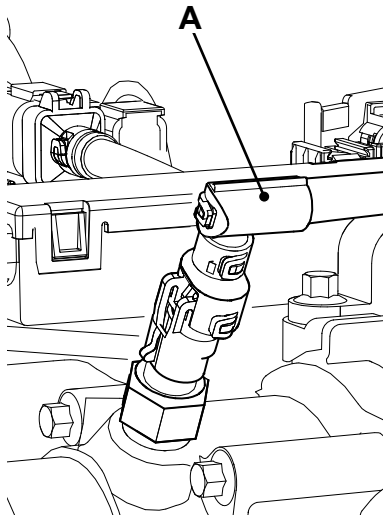
1. For the full inspection and testing procedure, refer to the help files in ServiceMaster.

Remove and Install

Before Removal

1. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.

Figure 184.



A Intercooler outlet temperature sensor

Remove

1. Get access to the engine.
2. Disconnect the electrical connector at the sensor.
3. Remove the sensor from the air intake.
4. Cap the open port with a blanking cap to prevent dirt ingress.

Install

1. The installation procedure is the opposite of the removal procedure. Additionally do the following step.
2. Tighten the sensor to the correct torque value.

Table 100. Torque Values

Item	Nm
A	8.5



87 - Switch

Contents	Page No.
15-87-00 General	15-297
15-87-03 Engine Oil Pressure	15-298

00 - General

Introduction

The engine electrical switches send signals to the ECM (Engine Control Module) to help the ECM to control the smooth running of the engine and related components. The ECM processes signals from the switches and its response will be based on an evaluation of the combination of the switches signals.

After removal from the engine, protect the switches from knocks, dampness and any high temperature sources. The switches are not serviceable, therefore they must be replaced in the event of damage.

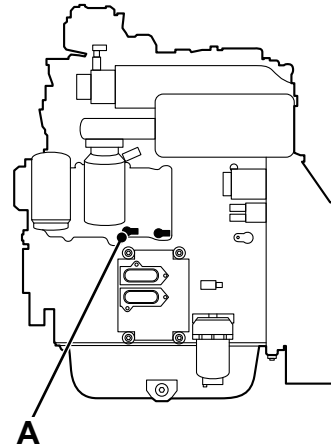
03 - Engine Oil Pressure

Introduction	15-298
Operation	15-299
Check (Operation)	15-299
Remove and Install	15-300

Introduction

The oil pressure switch is mounted in a port on the oil cooler housing.

Figure 185.



A Engine oil pressure switch



Operation

The oil pressure switch contacts open when the engine oil pressure is below 0.6bar.

Check (Operation)

1. For the full inspection and testing procedure, refer to the help files in ServiceMaster.

Remove and Install

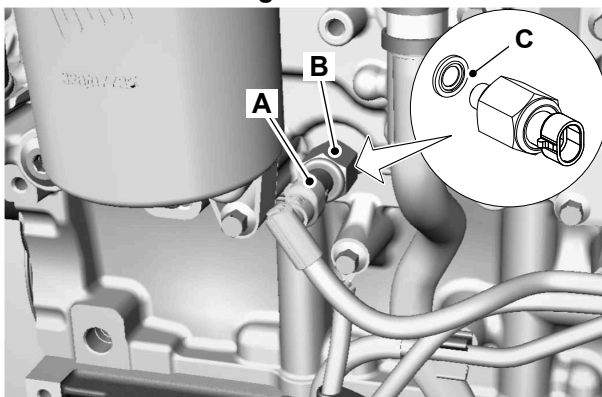
Before Removal

1. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.

Remove

1. Get access to the engine.
2. Disconnect the electrical connector from the engine oil pressure switch.

Figure 186.



- A** Electrical connector
- B** Engine oil pressure switch
- C** Sealing washer

3. Remove the switch.
4. Discard the sealing washer. Plug all the open ports to prevent contamination.

The engine oil pressure switch is a non-serviceable item. If the switch is faulty or damaged it must be renewed.

Install

1. The installation procedure is the opposite of the removal procedure. Additionally do the following steps.
2. Replace the sealing washer.
3. Tighten the engine oil pressure switch to the correct torque value.

Table 101. Torque Values

Item	Nm
B	19–23



18 - Fuel and Exhaust System

Contents	Page No.
Acronyms Glossary	18-2
18-00 Fuel and Exhaust System	
18-00-00 General	18-3
18-09 Filter	
18-09-00 General	18-17
18-09-03 Filter Element	18-20
18-09-09 Pre-Filter Element	18-21
18-12 Water Separator	
18-12-00 General	18-25
18-12-04 Water in Fuel Sensor	18-28
18-18 Injection	
18-18-00 General	18-31
18-18-03 Injector	18-45
18-18-07 Injector Seal	18-54
18-18-12 Rail	18-56
18-18-15 Pump	18-58
18-18-27 High Pressure Rail Valve	18-65
18-21 Fuel Pump	
18-21-00 General	18-69
18-24 Exhaust	
18-24-00 General	18-79
18-24-03 Inlet Manifold	18-81
18-24-04 Outlet Manifold	18-85
18-24-06 Silencer	18-89
18-24-27 Spark Arrestor	18-90
18-27 Exhaust Gas Recirculation (EGR)	
18-27-00 General	18-93
18-27-03 Actuator	18-100
18-30 Aftertreatment System	
18-30-06 Filter	18-103
18-35 Turbocharger	
18-35-00 General	18-107
18-36 Variable Geometry Turbocharger (VGT)	
18-36-00 General	18-115
18-36-03 Actuator	18-123
18-96 Fuel Pipe	
18-96-00 General	18-125
18-96-03 High Pressure Pipe	18-127
18-96-06 Low Pressure Pipe	18-130



Acronyms Glossary

CAN	Controller Area Network
DEF	Diesel Exhaust Fluid
DLA	Data Link Adaptor
DTI	Dial Test Indicator
ECM	Engine Control Module
ECU	Electronic Control Unit
EGR	Exhaust Gas Recirculation
HPV	High Pressure Valve
IMV	Inlet Metering Valve
NOx	Nitrogen Oxide
PWM	Pulse Width Modulation
SCR	Selective Catalytic Reduction
TMAP	Temperature Manifold Absolute Pressure
VGT	Variable Geometry Turbocharger
WIF	Water in Fuel



00 - Fuel and Exhaust System

Contents

Page No.

18-00-00 General 18-3



Notes:

00 - General

Introduction	18-3
Health and Safety	18-4
Technical Data	18-4
Component Identification	18-5
Operation	18-6
Fault-Finding	18-9
Discharge and Pressurise	18-11
Clean	18-11
Check (Pressure)	18-13
Bleed	18-15

Introduction

USE THE CORRECT FUEL. The potential for engine damage due to the use of incorrect or contaminated fuel is much greater with common rail injection technology than with mechanical injection systems. For information about fuel types and cleanliness requirements, refer to Consumable Products. Refer to: [PIL 75-00-00](#). Technical Data, Fuel, Acceptable and Unacceptable Fuels and Cleanliness Requirements.

For information about the fuel injection system. Refer to: [PIL 18-18-00](#).

Common Rail Fuel Injection

The common rail fuel injection system enables the following advantages when compared with mechanical direct injection systems:

- Reduced engine noise.
- Reduced polluting emissions.
- Increased engine performance, higher torque at lower engine speeds in particular.

Unlike mechanical direct injection systems, common rail systems employ electrically operated computer controlled fuel injectors. The high pressure fuel injection pump no longer controls the point of injection but continually supplies pressurised fuel to a common fuel rail.

The injectors are connected to the common rail and inject fuel when supplied with electrical signals from the ECM (Engine Control Module).

Several electrical sensors supply the ECM with engine operating parameters such as engine speed, engine phase (firing order), engine temperature, inlet manifold air pressure and temperature, throttle position etc. Software in the ECM memory is used to interpret the data from the sensors and the fuel injection characteristics are adjusted accordingly.

Prevention of fuel system contamination is even more important than with mechanical direct injection systems. To combat fuel contamination, a water separator and pre-filter is installed in addition to the main filter.

Health and Safety

Fuel

Fuel is flammable, keep naked flames away from the fuel system. Stop the engine immediately if a fuel leak is suspected. Do not smoke while refuelling or working on the fuel system. Do not refuel with the engine running. Completely wipe off any spilt fuel which could cause a fire. There could be a fire and injury if you do not follow these precautions.

Fluid Under Pressure

Fine jets of fluid at high pressure can penetrate the skin. Keep face and hands well clear of fluid under pressure and wear personal protective equipment. Hold a piece of cardboard close to suspected leaks and then examine the cardboard for signs of fluid. If fluid penetrates your skin, get medical help immediately.

WARNING! Do not open the high pressure fuel system with the engine running. Engine operation causes high fuel pressure. High pressure fuel spray can cause serious injury or death.

Notice: Do not allow dirt to enter the fuel system. Before disconnecting any part of the fuel system, thoroughly clean around the connection. When a component has been disconnected, for example a fuel pipe, always install protective caps and plugs to prevent dirt ingress. Failure to follow these instructions will lead to dirt entering the fuel system. Dirt in the fuel system will seriously damage the fuel injection equipment and could be expensive to repair.

Notice: The high pressure fuel system is extremely susceptible to damage if it is contaminated. Always clean the engine using the correct procedures before carrying out maintenance. Contamination of the fuel system can cause catastrophic failure of the engine.

Notice: Running the engine with air in the system could damage the fuel injection pump. After maintenance, the system must be bled to remove any air.

Notice: Clean the engine before you start engine maintenance. Obey the correct procedures. Contamination of the fuel system will cause damage and possible failure of the engine.

CAUTION! It is illegal to pollute drains, sewers or the ground. Clean up all spilt fluids and/or lubricants. Used fluids and/or lubricants, filters and contaminated materials must be disposed of in accordance with local regulations. Use authorised waste disposal sites.

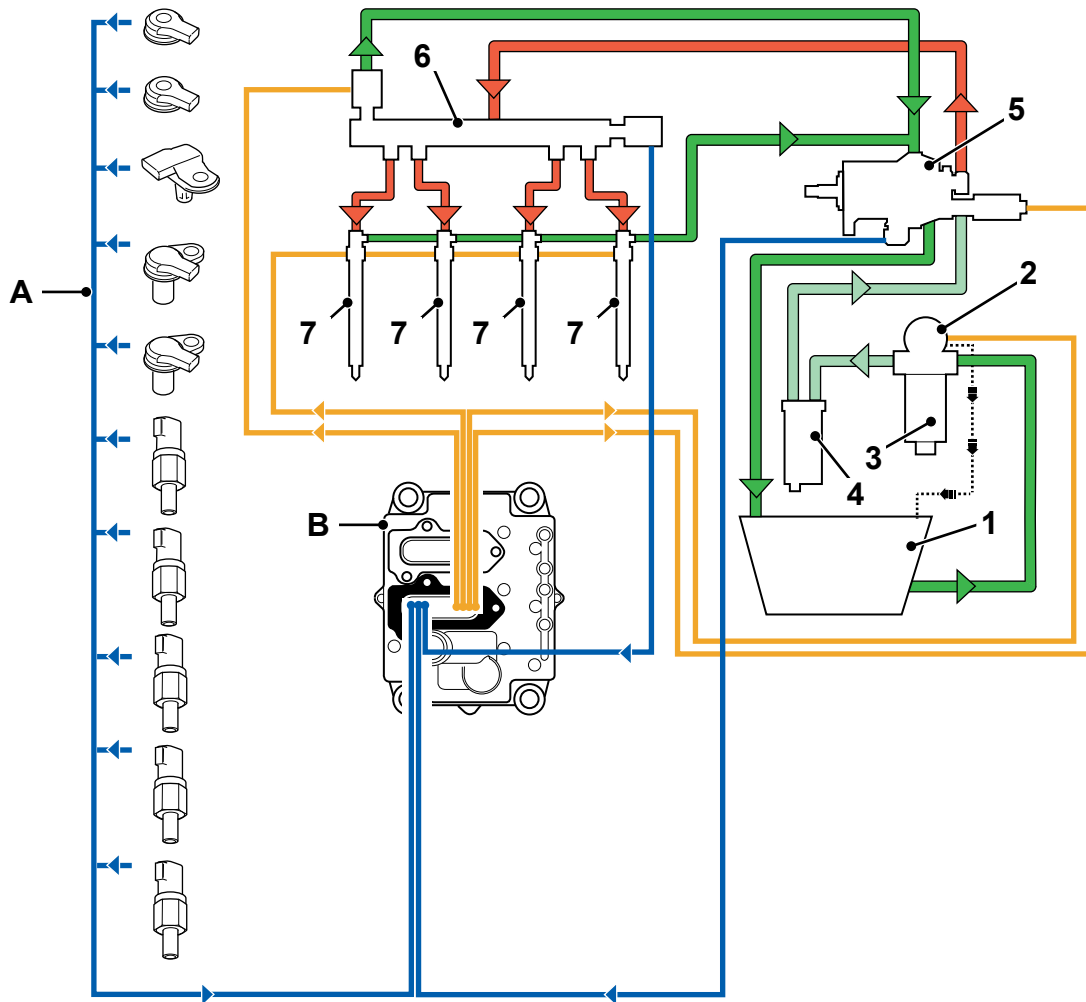
Technical Data

Table 102. Fuel System Data

High pressure pump type	Delphi DFP 4.2
Direction of rotation from drive end	Anti-clockwise
Fuel lift pump type	Electrically operated
Fuel filter micron rating	
Pre-filter	5 micron
Main filter	2 micron
Fuel filter restriction - maximum pressure drop	0.65bar (9.4psi)
Fuel return restriction - maximum	0.22bar (3.2psi)
Injector information	Electronically controlled solenoid actuated injectors. Each injector is marked with a unique calibration code.

Component Identification

Figure 187.



- 1 Fuel tank
- 3 Fuel pre-filter and water separator
- 5 Fuel injection pump
- 7 Fuel injectors
- B ECM (Engine Control Module)

- 2 Fuel lift pump
- 4 Fuel filter
- 6 Fuel rail
- A Engine sensors

Operation

The fuel system is central to the performance and efficiency of the engine, distributing an accurate amount of fuel to each cylinder at exactly the right time.

Fuel is drawn from the fuel tank by the electric lift pump integral via the pre-filter/water separator. (The fuel lift pump is integral with the pre-filter/water separator assembly.)

Fuel is pressurised at low pressure by the electric lift pump and passes through an engine mounted fuel filter on its way to the inlet on the high pressure pump.

Important: Use of the correct fuel grade, together with effective filtration and decontamination of the fuel is essential. The high pressure pump, injectors and engine can be damaged beyond repair by contaminated fuel or use of incorrect fuel.

The high pressure fuel injection pump is a rotary type and is gear driven by the engine. The pump consists of two sections, the transfer pump and high pressure pump. Fuel is first pressurised to about 6bar (87.0psi) by the transfer pump. A constant pressure is maintained regardless of engine speed by the regulating valve.

Fuel is transferred to the high pressure pump via the IMV (Inlet Metering Valve). The metering valve controls the amount of fuel transferred depending on the engine operating parameters (throttle position, coolant temperature etc.). The metering valve is controlled by the ECM (Engine Control Module).

Some fuel flows through the pump at all times to provide internal lubrication and cooling. This fuel bleeds back to tank via the bleed-off fuel lines.

Pressurised fuel from the high pressure pump passes into the common fuel rail. The high pressure pump is capable of pressurising the fuel in the rail up to 2,000bar (28,985.4psi). The ECM controlled IMV is used to control the amount, and therefore pressure of the fuel in the common rail.

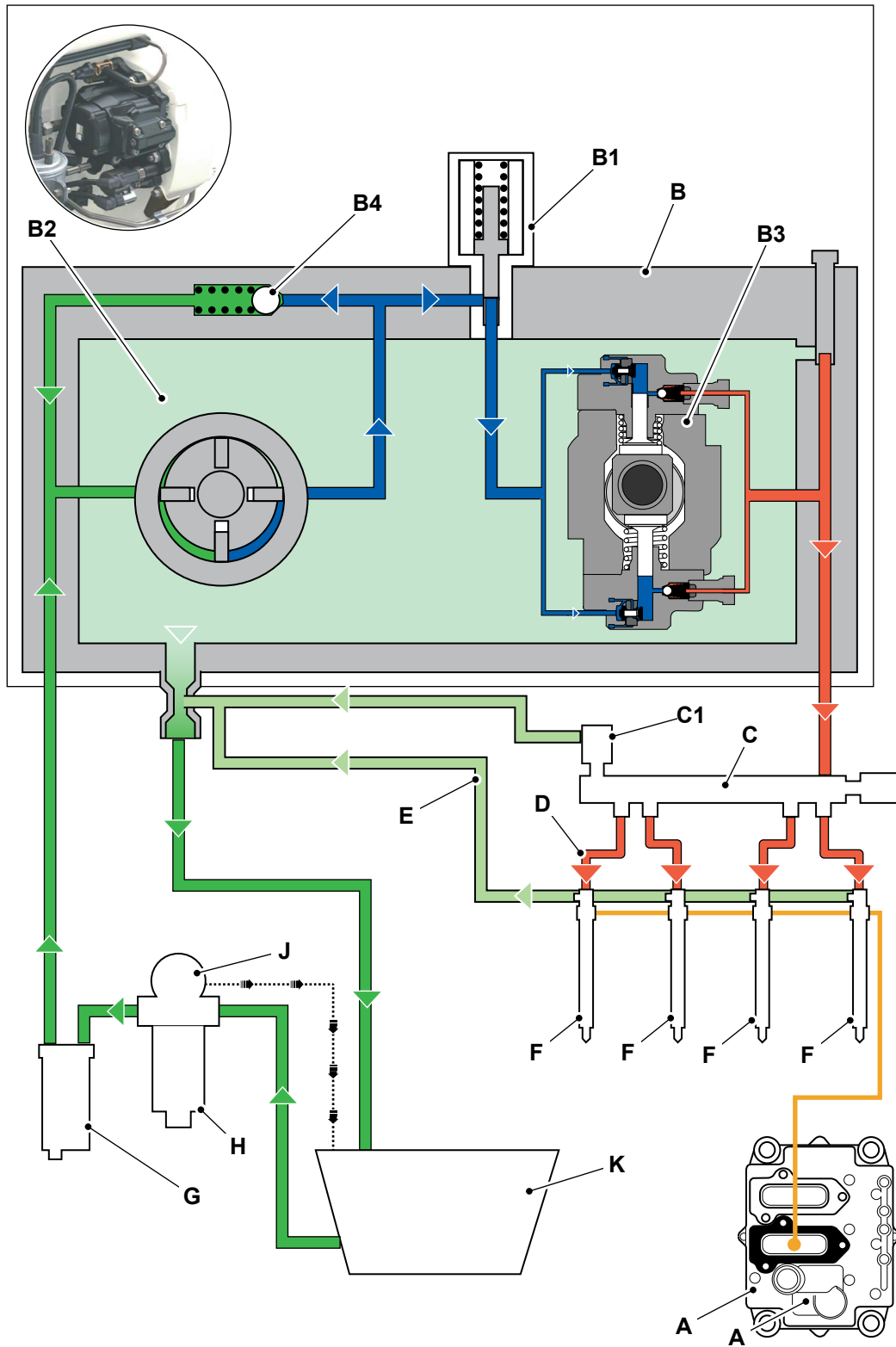
In some operating conditions the inlet metering valve is not able to reduce the rail pressure quickly enough (if the operator goes from full throttle to no throttle suddenly for example). In these circumstances the rail pressure is dumped to the bleed off line using the ECM controlled electric HPV (High Pressure Valve).

High pressure fuel pipes connect the injectors to the common fuel rail. The injectors are electrically controlled and incorporate a small solenoid valve.

Injection timing is determined by the ECM. Electrical data from several sensors is continually monitored and processed by the ECM to determine when, how much and to which cylinder fuel must be injected.

The injectors inject fuel in response to a supply of electrical current from the ECM. So precise is the control that several injections of fuel occur during each firing stroke for maximum efficiency and minimum emissions. During fuel injection some fuel bleeds off the injectors and back to tank via bleed off lines.

Figure 188.



A ECM
B1 IMV

B Fuel high pressure pump
B2 Fuel high pressure pump (transfer section)



- B3** Fuel high pressure pump (high pressure section)
- C** Common fuel rail
- D** High pressure fuel lines
- F** Fuel injectors
- H** Pre-filter/water separator
- K** Fuel tank

- B4** Pressure regulating valve (transfer section)

- C1** HPV
- E** Bleed off fuel lines
- G** Fuel filter
- J** Electric fuel lift pump

Table 103. Colour code key

Colour	Component
Green	Tank pressure
Blue	Transfer pressure
Red	Injection rail pressure
Yellow	Electrical connections -ECM - injectors
Light Green	Pump internal pressure, injector bleed-off



Fault-Finding

Fault

Fuel Consumption Excessive

Table 104.

Page 18-9

Fuel/Oil- Leaking from Exhaust Manifold

Table 105.

Page 18-9

General Fuel System Faults

Table 106.

Page 18-10

Exhaust Gas Recirculation

Table 107.

Page 18-10

Table 104. Fuel Consumption Excessive

Cause	Remedy
Additional load on engine.	Check/repair accessories and vehicle components. Refer to the equipment manufacturer's procedures.
Operator technique.	Review operation for correct gear shifts, deceleration and idling.
Fuel leaks.	Check for external leaks at the fuel tank, fuel lines, filters and lift pump WARNING: Do not repair defective fuel lines. If there is a fuel leak remove and discard the necessary components and install new ones.
Air intake or exhaust leaks.	
Engine compression low in one or more cylinders.	Check the engine compression.
ECM (Engine Control Module) or electrical sensor fault.	Check the electronic fault codes. Check the electrical connections at the ECM and sensors.
One or more engine injectors worn or malfunctioning.	Check the electronic fault codes. Check the electrical connections at the injectors.
Inlet and exhaust valve clearances set incorrectly.	Set the valve clearances to the recommended clearances.

Table 105. Fuel/Oil- Leaking from Exhaust Manifold

Cause	Remedy
Operating for extended periods under light or no load conditions.	Review operation for correct gear shifts, deceleration and idling.
Air intake or exhaust leaks.	
Turbocharger lubricating oil drain line obstructed.	Check/clean line.
Exhaust leak at the Manifold or Turbocharger.	Check/repair leaks in the manifold or turbocharger gaskets. Check for a cracked manifold.
Valve guide seals are leaking.	Replace valve guide stem seals as required.
ECM or electrical sensor fault.	Check the electronic fault codes. Check the electrical connections at the ECM and sensors.
One or more engine injector worn or malfunctioning.	Check the electronic fault codes. Check the electrical connections at the injectors.

Table 106. General Fuel System Faults

Cause	Remedy
Fuel supply fault	Check the low pressure circuit connections are secure.
	Check the fuel pressure in low circuit/tank level.
	Check the fuel type (EN590 Specification).
	Check for the external diesel fuel leaks.
	Check the filter is not blocked
	Check the fuel lift pump operation (Refer to ServiceMaster help files).
	Replace/repair as necessary. If no faults are found, proceed to "Engine does not start," or "Engine starts," depending on symptoms
Engine does not start	Complete the 'Static Injector Leak Test'.
	If the injector back leak is above the limit, replace injector(s) as necessary.
	If the injector back leak is OK check the rail pressure is above 300 bar, if not, replace the high pressure pump.
	If the rail pressure is OK and back leak is within limits, raise Techweb Helpdesk Call.
Engine starts	Complete the 'Dynamic IMV (Inlet Metering Valve) Test'.
	If the IMV is faulty replace the high pressure pump.
	If the IMV is OK complete the 'Dynamic Injector Back leak Test'
	If the back leak is above the limit, replace the injector(s).
	If the back leak is OK complete the 'Dynamic HPV (High Pressure Valve) test'
	If the pump capacity is below the limit, replace the high pressure pump. If the pump capacity is OK, raise Techweb Helpdesk Call.

Table 107. Exhaust Gas Recirculation

Cause	Remedy
Air inlet circuit fault	Check the air inlet circuit: – Valve position using ServiceMaster – Check the EGR (Exhaust Gas Recirculation) linkage – Vane state
	If no fault is found proceed to 'EGR valve connection fault'.
EGR valve connection fault	Check the EGR valve connection. Check that the supply voltage is correct. Repair as necessary.
	Check that the EGR valve position can reach MIN (0%) to MAX position (100%). Use ServiceMaster to launch the learning procedure of the EGR position.

Discharge and Pressurise

▲ **Notice:** Running the engine with air in the system could damage the fuel injection pump. After maintenance, the system must be bled to remove any air.

Obey all fuel system health and safety information.
[Refer to: PIL 18-00-00.](#)

The entry of air into the fuel system can cause problems such as difficult engine starting and unstable engine running. Air can enter the system if the following occurs:

- A fuel system component has been disconnected. For example, a fuel filter renewal.
- A leak in the low pressure side of the fuel system during engine operation, or the low pressure pipes have been disconnected. Refer to Fuel System - General (PIL 18-00) for a more detailed description of the fuel circuit.
- The fuel tank is allowed to drain fully during normal operation.

The engine installation features an electrically operated fuel lift pump. The system is designed to bleed automatically when the lift pump is operated. Make sure that as much air is removed from the fuel as possible before you start the engine. Bleed the system as follows:

Important: DO NOT attempt to bleed the high pressure fuel system by loosening the high pressure pipe connections even when the engine is not running. To bleed the fuel system follow the correct procedure.

1. Turn on the ECU (Electronic Control Unit) override to start the fuel lift pump. DO NOT start the engine. Allow the pump to run for specified duration.
Duration: 30s
2. Turn off the ECU override to stop the fuel lift pump.
 - 2.1. Wait for specified duration and turn the ECU override to start the pump. DO NOT start the engine.
Duration: 10s
 - 2.2. Allow the pump to run for specified duration.
Duration: 30s
3. Repeat step 2 two times more before you start the engine.
4. Start the engine and make sure it runs smoothly.

Clean

Cleanliness Requirements

Important: Additional cleaning must be carried out prior to working on the high pressure fuel system. It is extremely important the high pressure fuel components and the adjacent parts of the engine are meticulously cleaned before any components are removed. Refer to: Effects of Contamination.

Before starting work on the high pressure fuel system, make sure that the working environment is suitable. Refer to: Maintenance Environment, Common Rail Fuel Injection.

1. Obey all fuel system health and safety information.
[Refer to: PIL 18-00-00.](#)
2. Clean the machine, prior to completing any maintenance work.
3. Clean the engine.
[Refer to: PIL 15-00-00.](#)
4. Remove the hoses, electrical harnesses and ancillaries to improve access and expose any remaining trapped dirt close to the relevant high pressure components.
5. Wash away any remaining dirt or debris and then dry the area using a compressed air jet. When the area is dry use a soft clean brush to remove sand or grit particles that remain.

Effects of Contamination

Whilst the requirement for a good level of cleanliness is well known and common practice, the introduction of high pressure common rail fuel injection necessitates working to new levels of cleanliness.

Once inside the system, fuel circuit contaminants greatly affect the performance and life of the fuel injection equipment. For example, contaminants in the fuel pump will develop internal wear to cause internal leakage and hence lower discharges. Use of poor quality fuels and poor maintenance could also lead to contaminants entering the fuel injectors. There is a possibility of catastrophic equipment failure if debris should prevent the injectors from fully closing. The main contaminants can be classified as follows:

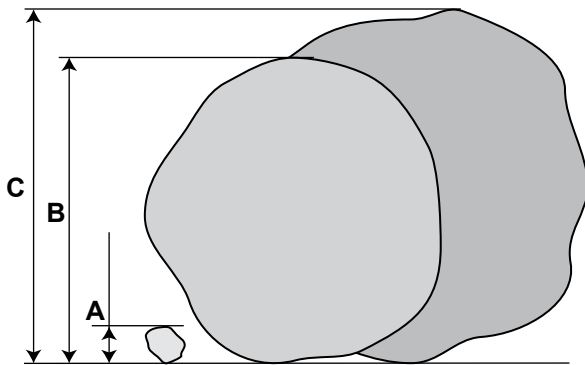
- Solid Particles - sand, fibres, metallic particles, welding scale, sealing materials and wear particles etc.
- Liquid - usually water and incompatible oils and greases.

- Gases - Air, sulphur dioxide etc. which can create corrosive compounds if dissolved in the fluid.

These contaminants can appear during manufacture, assembly, operation and maintenance.

The main filter is rated at 2 micron = 0.002 mm (0.0007874 in). The pre-filter is rated at 5 micron. Listed are a few typical comparisons of micron size:

Figure 189.



- A** 8 Microns
- B** 70 Microns
- C** 100 Microns

- Red Blood Cell = 8 microns (0.008 mm, 0.000315 in).
- Human Hair = 70 microns (0.07 mm, 0.00275 in).
- Grain of Salt = 100 microns (0.1 mm, 0.00394 in).
- The smallest particle visible to the naked eye is 40 microns (0.00157in) approximately.

The main filter and pre-filter must be changed in accordance with the applicable service schedule and procedures. The water in fuel sensor must be maintained to ensure correct operation at all times.

The potential for engine damage due to fuel contamination is much greater when using common rail injection technology than with mechanical injection systems. This is because common rail requires components with smaller manufacturing tolerances, especially the fuel injectors. In addition, common rail operates at much higher fuel pressures, over five times that of mechanical systems.

Similar pressures are used by commercial water jet cutting machines to cut metal. Fortunately clean diesel fuel has lubricating qualities that prevents erosion of components but it is obvious that contaminated fuel will cause serious damage at such high pressures.

Maintenance Environment, Common Rail Fuel Injection

Depending on circumstances engine maintenance may be required in various working environments. Obviously procedures are best carried out in a dedicated workshop equipped with a suitable clean room, but in practice this is not always possible.

Maintenance procedures requiring removal or replacement of fuel system components, particularly high pressure components, require special precautions to make the working environment suitable, reducing the risk of contamination to an absolute minimum.

Use the following guidelines to make sure you reduce the chances of fuel system contamination when working in different environments:

Worksite - Open to weather

This repair site is not an acceptable location. Only in extreme circumstances should a machine be repaired on an open site. Use the guidelines below:

- Clean the engine, [Refer to: PIL 15-00-00](#). If the machine is on hard standing, clean away the material washed from the engine.
- Place suitable clean boards on the ground around the machine.
- Erect clean plastic sheeting to shelter the engine from wind and rain.
- Wear a new disposable environmental type suit when working on the fuel system. If the suit becomes contaminated with mud, move away from the engine and change into a new suit.
- Use clean latex gloves (non-powdered).
- Before you start work make sure that all the required replacement parts and tools are on site. Make sure that the replacement parts are still sealed inside their packaging.
- Cap all exposed ports and orifices immediately. Do not leave them open.
- High pressure fuel pipes **MUST BE REPLACED** if any pipe joint is loosened or disconnected. **DO NOT** re-use the original pipe.

Worksite - Closed to weather from above

This repair site is the least acceptable condition, if possible move the machine to a more suitable environment. Use the guidelines below:

- Clean the engine, [Refer to: PIL 15-00-00](#). Clean the floor of all material washed from the engine.
- Place suitable clean boards on the ground around the machine.

- Erect clean plastic sheeting to shelter the engine from the wind and the possibility of debris such as dirt and dust falling from above.
- Wear a new disposable environmental type suit when working on the fuel system. If it becomes contaminated with mud, move away from the engine and change into a new suit.
- Use clean latex gloves (non-powdered).
- Before you start work make sure that all the required replacement parts and tools are on site. Make sure that the replacement parts are still sealed inside their packaging.
- Cap all exposed ports and orifices immediately. Do not leave them open.
- High pressure fuel pipes **MUST BE REPLACED** if any pipe joint is loosened or disconnected. **DO NOT** re-use the original pipe.

Vehicle Maintenance Workshop

Unless the workshop has a dedicated 'sealable clean room' work bay, precautions must still be taken.

- Clean the engine, [Refer to: PIL 15-00-00](#).
Clean the engine in the dedicated area and then move it to the workshop.
- Clean the floor area around the machine.
- Erect clean plastic sheeting to shelter the engine from any wind and the possibility of debris such as dirt and dust falling from above.
- Ensure that workshop doors to the outside are kept closed. A gust of wind through an open door will easily blow sand particles into the air.
- Make sure your work wear is clean, non-flocking and lint free. If in doubt wear a new disposable environmental type suit.
- Use clean latex gloves (non-powdered).
- Before you start work make sure that all the required replacement parts and tools are on site. Make sure that the replacement parts are still sealed inside their packaging
- Cap all exposed ports and orifices immediately. Do not leave them open.
- High pressure fuel pipes **MUST BE REPLACED** if any pipe joint is loosened or disconnected. **DO NOT** re-use the original pipe.

Check (Pressure)

When it is necessary to check the fuel rail pressure function on a faulty vehicle, it is often difficult to decide which component of the system has failed. It is essential to keep in mind the principles of the function of the Common Rail Fuel system:

Table 108.

Principle	Function
Pressure production	The pump compresses the fuel at high pressure
Pressure regulation	The pressure thus produced is accumulated in a rail and measured and regulated (the rail pressure sensor, the ECU (Electronic Control Unit) and the IMV (Inlet Metering Valve) function in a closed loop, excess pressure is drained to tank by the HPV (High Pressure Valve)
Pressure consumption	This pressure is finally consumed by the injectors (injection into the engine cylinders and injector management)

This means that a pressure fault may come from the producer, the regulator or the consumers. Simply studying the physical parameters of the rail pressure does not allow the disassociation of the producer and the consumer.

Symptoms

- The engine won't start or is difficult to start.
- The engine stalls while running.
- Lack of power and dashboard warning lamps light: the recovery mode may lead to engine stop.

Fuel Flow Status Analysis

Fuel flow balance is established as follows:

Injected flow + Back leaks flow (Flow consumed)
= Capacity of the HP pump to supply the flow requested for a given diesel fuel temperature

Fuel flow balance is upset if:

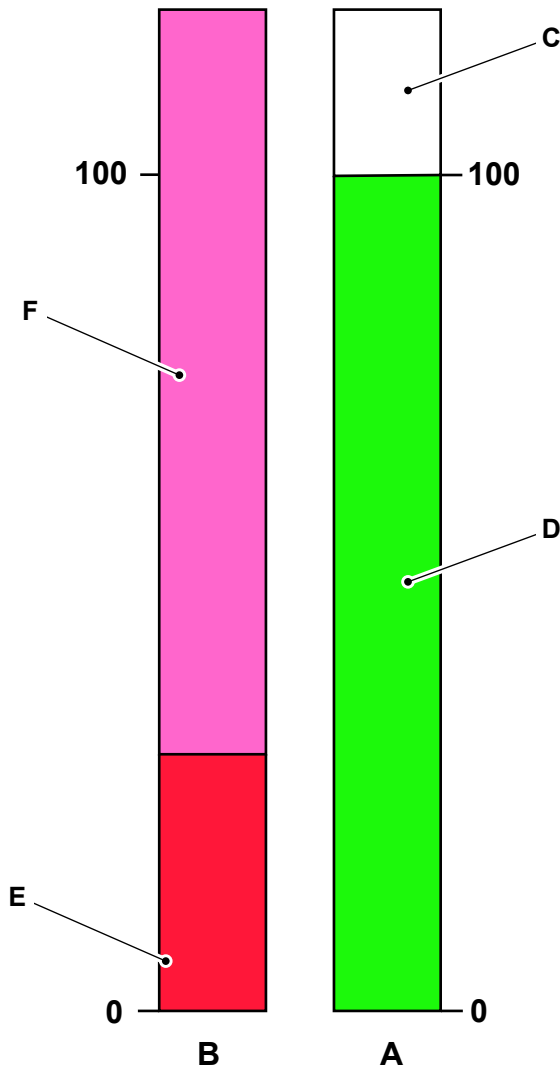
- The Injector back leak flow increases sharply, exceeding the pump capacity.
- This can happen when particles disturb the internal injector sealing, increasing the back leak flow from one/several injectors or HPV

Examples:

- Heavy contamination of the fuel wear and tear on the pump leads to the production of metallic particles that will seriously disturb the injector function.
- Mechanical wear in the injector.
- HPV stuck open.

The capacity of the pump to supply the required pressure is reduced due to internal pump wear, pressure is reduced due to internal pump wear or a fuel feed problem.

Figure 190. Increased Back Leak Flow



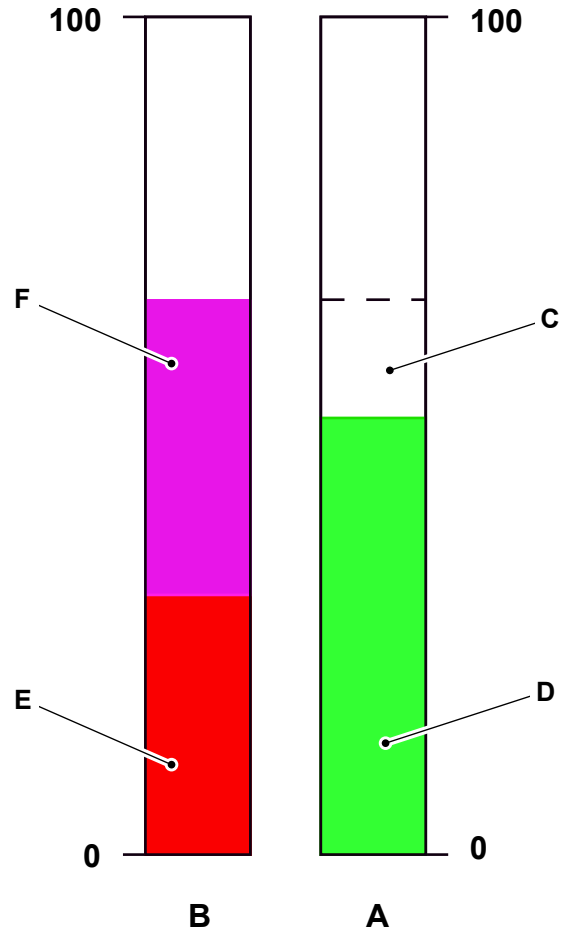
- A Production
- B Consumption
- C Increased back leak flow
- D Pressure deficit
- E Pump capacity
- F Injected flow

Example

- Presence of air in the low pressure circuit.

- Excessive negative pressure at the pump inlet (< -300m Bar, fuel filter blocked).
- Mechanical wear in the pump.
- Excessive pump inlet temperature.

Figure 191. Reduction in HP Pump Capacity



- A Production
- B Consumption
- C Reduction in HP pump capacity
- D Pressure deficit
- E Pump capacity
- F Injected flow
- G Back Leak flow

Bleed

▲ **WARNING** Do not open the high pressure fuel system with the engine running. Engine operation causes high fuel pressure. High pressure fuel spray can cause serious injury or death.

WARNING Bleeding of the high pressure fuel system by opening the high pressure lines is not required. High fuel pressure can persist for a period of time when the engine has stopped. High pressure fuel spray can cause serious injury or death.

The engine installation contains an electrically operated fuel lift pump. The system is designed to bleed automatically when the lift pump is operated. Make sure that as much air is removed from the fuel as possible before the engine is started.

Do not try to bleed the high pressure fuel system by loosening high pressure pipe connections even when the engine is stopped. To bleed the fuel system follow the steps below.

1. Turn on the ignition to start the fuel lift pump.
2. Do not start the engine. Allow the pump to run for the specified time.
Duration: 30s
3. Turn off the ignition key.
 - 3.1. Wait for the specified time and turn the ignition key to start the pump.
Duration: 10s
 - 3.2. Do not start the engine. Allow the pump to run for the specified time.
Duration: 30s
4. Repeat 3 two more times before you start the engine.
5. Start the engine and make sure it runs smoothly.



09 - Filter

Contents	Page No.
18-09-00 General	18-17
18-09-03 Filter Element	18-20
18-09-09 Pre-Filter Element	18-21



00 - General

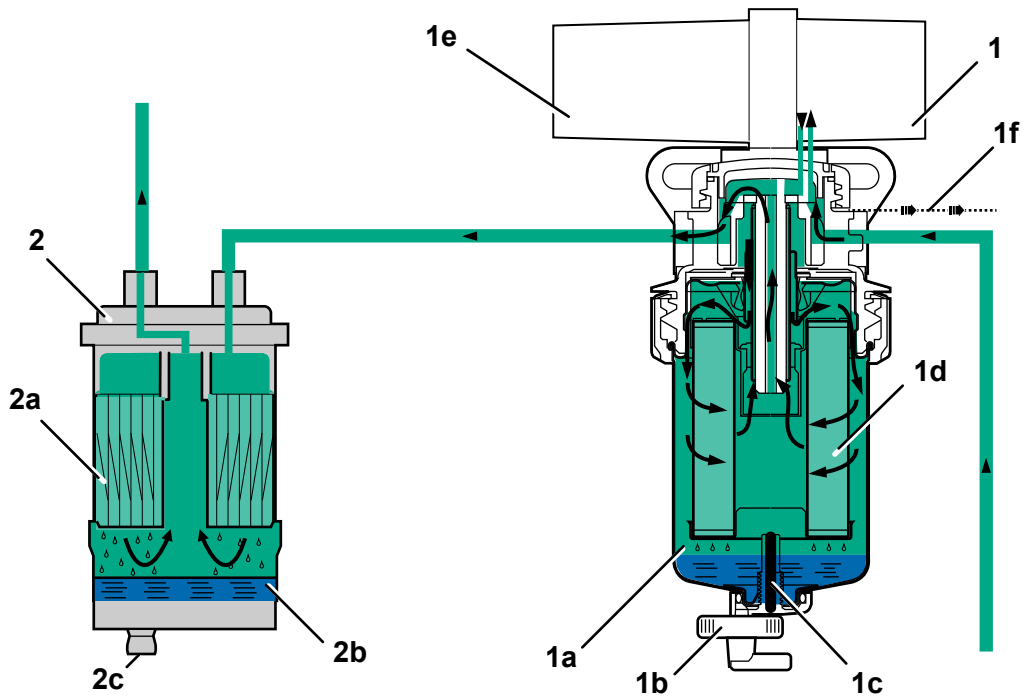
Introduction 18-17
Component Identification 18-18
Operation 18-19
Drain and Fill 18-19

Introduction

The fuel filter consists of filtration media folded in such a way as to give a very large surface area. This is known as the filter element. It is most important that the fuel filter is changed regularly in accordance with the machine maintenance schedule. Use only the correct specification filters.

Component Identification

Figure 192.



- 1 Fuel pre-filter/ water separator
- 1b Drain screw
- 1d Fuel filter element
- 1f Air bleed to tank
- 2a Filtration media
- 2c Drain screw

- 1a Water bowl
- 1c Water level probe
- 1e Electric lift pump
- 2 Fuel filter
- 2b Sediment bowl

Operation

The fuel pre-filter works under suction. The fuel is pulled through the filter media by the fuel lift pump where any dirt particles or water droplets are retained. Water droplets congeal and drop down into the integral water sediment bowl. The water can be drained off by means of a drain valve in the bottom of the water sediment bowl.

Drain and Fill

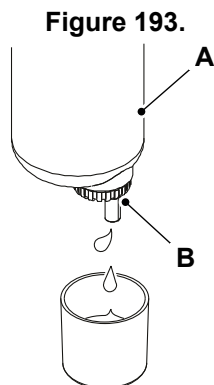
1. Make the machine safe
[Refer to: PIL 01-03.](#)
2. Drain off any water in the filter element by turning the drain valve. Any fuel and water mix drained must be disposed of in accordance with local regulations. Do not reuse the drained fuel.
3. Drain off any water in the water separator bowl. Any fuel and water mix drained must be disposed of in accordance with local regulations. Do not reuse the drained fuel.

03 - Filter Element

Remove and Install

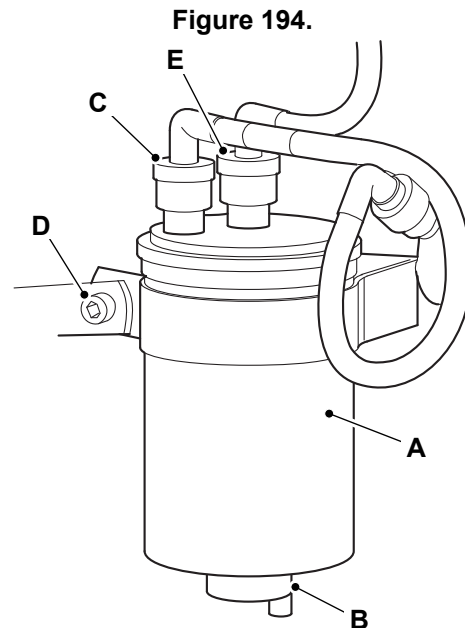
Before Removal

1. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.
2. Get access to the filter.
 - 2.1. On some machines the filter is located on the engine. Other machines have remotely located filters. There may be more than one filter. Refer to the relevant service point information for details.
3. Thoroughly clean the outside of the filter housing and around the filter head.
4. On machines with a fuel shut-off valve, set the valve to isolate the fuel supply.
5. Loosen the drain tap and allow the water / fuel to drain into a suitable container.



- A** Fuel filter element
B Drain tap

Remove



- A** Filter
B Drain tap
C Low pressure fuel line
D Screw
E Low pressure fuel line

1. Remove the low pressure fuel lines.
 - 1.1. Put a label on the hoses to help installation.
 - 1.2. Plug all the open ports and hoses to prevent contamination.
2. Release the filter strap retaining screw and lift the filter upward.

Install

1. Make sure that the filter is in the correct position to enable connection of the fuel lines.
2. Install the filter strap.
 - 2.1. Tighten the filter strap to the correct torque value.
 Torque: 24N·m
3. Install the low pressure fuel lines.
 - 3.1. Make sure they are installed at the correct ports.
4. Open the fuel shut-off valve (if applicable).
5. Bleed the fuel system. Refer to applicable engine service manual.

Refer to: servicepro.jcb.com.



09 - Pre-Filter Element

Introduction 18-21
Remove and Install 18-22

Introduction

The fuel pre-filter with water separator is installed on to the fuel lift pump. The fuel lift pump is a sealed integral electrical unit.

Remove and Install

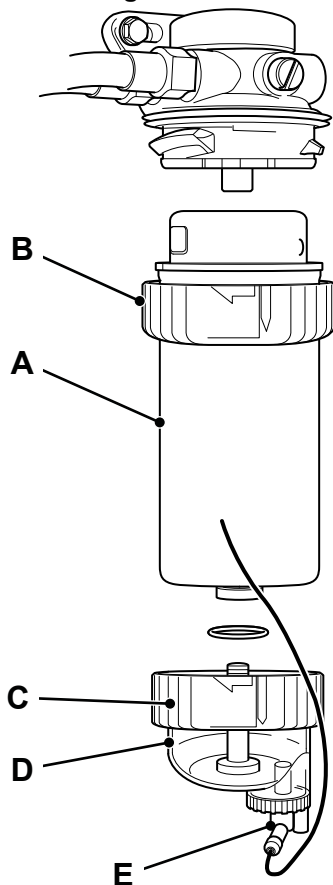
Remove

1. Make the machine safe.
2. Get access to the filter.
3. On machines with a fuel shut off valve, set the valve to isolate the fuel supply.
4. Drain the water separator bowl.
5. Disconnect the water in fuel sensor.
6. Release the locking ring and remove water separator bowl. Any fuel and water mix drained must be disposed of in accordance with local regulations. Do not reuse the drained fuel.
7. Release the locking ring and remove the filter element, discard the element.

Install

1. The installation procedure is the opposite of the removal procedure. Additionally do the following steps.
2. Install a new filter element and secure in position with the locking ring.
3. Make sure that the water in fuel electrical connector is correctly installed.
4. On machines with a fuel shut-off valve, set the valve to connect the fuel supply.

Figure 195.



- A Filter Element
- B Filter element locking ring
- C Water separator bowl locking ring
- D Water separator bowl
- E Water in fuel electrical connector



12 - Water Separator

Contents	Page No.
18-12-00 General	18-25
18-12-04 Water in Fuel Sensor	18-28



Notes:

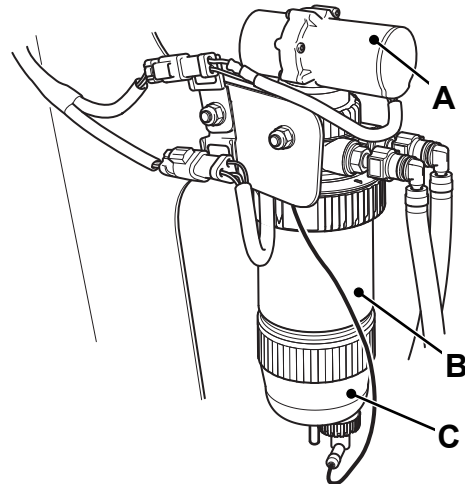
00 - General

Introduction	18-25
Drain and Fill	18-26
Clean	18-26
Remove and Install	18-27

Introduction

The water separator with fuel pre-filter and the fuel lift pump is a sealed integral electrical unit. The assembly is a non-serviceable component. If any part is defective, replace the complete pump, filter and separator assembly.

Figure 196.



- A** Fuel lift pump
- B** Fuel pre- filter
- C** Water separator

The pre-filter/water separator is designed to separate water and dirt from the fuel using a special chemically treated paper filter element. A bowl installed in the bottom of the trap collects the water removed from the fuel.

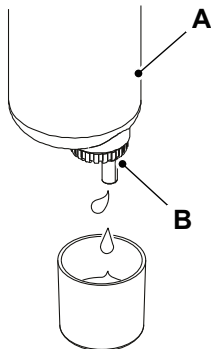
The bowl is installed with an electric probe which senses when the water is above a preset level. The probe enables a suitable alarm/indicator device. Water can be drained off by means of the drain screw installed in the base of the bowl. It is essential that the water trap is drained regularly. Water must be drained immediately if the probe signals an alarm.

Refer to fuel and exhaust system, filter, component identification, (PIL 18-09).

Drain and Fill

1. Obey all fuel system health and safety information.
Refer to: [PIL 18-00-00](#).
2. Make the machine safe.
Refer to: [PIL 01-03](#).
3. Drain off any water in the filter element by turning the tap.
4. Drain off any water in the water separator bowl by turning the tap. Do not disconnect the water in fuel electrical connector (if installed).
5. If there is sediment in the bowl after draining, support the bowl and release the locking ring.
6. Wash the bowl in clean fuel.
7. Install the bowl, secure in position with the locking ring.
8. Make sure that the water in fuel electrical connector is correctly installed.

Figure 197. Typical Engine



- A** Fuel filter
- B** Drain tap

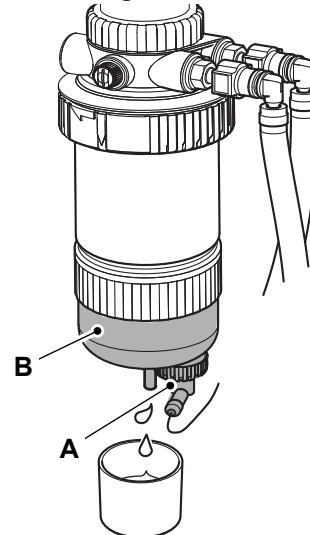
Clean

(For: G70RS [HXN])

Draining the Water Separator

1. Make the machine safe.
2. Get access to the filter.
3. If there is water but no sediment, open the tap to drain the water. If there is any sediment in the bowl replace the fuel filter element. Do not disconnect the electrical connector (if installed).
4. Tighten the drain tap when all the water is drained.

Figure 198.



- A** Tap
- B** Bowl



Remove and Install

Refer to Fuel and Exhaust system - Filter - Pre-Filter Element. [Refer to: PIL 18-09.](#)



04 - Water in Fuel Sensor

Introduction 18-28
Remove and Install 18-29

Introduction

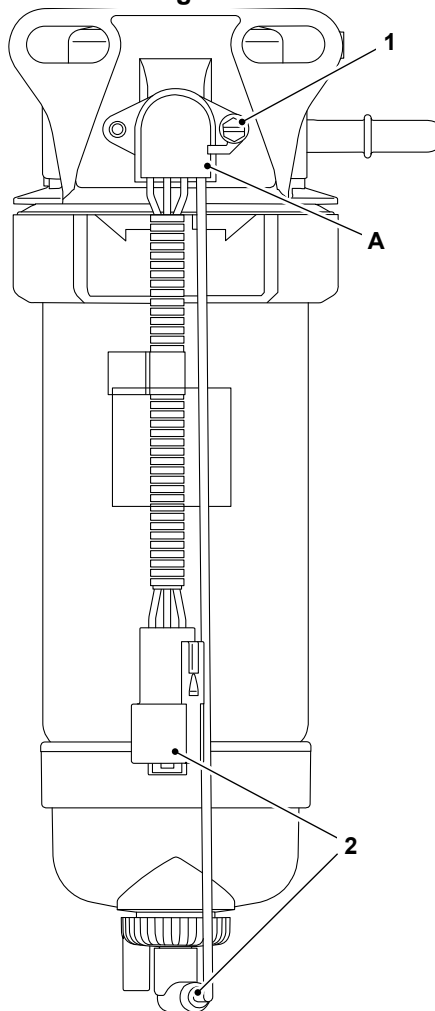
The water in fuel sensor is installed in the fuel filter water bowl. A warning light will illuminate in the instrument panel to indicate that water has accumulated in the fuel filter water bowl and must be drained.

Remove and Install

Remove

1. Make the machine safe.
[Refer to: PIL 01-03.](#)
2. Remove the ignition key.
3. Get access to the fuel filter.
4. Disconnect the electrical connections.
5. Remove the sensor fixing screw.
6. Remove the sensor.

Figure 199.



- 1 Fixing screw
- 2 Electrical connections
- A Water in fuel sensor

Install

1. The installation procedure is the opposite of the removal procedure.



18 - Injection

Contents	Page No.
18-18-00 General	18-31
18-18-03 Injector	18-45
18-18-07 Injector Seal	18-54
18-18-12 Rail	18-56
18-18-15 Pump	18-58
18-18-27 High Pressure Rail Valve	18-65

00 - General

Introduction	18-31
Component Identification	18-32
Operation	18-33
Fault-Finding	18-36
Check (Operation)	18-43

Introduction

Fuel at rail pressure is continuously supplied to the injectors via high pressure fuel pipes.

The high pressure fuel injector fuel pipes consist of thick walled, seamless steel tubing. The ends of the tubes are formed with conical nipples for sealing in the sealing cones on the common rail and on the injector at port. It is essential that the tubes are maintained and installed correctly for safe and effective engine operation.

Important: If the high pressure fuel pipes are removed for any reason they must be renewed. Installing the original fuel pipes will cause fuel leaks at the pipe connections.

Fuel injection takes place when the solenoid coil is energised by the ECM (Engine Control Module).

Combustion

The engine employs a direct injection system. Fuel is injected directly into the cylinder, the mixing taking place in the combustion chamber which is recessed into the crown of the piston.

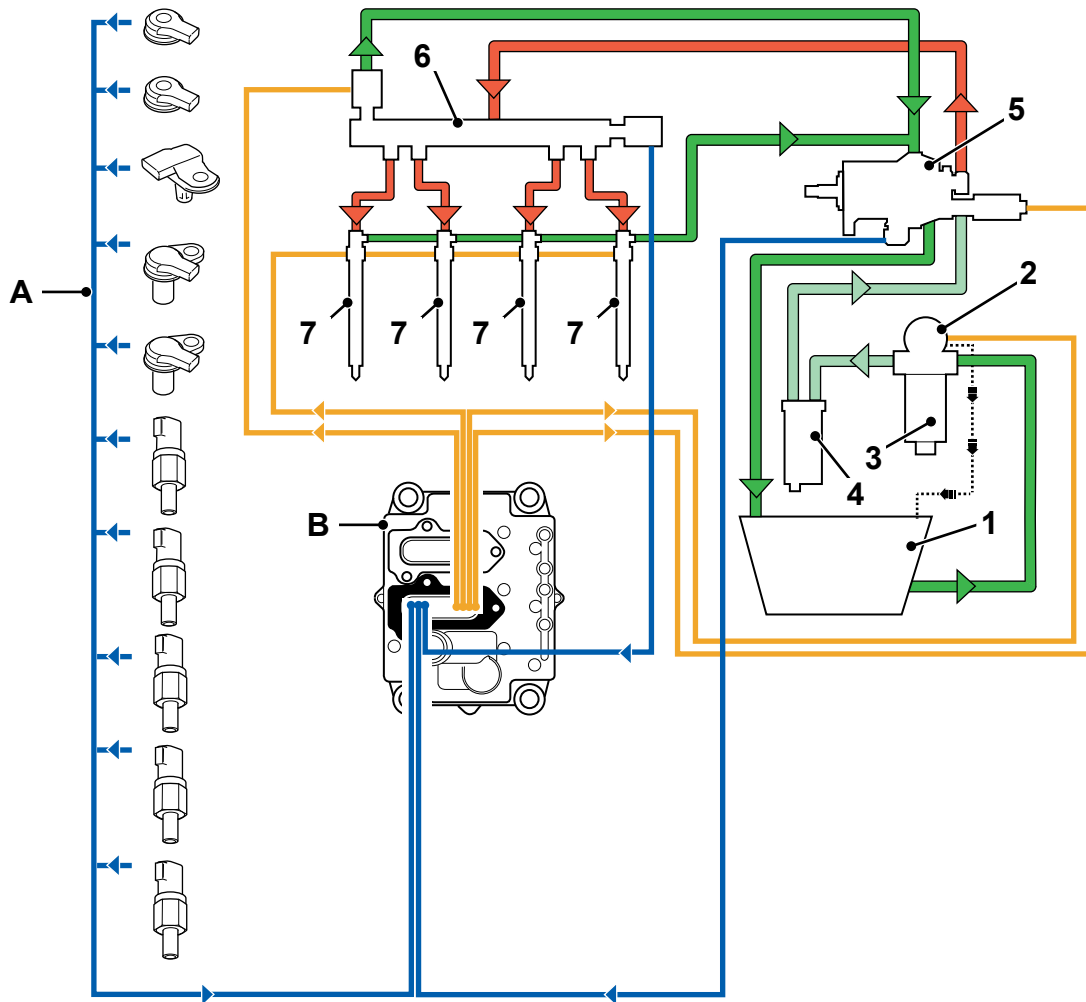
The process of mixing starts during the induction stroke and continues throughout the compression stroke. The inlet porting and combustion chamber are carefully designed to ensure that when the fuel is injected it is mixed thoroughly with the air.

The multi-point injector and high injection pressure ensure a good distribution of fuel throughout the air which aids mixing. The mixing process continues until combustion is complete.

To further enhance efficient combustion, the ECM initiates several separate injections of fuel during the compression stroke. The timing of the fuel injections is also varied by the ECM depending on engine operating parameters.

Component Identification

Figure 200.

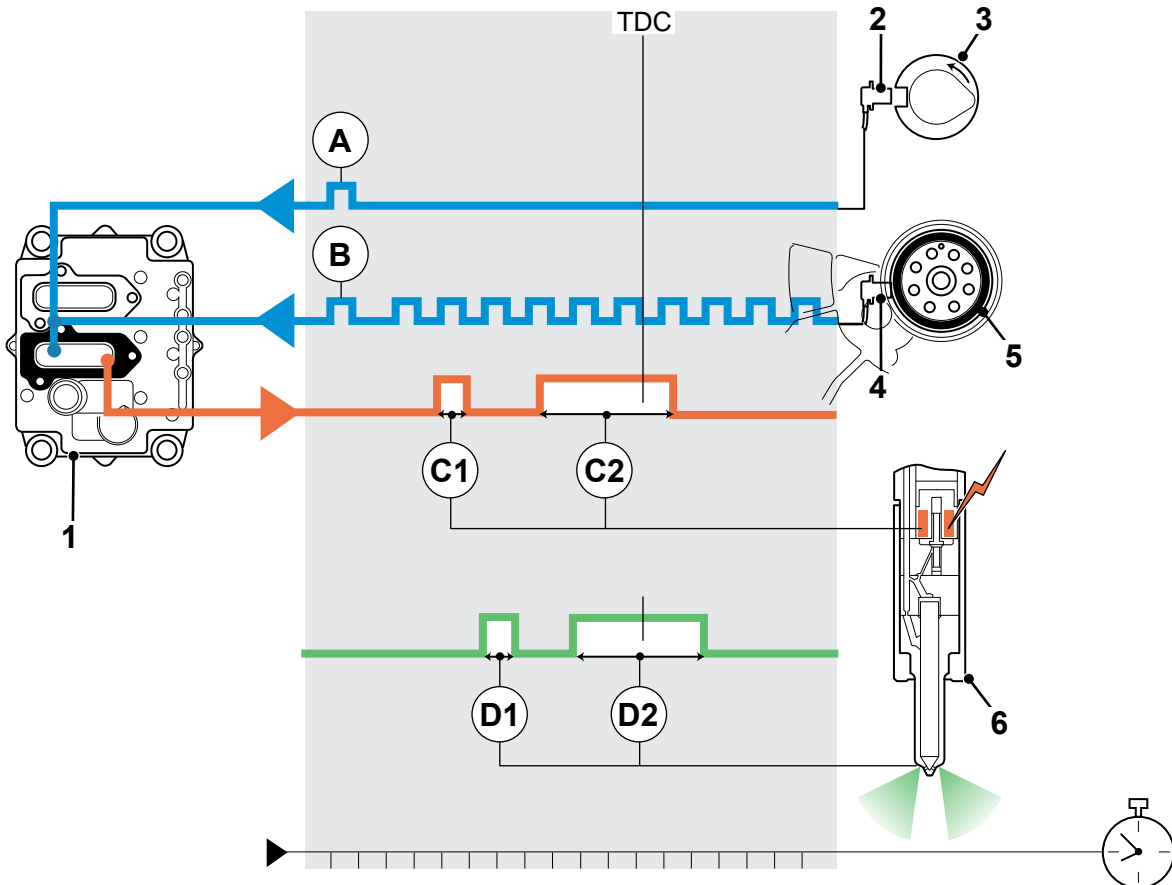


- | | |
|---------------------------------------|------------------|
| 1 Fuel tank | 2 Fuel lift pump |
| 3 Fuel pre-filter and water separator | 4 Fuel filter |
| 5 Fuel injection pump | 6 Fuel rail |
| 7 Fuel injectors | A Engine sensors |
| B ECM (Engine Control Module) | |

Operation

Fuel Injection Cycle

Figure 201.



- | | |
|--|--|
| <p>1 ECM (Engine Control Module)</p> <p>3 Camshaft target disc</p> <p>5 Crankshaft mounted target disc</p> <p>A Camshaft sensor signal - Signal is generated by camshaft target disc 3 and sensor 2. Processed by the ECM 1 to determine which cylinder to inject.</p> <p>C1-C2 Current pulse - injector solenoid coil - Sent to the injector (6) solenoid coil by the ECM 1 to initiate injection. Time of pulse calculated by the ECM to control the amount of fuel injected. Pulse C1 controls pilot injection. Pulse C2 controls the main injection.</p> <p>TDC Top dead centre - Shows when piston is at top dead centre in relation to the injection sequence.</p> | <p>2 Camshaft position sensor</p> <p>4 Crankshaft position sensor</p> <p>6 Fuel injector</p> <p>B Crank position sensor signal - Signal is generated by crankshaft mounted target disc 5 and sensor 4. Processed by the ECM 1 to determine timing of injection.</p> <p>D1-D2 Fuel Injection - Start and duration of actual injection. It can be seen that there is a time shift between the current pulse and actual injection. This is due to electrical resistance and the individual characteristics on the fuel injector assembly 6. D1 indicates the pilot injection and D2 the main injection. Total fuel injected for one cycle = D1 + D2.</p> |
|--|--|

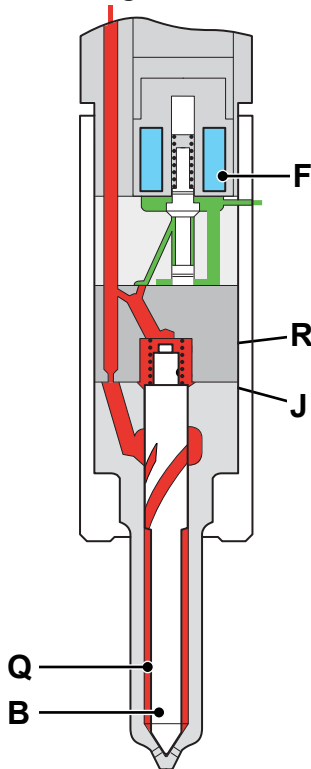
Injection Cycle

It is important to remember that the injector solenoid coil does not directly lift the injector needle. Instead it operates a tiny valve which causes a fuel pressure imbalance inside the injector. In this way the needle is lifted hydraulically. The method of operation is as follows:

State 1 - No fuel injection

The solenoid coil is not energised. Fuel at rail pressure fills the small chamber around the needle. Fuel at rail pressure also fills the control chamber. Since the surface area of the needle inside the control chamber is greater than the area inside chamber the needle is held on its seat by hydraulic (fuel) pressure. Spring holds the needle on its seat when the engine is stopped (when the rail pressure is low or zero).

Figure 202.



- B Needle
- F Solenoid coil
- J Spring
- Q Small chamber
- R Control chamber

State 2 - Fuel injection start

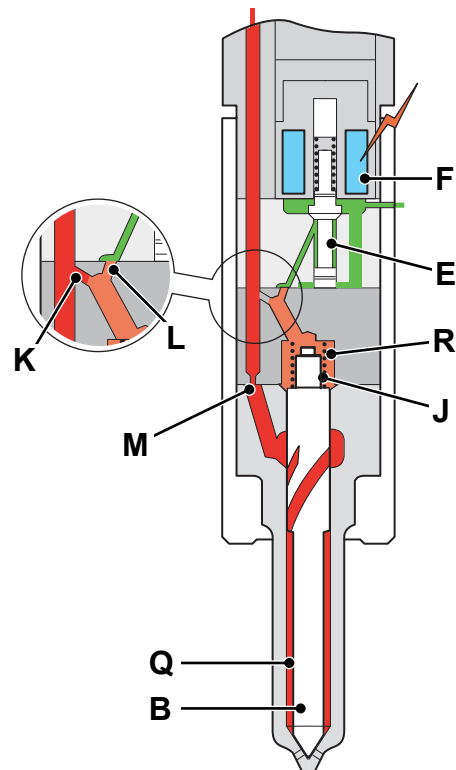
At the commencement of fuel injection the solenoid coil is energised by the ECM. The solenoid coil lifts spool valve off its seat. Fuel at rail pressure is allowed

to bleed from the control chamber and ultimately back to the fuel tank via the bleed off lines.

Although the control chamber is still connected to the rail pressure different sized metering orifices K and L cause the pressure in the chamber to fall below the rail pressure. The metering orifice ensures full rail pressure is maintained in the chamber around the needle.

When the pressure imbalance in the chambers is sufficient to overcome spring the needle lifts and injection begins.

Figure 203.

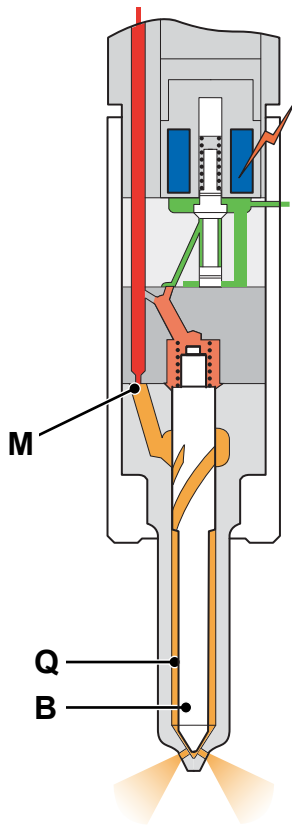


- B Needle
- E Spool valve
- F Solenoid coil
- J Spring
- K Metering orifice
- L Metering orifice
- M Metering orifice
- Q Small chamber
- R Control chamber

State 3 - Fuel injection

When the flow of fuel to the injection nozzle is established the metering orifice causes a pressure drop in the small chamber. Since the needle is now lifted its surface area subjected to the pressure in the small chamber is increased. The force is sufficient to keep the needle lifted.

Figure 204.



- B** Needle
- M** Metering orifice
- Q** Small chamber

State 4 - Fuel injection stop

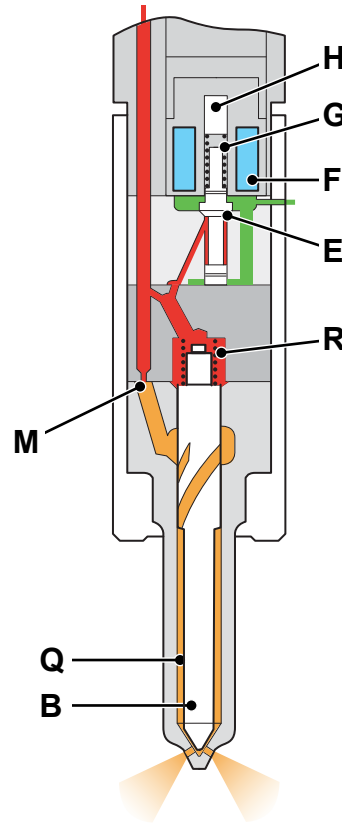
To stop fuel injection the ECM de-energises the solenoid coil. The spool valve is pushed on to its seat by the force of the spring. Fuel no longer bleeds from the control chamber.

A calibration dowel, selected during manufacture, is used to finely set the force from the spring.

Fuel pressure inside the control chamber reaches the rail pressure. Since the needle is lifted its surface area under pressure from the fuel in the small chamber is increased. Force from the fuel in the control chamber is now insufficient to push the needle on to its seat.

The only way to push the needle on to its seat is to reduce the fuel pressure in the small chamber. This is achieved by the metering orifice. As fuel flows through the metering orifice a pressure drop in the small chamber is produced. The needle is forced on to its seat by pressure in the control chamber. Fuel injection stops.

Figure 205.



- B** Needle
- E** Spool valve
- F** Solenoid coil
- G** Spring
- H** Calibration dowel
- J** Spring
- M** Metering orifice
- Q** Small chamber
- R** Control chamber

Fault-Finding

Fault

Injector Calibration	Table 109.	Page 18-36
Injector Trim Codes	Table 110.	Page 18-36
Open Circuit Injector	Table 111.	Page 18-37
Injection Bank	Table 112.	Page 18-37
Short Circuit Injector	Table 113.	Page 18-38
Engine Low on Power	Table 114.	Page 18-38
Injector Calibration	Table 115.	Page 18-39
Open Circuit Injector	Table 116.	Page 18-39
High Pressure Injection Diagnostics	Table 117.	Page 18-40
Fuel Rail Pressure Calibration	Table 118.	Page 18-40
IMV	Table 119.	Page 18-41
HPV	Table 120.	Page 18-41

Table 109. Injector Calibration

Cause	Remedy
Old/incorrect software version	<p>Check if the software is up to date or new software that will solve this problem is available. Upgrade as necessary. Re-flash the injector calibration codes, respecting power down and up delay and taking care of injector position; erase all the faults.</p> <p>If no fault is found proceed to 'Injector cylinder position and value fault'</p>
Injector cylinder position and value fault	<p>Check that 'individual injector corrections' are correctly entered in ECM (Engine Control Module). Check the cylinder position and value.</p> <p>If no faults is found, proceed to 'Injector program fault'.</p>
Injector program fault	<p>Re-flash the injector calibration codes, respecting power down and up delay and taking care of injector position; erase all the faults.</p>
Electrical connection faulty	<p>Check the knock sensor connection and screw torque, repair as necessary. Note: Check the ground shield connection of knock sensor.</p> <p>If no knock sensor is installed, raise Techweb Helpdesk call.</p>

Table 110. Injector Trim Codes

Cause	Remedy
Sensor connection fault	<p>Check the following sensors and make sure they work correctly. – Knock sensors – Water temperature sensor – Air temperature sensor – Fuel temperature sensor – Barometric pressure sensor (built inside the ECM).</p> <p>Check the knock sensors connection and screwing torque (Check particularly the ground shield connection). Repair as necessary and re-enter all injector calibration codes (read then write) in correct position to reset learned parameters.</p> <p>If no fault is found proceed to 'Knock sensors ground fault'.</p>
Knock sensors ground fault	<p>Check the grounding of knock sensors, repair as necessary.</p> <p>If no fault is found proceed to ECM connection fault'.</p>

Cause	Remedy
ECM connection fault	Disconnect the harness from ECM and inspect. Check seals are in place, check for signs of corrosion or contamination.
	If ECM pins are damaged, replace ECM and re-flash appropriate calibration (see Re-flashing an ECM).
	If harness is damaged, repair or replace as necessary.
	If no fault is found proceed to 'Wiring fault'.
Wiring fault	Check the harness continuity and electrical insulation, repair/replace as necessary.
	If no fault is found proceed to 'Injector calibration codes faulty'.
Injector calibration codes faulty	Check the injector calibration codes recorded in ECM, if found fault re-enter all injector calibration codes (read then write) in correct position to reset learned parameters.
	If the injector calibration codes are OK, test the vehicle on road and check the Defect Trouble Code (DTC) again with the diagnostic tool. If the problem is still present change the knock sensor.
	If no fault is found raise Techweb Helpdesk call.

Table 111. Open Circuit Injector

Cause	Remedy
Fuel injector fault	Perform the injector buzz test, if the injector is faulty it will not produce a buzzing sound. In such instances raise Techweb Helpdesk call.
	If no fault is found proceed to 'Injector connection fault'.
Injector connection fault	Check the resistance of injector – For solenoid, it should be less than 1 ohm.
	If the resistance is incorrect, change the injector and calibrate it.
	If no fault is found proceed to 'Electrical/ECM connection fault'.
Electrical/ECM connection fault	Disconnect the harness from engine ECM and inspect. Check seals are in place, check for signs of corrosion or contamination.
	If harness is damaged, repair or replace as necessary.
	If no fault is found proceed to 'Wiring fault'.
Wiring fault	Check the harness continuity and electrical installation, repair/replace as necessary.
	If no fault is found raise Techweb Helpdesk call.

Table 112. Injection Bank

Cause	Remedy
Injector connection fault	Check the injector connections corresponding to faulty bank, repair as necessary.
	If no fault is found proceed to 'Injector faulty'.
Injector faulty	Check all the injectors individually. Replace the injector and re-calibrate the ECM with the trim file of the new injector.
	If no fault is found proceed to 'Electrical/ECM connection fault'.

Cause	Remedy
Electrical/ECM connection fault	Disconnect the harness from engine ECM and inspect. Check seals are in place, check for signs of corrosion or contamination.
	If ECM pins are damaged, replace ECM and re-flash appropriate calibration (see Re-flashing an ECM).
	If harness is damaged, repair or replace as necessary.
	If no fault is found proceed to 'Wiring fault'.
Wiring fault	Check the harness continuity and electrical installation, repair/replace as necessary.
	If no fault is found raise Techweb Helpdesk call.

Table 113. Short Circuit Injector

Cause	Remedy
Fuel injector fault	Perform the injector buzz test, if the injector is faulty it not will produce a buzzing sound. In such instances raise Techweb Helpdesk call.
	If no fault is found proceed to 'Injector connection fault'.
Injector connection fault	Disconnect the injector (one by one) to see if the fault disappeared. Repair/ replace as necessary.
	Disconnect the engine harness inter connect plug it to see if the fault disappears. Repair/replace as necessary.
	If no fault is found proceed to 'Electrical/ECM connection fault'.
Electrical/ECM connection fault	Disconnect the harness from engine ECM and inspect. Check seals are in place, check for signs of corrosion or contamination.
	If ECM pins are damaged, replace ECM and re-flash appropriate calibration (see Re-flashing an ECM).
	If no fault is found proceed to 'Wiring fault'.
Wiring fault	Check the harness continuity and electrical installation, repair/replace as necessary.
	If no fault is found raise Techweb Helpdesk call.

Table 114. Engine Low on Power

Cause	Remedy
Injector fault - electrical	If an electrical injector fault is present raise Techweb Helpdesk call.
	If no fault is found proceed to 'Injector connection fault'.
Injector connection fault	Check the Individual Injector Corrections and injector connections. If the problem with C31 or injector connection is evident, replace/repair as necessary.
	If no fault is found proceed to 'Fuel rail pressure'.
Fuel rail pressure	Check the fuel rail pressure.
	If no fault is found proceed to 'Engine Cylinder compression fault'.
Engine Cylinder compression fault	Run the compression test (automatic or manual), if any of the engine cylinder pressure is not in the limits, repair/replace as necessary.
	If no fault is found proceed to 'Blocked inlet tubes'.

Cause	Remedy
Blocked inlet tubes	Check the fuel lines for any blockage and contamination. Clean the fuel lines as necessary. If no fault is found proceed to 'Injector faulty'.
Injector faulty	Swap the injectors with another. Re-write the trim codes. Replace/repair as necessary and re-flash the injector calibration codes.

Table 115. Injector Calibration

Cause	Remedy
Injector calibration fault	Re-write the injector calibration codes allowing the power down and up delay and taking care of injector position, erase the faults. If no fault is found proceed to 'Power relay operation fault'.
Power relay operation fault	Check the power relay operation, repair the relay or wiring as necessary. If no fault is found proceed to 'ECM connection fault'.
ECM connection fault	Disconnect the harness from engine ECM and inspect. Check seals are in place, check for signs of corrosion or contamination. Check the harness continuity and electrical installation, repair/replace as necessary. If harness is damaged, repair or replace as necessary. If no fault is found raise Techweb Helpdesk call.

Table 116. Open Circuit Injector

Cause	Remedy
Fuel injector fault	Perform the injector buzz test, if the injector is faulty it will not produce a buzzing sound. In such instances raise Techweb Helpdesk call. If no fault is found proceed to 'Injector connection fault'.
Injector connection fault	Check the resistance of injector. – For solenoid, it should be less than 1 Ohm. If the resistance is incorrect, change the injector and calibrate it. If no fault is found proceed to 'Electrical/ECM connection fault'.
Electrical/ECM connection fault	Disconnect the harness from engine ECM and inspect. Check seals are in place, check for signs of corrosion or contamination. If ECM pins are damaged, replace ECM and re-flash appropriate calibration (see Re-flashing an ECM). If harness is damaged, repair or replace as necessary. If no fault is found proceed to 'Wiring fault'.
Wiring fault	Check the harness continuity and electrical insulation, repair/replace as necessary. If no fault is found raise Techweb Helpdesk call.

Table 117. High Pressure Injection Diagnostics

Cause	Remedy
Pressure diagnostics fault	Check the fault of type IMV (Inlet Metering Valve) or HPV (High Pressure Valve) (if applicable) or rail pressure sensor, repair the corresponding fault.
	If no fault is found proceed to 'High pressure system fault'.
High pressure system fault	Read the Diagnostic Trouble Code (DTC).
	Connect the battery booster.
	If the DTC links to high pressure control: – Check the fuel feed circuit is in good condition – Check the diesel fuel is present in the system – Check there is no air bubbles or emulsion in the pipes – Check there is enough fuel pressure in the inlet pump – Check there are no high pressure circuit leaks – Check the quality and type of the diesel fuel.
	If the low pressure circuit is faulty, repair the low pressure circuit.
	If no faults are found, proceed to 'Engine does not start' or 'Engine starts' depending on symptoms, replace the corresponding injectors.
Engine does not start	Perform the 'Dynamic IMV Test'.
	If the IMV is faulty replace the IMV.
	If the IMV is OK complete the 'Dynamic Injector Back leak Test'
	If the back leak is above the limit, replace the corresponding injector(s).
	If the back leak is OK complete the 'Pump Pressure Build Capacity Test'
	If the pump capacity is below the limit, replace the high pressure pump.
If the pump capacity is OK, raise Techweb Helpdesk Call.	

Table 118. Fuel Rail Pressure Calibration

Cause	Remedy
Sensor connection faulty	Check the condition of sensor to harness connection, repair/replace as necessary.
	If no fault is found, proceed to 'ECM connection fault'.
ECM connection fault	Disconnect the harness from engine ECM and inspect. Check seals are in place, check for signs of corrosion or contamination.
	If ECM pins are damaged, replace ECM and re-flash appropriate calibration (see Re-flashing an ECM).
	If harness is damaged, repair or replace as necessary.
	If no fault is found proceed to 'Sensor failure'.
Sensor failure	Check the sensor resistance (see relevant help file page). If sensor is out of specification replace, the sensor.
	If no faults is found, proceed to ECM connection fault'.

Cause	Remedy
ECM connection fault	Disconnect the harness from engine ECU (Electronic Control Unit) and inspect. Check seals are in place, check for signs of corrosion or contamination.
	If ECM pins are damaged, replace ECM and re-flash appropriate calibration (see Re-flashing an ECM).
	If harness is damaged, repair or replace as necessary.
	If no fault is found proceed to 'Rail pressure sensor and rail fault'.
Rail pressure sensor and rail fault	Replace the rail pressure sensor and rail.
	If the problem still not solved, raise Techweb Helpdesk call.

Table 119. IMV

Cause	Remedy
IMV (Inlet Metering Valve) connection fault	Check the connection to IMV
	If the IMV connection is faulty, replace the high Pressure fuel injection pump.
	If no fault is found proceed to 'ECM connection fault'.
ECM connection fault	Disconnect the harness from engine ECM and inspect. Check seals are in place, check for signs of corrosion or contamination.
	If ECM pins are damaged, replace ECM and re-flash appropriate calibration (see Re-flashing an ECM).
	If harness is damaged, repair or replace as necessary.
	If no fault is found proceed to 'Wiring fault'.
Wiring fault	Check the harness continuity and electrical insulation, repair/replace as necessary.
	If no fault is found proceed to 'Electrical resistance fault'.
Electrical resistance fault	Measure the IMV electrical resistance around 5.3 ohms at 20 degrees C.
	replace the high Pressure fuel injection pump if the resistance fault occurs.
	If no fault is found proceed to IMV buzz fault'.
IMV buzz fault	Perform the IMV buzz test. If the IMV is not buzzing replace the high Pressure fuel injection pump.
	If the IMV buzzes, raise Techweb Helpdesk call.

Table 120. HPV

Cause	Remedy
HPV (High Pressure Fuel Valve) connection fault	Check the connection of HPV
	If the HPV connection is faulty, repair or replace as necessary.
	If no fault is found proceed to ECM connection fault'.
ECM connection fault	Disconnect the harness from engine ECM and inspect. Check seals are in place, check for signs of corrosion or contamination.
	If ECM pins are damaged, replace ECM and re-flash appropriate calibration (see Re-flashing an ECM).
	If harness is damaged, repair or replace as necessary.
	If no fault is found proceed to 'Wiring fault'.



Cause	Remedy
Wiring fault	Check the harness continuity and electrical insulation, repair/replace as necessary.
	If no fault is found proceed to 'Electrical resistance fault'.
Electrical resistance fault	Measure the HPV electrical resistance, it should be around 2.2 ohms at 25 degrees C.
	If the electrical resistance is OK, replace the rail and HPV.
	If no fault is found proceed to 'HPV buzzing fault'.
HPV buzzing fault	Perform the HPV buzz test. If the HPV is not buzzing replace the rail and HPV.
	If the HPV buzzes, raise Techweb Helpdesk call.

Check (Operation)

Special Tools

Description	Part No.	Qty.
Data Link Adaptor (DLA) Kit Data Link Adaptor (DLA 2.0) Kit	892/01174 728/H5409	1*
Injector Leak-off Test Kit ((Electronic Engine))	892/12350	1
Fuel Injection Equipment Cap Kit (444/448 T4i/T4F/BS4/STV Engine)	892/12359	1

*Unless otherwise stated, you can use any of the tools shown.

Use the Servicemaster engine diagnostic tool to test the fuel injection system. There are two test options available, static actuator tests, which supply a voltage signal to the actuators, and dynamic diagnostic tests which require the engine to be cranked or started.

Static Actuator Tests

The following devices can be tested using a static test, refer to the applicable Check (Operation) procedure.

- IMV (Inlet Metering Valve)
- HPV (High Pressure Valve)
- Fuel injectors

Dynamic Diagnostic Tests

To diagnose fuel system faults the return flow from the fuel system must be measured using the fuel injector leak off test kit. Install the leak off test kit as follows.

1. Connect the test pipes to the leak off ports on the four injectors.
 Special Tool: Injector Leak-off Test Kit ((Electronic Engine)) (Qty.: 1)
 Special Tool: Fuel Injection Equipment Cap Kit (444/448 T4i/T4F/BS4/STV Engine) (Qty.: 1)
2. Position the four plastic bottles as upright as possible. Keep the test equipment clear of components that get hot when the engine is operated.
3. Connect a test pipe to the leak off ports on the high pressure valve outlet. Cap the open pipe.
4. Connect the Servicemaster engine diagnostics tool.

Special Tool: Data Link Adaptor (DLA) Kit / Data Link Adaptor (DLA 2.0) Kit (Qty.: 1)

5. Make sure it is safe to start the engine.

There are two sets of dynamic tests, one for when the engine does not start (cranking only) and one for when the engine does start (engine running).

Fuel System Diagnostic Test (Cranking only)

This test can be found in the fuel system diagnostic test (cranking) tab in the engine test section on the engine diagnostic tool within Servicemaster. This test closes the injectors, opens the IMV and controls the rail pressure using the HPV.

1. Use the Servicemaster engine diagnostics tool to control the tests and follow the on screen instructions in Servicemaster.
2. Measure the quantity of diesel fuel obtained in the leak off kit.
3. Replace the injectors whose back leak exceeds the specified value. Refer to Table 121..
4. The HPV is a non-serviceable part. Replace the fuel rail if the HPV return volume exceeds the specified value. Refer to Table 121..
5. After each replacement confirm the results by re-testing.
6. If the leak off volumes are within limits and the maximum rail pressure during the test is below 500 bar this indicates the high pressure pump capacity may be low.

Fuel System Diagnostic Tests (Engine Running)

These tests can be found in the fuel system diagnostic test (engine running) tab in the engine test section on the engine diagnostic tool within Servicemaster.

IMV test

1. Warm the engine to over 60°C (depending on the application) and the fuel temperature to over 20°C to be able to start the cycle.
2. Use the Servicemaster engine diagnostic tool to control the tests and follow the on screen instructions in Servicemaster.
3. Check status. If test OK, it should report Diagnosis finished and no problem detected.

- 3.1. If the test indicates it is not OK (problem detected), replace the high pressure pump. The IMV is a non-serviceable part.

IMV Diagnostic test

This test is designed to check the fuel system by controlling the rail pressure using the IMV only. Excessive HPV Leak off indicates a leaking HPV, excessive leak off from the injectors indicates a faulty injector.

1. Warm the engine to over 60°C (depending on the application) and the fuel temperature to over 20°C to be able to start the cycle.
2. Connect the fuel leak off test kit, make sure all open fuel pipes are capped.
3. Use the Servicemaster engine diagnostic tool to control the tests and follow the on screen instructions in Servicemaster.
4. Measure the quantity of diesel fuel obtained in the leak off kit.
5. Replace the injectors whose back leak exceeds the specified value. Refer to Table 121..
6. Replace the fuel rail if the HPV return volume exceeds the specified value. Refer to Table 121..
 - 6.1. The HPV is a non-serviceable part. Make sure you replace the high pressure fuel pipes at the same time.

7. After each replacement confirm the results by re-testing.

HPV Test

This test is designed to check the fuel pump capacity by opening the IMV fully and controlling the rail pressure using the HPV. Leak off flow from the HPV indicates the high pressure pump capacity.

1. Warm the engine coolant to over 60°C (depending on the application) and the fuel temperature to over 20°C to be able to start the cycle.
2. Connect the HPV leak off bottle, make sure all open fuel pipes are capped.
3. Use the Servicemaster engine diagnostic tool to control the tests and follow the on screen instructions in Servicemaster.
4. Measure the quantity of diesel fuel obtained in the HPV leak off bottle. The amount should be less than the volume specified. Refer to Table 121..
5. Replace the fuel rail if the HPV return volume exceeds the specified value. Refer to Table 121..
 - 5.1. The HPV is a non-serviceable part, the complete fuel rail assembly must be replaced.
6. After each replacement confirm the results by re-testing.

Table 121. Fuel system limits

Test	Limit
Leak-off test (Cranking only)	Injectors: Less than 250mm of fuel in the fuel leak-off pipes
	HPV: Less than 50mm of fuel in the fuel leak-off pipe
Leak-off test (Engine running)	Injectors: Less than 45L of fuel in each fuel leak-off bottle and less than 0.015L difference between each injector
	HPV: Less than 0.015L of fuel in the fuel leak-off bottle

03 - Injector

Introduction 18-45
 Component Identification 18-46
 Check (Operation) 18-47
 Calibrate 18-48
 Remove and Install 18-51

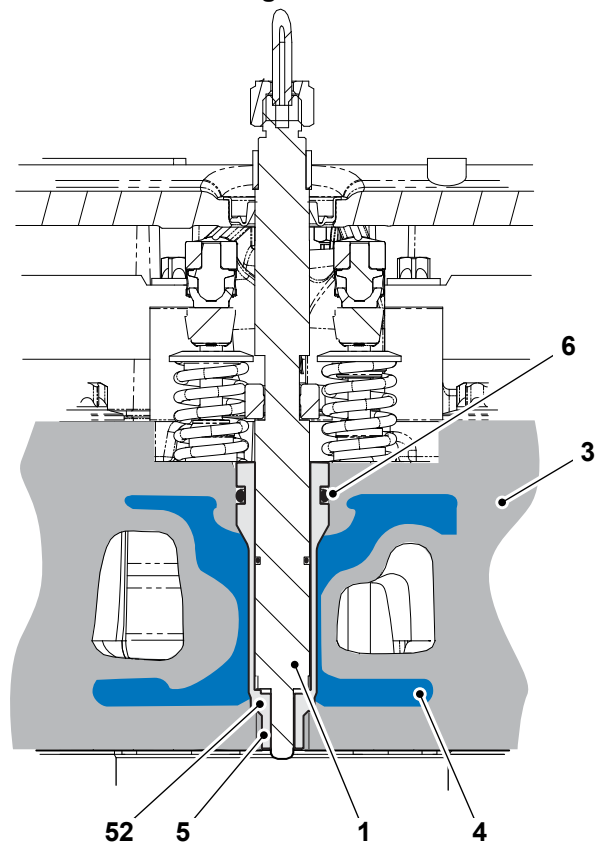
Introduction

The fuel injectors are electronically controlled and incorporate a small solenoid valve. The injectors are supplied with pressurised fuel by the high pressure fuel injection pump and when energised, the injector atomizes the fuel into a fine mist so that it can burn easily by the vehicle's engine.

The fuel injectors are mounted in the cylinder head so that fuel is sprayed directly into the combustion chamber. A fuel supply rail connects all of the fuel injectors to the fuel supply.

The injector tips are located inside the combustion chambers, so effective cooling is essential. A special thin walled sleeve is screwed into the cylinder head which allows a coolant jacket close to the injector. The coolant jacket is sealed at the bottom by sealant on the sleeve thread and at the top by O-ring.

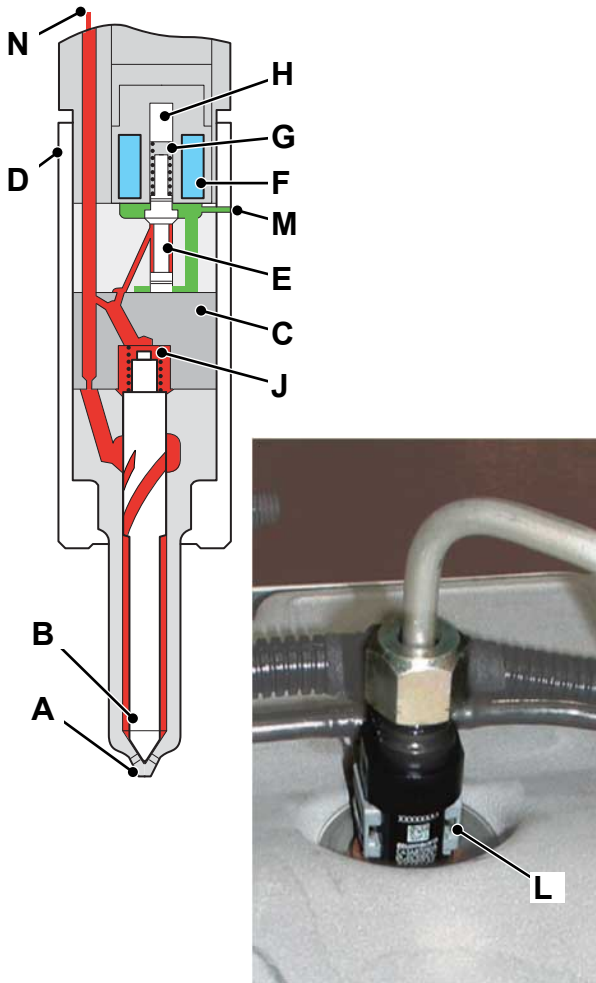
Figure 206.



- 1 Injector
- 2 Sleeve
- 3 Cylinder head
- 4 Coolant jacket
- 5 Sleeve thread
- 6 O-ring

Component Identification

Figure 207.



- A Multi-point injector nozzle
- B Needle
- C Spacer
- D Cap
- E Valve
- F Solenoid coil
- G Valve spring
- H Calibration dowel
- J Injector spring
- L Electrical connector
- M Leak off port
- N Feed port

Check (Operation)

Leak Off Test

The injectors can be tested using Servicemaster engine diagnostics and by means of a leak off test. The test is performed with the engine cranking or engine running as applicable.

To test for a defective injector first use Servicemaster to diagnose the problems with the high pressure fuel injection equipment, specifically when the engine does not start. Refer to: [PIL 18-18-00](#).

Injector Static Test

Do the following test to identify the electrical faults between the ECM (Engine Control Module) and the fuel injector.

Make sure that you do not operate this test on new injectors, run the engine to lubricate the injectors with fuel before running the test.

1. Turn the ignition switch ON. Do not start the engine.

2. Make sure that the fuel rail pressure is less than the specified value.

Pressure: 50bar (724.6psi)

3. Using the Servicemaster engine diagnostic tool, select the injector test.

4. The ECM supplies a voltage signal to the fuel injectors which creates a noise as the injector solenoid operates.

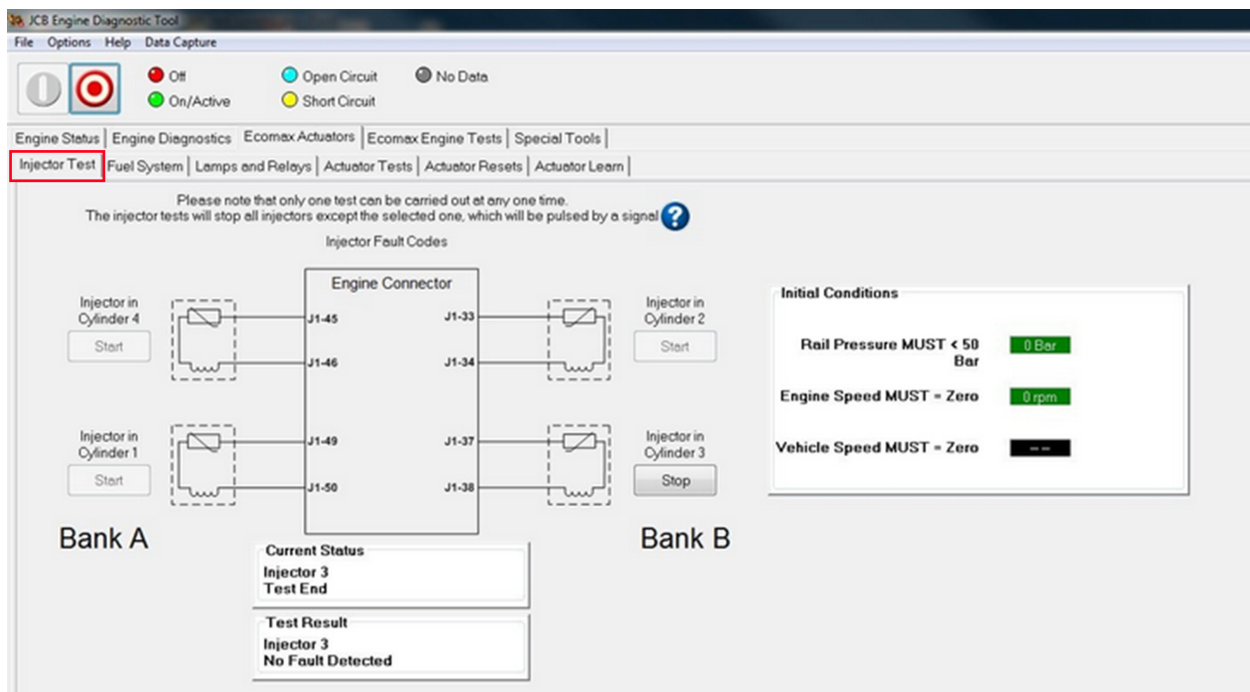
5. The test will run for specified duration and a report will be generated.

Duration: 30s

6. An faint buzzing noise from the injectors indicates the circuit is operating. The test report will identify the following results.

- No fault detected
- Injector open circuit
- Injector short circuit
- Injector bank short circuit to battery voltage
- Injector bank short circuit to ground

Figure 208. Servicemaster injector test screen



Calibrate

Since the injector operating components are by necessity very small, even the most advanced manufacturing techniques do not ensure consistent injection cycle characteristics between injectors.

For example, small variations in the metering orifice sizes will alter the time durations for the start and stop of fuel injection. The small dimensions involved mean that only a tiny variation will alter the orifice area by a relatively large percentage.

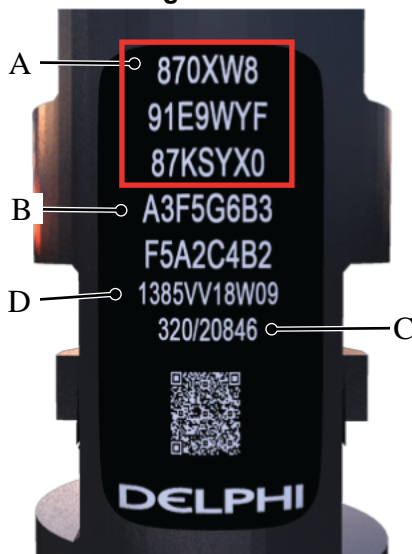
For this reason it is necessary to individually test and record the operating characteristics of each injector assembly at the factory. The results of the test are recorded in the form of a calibration code and attached to the injector body.

The codes for each injector installed to the engine are programmed into the ECM (Engine Control Module). The operating software in the ECM uses the data to adjust the control of the injector solenoid coil accordingly. The injector is therefore effectively recalibrated by the ECM.

It follows that if injectors are removed they must always be installed in their original positions. If new injectors are installed the ECM must be reprogrammed with the new injector codes as follows.

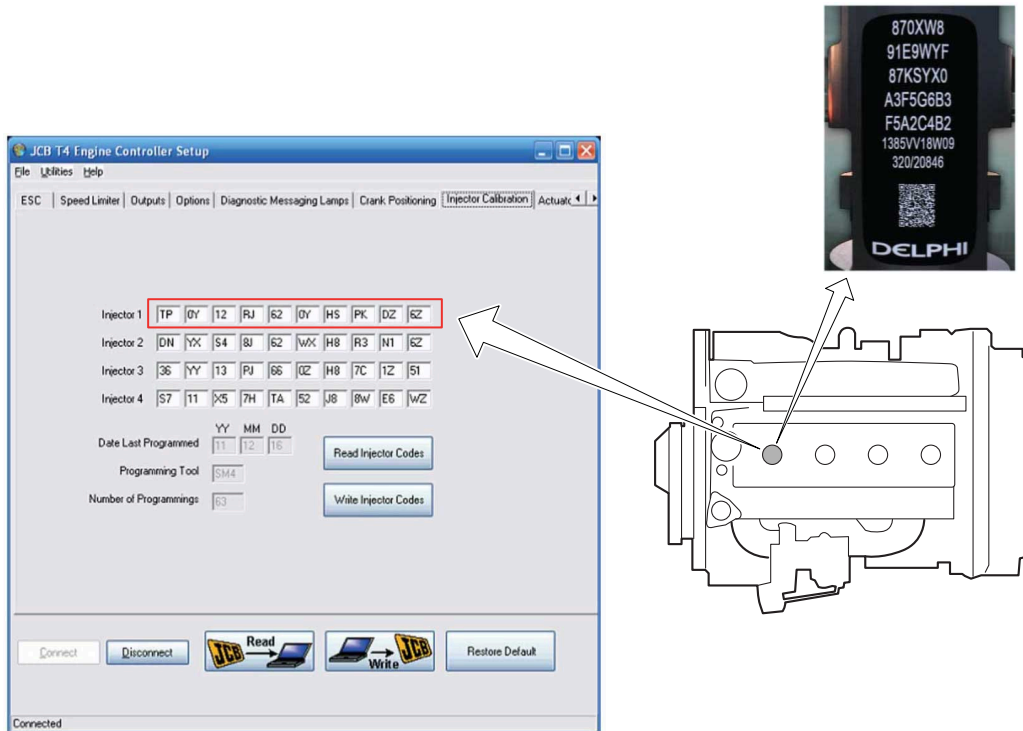
1. Make the machine safe.
[Refer to: PIL 01-03.](#)
2. Connect Servicemaster and use JCB Ecomax engine setup software to program injector calibration codes as necessary.
 - 2.1. Change the existing codes to the new ones and then write to the ECM.

Figure 209.



- A** Calibration code (20 characters)
- B** Manufacturers reference
- C** JCB part number
- D** Injector serial number

Figure 210. JCB Ecomax Engine Seup - injector calibration screen

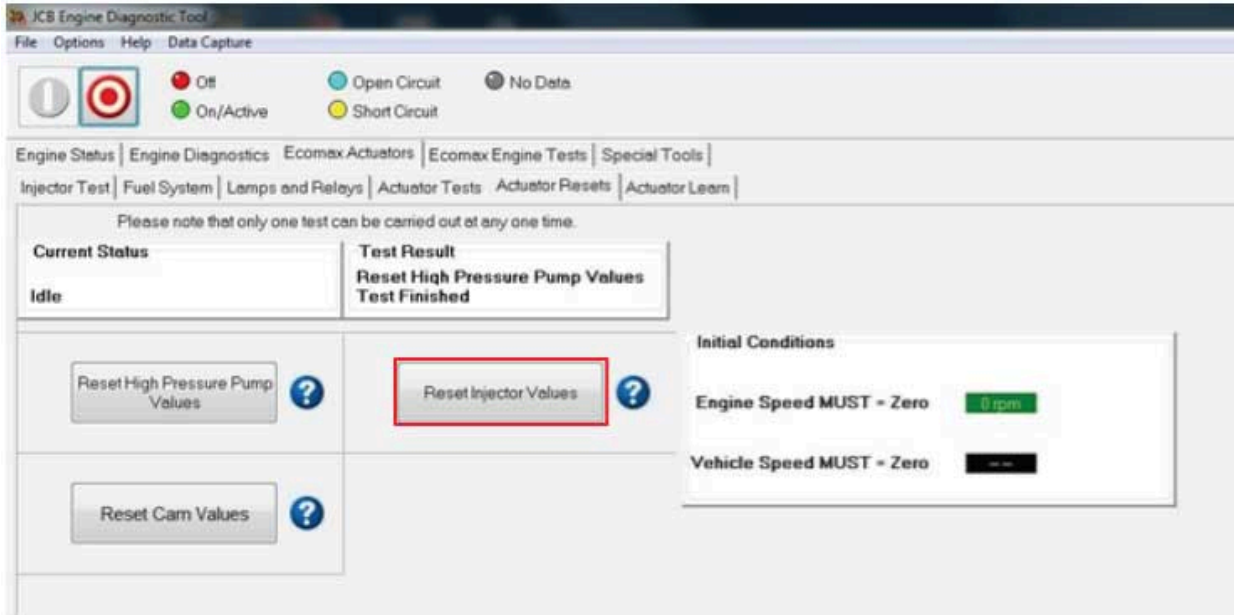


3. Reset the learned values.
 - 3.1. Over time the injection components wear. The ECM adapts (learns) as necessary.

When new or different injectors are installed these learnt values should be reset.

- 3.2. Use the Servicemaster engine diagnostic tool to reset the injector values.

Figure 211. Servicemaster reset injector values screen



Remove and Install

Special Tools

Description	Part No.	Qty.
Data Link Adaptor (DLA) Kit	892/01174	1*
Data Link Adaptor (DLA 2.0) Kit	728/H5409	
Injector Leak-off Test Kit ((Electronic Engine))	892/12350	1
Fuel Injection Equipment Cap Kit (444/448 T4i/T4F/BS4/STV Engine)	892/12359	1

*Unless otherwise stated, you can use any of the tools shown.

The following procedure is for one injector, the procedures are identical for all injectors.

The injectors and high pressure fuel pipes must not be removed unless a fault has been confirmed through injector diagnosis.

Before Removal

1. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.

2. Get access to the engine.

3. Clean the engine.

Refer to: PIL 15-00-00.

- 3.1. Additional cleaning must be carried out prior to working on the high pressure fuel system.

Refer to: PIL 18-00-00.

4. Remove the high pressure fuel pipes.

Refer to: PIL 18-96-03.

- 4.1. Plug all open ports and hoses to prevent contamination.

Special Tool: Fuel Injection Equipment Cap Kit (444/448 T4i/T4F/BS4/STV Engine) (Qty.: 1)

5. Remove the fuel bleed off fuel pipes.

Refer to: PIL 18-96-06.

- 5.1. Plug all open ports and hoses to prevent contamination.

Special Tool: Fuel Injection Equipment Cap Kit (444/448 T4i/T4F/BS4/STV Engine) (Qty.: 1)

6. Disconnect the electrical connector from the injector.

7. Remove the rocker cover.

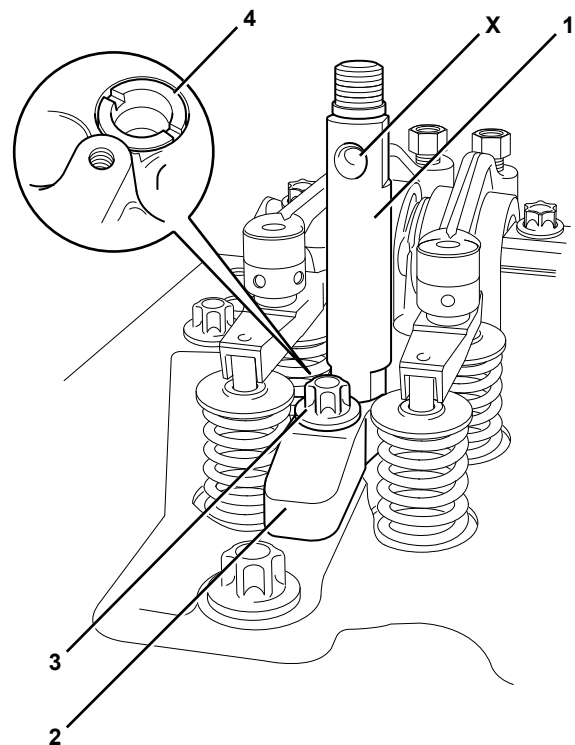
Refer to: PIL 15-42-06.

8. Record which injector is for which cylinder. The injectors must be installed in the same positions.

- 8.1. If a fuel injector is defective, it must be replaced.

9. Remove the injector clamp retaining bolt and lift the clamp away.

Figure 212.



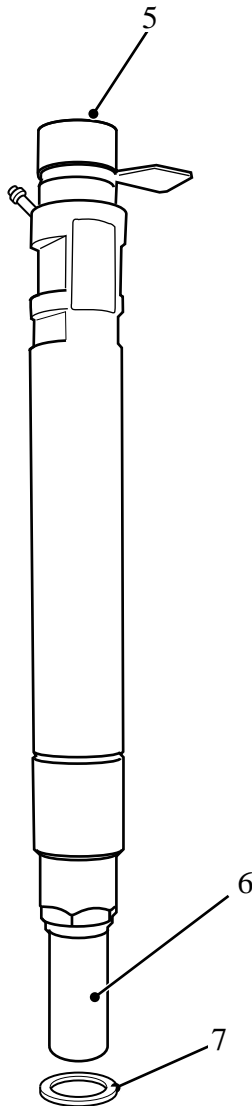
- 1 Injector
- 2 Injector clamp
- 3 Retaining bolt
- 4 Injector sleeve
- X Injector bleed-off port

10. Remove and discard the sealing washer. Label the injector to make sure it is installed in its original cylinder. Put a clean protective cap over the nozzle of the injector.

Special Tool: Fuel Injection Equipment Cap Kit (444/448 T4i/T4F/BS4/STV Engine) (Qty.: 1)

11. Remove and discard the O-ring.

Figure 213.



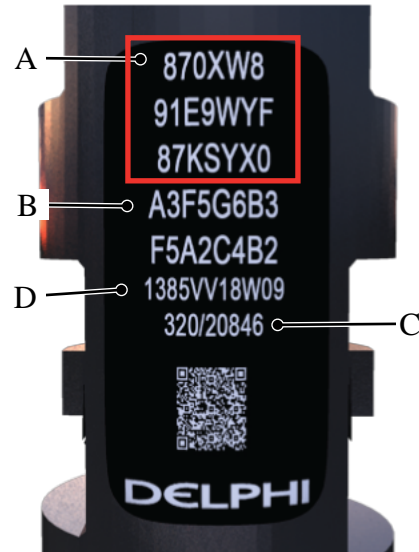
- 5 Protective cap
- 6 Protective cap
- 7 Sealing washer

Install

The fuel injectors are not interchangeable between cylinders or other engines. Make sure you install the injectors in the same positions. If a new or different injector is installed, the ECM (Engine Control Module) must be re-programmed. [Refer to: PIL 18-18-03.](#)

The original injector calibration codes are located on a label on the rocker cover.

Figure 214.



- A Calibration code (20 characters)
- B Manufacturers reference
- C JCB part number
- D Injector serial number

1. Clean off oil or sludge from the inner bore of the injector sleeve. Make sure you do not damage the surface of the bore. Damage or surface contamination will cause the injector sealing O-ring to fail.
2. Install a new O-ring.
3. Install a new sealing washer.
4. Install the injector.
 - 4.1. Make sure that the injector is installed in the correct orientation, with the bleed-off port facing the right hand side (exhaust manifold) of the engine. Make sure the injector is pushed fully into the cylinder head.
5. Install the injector clamp and retaining bolt.
 - 5.1. Tighten the injector clamp bolt to the correct torque value.
6. Install the rocker cover.

[Refer to: PIL 15-42-06.](#)
7. Install new high pressure fuel pipes.

[Refer to: PIL 18-96-03.](#)
8. Connect the injector leak off test kit.

[Special Tool: Injector Leak-off Test Kit \(\(Electronic Engine\)\) \(Qty.: 1\)](#)
9. Prime the fuel system.

- 9.1. Crank the engine for the specified time period.
Duration: 5s
- 9.2. Repeat 9.1 a maximum of 3 times or until fuel appears in the leak off pipes.
10. Disconnect the injector leak off test kit.
11. Install the low pressure fuel pipes.
[Refer to: PIL 18-96-06.](#)
12. Connect the electrical connector to the injector.
13. Connect the DLA (Data Link Adaptor) to the machine.
[Special Tool: Data Link Adaptor \(DLA\) Kit / Data Link Adaptor \(DLA 2.0\) Kit \(Qty.: 1\)](#)
14. Use Servicemaster to clear the error codes from the ECM.
 - 14.1. Fault codes will have been generated while cranking the engine to prime the fuel system with the injectors disconnected.
15. If a new or different injector has been installed, the ECM must be re-programmed with the new injector code.
[Refer to: PIL 18-18-03.](#)
16. Start the engine and allow it to idle.
17. Check for fuel leaks.

Table 122. Torque Values

Item	Nm
3	26–30

07 - Injector Seal

Remove and Install

Special Tools

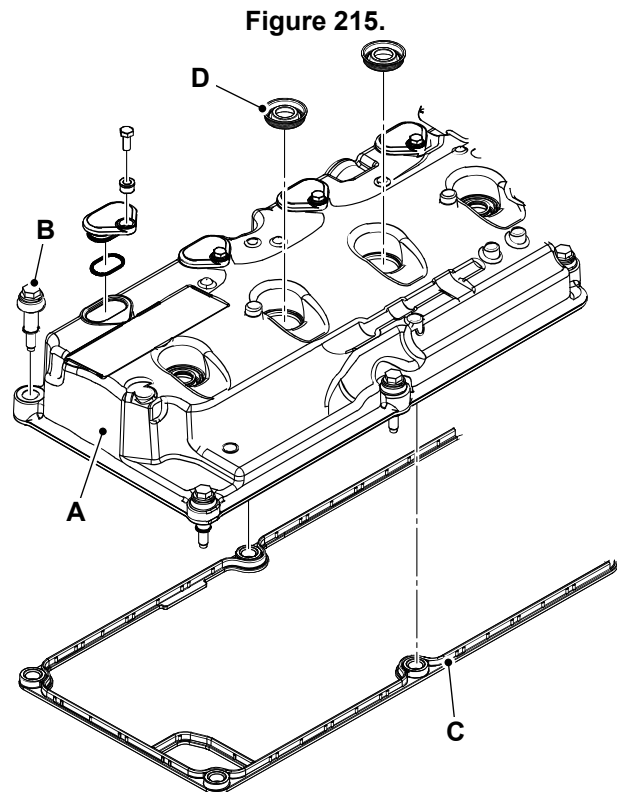
Description	Part No.	Qty.
Injector Seal Installation Tool (Electronic Engine)	892/12346	1

Before Removal

1. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.
2. Clean the engine.
Refer to: [PIL 15-00-00](#).

Remove

1. Remove the high pressure fuel pipes.
Refer to: [PIL 18-96-03](#).
2. Remove the low pressure fuel pipes.
Refer to: [PIL 18-96-06](#).
3. Remove the rocker cover from the cylinder head.
Refer to: [PIL 15-42-06](#).

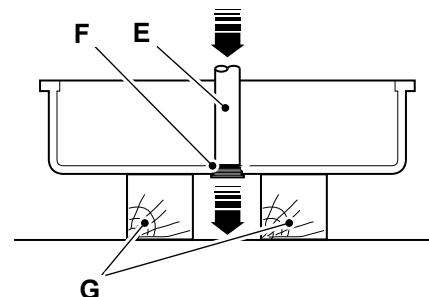


- A Rocker cover
- B Bolts
- C Gasket
- D Injector seals

4. Put wooden supports under the rocker cover and tap out the injector seals using the special tool. Discard the seals.

Special Tool: [Injector Seal Installation Tool \(Electronic Engine\)](#) (Qty.: 1)

Figure 216.



- E Injector seal installation tool
- F Injector seals
- G Wooden supports

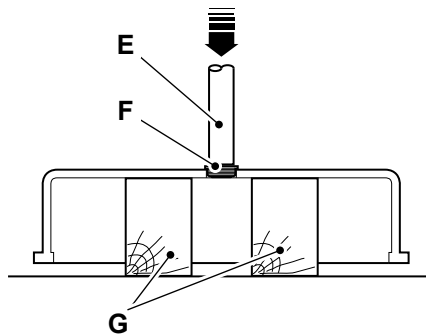
Install

1. The installation procedure is the opposite of the removal procedure. Additionally do the following steps.

2. Remove all oil and sludge contamination from inside the valve chamber.
3. Renew the injector seals. Put supports under the rocker cover and tap in the new seals using the special tool.

Special Tool: [Injector Seal Installation Tool \(Electronic Engine\)](#) (Qty.: 1)

Figure 217.



- E** Injector seal installation tool
- F** Injector seals
- G** Wooden supports

4. Renew the rocker cover gasket.
5. Prevent damage to the seals. Put sleeves/covers on the injectors. Apply a rubber lubricant to the seals.
6. Install the rocker cover.

[Refer to: PIL 15-42-06.](#)

After Installation

1. The high pressure fuel pipes must be replaced with new parts.
[Refer to: PIL 18-96-03.](#)
2. Start the engine and check for oil and fuel leaks.

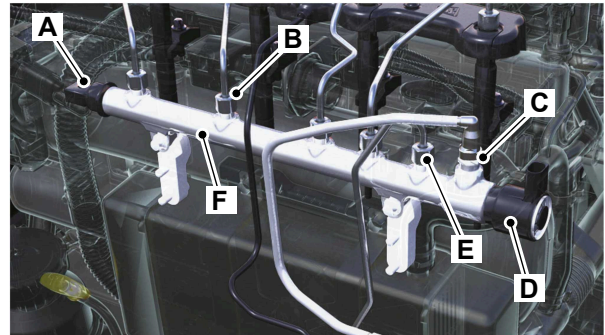
12 - Rail

Introduction	18-56
Remove and Install	18-57

Introduction

The fuel rail also known as a common rail, is a pipe resembling a rail that is used to deliver fuel to individual fuel injectors on internal combustion engines. It is designed to have an outlet for each injector, an inlet for a fuel supply and an outlet for a fuel bleed off.

The fuel rail also incorporates an attached fuel pressure sensor and a fuel valve. DO NOT remove the high pressure fuel valve or the fuel pressure sensor from the rail. If these components are defective replace the complete common rail assembly.

Figure 218.

- A Fuel pressure sensor
- B Outlet
- C Bleed off
- D High pressure fuel valve
- E Inlet
- F Rail assembly

Remove and Install

Special Tools

Description	Part No.	Qty.
Fuel Injection Equipment Cap Kit (444/448 T4i/T4F/BS4/STV Engine)	892/12359	1

Remove

This procedure requires service parts. Make sure you have obtained the correct service parts before you start. Refer to the Parts Catalogue.

- Obey all fuel system health and safety information.

Refer to: [PIL 18-00-00](#).

- Make sure that the engine is safe to work on. The engine must cool and pressure in the fuel system must decay before you start work. If the engine has been running, wait at least one hour before you start work.

- Clean the engine.

Refer to: [PIL 15-00-00](#).

- 3.1. Additional cleaning must be carried out prior to working on the high pressure fuel system.

Refer to: [PIL 18-00-00](#).

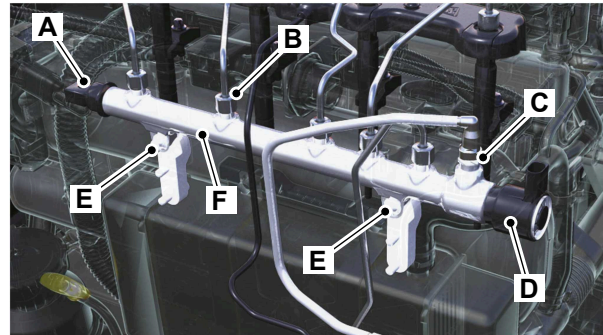
- Remove the high pressure fuel pipes. The high pressure fuel pipes must not be reused. Discard the high pressure fuel pipes.

Refer to: [PIL 18-96-03](#).

- 4.1. Plug all open ports and hoses to prevent contamination.

Special Tool: Fuel Injection Equipment Cap Kit (444/448 T4i/T4F/BS4/STV Engine) (Qty.: 1)

Figure 219.



- A Fuel pressure sensor
- B High pressure fuel pipe
- C Fuel bleed off pipe connector
- D High pressure fuel valve
- E Bolts (x2)
- F Rail assembly

- Remove the fuel bleed off pipe at the rail.

Refer to: [PIL 18-96-06](#).

- 5.1. Plug all open ports and hoses to prevent contamination.

Special Tool: Fuel Injection Equipment Cap Kit (444/448 T4i/T4F/BS4/STV Engine) (Qty.: 1)

- Disconnect the electrical connector at the high pressure fuel valve.

- Disconnect the electrical connector at the fuel rail pressure sensor.

- Remove the bolts (x2) and remove the common rail assembly.

Seal the common rail assembly inside a clean plastic bag until it is ready for use. If the fuel rail assembly is defective, it must be replaced.

Install

- The installation procedure is the opposite of the removal procedure. Additionally do the following step.

- Replace the high pressure fuel pipes.

Table 123. Torque Values

Item	Nm
C	25



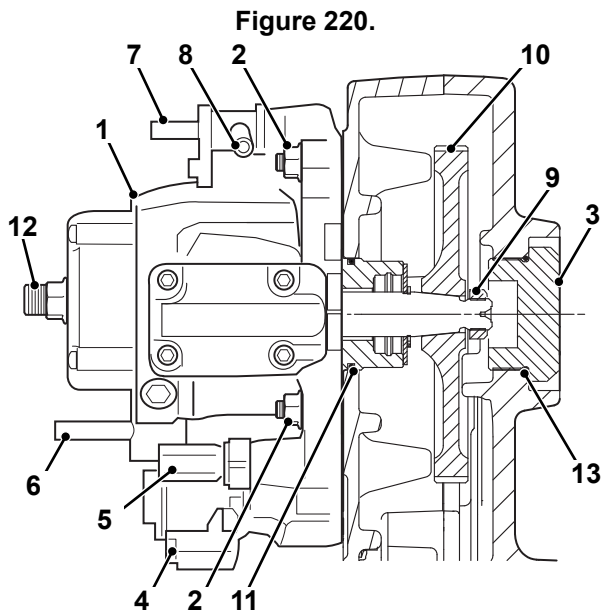
15 - Pump

Introduction	18-58
Component Identification	18-59
Operation	18-59
Remove and Install	18-61

Introduction

The high pressure fuel injection pump is a rotary type device that pumps fuel into the cylinders of the engine. The pump is driven indirectly from the crankshaft by gears.

Component Identification



- Figure 220.**
- 1 Fuel injection pump
 - 2 Pump fixing nuts (x3)
 - 3 Injection pump gear cover
 - 4 Inlet metering valve electrical connector
 - 5 Fuel temperature sensor electrical connector
 - 6 Fuel pipe connector (inlet)
 - 7 Fuel bleed-off connector
 - 8 Fuel bleed-off connector, injector bleed off
 - 9 Drive shaft nut
 - 10 Drive gear
 - 11 Injection pump O-ring oil seal
 - 12 High pressure fuel outlet port
 - 13 Gear cover O-ring oil seal

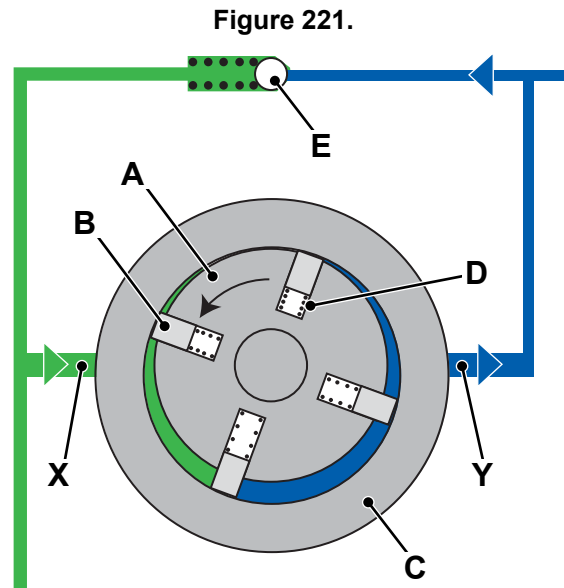
Operation

The high pressure fuel injection pump is driven via a gear on the engine and rotates at half engine speed. The pump comprises of two sections, the transfer pump and the high pressure pump.

Although the pump does not control fuel injection timing, it is still timed in relation to engine phasing. By timing the pump pressure pulses, the load on the engine timing gears is reduced together with reduced mechanical noise.

Transfer Pump Operation

The integral transfer pump is a vane type. An engine driven rotor houses four vanes in slots. The rotor rotates inside an eccentric liner. The vanes are held in contact with the liner by springs. Fuel is drawn into the pump chamber at port X, pressurised by the decreasing volume inside the chamber and expelled at port Y. Fuel pressure generated by the transfer pump is limited to a specified pressure by an integral pressure regulating valve. This pressure is maintained regardless of engine speed. 6bar (87.0psi)



- Figure 221.**
- A Rotor
 - B Vanes (x4)
 - C Eccentric liner
 - D Springs
 - E Regulating valve
 - X Port X
 - Y Port Y

High Pressure Pump Operation

Fuel passes to the high pressure pump via the IMV (Inlet Metering Valve). The ECM (Engine Control

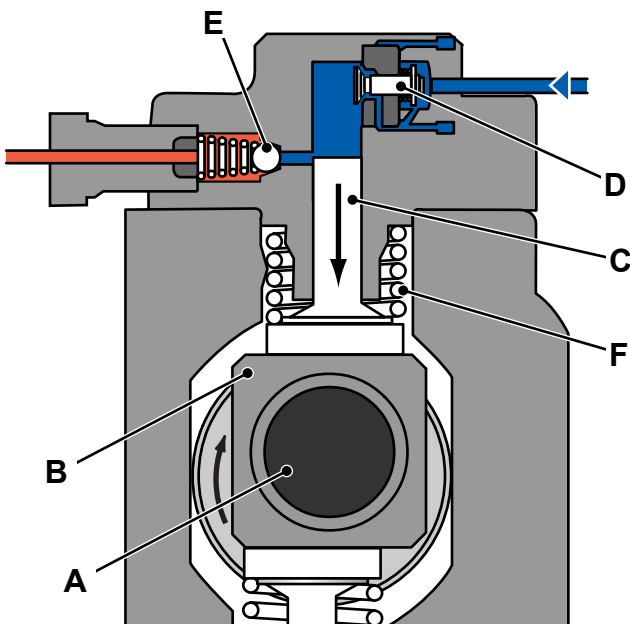
Module) controlled IMV determines the amount of fuel transferred to the high pressure pump. The plunger actuator block is located on the engine driven eccentric shaft. When the shaft rotates the actuator block operates the two plungers. As one plunger is pushed up its chamber the other is pushed down by its spring.

State 1 - Charging

Note: The description is for one plunger. The opposite plunger operates in an identical way. The inlet and delivery ports from each plunger are connected by internal galleries.

When the eccentric shaft is in the position shown force from spring moves the plunger down its chamber. Pressure in the chamber falls below the rail pressure and the delivery valve closes. Transfer pressure is now sufficient to force inlet valve off its seat and allow the fuel to fill the chamber.

Figure 222.



- A Eccentric shaft
- B Actuator block
- C Plunger
- D Inlet valve
- E Delivery valve
- F Spring

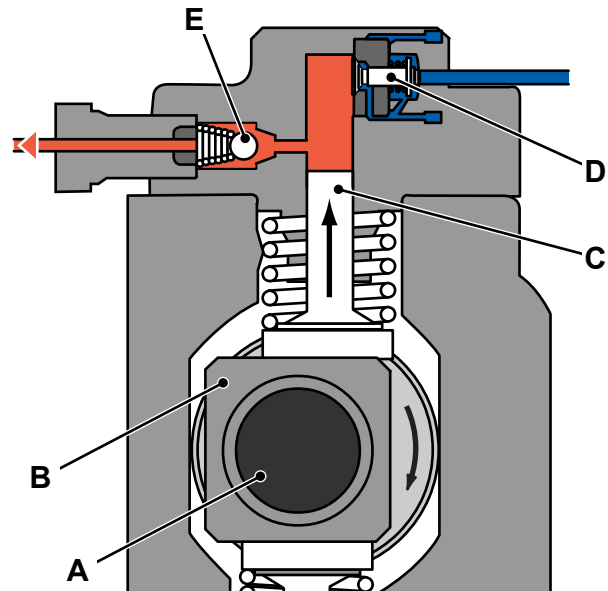
State 2 - Pumping

Note: The description is for one plunger. The opposite plunger operates in an identical way. The inlet and delivery ports from each plunger are connected by internal galleries.

When the eccentric shaft is in the position shown the actuator block moves the plunger up its chamber.

Fuel pressure in the chamber rises and forces the inlet valve on to its seat. As the plunger is pushed further up its chamber the fuel pressure exceeds that of the rail pressure and the delivery valve is forced off its seat. Fuel is forced into the rail at high pressure.

Figure 223.



- A Eccentric shaft
- B Actuator block
- C Plunger
- D Inlet valve
- E Delivery valve

Remove and Install

Special Tools

Description	Part No.	Qty.
C-Shaped Ring Spanner	320/00925	1
Crankshaft Turning Tool (95.25mm PCD)- JCB 4 Cylinder Ecomax and Dieselmax	892/01147	1
Crankshaft / Camshaft Timing Pin (444/448/672 Engine)	892/01148	1
Tamper proof Cover Removal Tool	892/01154	1
Pump Gear Removal Tool	892/01155	1
Fuel Injection Equipment Cap Kit (444/448 T4i/T4F/BS4/STV Engine)	892/12359	1
Torque Wrench (10-100Nm)	993/70111	1

Important: The following procedures include removal and replacement of fuel system components. Before starting the procedures the engine assembly must be cleaned. Refer to: PIL 15-00-00. and Refer to: PIL 18-00-00.

Important: Service procedures on the high pressure fuel pump can only be carried out by specialist personnel with the relevant training and equipment.

Important: When removing components dirt and debris may become exposed or dislodged. Stop the removal procedures and clean away the exposed deposits. Refer to: PIL 15-00-00.

Remove

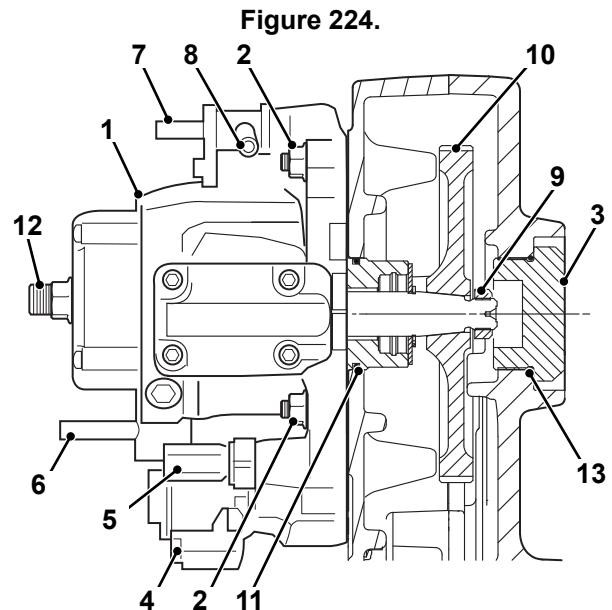
1. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.
2. Get access to the engine.
3. Clean the engine.
Refer to: PIL 15-00-00.
 - 3.1. Additional cleaning must be carried out prior to working on the high pressure fuel system.
Refer to: PIL 18-00-00.
4. Disconnect the electrical connectors from the IMV (Inlet Metering Valve) and the fuel temperature sensor.

5. Disconnect the low pressure fuel pipes from the fuel inlet, fuel bleed off and injector bleed off ports.

Refer to: PIL 18-96-06.

- 5.1. Cap all open ports and hoses to prevent contamination.

Special Tool: Fuel Injection Equipment Cap Kit (444/448 T4i/T4F/BS4/STV Engine) (Qty.: 1)



- 1 Fuel injection pump
- 2 Pump fixing nuts (x3)
- 3 Injection pump gear cover
- 4 IMV electrical connector
- 5 Fuel temperature sensor electrical connector
- 6 Fuel pipe connector (inlet)
- 7 Fuel bleed-off connector
- 8 Fuel bleed-off connector, injector bleed off
- 9 Drive shaft nut
- 10 Drive gear
- 11 Injection pump O-ring oil seal
- 12 High pressure fuel outlet port
- 13 Gear cover O-ring oil seal

6. Disconnect the high pressure fuel pipe from the fuel outlet port. The High pressure fuel pipe must NOT be reused. Discard the high pressure fuel pipe.

Refer to: PIL 18-96-03.

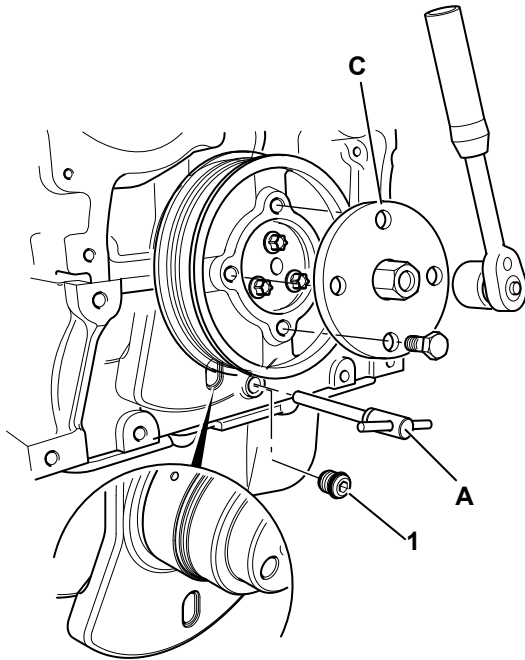
- 6.1. Cap all open ports and hoses to prevent contamination.

Special Tool: Fuel Injection Equipment Cap Kit (444/448 T4i/T4F/BS4/STV Engine) (Qty.: 1)

7. If it necessary to improve access to the pump, remove the fuel filter.

8. Remove the bedplate plug.

Figure 225.



- 1 Bedplate plug
- A Crankshaft / Camshaft timing pin
- C Crankshaft turning tool

9. Use the crankshaft turning tool to turn the crankshaft until the timing pin engages in the crankshaft timing hole.

Special Tool: Crankshaft Turning Tool (95.25mm PCD)- JCB 4 Cylinder Ecomax and Dieselmex (Qty.: 1)

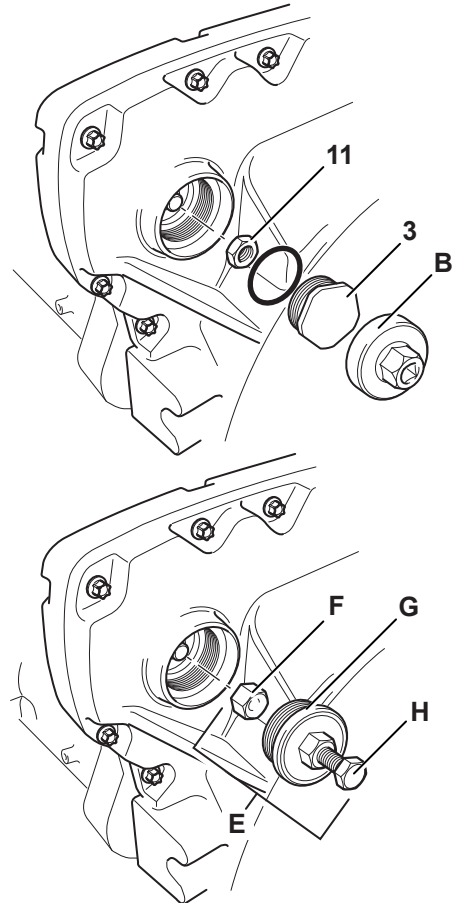
Special Tool: Crankshaft / Camshaft Timing Pin (444/448/672 Engine) (Qty.: 1)

10. Use the tamper proof cover removal tool and a suitable ratchet drive to remove the fuel injection pump gear cover.

Special Tool: Tamper proof Cover Removal Tool (Qty.: 1)

11. Remove the drive shaft nut.

Figure 226.



- 3 Gear cover
- 11 Drive shaft nut
- B Gear removal tool
- E Pump gear removal tool, comprises:
 - F Pump gear removal tool (Reaction cap)
 - G Pump gear removal tool (Body)
 - H Pump gear removal tool (Bolt)

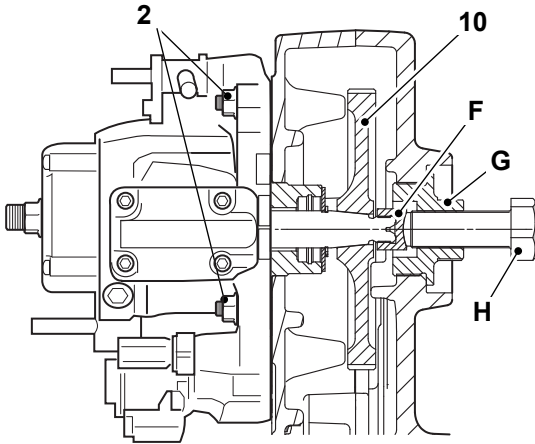
12. Remove the nuts (x3). Use the special C shaped ring spanner to remove the nut closest to the crankcase.

Special Tool: C-Shaped Ring Spanner (Qty.: 1)

13. Install the reaction cap over the pump shaft. Screw the body to the housing. Use a suitable ratchet drive and socket to screw the bolt in until you feel a slight resistance.

Special Tool: Pump Gear Removal Tool (Qty.: 1)

Figure 227.



- 2** Fixing nuts
- 10** Injection pump drive gear
- F** Pump gear removal tool (Reaction cap)
- G** Pump gear removal tool (Body)
- H** Pump gear removal tool (Bolt)

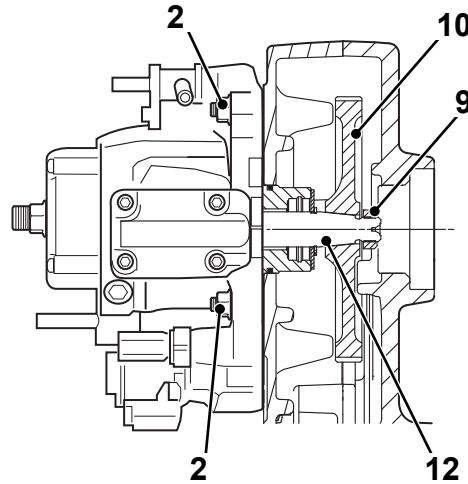
14. The injection pump drive gear is located on a taper on the pump drive shaft. To remove the pump the taper lock must be broken. Support the fuel pump. Tap the end of the pump gear removal tool bolt with a soft faced hammer. When the taper breaks there will be an audible sound. The pump drive gear connects to the injection pump drive shaft by means of taper lock alone, there is no mechanical locking key.

15. Remove the service tools. Remove the pump from the flywheel housing.

Install

1. Make sure that the taper surfaces on the injection pump drive shaft and gear are clean and free from oil and damage.

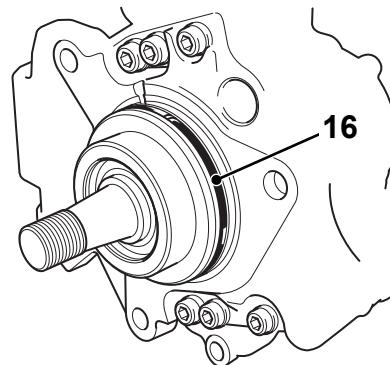
Figure 228.



- 2** Fixing nuts
- 9** Gear pump nut
- 10** Drive gear
- 12** Drive shaft

2. Make sure that the oil seal is correctly located on the pump mounting face.

Figure 229.



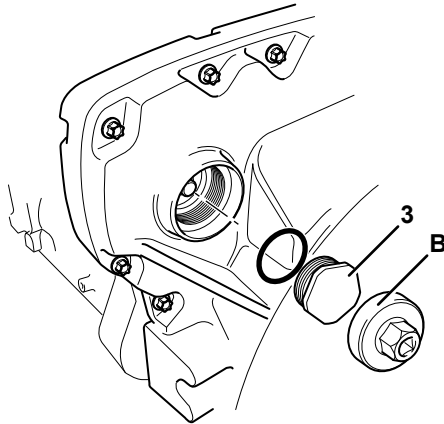
- 16** Oil seal

3. Locate the pump on to the mounting studs. Locate the drive gear over the pump drive shaft.
4. Install the fixing nuts and tighten to the correct torque value.
5. Install the gear pump nut and tighten to the correct torque value. If a washer is supplied with a replacement pump, Do not install the washer. Secure the gear with the gear pump nut only.
6. Use the tamperproof cover removal tool to install the gear cover. Make sure its sealing O-ring is correctly installed. Tighten the gear cover to the correct torque value.

Special Tool: Torque Wrench (10-100Nm) (Qty.: 1)

Special Tool: Tamper proof Cover Removal Tool (Qty.: 1)

Figure 230.

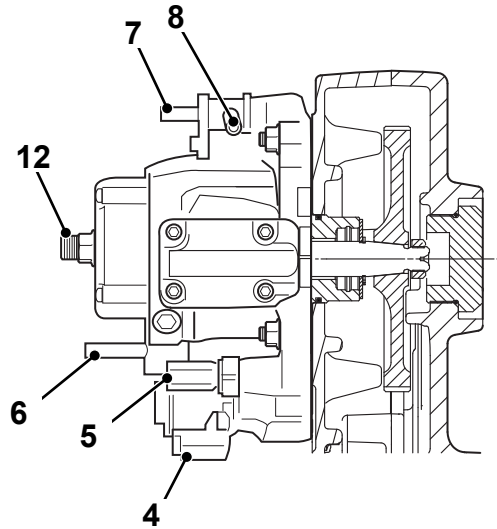


- 3 Gear cover
- B Tamperproof cover removal tool

After Installation

1. Remove the crankshaft turning tool.
2. Remove the crankshaft timing pin and install the bedplate plug.
3. Connect the low pressure fuel pipes to the fuel inlet connection, fuel bleed-off connections and injector bleed off ports.
[Refer to: PIL 18-96-06.](#)
4. Install a new high pressure fuel pipe.
[Refer to: PIL 18-96-03.](#)
5. Connect the electrical connectors at the IMV and the fuel temperature sensor.
6. If the fuel filter was removed, install the fuel filter.
7. Bleed the fuel system.
8. Start the engine and check for fuel leaks.

Figure 231.



- 4 IMV electrical connector
- 5 Fuel temperature sensor electrical connector
- 6 Fuel pipe connector (inlet)
- 7 Fuel pump bleed-off connection
- 8 Fuel pump bleed-off connection
- 12 High pressure fuel outlet port

Table 124. Torque Values

Item	Nm
2	24
3	70
9	65

27 - High Pressure Rail Valve

Introduction	18-65
Operation	18-66
Check (Operation)	18-66
Remove and Install	18-67

Introduction

The HPV (High Pressure Valve) is an integral part of the common fuel rail assembly. If the valve is defective replace the complete common rail assembly. (Refer to PIL 18-18).

Figure 232. High pressure valve location

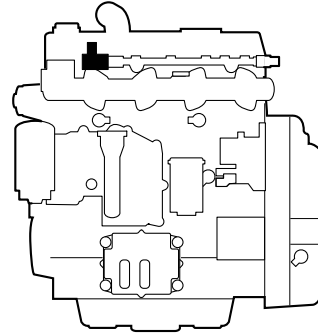
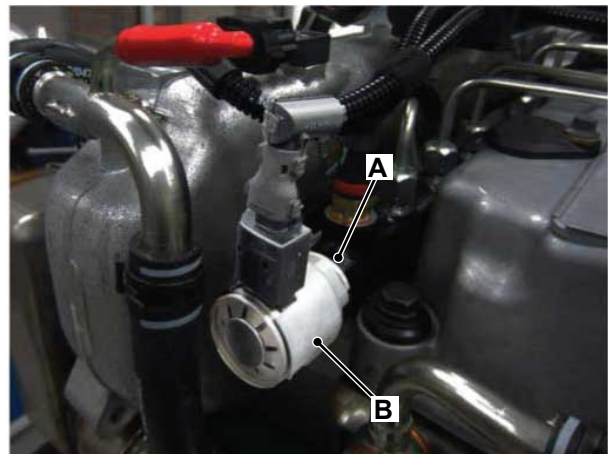


Figure 233.



- A HPV
- B Solenoid coil

Operation

In certain operating conditions, the HPV (High Pressure Valve) controls the fuel pressure inside the common rail.

When the valve opens, fuel is bled from the rail back to the fuel tank, reducing the fuel pressure inside the fuel rail. The valve is actuated by a solenoid coil and features proportional control. The fuel flow through the valve is proportional to the current supplied to the coil. The current value is controlled by the ECM (Engine Control Module) using PWM (Pulse Width Modulation).

During normal engine operation, the fuel pressure is controlled solely by the IMV (Inlet Metering Valve), refer to (PIL 18-18).

In some operating circumstances, the IMV is unable to alter the fuel pressure in the common rail quickly enough. At these times, the ECM activates the HPV. Typically the valve is used in the following conditions:

- Extreme transients, for example if the operator goes from full throttle to no throttle quickly.
- When the fuel is cold.

In the event of an IMV failure, the ECM compensates by altering the control of the HPV to ensure the engine performance is sufficient to limp home.

Check (Operation)

For the full inspection and testing procedure, refer to the help files in ServiceMaster.



Remove and Install

This part is a non-serviceable component, if it is defective, replace the complete common rail assembly.



21 - Fuel Pump

Contents

Page No.

18-21-00 General 18-69

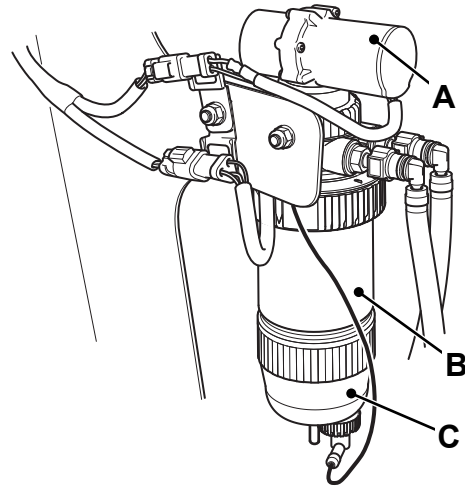
00 - General

Introduction	18-69
Technical Data	18-71
Operation	18-72
Check (Operation)	18-73
Remove and Install	18-75

Introduction

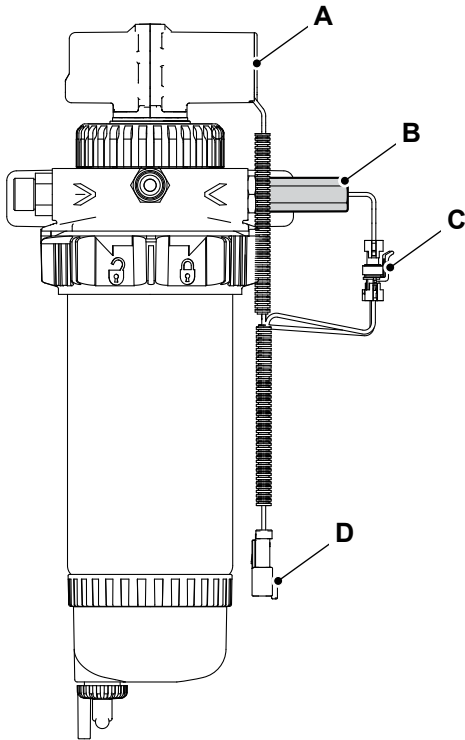
The fuel lift pump is a sealed electrical unit integral with the fuel pre-filter and water separator.

The fuel lift pump is a non-serviceable component. If any part is defective, replace the complete pump, filter and separator assembly.

Figure 234.

- A** Fuel lift pump
- B** Fuel pre- filter
- C** Water separator

Some lift pump installations are modified to operate from a 24V supply by means of an in-line voltage reducer.

Figure 235.

- A** Lift pump motor
- B** Voltage reducer
- C** In-line electrical connector
- D** Harness electrical connector

Technical Data**Table 125.**

Component	Value
Operating pressure	0.8bar (11.6psi)
Expected minimum free flow delivery	2.5L/min

Table 126. Expected electrical values

Machine Voltage V	Minimum Voltage V	Maximum Voltage V	Minimum Resistance Ohms	Maximum Resistance Ohms	Minimum Current Draw A	Maximum Current Draw A
12	8	16	0.8	1.5	4	8
24	20	30	4.9	5.7	4	5.5



Operation

The pump draws fuel from the tank, through the water separator, pumping it through the fuel filter and into the fuel injection pump. The pump has a built in protection against running dry and will shut down after 2min if no fuel is present.

Check (Operation)

Flow Test

If the fuel lift pump is suspect, measure the delivery flow rate.

1. Make the machine safe.

[Refer to: PIL 01-03.](#)

2. Disconnect the fuel hose from the outlet of the pump/ filter assembly.
3. Connect a length of fuel hose from the pump outlet to a suitable fuel container.
Volume: 5L
4. Activate the fuel pump. Do not attempt to start the engine.
5. Run the pump. The fuel flow must be equal to or greater than the value shown.

Duration: 1min

Flowrate: 2.5L/min

Fuel Lift Pump Test - Machines with Electronic Control Fuel Injection

When the ignition is set to ON the ECM (Engine Control Module) energises the fuel lift pump. If the engine is not started the pump is de-energised after a period of 24s. A fuel pump flow test can be carried

out during this period of time. Minimum expected fuel flow. 1L in 24s.

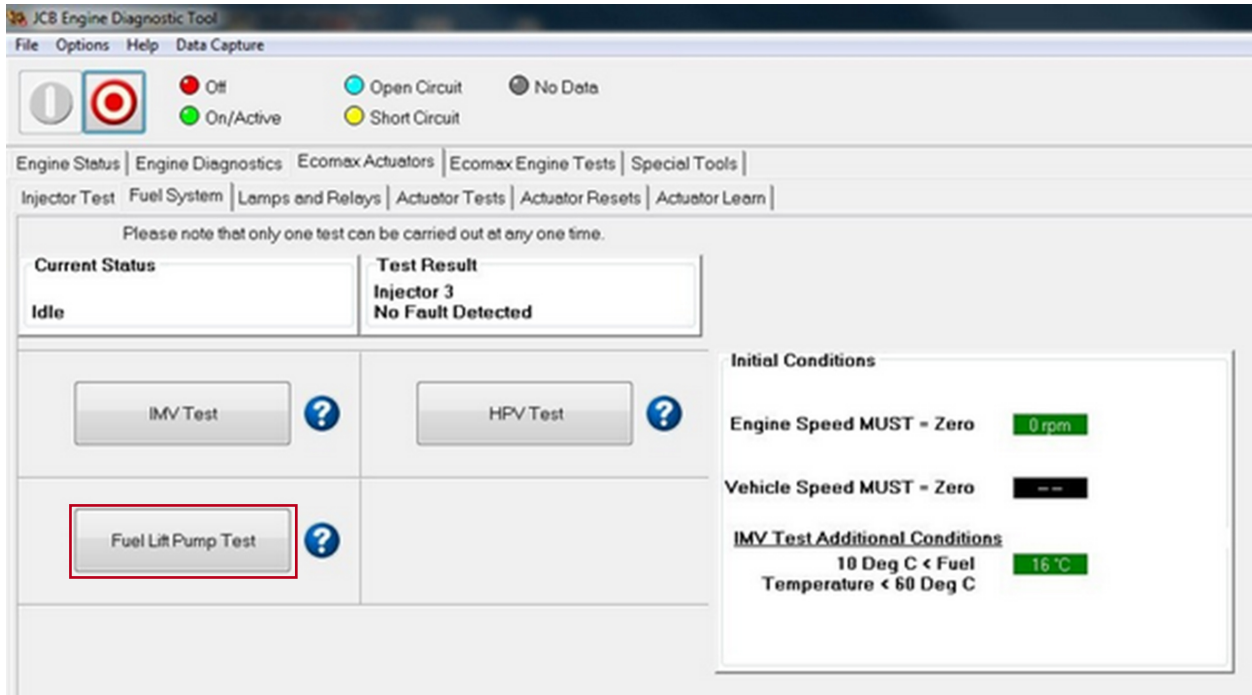
Alternatively use Servicemaster to energise the fuel pump as follows.

1. Make the machine safe.

[Refer to: PIL 01-03.](#)

2. Turn the ignition switch ON. Do not start the engine.
3. Allow the fuel pump priming to occur at key on before starting the test.
4. Put a container of suitable capacity to collect the fuel at the outlet port of the lift pump.
5. Select the fuel lift pump test using Servicemaster.
6. There is a delay of the specified duration before the test starts.
Duration: 5s
7. The test will operate the lift pump for specified duration.
Duration: 24s
8. Make sure that the fuel collected in the container is not more or less than the specified value.
Volume: $1 \pm 0.2L$

Figure 236. Servicemaster fuel lift pump test screen



Remove and Install

The fuel lift pump assembly and the fuel pipe connections may vary slightly depending on the application. The removal and installation procedure will be similar.

Remove

1. Make the machine safe.
[Refer to: PIL 01-03.](#)
2. Disconnect the battery.
3. Disconnect the fuel lift pump electrical connector.

Figure 237.

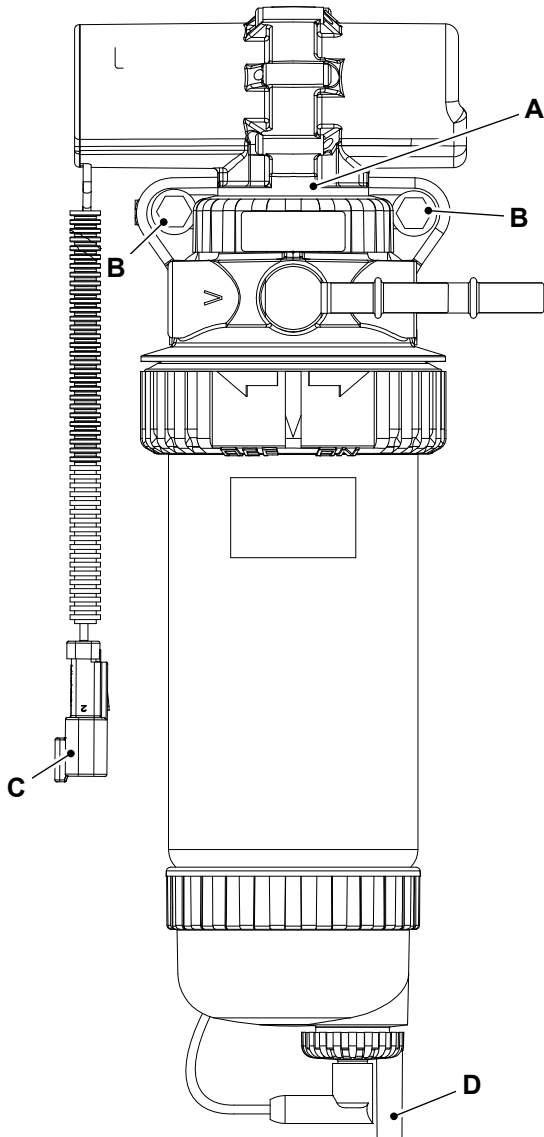
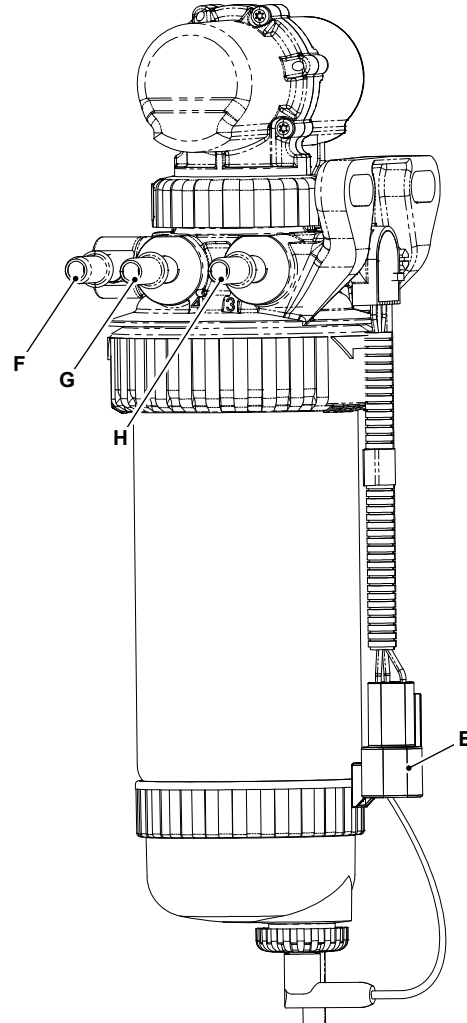


Figure 238.



- A** Fuel lift pump and pre-filter assembly
- B** Bolts (x2)
- C** Fuel lift pump electrical connector
- D** Water separator drain tap
- E** WIF (Water in Fuel) sensor electrical connector
- F** Fuel pipe - Air bleed (blue)
- G** Fuel pipe - Fuel inlet from tank (red)
- H** Fuel pipe - Fuel outlet (yellow)

4. Disconnect the WIF sensor electrical connector.
5. If necessary, put a label on the fuel pipes to aid installation.
6. Disconnect the fuel pipes at the fuel lift pump by means of the quick release connectors.
 - 6.1. Plug all open ports and hoses to prevent contamination.
7. If installed, disconnect the drain hose from the water separator drain tap.
8. Support the fuel lift pump and remove the bolts (x2).

9. Remove the fuel lift pump and pre-filter assembly from the machine.

Install

1. The installation procedure is the opposite of the removal procedure. Additionally do the following step.
2. Bleed the fuel system.
[Refer to: PIL 18-00-00.](#)



24 - Exhaust

Contents	Page No.
18-24-00 General	18-79
18-24-03 Inlet Manifold	18-81
18-24-04 Outlet Manifold	18-85
18-24-06 Silencer	18-89
18-24-27 Spark Arrestor	18-90



Notes:



00 - General

Introduction	18-79
Health and Safety	18-80
Check (Condition)	18-80

Introduction

The exhaust system is used to guide exhaust gases away from the controlled combustion inside the engine by means of an exhaust pipe. Depending on the machine design, the exhaust gas may flow through the following components:

- Cylinder head and exhaust manifold.
- Turbocharger to increase the engine power (if installed).
- A catalytic converter or EGR (Exhaust Gas Recirculation) system to reduce air pollution (if installed).
- SCR (Selective Catalytic Reduction) (if installed). In SCR system exhaust gases pass through the DEF (Diesel Exhaust Fluid) injection chamber to lower the NOx (Nitrogen Oxide) concentration in the exhaust gases.
- A silencer or muffler to reduce noise (if installed).

The exhaust pipe carries the toxic and noxious gases away from the users of the machine. Note machines or generators that work indoors can quickly fill an enclosed space with carbon monoxide or other poisonous exhaust gases if they are not properly vented to the outdoors.

Health and Safety

Exhaust Gases

Breathing the machine exhaust gases can harm and possibly kill you. At time of machine installation in a confined space a system ventilation risk assessment must be carried out by suitably qualified personnel. If deemed necessary a suitable local exhaust ventilation system must be installed and operated when the machine is being used.

Sparks

Explosions and fire can be caused by sparks from the exhaust or the electrical system. Do not use the machine in closed areas where there is flammable material, vapour or dust.

Hazardous Atmospheres

This machine is designed for use in normal outdoor atmospheric conditions. It must not be used in an enclosed area without adequate ventilation. Do not use the machine in a potentially explosive atmosphere, i.e. combustible vapours, gas or dust, without first consulting your JCB dealer.

Hot Components

Touching hot surfaces can burn skin. The engine and machine components will be hot after the unit has been running. Allow the engine and components to cool before servicing the unit.

WARNING! *The engine has exposed rotating parts. Switch off the engine before working in the engine compartment. Do not use the machine with the engine cover open.*

Check (Condition)

Excessive smoke from the exhaust stack combined with a complaint of low power could be as a result of:

- Dirt or dust (unfiltered air) ingested directly into the engine, resulting in damage to the cylinder bores and/or turbocharger (if installed). There will also be a possible increase in oil consumption.
- Air leaks from the air hose connections.
- Exhaust manifold leaks.



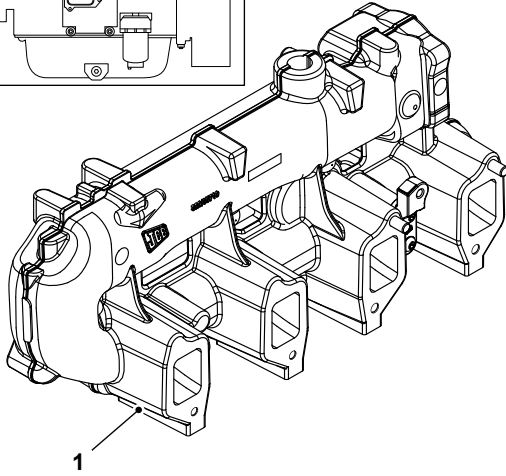
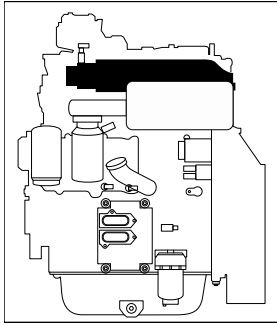
03 - Inlet Manifold

Introduction	18-81
Component Identification	18-82
Check (Condition)	18-82
Remove and Install	18-83

Introduction

The inlet manifold (or intake manifold) supplies combustion air to the cylinders in compression ignition engines or the air/fuel mixture for spark ignition engines (except most direct injection spark ignition engines). Even distribution of the air or air/fuel is important to optimize the efficiency and performance of the engine.

The manifold is required to be air tight under pressure and vacuum conditions and can be required to provide mounting points for sensors, grid heaters, throttle bodies and other components depending on the engine type and specification.

Component Identification**Figure 239.**

1 Inlet Manifold

Check (Condition)

1. Check the manifold mating faces for signs of damage and distortion.
2. Check the manifold casting for signs of cracks.
3. Renew the manifold if there are any signs of defect.

Remove and Install

Before Removal

1. This procedure requires service parts. Make sure you have obtained the correct service parts before you start, refer to Parts Catalogue.

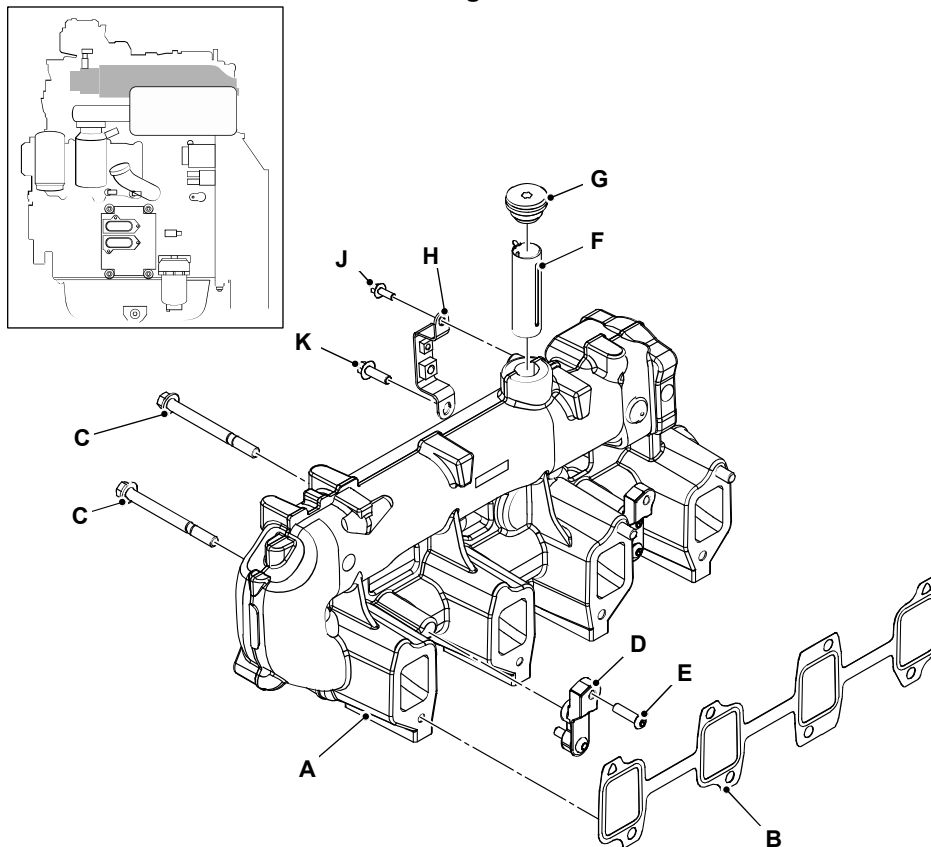
2. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.

3. Get access to the engine.

4. Remove the fuel rail assembly.

[Refer to: PIL 18-18-12.](#)

Figure 240.



A Inlet manifold
C Bolt 1 (x8)
E Screw (x4)
G EGR Plug
J Bolt 2 (x1) (M6 x 16mm)

B Manifold gasket
D Fuel rail mount
F EGR (Exhaust Gas Recirculation) mixer tube
H Inlet manifold bracket
K Bolt 3 (x1) (M8 x 25mm)

Remove

1. Disconnect the TMAP (Temperature Manifold Absolute Pressure) sensor electrical connector.
2. Disconnect the air inlet hose.
3. Remove the bolts 1 (x8) and lift the inlet manifold from the cylinder head. Discard the gasket.
4. Cap the inlet ports with blanking caps to prevent ingress of dirt.

5. Inspect the manifold.

[Refer to: PIL 18-24-03.](#)

Install

1. The installation procedure is the opposite of the removal procedure. Additionally do the following steps.
2. Replace the manifold gasket.



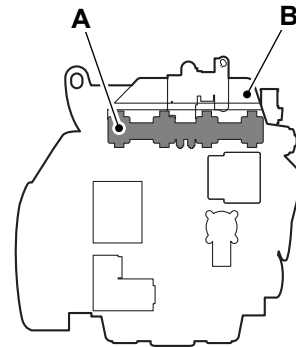
3. Loosely assemble the manifold, together with the new inlet gasket to the cylinder head, use the two bolts (one at each end).
4. With the manifold and gasket in position, install the remaining six bolts.
5. Tighten the bolts to the correct torque value.

Table 127. Torque Values

Item	Nm
C	43–47
E	23–27
J	9–12
K	23–27

04 - Outlet Manifold

Component Identification	18-85
Check (Condition)	18-86
Remove and Install	18-87

Component Identification**Figure 241.**

- A** Exhaust manifold
- B** Manifold gasket and heat shield

Check (Condition)

1. Check the manifold mating faces for signs of damage and distortion.
2. Check the manifold casting for signs of cracks.
3. Renew the manifold if there are any signs of defect.
4. Visually inspect for leaks at the exhaust manifold. Make sure all gaskets are in good condition, replace as required.

Remove and Install

Before Removal

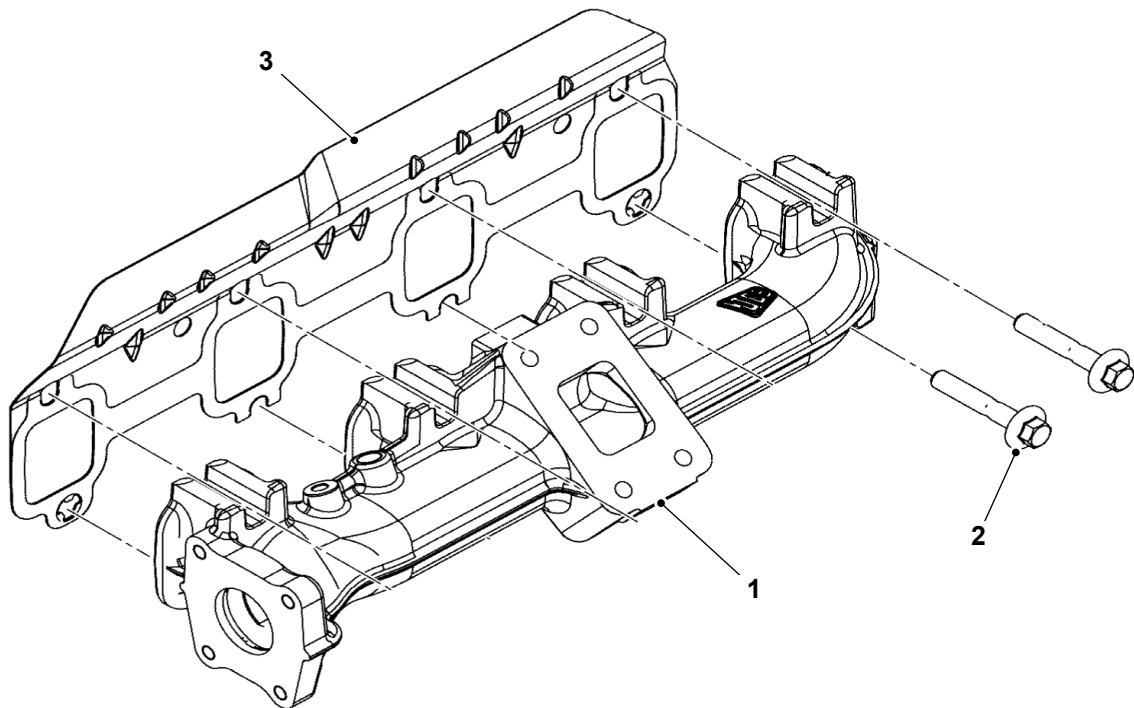
1. This procedure requires service parts. Make sure you have obtained the correct service parts before you start, refer to Parts Catalogue.
2. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.

3. Get access to the engine.
4. Remove the alternator.
[Refer to: PIL 15-72-00.](#)
5. Disconnect the oil pipes to the turbocharger.

Remove

1. Remove the upper four bolts.

Figure 242.



- 1 Exhaust manifold
3 Manifold gasket

- 2 Fixing bolts M10 x 57mm (x8)

2. Loosen the lower four bolts and lift the exhaust manifold from the cylinder head. Remove the bolts and discard the gasket.
3. Cap the exhaust ports to prevent ingress of dirt.
4. Inspect the manifold.
[Refer to: PIL 18-24-04.](#)

2. Renew the manifold gasket.
3. Install the lower four bolts, together with the new exhaust gasket to the cylinder head (screw in the bolts the specified distance).
Length/Dimension/Distance: 8mm
4. Rest the manifold in position on the row of lower bolts by locating the slots, then install the remaining four upper bolts.
5. Tighten the bolts to the first stage torque value.
6. Tighten the bolts to the final stage torque value.

Install

1. The installation procedure is the opposite of the removal procedure. Additionally do the following steps.



After Installation

1. Reconnect the oil pipes to the turbocharger (if installed).
2. Install the exhaust pipe and the silencer box.
3. Install the alternator.
[Refer to: PIL 15-72-00.](#)
4. Start the engine and check for exhaust leaks.

Table 128. Torque Table

Item	Torque Value (Nm)	Torque Angle (Degrees)
2 (First Stage)	25	
2 (Final Stage)		+90

06 - Silencer

Introduction

The silencer is a device used to reduce noise level of the engine exhaust system to accepted level.

The silencer on this machine is mounted in a separate compartment on the generator chassis and the exhaust exits the top of the canopy to be topped off by a hinged rain cap.

27 - Spark Arrestor

Remove and Install

Hot Components

Touching hot surfaces can burn skin. The engine and machine components will be hot after the unit has been running. Allow the engine and components to cool before servicing the unit.

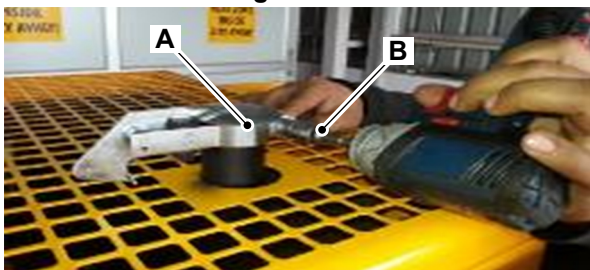
CAUTION! The exhaust pipe becomes extremely hot when the engine is running and will remain so for some time after the engine is stopped. If you touch the hot pipe you could be severely burned.

The spark arrestor is optional to the secondary silencer.

Remove

1. Make the machine safe.
[Refer to: PIL 01-03.](#)
 - 1.1. Obey all exhaust system health and safety information.
[Refer to: PIL 18-00-00.](#)
2. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.
3. Remove the rear access cover.
[Refer to: PIL 06-06-14.](#)
4. Isolate the battery.
[Refer to: PIL 33-03-00.](#)
5. Remove the exhaust system.
6. If necessary, remove the exhaust rain cap.

Figure 243.

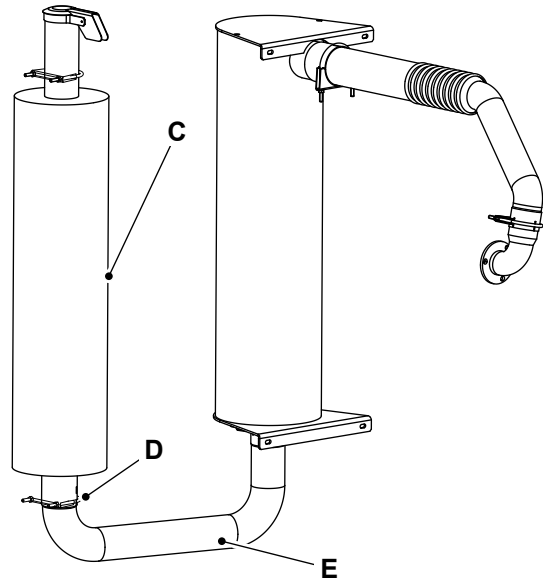


- A Exhaust rain cap
- B Bolt

- 6.1. Remove the bolt.
- 6.2. Remove the exhaust rain cap from the spark arrestor.
7. Support the exhaust assembly.

8. Remove the nut from the U clamp (x2). Remove the U clamp (x2) and remove the spark arrestor from the silencer pipe.

Figure 244.



- C Spark arrestor
- D U clamp (x2)
- E Silencer pipe

Install

1. The installation procedure is the opposite of the removal procedure. Additionally do the following step.
2. Tighten the fasteners to the correct torque value.



27 - Exhaust Gas Recirculation (EGR)

Contents	Page No.
18-27-00 General	18-93
18-27-03 Actuator	18-100



Notes:



00 - General

Introduction	18-93
Component Identification	18-94
Operation	18-95
Check (Condition)	18-96
Remove and Install	18-97

Introduction

The EGR (Exhaust Gas Recirculation) system is a technique that re-circulates a portion of the exhaust gases back into the combustion chamber. The system cools and controls the quantity of re-circulated exhaust gas.

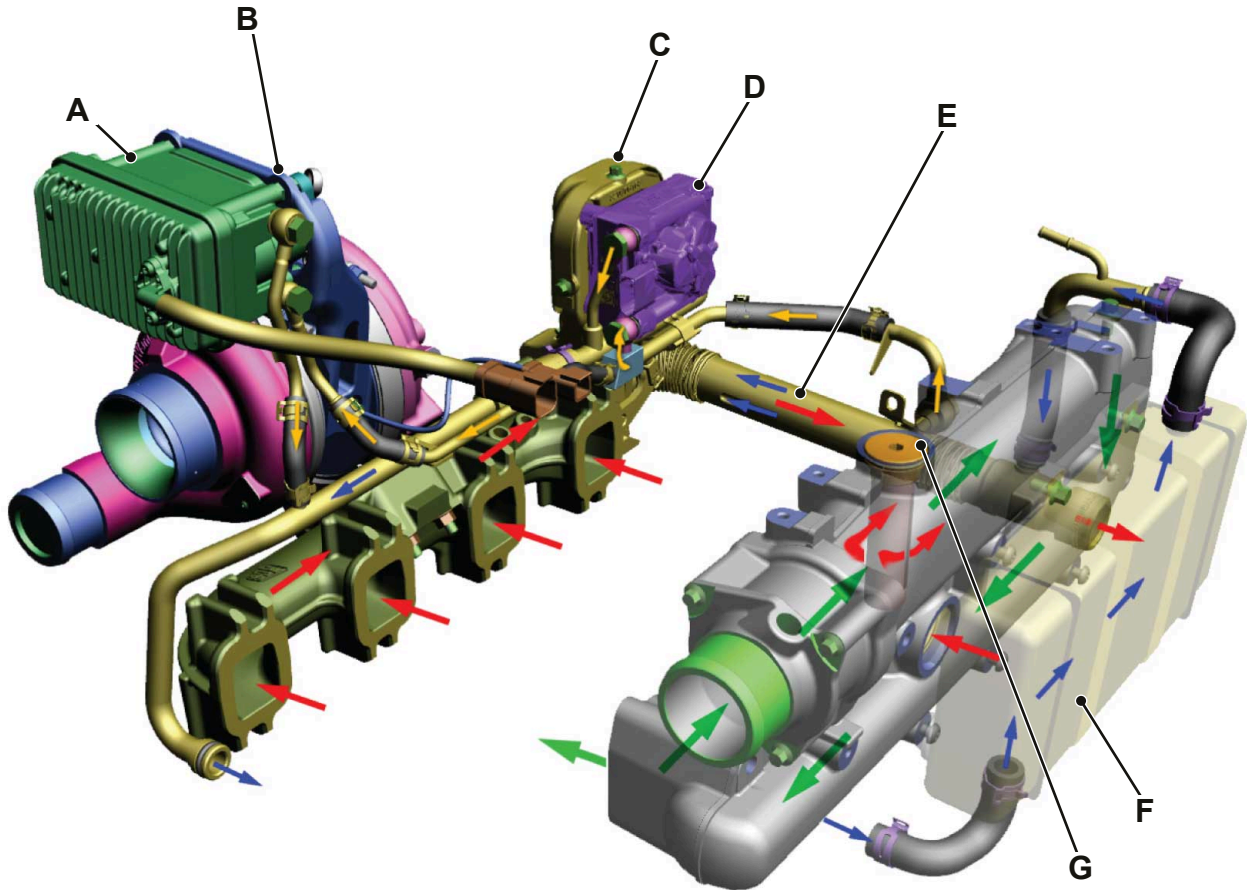
The EGR valve is controlled by the CAN (Controller Area Network) bus system (PIL 33-45), the valve opens and closes to allow the exhaust gases to flow back into the intake system via the EGR cooler. This has the effect of lowering the combustion temperature and reducing the formation of NOx (Nitrogen Oxide).

In order to ensure full power is always available when it is needed, the EGR valve will close when full power is needed or when the engine is cold and inherently inefficient this means that the engine is running as lean and efficiently as possible at all times.

The EGR valve system comprises an actuator with a feedback position sensor, linkage and a valve mechanism. The valve actuator, which is controlled by the CAN bus system, position sensor and linkage, drives the valve to the demanded position.

Component Identification

Figure 245.



A VGT (Variable Geometry Turbocharger) actuator
 C EGR (Exhaust Gas Recirculation) valve
 E EGR intermediate cooler
 G Mixer tube

B VGT
 D EGR actuator
 F Main plate cooler

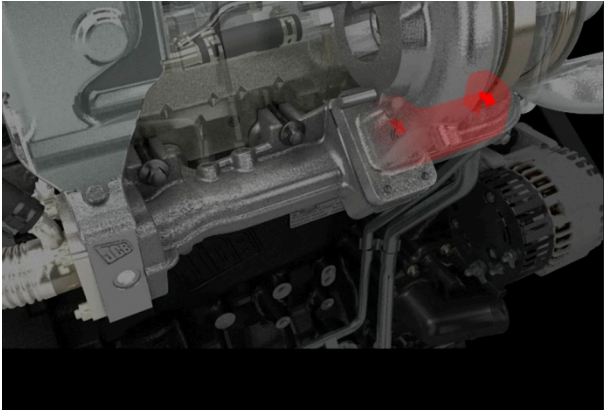
Table 129. Colour Code Key

Colour	System
Blue	Coolant Flow 1
Red	Recirculated Gas Flow
Green	Air Flow
Yellow	Coolant flow 2

Operation

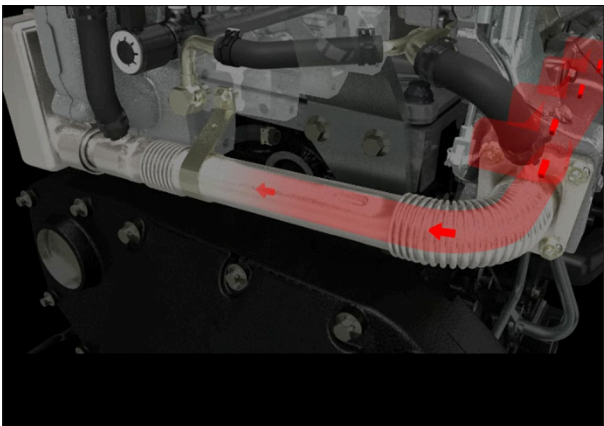
1. Exhaust gases enter the exhaust manifold.

Figure 246.



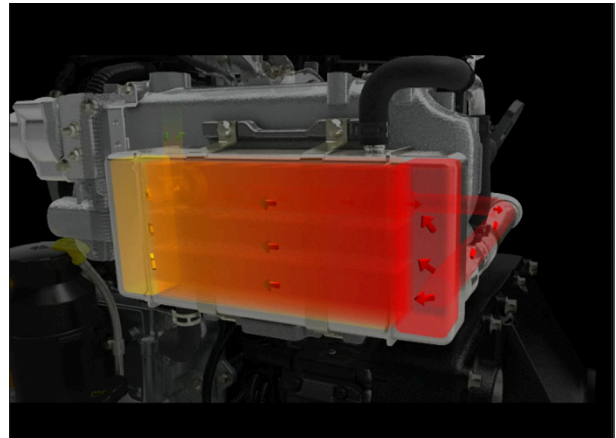
2. The exhaust gases travel through the intermediate EGR (Exhaust Gas Recirculation) cooler.

Figure 247.



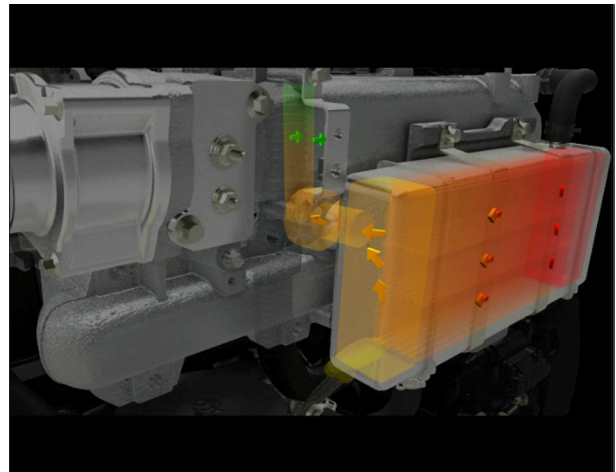
3. The exhaust gases enter the main cooler which reduces the heat.

Figure 248.



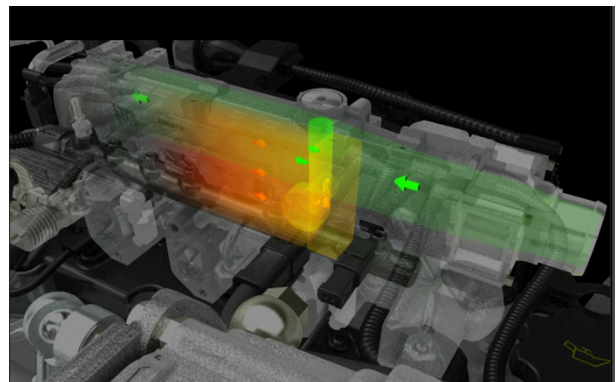
4. Exhaust gases enter the mixer tube.

Figure 249.



5. The exhaust gases are mixed with new air and re-enter the engine.

Figure 250.



Check (Condition)

Check the general condition of the EGR (Exhaust Gas Recirculation) system as follows.

1. Check the integrity of the air inlet circuit.
 - 1.1. Make sure that the air filter is not blocked.
 - 1.2. Make sure that the air filter housing is in good condition and free from air leaks.
 - 1.3. Check that the air intake hoses connecting the turbocharger, charge air cooler and inlet manifold are free from air leaks and restrictions.
 - 1.4. Check that the inlet manifold and its gasket are installed correctly.
 - 1.5. Repair or replace components as necessary.
2. Check for blockages or carbon build up in the following components.
 - 2.1. The inlet manifold.
 - 2.2. The EGR mixer valve.
 - 2.3. The exhaust manifold pressure sensor feed pipe.
 - 2.4. The EGR valve.
 - 2.5. The EGR cooler.
 - 2.6. Repair or replace components as necessary.
3. Check the operation of the EGR valve assembly as follows.
 - 3.1. Inspect the actuator linkage for signs of wear or defects. If the linkage is defective the EGR assembly must be replaced.
 - 3.2. Check the condition of the actuator electrical connector and associated wiring. Replace or repair components as necessary.
 - 3.3. Do the EGR calibration procedure. Refer to Calibrate.
 - 3.4. If faults persist, replace the EGR assembly.

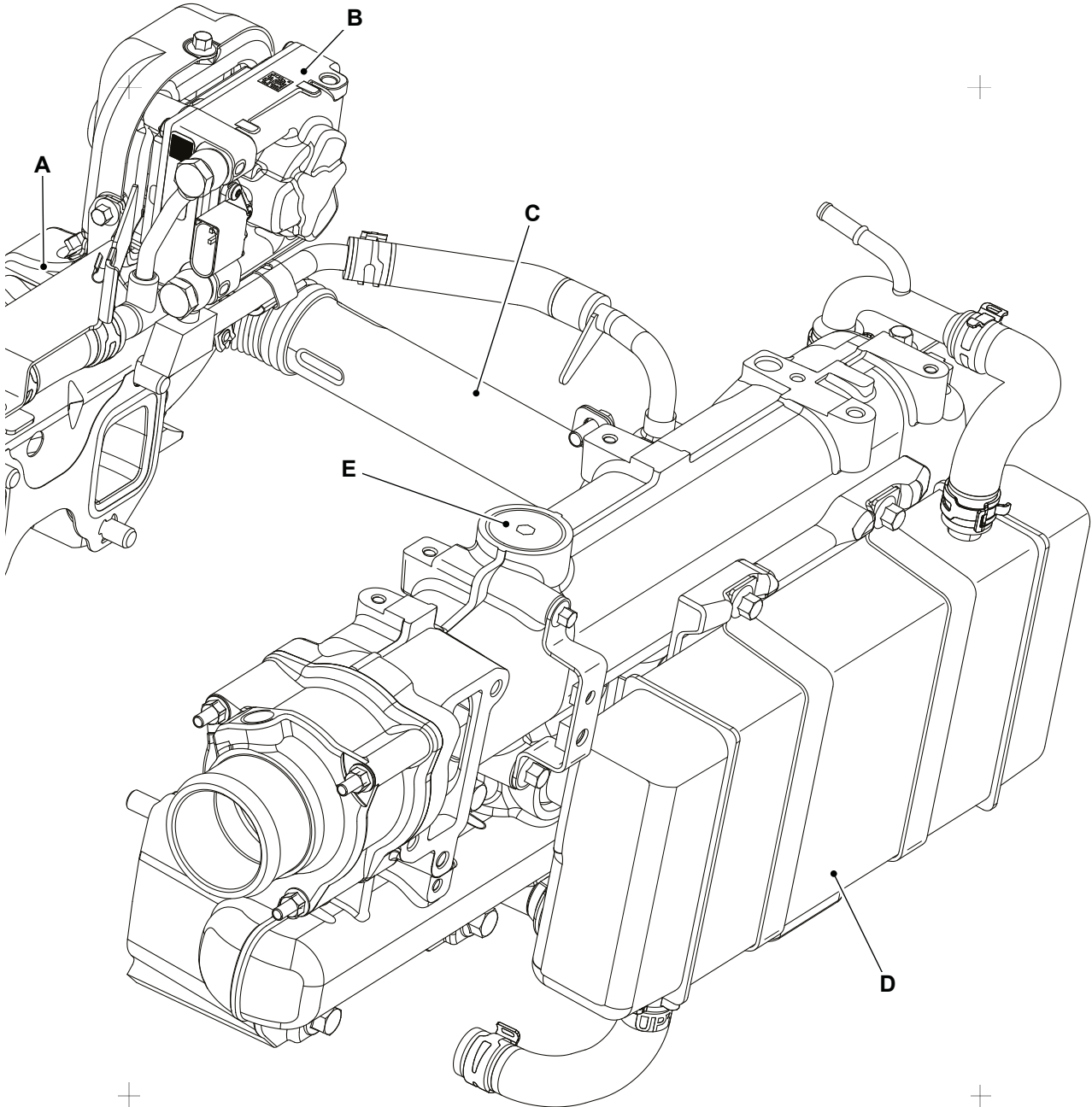
Remove and Install

Before Removal

1. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.

2. Get access to the engine.

Figure 251.



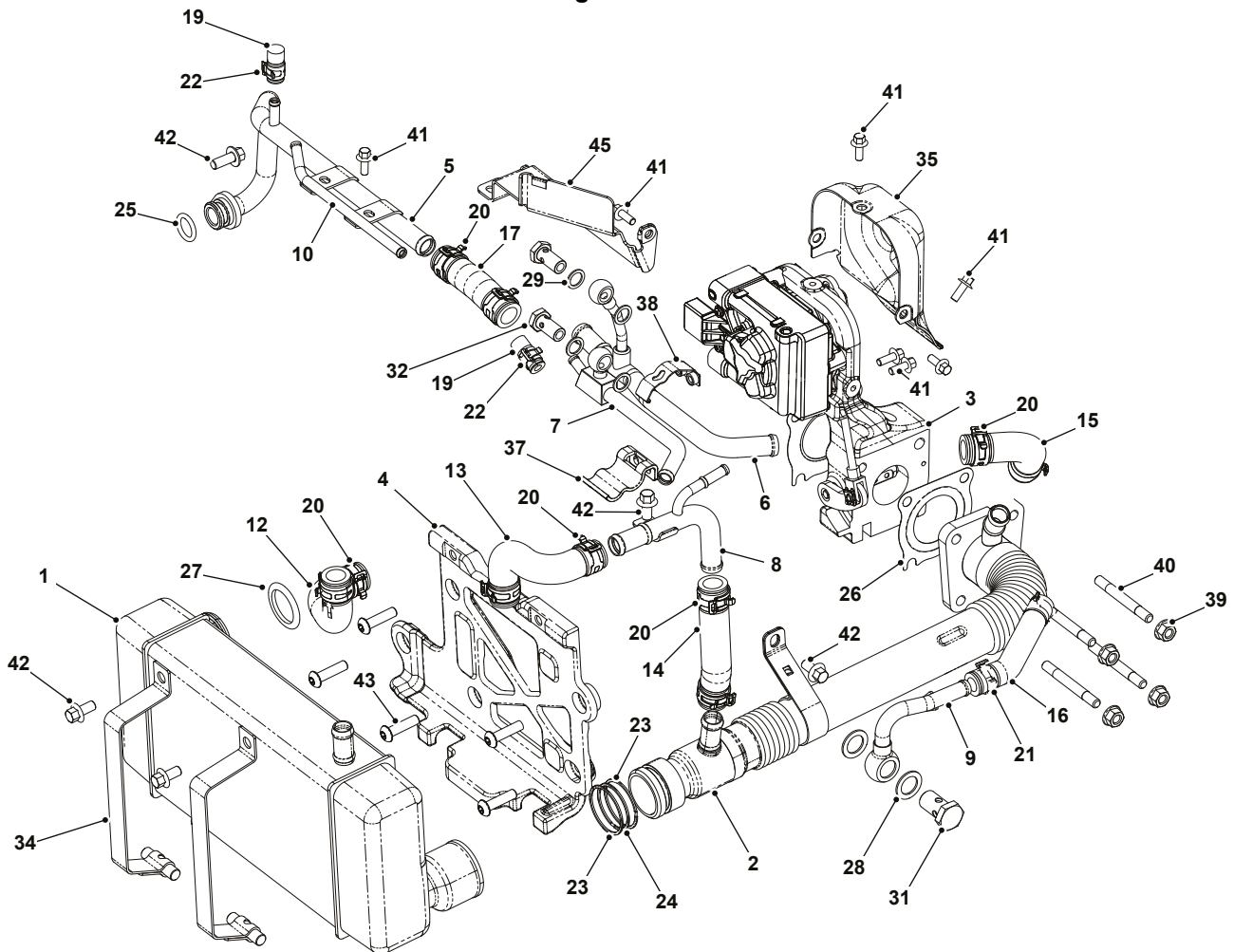
A EGR (Exhaust Gas Recirculation) actuator
C EGR intermediate cooler
E Mixer tube

B EGR valve
D Main EGR cooler

Remove

1. Remove the EGR cooler hose (Left side viewed from the rear of the engine).
2. Remove the EGR cooler bracket assembly bolts (x2).
3. Carefully remove the main EGR cooler.
4. Remove the EGR cooler hose (Right side viewed from the rear of the engine).
5. Remove the nuts (x4) fixing the EGR tube in tube cooler pipe assembly to the EGR valve.
6. Remove the EGR actuator control rod pivot pin fixing clips and the EGR control rod.
7. Remove the bolt fixing the EGR tube in tube cooler to the rear of the cylinder head.
8. Remove the bolts (x4) that retain the heat shield to the EGR control module.
9. Remove the bolt from the cooler pipe.
10. Remove the cooler connections (banjo fittings (x4) and copper washers) from the EGR control module and electrical harness connector.
11. Remove the small bolts (x3) that fix the control module to the EGR valve.
12. Remove the bolts (x2) that fix the EGR bracket to the W-clip that clamp the cooler pipes together (captive nuts).
13. Remove the EGR valve body from the mounting studs fixed to the manifold with a steel gasket both sides.

Figure 252.



- | | |
|---|-----------------------------------|
| 1 Main EGR cooler | 2 Intermediate EGR cooler |
| 3 EGR valve | 5 Pipe (Coolant return to header) |
| 6 Pipe (Under actuator to coolant return) | 7 Pipe (EGR actuator feed) |

- | | |
|---|--|
| <ul style="list-style-type: none"> 8 Pipe (EGR cooler out) 10 Pipe (Turbo actuator feed) 12 Hose (EGR cooler in) 14 Hose (EGR in, intermediate cooler) 16 Hose (EGR actuator feed) 18 Hose (Turbo actuator feed) 20 Spring-band clamp form B (24mm Diameter) 22 Spring-band clamp (14mm Diameter) 24 Laminar seal ring (Small) 26 Gasket (EGR to Manifold) 28 Copper washer (M16) 30 Copper washer (M10) 32 Banjo bolt (M12) 35 EGR Valve heat-shield 37 Coolant pipe clamp 39 Locknut (M8 Special) 41 Bolt flange hexagon head (M6 x 16mm) 43 Screw hexagon head (M8 x 30mm) | <ul style="list-style-type: none"> 9 Pipe (rear of head feed) 11 Pipe (Turbo actuator return) 13 Hose (EGR cooler out) 15 Hose (EGR cooler out, intermediate cooler) 17 Hose (EGR cooler return) 19 Hose (Turbo actuator feed/return) 21 Spring-band clamp form B (20mm Diameter) 23 Laminar seal ring (Large) 25 O-ring (I.D.17.0mm x 3.5mm) 27 Outlet lobe seal 29 Copper washer (M12) 31 Banjo bolt (M16) 34 EGR Cooler strap 36 W-Clip for 8mm O.D. pipe 38 Pipe clamp strap 40 Stud (M8 x 80mm) 42 Bolt flange hexagon head (M8 x 16mm) |
|---|--|

Install

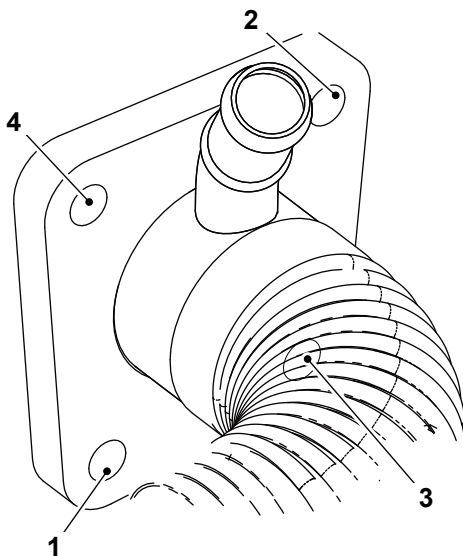
1. The installation procedure is the opposite of the removal procedure. Additionally do the following steps.
2. Renew all O-rings, sealing washers and gaskets.
3. Tighten the fixings to the correct torque value. Note: Tighten the EGR cross over tube bolts in the correct order, 1 to 4 as shown in 2 stages.

3. The EGR actuator is a CAN (Controller Area Network) driven device and can only be evaluated with the use of Servicemaster.
4. All conditions of the EGR are reported by the fault codes.

Table 130. Torque Values

Item	Nm
31	50 ± 3
32	24 ± 1
39	24 ± 2
40	10 ± 1
41	11 ± 1
42	24 ± 2
43	24 ± 3
44	24 ± 3

Figure 253.



After Installation

1. Complete the actuator learn procedure, Refer to Servicemaster, JCB Engine > Diagnostic Tool > Ecomax Actuators > Actuator Learn > EGR Valve Position Learn.
2. Start the engine and check for exhaust leaks and coolant leaks.



03 - Actuator

Introduction	18-100
Remove and Install	18-101

Introduction

The EGR (Exhaust Gas Recirculation) actuator is a smart electronic CAN driven device and can only be evaluated with the use of Servicemaster.

The device does a self check on the operating range to check the adaption window every time the ignition is switched off and on. The unit is extremely sensitive and constantly monitors the conditions it is operating under. If it detects over voltage, under voltage, high or low current, movement, temperature etc, if it is working outside of it's desired limits in any way at all, it will shut down until the fault is rectified.



Remove and Install

The EGR (Exhaust Gas Recirculation) electronic actuator is not a serviceable component, if it fails replace the EGR valve assembly.



30 - Aftertreatment System

Contents

Page No.

18-30-06 Filter	18-103
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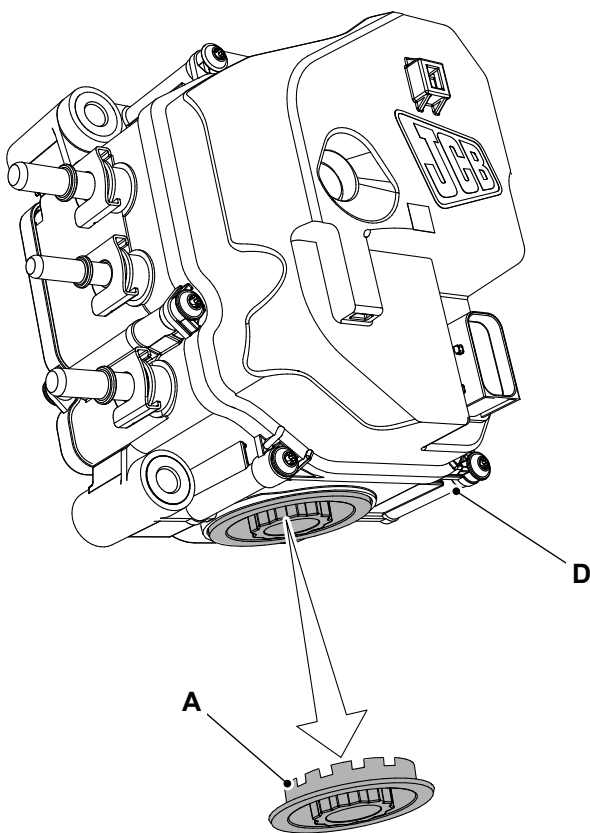
06 - Filter

Remove and Install

Remove

1. Perform the DEF (Diesel Exhaust Fluid) emptying routine using ServiceMaster.
2. Get access to the DEF supply module.
3. Remove the filter cover.

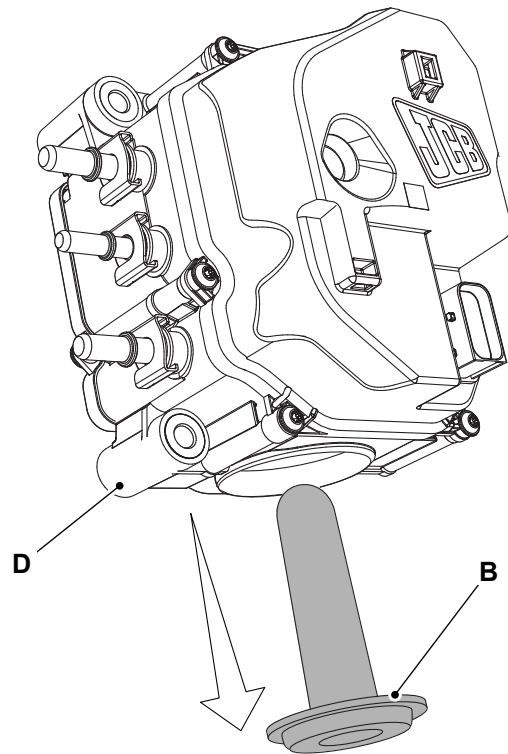
Figure 254.



- A** Filter cover
- D** Supply module

4. Remove and discard the pressure equalising element.

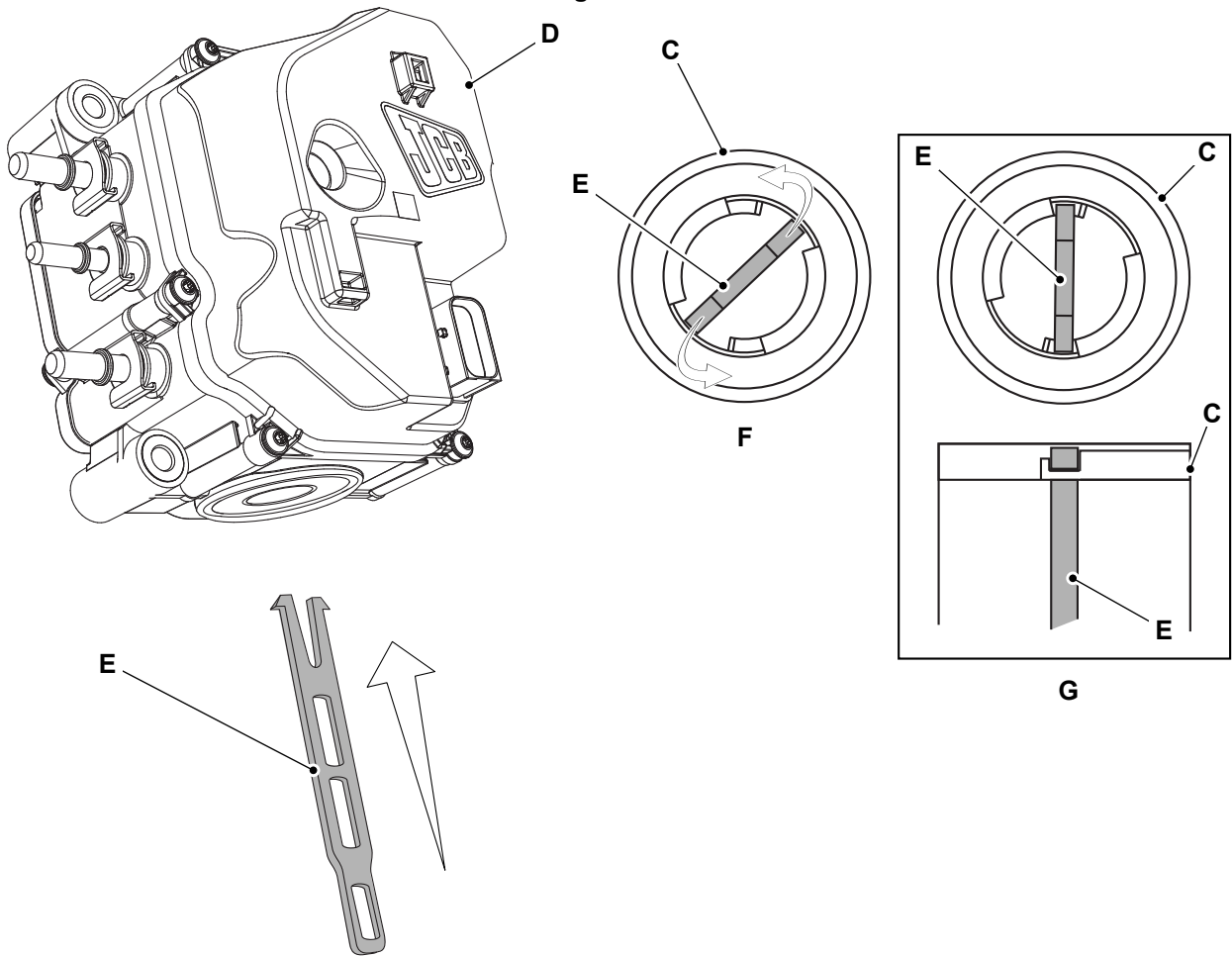
Figure 255.



- B** Pressure equalising element

5. Use the filter extraction tool to remove the filter from the supply module. The filter extraction tool is supplied with each new filter.
 - 5.1. Insert the split end into the filter element. Gently rotate the tool to position it in the correct position. Then rotate the tool in a clockwise motion to engage the tool with the filter.

Figure 256.



C Filter element

E Filter extraction tool

G Extraction tool- engaged with filter ready for removal

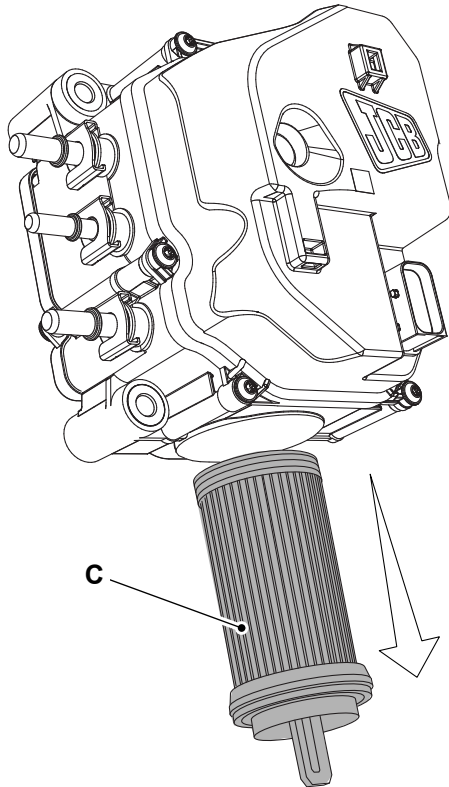
D Supply module

F Extraction tool- not engaged with filter

6. Place a suitable tool through the slot in the end of the filter extraction tool and pull hard to remove the filter element.

7. Discard the filter element.

Figure 257.



C Filter element

Install

1. Lubricate the 0-rings with distilled water or DEF.
2. Install a new filter element into the supply module.
3. Install a new pressure equalising element.
4. Install the filter cover, tighten to the correct torque value.

Table 131. Torque Values

Item	Nm
3	22.5



35 - Turbocharger

Contents

Page No.

18-35-00 General	18-107
------------------------	--------



00 - General

Introduction	18-107
Component Identification	18-108
Check (Condition)	18-109
Check (Operation)	18-110
Remove and Install	18-111

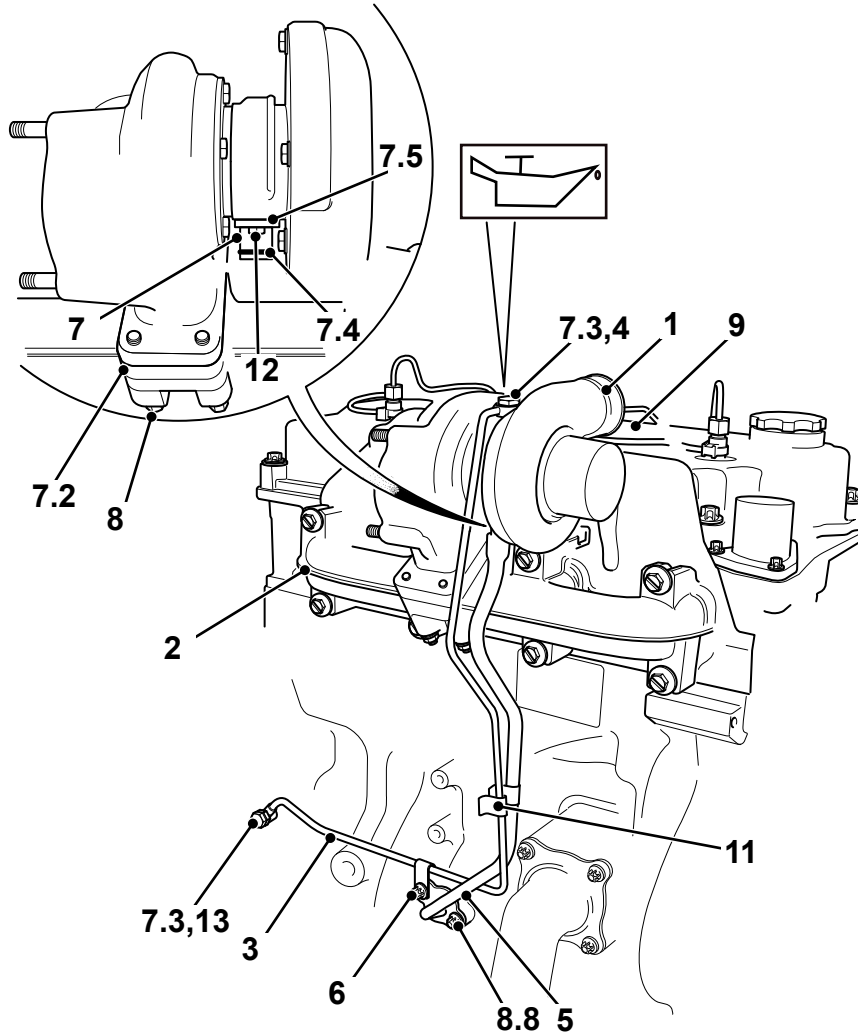
Introduction

The turbocharger (turbo) is a turbine driven forced induction device that makes an engine more efficient and helps to produce more power for its size.

Engine exhaust gasses drive a turbine, which in turn drives a compressor via a common shaft. The shaft bearings are lubricated by a feed from the engine lubrication system.

A turbocharged engine is more powerful and efficient than a naturally aspirated engine because the turbine forces more air, and proportionately more fuel, into the combustion chamber than atmospheric pressure alone.

Some variants incorporate a wastegate assembly. A flap type valve is housed in the turbocharger body. The valve is actuated by a diaphragm type actuator via an actuator rod. When the pressure generated by the turbocharger compressor reaches a pre-set value the actuator opens the valve, some exhaust gas is diverted back to the exhaust manifold and the turbocharger turbine speed reduces. In this way the pre-set maximum boost pressure from the turbo charger is not exceeded, regardless of engine speed.

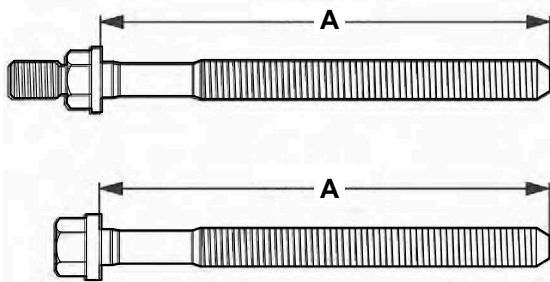
Component Identification
Figure 258.


- | | | | |
|----|-------------------------------------|----|---|
| 1 | Turbocharger | 2 | Exhaust manifold |
| 3 | Oil feed pipe (turbo bearing) | 4 | Banjo bolts M12 |
| 5 | Oil drain pipe (turbo bearing) | 6 | Fixing bolts (x2) |
| 7 | Pipe adaptor (oil drain connection) | 8 | Retaining nuts (x4) |
| 11 | Pipe clip | 12 | Bolt - pipe adaptor (oil drain connection) |
| 13 | Banjo bolts M16 | | |

Check (Condition)

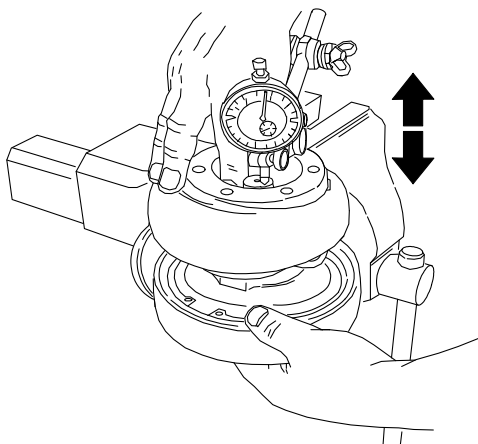
1. Visually inspect for leaks at the turbocharger. Make sure that all gaskets are in good condition, replace as required.
2. Check the turbine and compressor blades inside the turbocharger rotate freely and smoothly by hand. If the blades are stiff to turn, or damaged the turbocharger must be replaced.
3. Make sure that the oil feed pipe and oil drain pipe are clear and free from debris and sludge.
4. Check the turbine shaft running clearance.
 - 4.1. Place the stylus of a DTI (Dial Test Indicator) against the shaft.
 - 4.2. Move the shaft sideways.

Figure 259.



- 4.3. Make sure that the turbine shaft running clearance is within the specified limits.
5. Check the shaft end float.
 - 5.1. Place the stylus of the DTI against the end of the shaft.

Figure 260.



- 5.2. Move the shaft axially.

- 5.3. Make sure that the shaft end float is within the specified limits.

Check (Operation)

To maximise the duration of the turbocharger follow the rules described below.

Start-up

Start the engine and keep it at idle speed for about a minute. The oil operating pressure is reached within a few seconds, but it is useful to allow the moving parts to warm up in good lubrication conditions. Immediately increasing the engine speed after start up will result in the turbocharger running at high rpm with less than optimal lubrication. This may lead to premature failure of the turbocharger.

After maintenance

When carrying out maintenance on the engine or turbocharger, pre-lubricate the oil inlet of the turbocharger by adding clean lubricant until it is completely full. After pre-lubrication, let the engine run via the starter motor without firing (engine / fuel pump stop out) to allow the oil to circulate through the complete system under pressure. Upon engine start-up, make it run at idle speed for a few minutes, allowing the oil and bearings system to work satisfactorily.

Low temperature air or engine inactivity

If the engine has been inactive for a certain period of time or the air temperature is very low, start the engine and then let it run at idle speed. This enables the oil to go into the lubrication system before applying high loads and speeds to the engine and turbocharger.

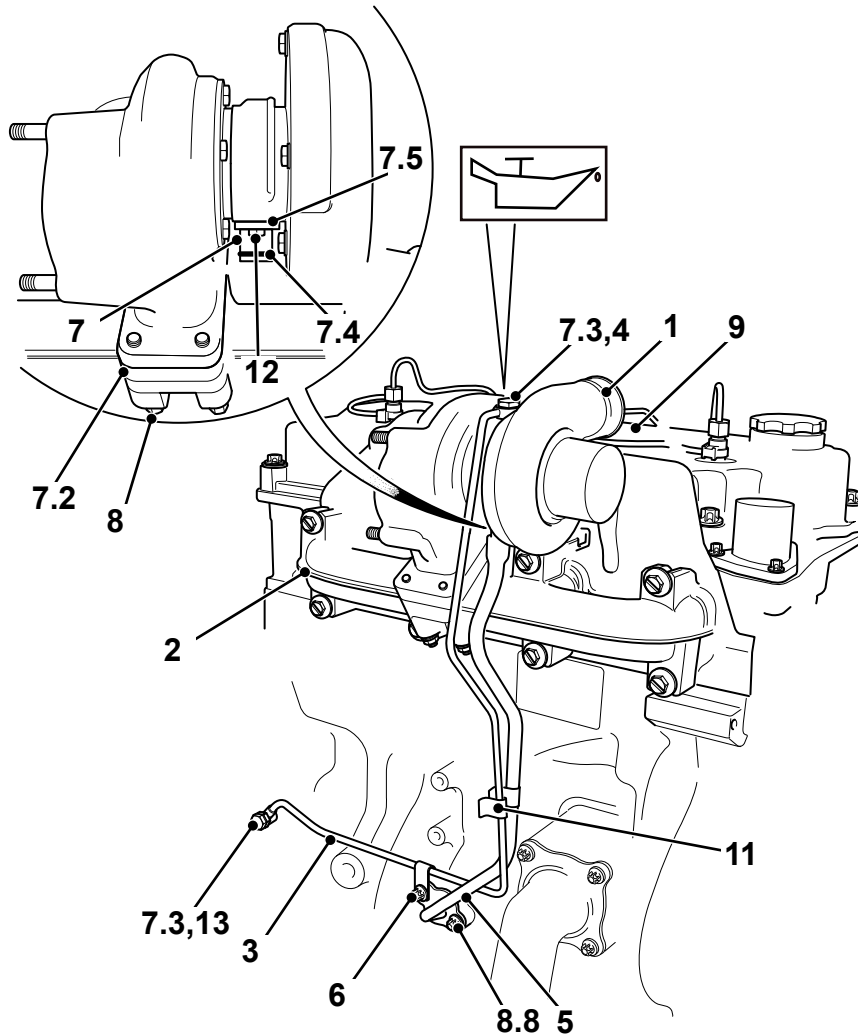
Engine shutdown

Before switching the engine off after intense activity, you must allow the turbocharger to cool down, let the engine run for 10 minutes to allow the turbocharger to cool.

Engine at idle speed

Avoid running the engine at idle speed for long periods (above 20-30 minutes). Idle operation leads to low pressure values in the turbocharger, which may cause oil leaks from the seals at the ends of the turbo bearing shaft. Even if this does not cause damage, it can cause blue smoke from the exhaust when the engine speed and load are increased.

Remove and Install

Figure 261.


- | | | | |
|----|-------------------------------------|----|---|
| 1 | Turbocharger | 2 | Exhaust manifold |
| 3 | Oil feed pipe (turbo bearing) | 4 | Banjo bolts M12 |
| 5 | Oil drain pipe (turbo bearing) | 6 | Fixing bolts (x2) |
| 7 | Pipe adaptor (oil drain connection) | 8 | Retaining nuts (x4) |
| 11 | Pipe clip | 12 | Bolt - pipe adaptor (oil drain connection) |
| 13 | Banjo bolts M16 | | |

Before Removal

1. This procedure requires service parts. Make sure you have obtained the correct parts before you start, refer to Parts Catalogue.
2. Make sure that the engine is safe to work on. If the engine has been running, make sure the engine has cooled sufficiently before you start.
3. Remove the ignition key.

4. Get access to the engine.
5. Drain the cooling system.

Remove

1. Disconnect the air induction hose at the inlet manifold and turbocharger. Remove the hose.
2. Remove the pipe clip. Undo fixing bolts and remove the oil drain pipe. Note that the pipe pulls

off the pipe adaptor, leaving the adaptor in place. Cap the open ports to prevent ingress of dirt. Discard the O-ring and the gasket.

3. Undo the banjo bolts at each end of the oil feed pipe, remove the pipe. Cap the open ports to prevent ingress of dirt. Discard the sealing washers.
4. Remove the exhaust manifold from the cylinder head complete with the turbocharger still installed, refer to Exhaust Manifold-Removal and Replacement. Discard the exhaust manifold gasket.
5. With the exhaust manifold removed from the engine, undo the nuts and separate the turbocharger from the manifold. Discard the gasket.
6. If the turbocharger is to be replaced remove the bolts and pipe adaptor. Discard the gasket.

Install

1. The installation procedure is the opposite of the removal procedure. Additionally do the following steps.
2. Check the condition of the turbocharger (PIL 18-35)
3. Prime the top of the turbo with 200ml of fresh clean engine oil. It is important: not to run the new turbo dry.
4. Renew all 'O' rings, sealing washers and gaskets.
5. Note that the exhaust manifold gasket also functions as a heat shield. Be sure to position the gasket the correct way round.
6. Tighten the nuts, bolts and banjo bolts to the correct torque value.

Table 132. Torque Values

Item	Nm
4	21
6	24
8	24
13	36



36 - Variable Geometry Turbocharger (VGT)

Contents

Page No.

18-36-00 General	18-115
18-36-03 Actuator	18-123



Notes:



00 - General

Introduction	18-115
Component Identification	18-117
Operation	18-118
Check (Condition)	18-119
Check (Operation)	18-119
Remove and Install	18-120

Introduction

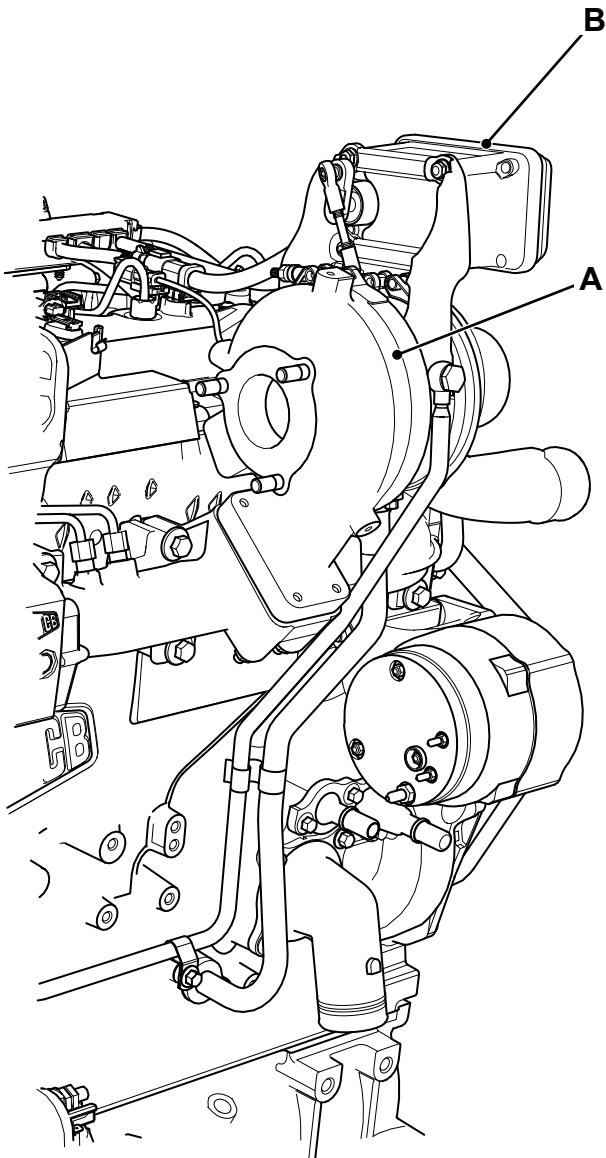
The VGT (Variable Geometry Turbocharger) uses variable vanes to control exhaust flow and to introduce EGR (Exhaust Gas Recirculation) to reduce emission in diesel engines. The turbocharger is bolted to the outlet port of the exhaust manifold.

The turbo uses heat and energy from the waste exhaust gases to drive a turbine which in turn drives the compressor to pull new air at high pressure into the cylinders. The extra volume of air allows more fuel to be injected increasing the engine power output.

This has the effect of lowering the combustion temperature and reduces formation of NOx (Nitrogen Oxide) gases.

The air is compressed to a minimum pressure of 1 bar (14.5 lb/in²) depending upon engine speed and load. The turbocharger spins at up to 100,000 rpm and reaches temperatures approaching 700 °C (1292 °F); it is essential, therefore, that a good supply of oil reaches it at all times. The oil not only lubricates the turbocharger but also carries away excess heat. External oil feed pipe connected to a port on the crankcase supplies oil to the turbocharger bearing. Oil returns to the engine oil sump via an external drain pipe. Integral oil seals prevent oil escaping to the compressor and turbine ends of the turbocharger.

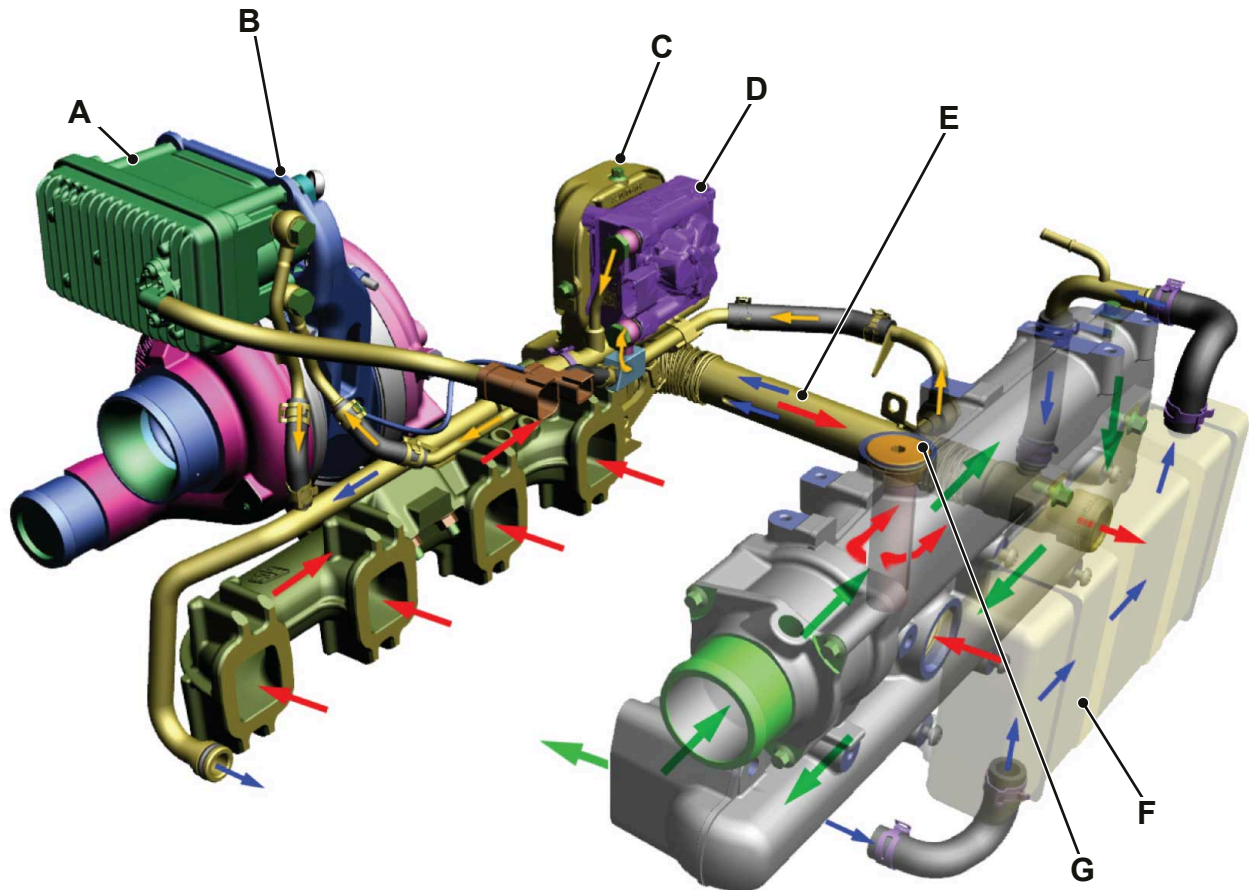
Figure 262.



- A VGT
- B VGT actuator

Component Identification

Figure 263.



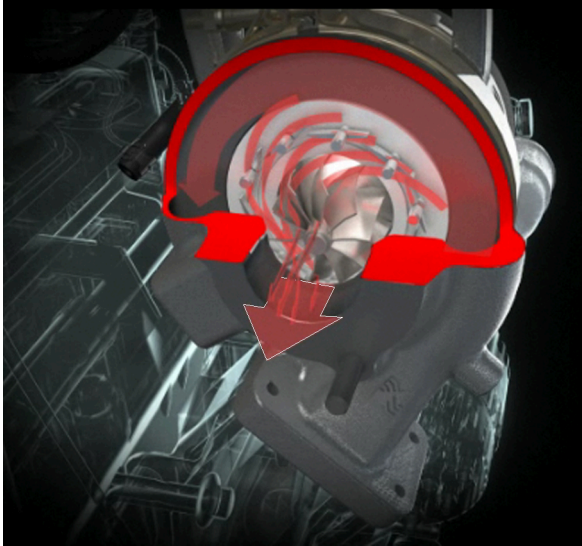
- A VGT (Variable Geometry Turbocharger) actuator
- C EGR (Exhaust Gas Recirculation) valve
- E EGR intermediate cooler
- G Mixer tube

- B VGT
- D EGR actuator
- F Main plate cooler

Operation

1. Exhaust gases move through the scroll volume spread across a slot and over the louvres turning the turbine and out of the outlet.

Figure 264.



2. The louvre ring sits inside the turbine housing with the turbine spinning in the centre.

Figure 265.



3. The outer ring is adjusted by the actuator.

Figure 266.



4. The angle of the airflow can be adjusted as it strikes the adjustable louvres to change the turbo performance.

Figure 267.



Check (Condition)

Visually inspect for leaks at the turbocharger. Make sure all gaskets are in good condition, replace as required.

Check (Operation)

To maximise the duration of the turbocharger follow the rules described below.

Start-up

Start the engine and keep it at idle speed for about a minute. The oil operating pressure is reached within a few seconds, but it is useful to allow the moving parts to warm up in good lubrication conditions. Immediately increasing the engine speed after start up will result in the turbocharger running at high rpm with less than optimal lubrication. This may lead to premature failure of the turbocharger.

After maintenance

When carrying out maintenance on the engine or turbocharger, pre-lubricate the oil inlet of the turbocharger by adding clean lubricant until it is completely full. After pre-lubrication, let the engine run via the starter motor without firing (engine / fuel pump stop out) to allow the oil to circulate through the complete system under pressure. Upon engine start-up, make it run at idle speed for a few minutes, allowing the oil and bearings system to work satisfactorily.

Low temperature air or engine inactivity

If the engine has been inactive for a certain period of time or the air temperature is very low, start the engine and then let it run at idle speed. This enables the oil to go into the lubrication system before applying high loads and speeds to the engine and turbocharger.

Engine shutdown

Before switching the engine off after intense activity, you must allow the turbocharger to cool down, let the engine run at idle speed for at least 2 minutes to allow the turbocharger to cool.

Engine at idle speed

Avoid running the engine at idle speed for long periods (above 20-30 minutes). Idle operation leads to low pressure values in the turbocharger, which may cause oil leaks from the seals at the ends of the turbo bearing shaft. Even if this does not cause damage, it can cause blue smoke from the exhaust when the engine speed and load are increased.



Remove and Install

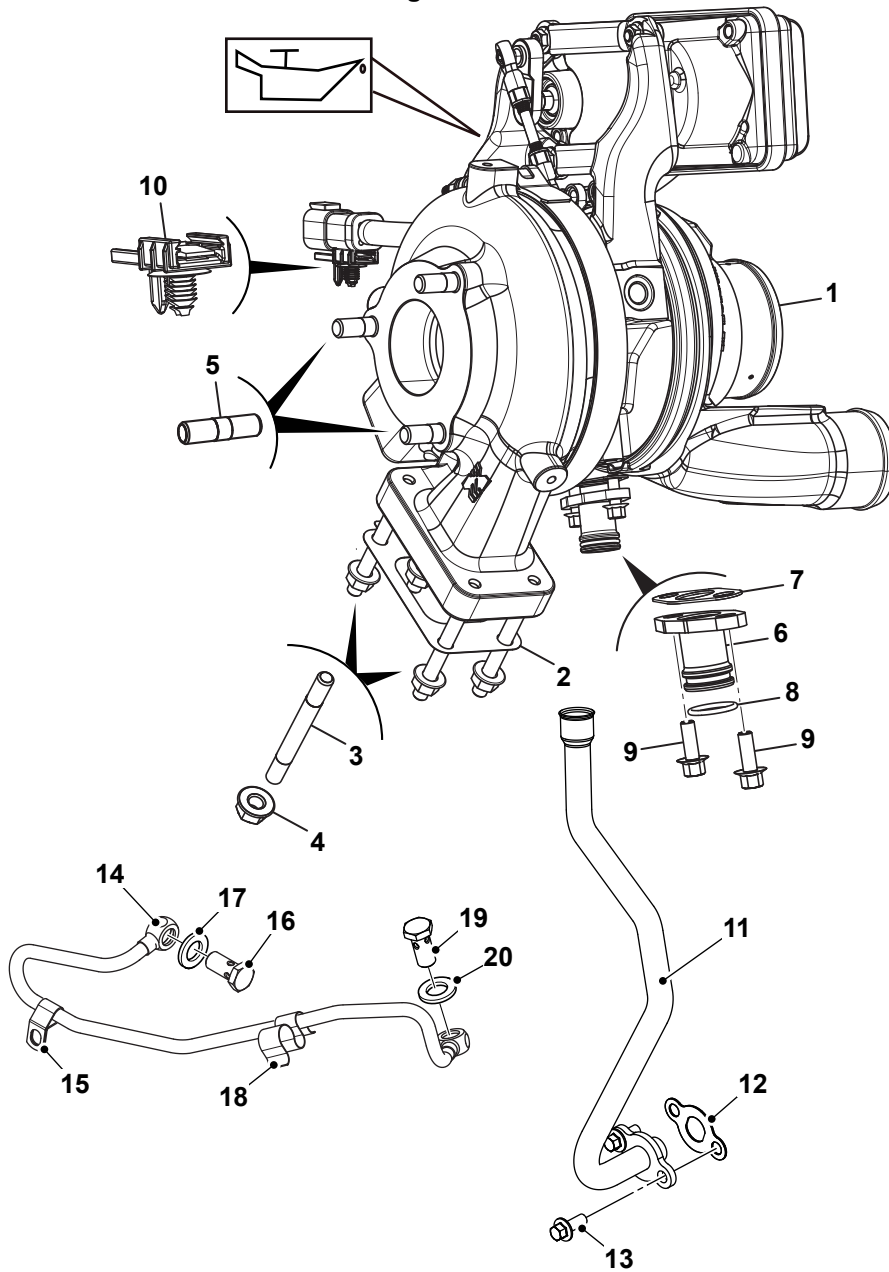
Special Tools

Description	Part No.	Qty.
Data Link Adaptor (DLA) Kit Data Link Adaptor (DLA 2.0) Kit	892/01174 728/H5409	1*
*Unless otherwise stated, you can use any of the tools shown.		

Before Removal

1. This procedure requires service parts. Make sure you have obtained the correct parts before you start, refer to Parts Catalogue.
2. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.
3. Remove the ignition key.
4. Get access to the engine.
5. Drain the cooling system. Refer to (PIL 21-00).

Figure 268.



- | | | | |
|-----------|--------------------------------------|-----------|-------------------------------------|
| 1 | VGT (Variable Geometry Turbocharger) | 2 | Gasket |
| 3 | Studs M8 | 4 | Lock nut |
| 5 | Studs M10 | 6 | Pipe adaptor (oil drain connection) |
| 7 | Gasket drain pipe | 8 | O-Ring |
| 9 | Bolt M6 | 10 | Clip |
| 11 | Oil drain pipe | 12 | Gasket drain pipe |
| 13 | Bolts M8 | 14 | Oil feed pipe |
| 15 | Pipe clip | 16 | Banjo bolts M12 |
| 17 | Copper Washer | 18 | W Clip |
| 19 | Banjo bolts M16 | 20 | Copper Washer M16 |

Remove

1. Disconnect the air induction hose at the inlet manifold and turbocharger. Remove the hose.
2. Undo the bolts and remove the oil drain pipe. Note that the pipe pulls off the pipe adaptor, leaving the adaptor in place. Cap the open ports to prevent ingress of dirt. Discard the O-ring and the gasket.
3. Remove the pipe clips. Undo the banjo bolts at each end of the oil feed pipe, remove the pipe. Cap the open ports to prevent ingress of dirt. Discard the sealing washers.
4. Remove the exhaust manifold from the cylinder head complete with the turbocharger still installed, refer to Exhaust Manifold- Removal and Replacement. Discard the exhaust manifold gasket.
5. With the exhaust manifold removed from the engine, undo the nuts and separate the turbocharger from the manifold. Discard the gasket
6. If the turbocharger is to be replaced remove the bolts and pipe adaptor. Discard gasket.

Table 133. Torque Values

Item	Nm
4	24
9	10
13	24
16	36
19	21

Install

1. The installation procedure is the opposite of the removal procedure. Additionally do the following steps.
2. Check the condition of the turbocharger. Refer to (PIL 18-35).
3. Prime the top of the turbo with 200ml of fresh clean engine oil. It is Important: not to run the new turbo dry.
4. Renew all O-rings, sealing washers and gaskets.
5. Note that the exhaust manifold gasket also functions as a heat-shield.
6. Tighten the nuts, bolts and banjo bolts to the correct torque value.

After Installation

1. Perform the 'VGT Replacement Set Up' procedure using Servicemaster.
[Special Tool: Data Link Adaptor \(DLA\) Kit / Data Link Adaptor \(DLA 2.0\) Kit \(Qty.: 1\)](#)
2. Start the engine and check for exhaust leaks.

03 - Actuator

Remove and Install

Special Tools

Description	Part No.	Qty.
Data Link Adaptor (DLA) Kit	892/01174	1*
Data Link Adaptor (DLA 2.0) Kit	728/H5409	

*Unless otherwise stated, you can use any of the tools shown.

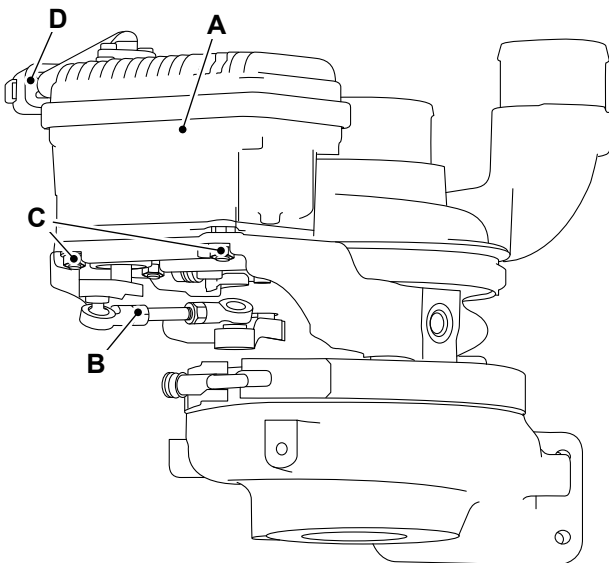
Before Removal

1. Make the machine safe. Refer to (PIL 01-03).
2. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.
3. Get access to the engine.

Remove

1. Disconnect the electrical connector.

Figure 269.



- A** Actuator
- B** Actuator linkage
- C** Nuts (x4)
- D** Electrical connector

2. Disconnect the actuator linkage from the actuator.
3. Disconnect the coolant hoses. Plug all the open ports and hoses to prevent contamination. Make sure that any spills or residual coolant is cleaned up immediately.

4. Remove the nuts (x4) and remove the actuator from the turbocharger housing.

Install

1. The installation procedure is the opposite of the removal procedure. Additionally do the following steps.
2. Perform the VGT (Variable Geometry Turbocharger) position learn routine using Servicemaster. Refer to the engine Helpfiles.

Special Tool: Data Link Adaptor (DLA) Kit / Data Link Adaptor (DLA 2.0) Kit (Qty.: 1)

Table 134. Torque Values

Item	Nm
B	10
C	13



96 - Fuel Pipe

Contents

Page No.

18-96-00 General	18-125
18-96-03 High Pressure Pipe	18-127
18-96-06 Low Pressure Pipe	18-130



00 - General

[Introduction](#) 18-125
[Component Identification](#) 18-126

Introduction

Fuel at rail pressure is continuously supplied to the injectors via high pressure fuel pipes. The high pressure fuel injector pipes consist of thick walled, seamless steel tubing. The ends of the tubes are formed with conical nipples for sealing in the sealing cones on the common rail and on the injector at port.

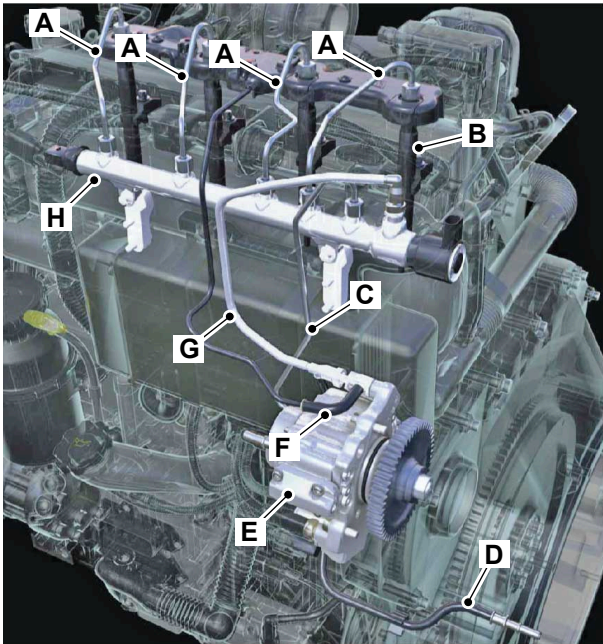
It is essential that the pipes are maintained and installed correctly for safe and effective engine operation.

The high pressure fuel pipes connect the injectors to the common rail. The injectors inject fuel in response to a supply of electrical current from the ECM (Engine Control Module). During fuel injection some fuel bleeds off the injectors and back to tank via the low pressure bleed off pipes.

Important: If the high pressure fuel pipes are removed for any reason they must be renewed. Installing the original fuel pipes will cause fuel leaks at the pipe connections.

Component Identification

Figure 270.



- A Pipe assembly high pressure - fuel rail to injector (x4)
- B Injector
- C Pipe assembly high pressure - injection pump to fuel rail
- D Pipe low pressure - return to tank
- E Injection pump
- F Pipe assembly low pressure - Fuel injectors to tank
- G Pipe assembly low pressure - fuel rail to tank
- H Fuel rail

03 - High Pressure Pipe

Remove and Install

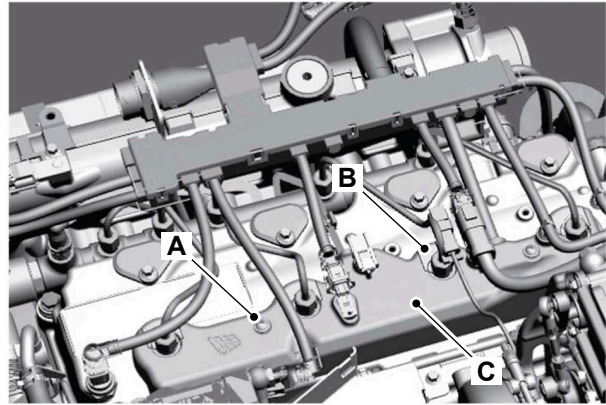
Special Tools

Description	Part No.	Qty.
Socket 17MM Offset - (HP Fuel pipes)	892/01267	1
Fuel Injection Equipment Cap Kit (444/448 T4i/T4F/BS4/STV Engine)	892/12359	1
Torque Wrench (10-100Nm)	993/70111	1

Important. Before disconnecting or removing fuel pipes proceed as follows.

1. Make sure that you have the correct new parts.
 - 1.1. The high pressure fuel pipes **MUST BE REPLACED** with new ones.
 - 1.2. The new fuel pipes must remain sealed inside their bags before use. If a bag is open **DO NOT USE** the fuel pipe, get a new one.
2. Obey all fuel system health and safety information.
[Refer to: PIL 18-00-00.](#)
3. Make sure that the engine is safe to work on.
 - 3.1. The engine must cool and pressure in the fuel system must decay before you start work.
 - 3.2. If the engine has been running, wait at least one hour before you start work.
4. Clean the engine.
[Refer to: PIL 15-00-00.](#)
 - 4.1. Additional cleaning must be carried out and precautions must be taken before working on the fuel system.
[Refer to: PIL 18-00-00.](#)
5. Remove the protective cover as follows.

Figure 271.



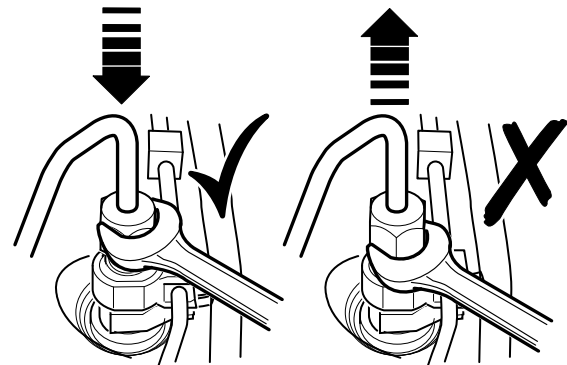
- A Screw
- B Plastic segment
- C Protective cover

- 5.1. Push out the plastic segments.
- 5.2. Remove the screws and lift off the cover.
- 5.3. Remove any dirt or debris that is exposed.

[Refer to: PIL 15-00-00.](#)

6. Always use a spanner at the top of the fuel pipe nut (this will prevent damage to the nut).

Figure 272.

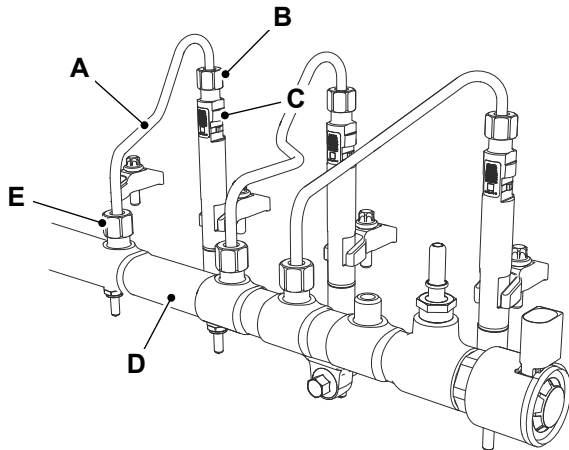


Injector Fuel Pipes

Remove

The procedure describes how to remove one fuel pipe.

Figure 273.



- A** Fuel pipe
- B** Nut 1
- C** Fuel injector
- D** Fuel rail
- E** Nut 2

1. Remove the fuel pipes one at a time as follows.
 - 1.1. Loosen the nut 2 at the fuel rail. Do not remove the nut at this step.
 - 1.2. Use the 17mm deep socket special tool at the top of nut. This will prevent damage to the nut.

Special Tool: Socket 17MM Offset - (HP Fuel pipes) (Qty.: 1)

Special Tool: Torque Wrench (10-100Nm) (Qty.: 1)
 - 1.3. Push the fuel pipe against the injector cone and at the same time remove the nut 1.
 - 1.4. Push the fuel pipe against the fuel rail cone and at the same time remove the nut 2.
 - 1.5. Make sure that there is no dirt or debris on the fuel pipe or the connectors.
 - 1.6. Remove the fuel pipe.
 - 1.7. Seal all the open ports, use the correct parts from the service kit.

Special Tool: Fuel Injection Equipment Cap Kit (444/448 T4i/T4F/BS4/STV Engine) (Qty.: 1)
2. Repeat step 1 to remove the other fuel pipes.
3. Discard the old fuel pipes.

Install

Important: The high pressure fuel pipes must be replaced with new ones. The new fuel pipes must remain sealed inside their bags before use. If a bag is open do not use the fuel pipe, get a new one. Do not open the bag until you are ready to assemble the fuel pipe.

1. Make sure that the bleed-off adaptors are assembled on the injectors before you install the high pressure pipes.
2. Assemble the fuel pipes one at a time. The procedure describes how to assemble one fuel pipe.
 - 2.1. Put the correct end of the fuel pipe against the correct injector cone.
 - 2.2. Tighten the nut 1 with your hand.
 - 2.3. Put the other end of the fuel pipe against the correct fuel rail cone.
 - 2.4. Tighten the nut 2 with your hand.
 - 2.5. Nuts must be tightened in the correct sequence. Tighten nut 1 and then nut 2.
 - 2.6. Use the special tool at the top of nut 1 and tighten it to the correct torque value.

Torque: 27N·m

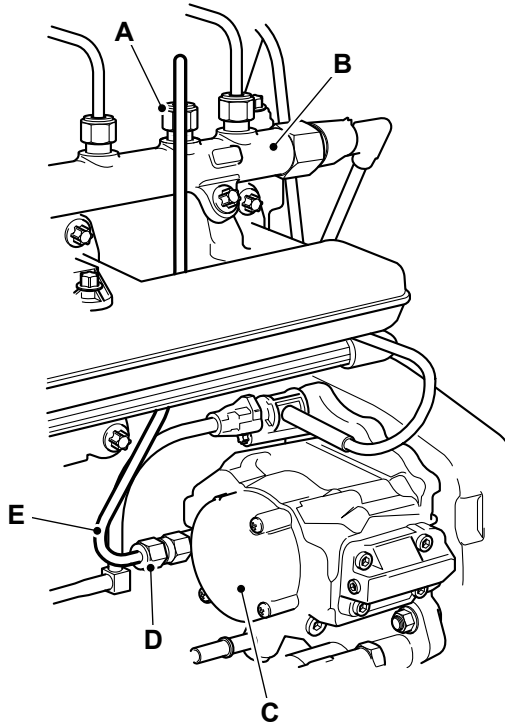
Special Tool: Socket 17MM Offset - (HP Fuel pipes) (Qty.: 1)
 - 2.7. Put the spanner at the top of nut 2 and tighten it to the correct torque value.

Torque: 27N·m

Injection Pump to Rail Fuel Pipe

Remove

Figure 274.



- A Nut 1
- B Fuel rail
- C Injection pump
- D Nut 2
- E Fuel pipe

1. Remove the fuel pipe as follows.
 - 1.1. Loosen the nut 2. Do not remove the nut at this step.
 - 1.2. Use the 17mm deep socket special tool at the top of nut. This will prevent damage to the nut.
 Special Tool: Socket 17MM Offset - (HP Fuel pipes) (Qty.: 1)
 Special Tool: Torque Wrench (10-100Nm) (Qty.: 1)
 - 1.3. Push the fuel pipe against the injector cone and at the same time remove the nut 1.
 - 1.4. Push the fuel pipe against the rail cone and at the same time remove the nut 2.
 - 1.5. Make sure that there is no dirt or debris on the fuel pipe or the connectors.
 - 1.6. Remove the fuel pipe.
 - 1.7. Seal all the open ports, use the correct parts from the service kit.

Special Tool: Fuel Injection Equipment Cap Kit (444/448 T4i/T4F/BS4/STV Engine) (Qty.: 1)

2. Discard the old fuel pipe.

Install

Important: The high pressure fuel pipes must be replaced with new ones. The new fuel pipes must remain sealed inside their bags before use. If a bag is open do not use the fuel pipe, get a new one. Do not open the bag until you are ready to assemble the fuel pipe.

1. To assemble the fuel pipe.
 - 1.1. Put the correct end of the fuel pipe against the correct pump cone at the injection pump.
 - 1.2. Tighten the nut 2 with your hand.
 - 1.3. Put the other end of the fuel pipe against the correct fuel rail cone.
 - 1.4. Tighten the nut 1 with your hand.
 - 1.5. Nuts must be tightened in the correct sequence. Tighten nut 2 and then nut 1.
 - 1.6. Use the special tool at the top of nut 2 and tighten it to the correct torque value.
 Torque: 27N·m
 Special Tool: Socket 17MM Offset - (HP Fuel pipes) (Qty.: 1)
 - 1.7. Put the spanner at the top of nut 1 and tighten it to the correct torque value.
 Torque: 27N·m

After Installation

1. Ensure that all pipes are correctly installed and located in retaining clips as applicable. If retaining clips are missing or damaged they must be replaced or renewed
2. Start the engine and check for fuel leaks.

06 - Low Pressure Pipe

Remove and Install

Special Tools

Description	Part No.	Qty.
Fuel Injection Equipment Cap Kit (444/448 T4i/T4F/BS4/STV Engine)	892/12359	1

DO NOT try to repair fuel pipes or connectors. Defective fuel pipe assemblies must be replaced.

Before Removal

- Obey all fuel system health and safety information.
[Refer to: PIL 18-00-00.](#)
- Make sure the engine is safe to work on. If the engine has been running let it cool before you start the service work.
- Clean the engine.
[Refer to: PIL 15-00-00.](#)
 - Additional cleaning must be carried out and precautions must be taken before working on the fuel system.
[Refer to: PIL 18-00-00.](#)

Low Pressure Fuel Pipes

Remove

The low pressure fuel pipes have a nylon fitting attached to the pipe that replaces the nut and olive. The fittings are part of the pipe and not a separate item.

- To release the fuel pipe, first press and hold the release buttons (one each side of the coupler). Push the coupler towards the connector spigot and then withdraw.
- Cap all open ports and pipes to prevent contamination.

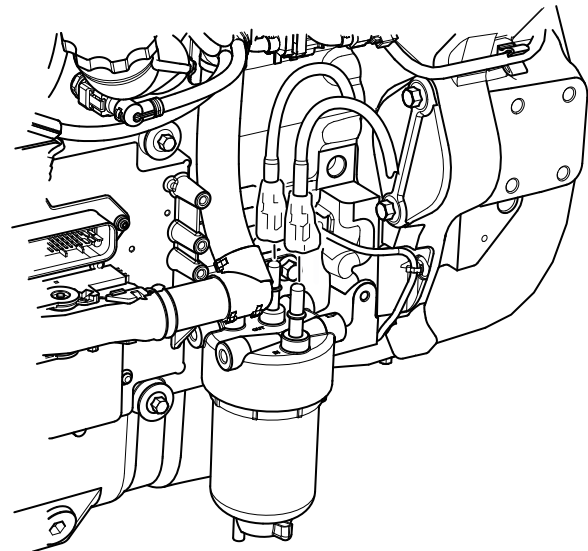
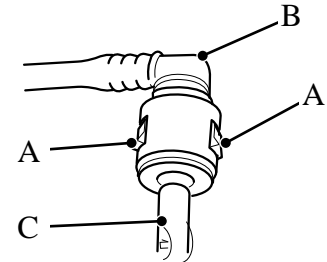
[Special Tool: Fuel Injection Equipment Cap Kit \(444/448 T4i/T4F/BS4/STV Engine\) \(Qty.: 1\)](#)

Install

- To install the fuel pipe, press and hold the release buttons. Push the coupler over the connector spigot and release the button. The connector will be heard to click when it is fully home and locked in place.

- To check that the connection has been fully made, attempt to pull the connector from the connector spigot without releasing the lock mechanism. (A gentle pull is all that is required, if the connection is not correct the connector will release very easily.)

Figure 275.



- A Release Buttons
- B Coupler
- C Spigot

After Installation

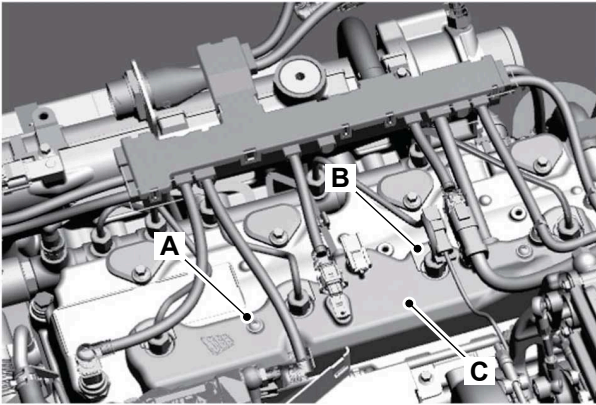
- Make sure that all the fuel pipes are correctly installed and located in the retaining clips as applicable. If retaining clips are missing or damaged, they must be replaced or renewed.
- Start the engine and check for fuel leaks.

Injector Bleed-off Pipes

Before Removal

- Remove the protective cover as follows.
 - Push out the plastic segments.
 - Remove the screws and lift off the cover.

Figure 276.



- A Screw
- B Plastic segment
- C Protective cover

1.3. Remove any dirt or debris that is exposed.

[Refer to: PIL 15-00-00.](#)

Remove

The following details the removal and replacement of one bleed-off connector. The procedure for the remaining connectors is identical.

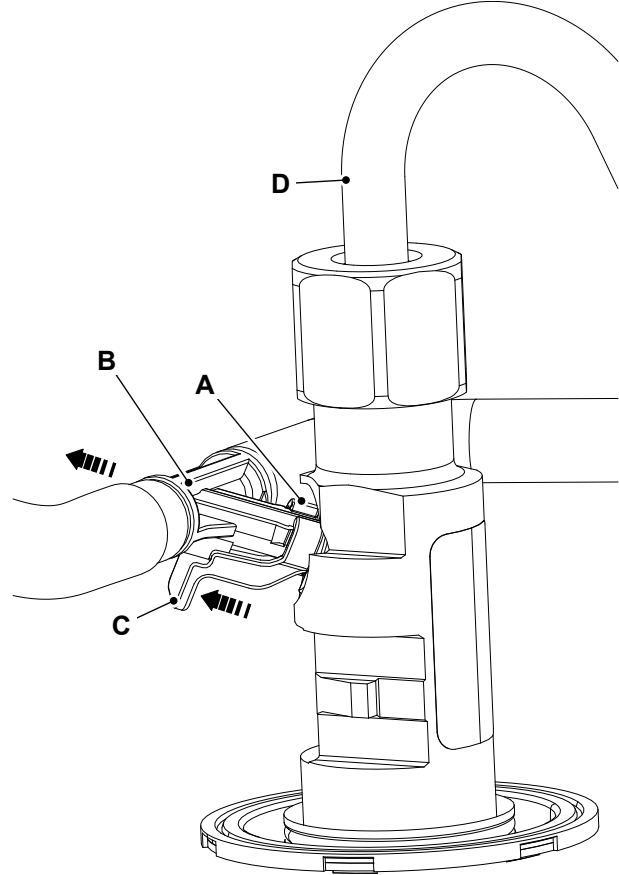
1. Gently pull out the tab on the bleed-off pipe clip to unlock the connector.
2. Pull out the bleed-off pipe connector out of the injector.
3. Remove and discard the O-ring.
4. If it is necessary to remove the bleed off pipe assembly, remove the nylon fitting at the high pressure pump.
5. Cap all open ports and pipes to prevent contamination.

[Special Tool: Fuel Injection Equipment Cap Kit \(444/448 T4i/T4F/BS4/STV Engine\) \(Qty.: 1\)](#)

Install

1. Install a new O-ring.
2. Push in the bleed-off pipe connector in the injector. Once it is fully installed, push in the tab to lock the connector.

Figure 277.



- A Location tabs
- B Bleed-off pipe connector
- C Bleed-off pipe tab
- D High pressure fuel pipe

After Installation

1. Make sure that all pipes are correctly installed and located in retaining clips as applicable. If the retaining clips are missing or damaged they must be replaced or renewed.
2. Start the engine and check for fuel leaks.
3. Install the protective cover. Refer to Figure 276.



Notes:



21 - Cooling System

Contents	Page No.
Acronyms Glossary	21-2
21-00 Cooling System	
21-00-00 General	21-3
21-03 Cooling Pack	
21-03-00 General	21-13
21-03-03 Radiator	21-16
21-03-15 Fan	21-21
21-06 Expansion Tank	
21-06-00 General	21-27
21-09 Pump	
21-09-00 General	21-31
21-12 Thermostat	
21-12-00 General	21-37
21-21 Inlet	
21-21-00 General	21-43
21-93 Hose	
21-93-00 General	21-47



Acronyms Glossary

DEF	Diesel Exhaust Fluid
ECM	Engine Control Module
EGR	Exhaust Gas Recirculation
SCR	Selective Catalytic Reduction



00 - Cooling System

Contents

Page No.

21-00-00 General 21-3



Notes:



00 - General

Introduction	21-3
Health and Safety	21-4
Technical Data	21-4
Component Identification	21-5
Operation	21-7
Fault-Finding	21-8
Drain and Fill	21-10

Introduction

During the working cycle of the engine a great deal of heat is generated. It is important that the engine is kept at its normal operating temperature to achieve maximum efficiency. It is the function of the cooling system to allow the engine to reach this temperature quickly and then maintain it.

Health and Safety

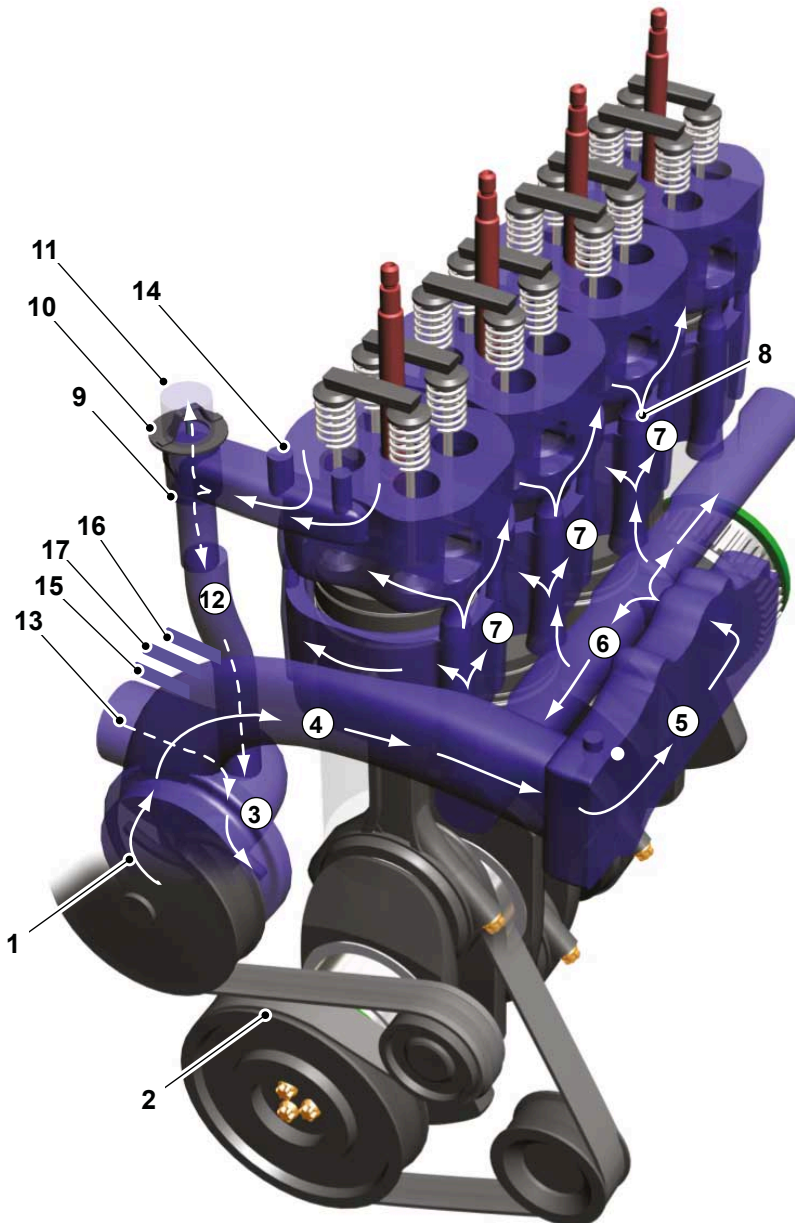
▲ **CAUTION** The cooling system is pressurised when the coolant is hot. When you remove the cap, hot coolant can spray out and burn you. Make sure that the engine is cool before you work on the cooling system.

CAUTION Antifreeze can be harmful. Obey the manufacturer's instructions when handling full strength or diluted antifreeze.

Technical Data

Table 135.

Radiator cap pressure setting	1bar (14.5psi)
Thermostat	Wax element with by-pass blanking
Thermostat operating temperature:	
- Nominal temperature	96°C (204.7°F)
- Start to open temperature	94–98°C (201.1–208.3°F)
- Full open temperature	110°C (229.8°F)
- Travel (fully open)	9mm
Cooling fan drive type	Engine driven belt
Coolant pump (non-serviceable part)	Bolt on, belt driven unit

Component Identification
Figure 278.


- | | | | |
|----|--|----|---|
| 1 | Coolant pump | 2 | Drive belt |
| 3 | Pump cavity (crankcase) | 4 | Pump outlet gallery (crankcase) |
| 5 | Oil cooler cavity (crankcase) | 6 | Coolant gallery (crankcase) |
| 7 | Cylinder cooling jackets (crankcase) | 8 | Link galleries (crankcase to cylinder head) |
| 9 | Thermostat housing (cylinder head) | 10 | Thermostat (cylinder head) |
| 11 | Top hose connection port (cylinder head) | 12 | By-pass gallery (cylinder head and crankcase) |
| 13 | Bottom hose connection port (crankcase) | 14 | Port for coolant temperature sensor and switch unit |
| 15 | Cab heater coolant supply | 16 | Cab heater coolant return |



- 17 Port for coolant supply to SCR (Selective Catalytic Reduction) dosing system and DEF (Diesel Exhaust Fluid) tank (if applicable)

Operation

The coolant pump is driven via a pulley and front end accessory drive belt, the pump draws coolant from the pump cavity.

The coolant is pumped through the outlet gallery to the oil cooler cavity in the left-hand side of the crankcase. As the coolant flows past the oil cooler matrix, heat is exchanged from the oil to the coolant. This enables the oil to function as a coolant as well as a lubricant. Refer to Oil Cooler (PIL 15-69) and Oil Filter (PIL 15-21).

The coolant leaves the oil cooler cavity and passes into the main crankcase gallery. The gallery is connected to the cylinder water jackets. Coolant flows around and up the jackets and then passes into the cylinder head via the link galleries. The coolant circulates around the cylinder head where it conducts heat away from the combustion chambers and also the fuel injector tips, refer to (PIL 18-18). The coolant then passes to the thermostat housing.

When the engine is below normal operating temperature the thermostat is closed, preventing coolant flowing to the machine radiator via the top hose connection port. Instead coolant is directed through the by-pass gallery back to the pump cavity and is again drawn into the pump. Refer to Thermostat (PIL 21-12).

When the engine is at operating temperature the thermostat opens, closing the by-pass gallery to the pump and opening the top hose connection port to the machine radiator. The coolant passes through the radiator matrix and is cooled. The coolant flows back to the engine via the bottom hose connection port and is again drawn into the pump. Refer to Thermostat (PIL 21-12).

A coolant temperature gauge and warning light sender unit is installed at port 14. Refer to Engine Sensors (PIL 15-84).

A cab heater hose can be installed at port 15. This enables coolant to circulate through a heater matrix when the thermostat is open or closed, ensuring fast heater warm up. The coolant returns to the engine through port 16.

Engine coolant is delivered to the SCR (Selective Catalytic Reduction) system and DEF (Diesel Exhaust Fluid) tank through port 17 irrespective of the thermostat position. This defrosts the DEF as quickly as possible in cold conditions so that the emissions control system can work effectively. The supply comes direct from the coolant pump outlet.

Fault-Finding

Fault

Coolant - Loss.

[Table 136.](#)
[Page 21-8](#)

Coolant - Over Temperature.

[Table 137.](#)
[Page 21-8](#)

Coolant - Under Temperature.

[Table 138.](#)
[Page 21-9](#)

Coolant - Contaminated.

[Table 139.](#)
[Page 21-9](#)
Table 136. Coolant - Loss.

Cause	Remedy
Incorrect coolant level.	Check the level.
DEF (Diesel Exhaust Fluid) tank heater circuit bleeding. ⁽¹⁾	The coolant to DEF tank heater circuit has not bled correctly after work has been carried out. When this circuit bleeds, the coolant level will drop until the circuit has bled fully. Check the level until it stabilises.
Coolant leaking from engine radiator or cab heater.	Visually inspect the radiator heater, hoses and connection to locate the leak. If oil is present in the coolant, check for a transmission or engine oil cooler leak.
External engine coolant leak.	Visually inspect the engine and components for seal, gasket hose connection leaks. Make sure all hose clips are in good condition and torqued to the recommended figure. Make sure all spring band clamps are in good condition and apply sufficient pressure to the hoses.
Overheating or compression gases leaking, resulting in loss through the radiator overflow.	See Also: Table 137. Coolant - Over Temperature.
If installed, transmission cooler leak.	Check/replace the transmission cooler. Check for coolant in the inlet manifold and in the oil.
Lubricating oil cooler leak.	Check/replace the oil cooler. Check for coolant in the oil.
EGR (Exhaust Gas Recirculation) cooler leak. ⁽¹⁾	Check/replace the EGR cooler. Check for signs of coolant leaking into combustion chamber.
SCR (Selective Catalytic Reduction) system leak. ⁽¹⁾	Check for signs of engine coolant in the DEF and DEF in the engine coolant. Check the dosing metering module and the head unit for leaks.
Cylinder head gasket leak.	Check/replace the head gasket.
Cylinder head cracked or porous.	Check/replace the cylinder head.
Crankcase coolant passages leaking.	Check/replace the crankcase.

(1) If installed

Table 137. Coolant - Over Temperature.

Cause	Remedy
Incorrect coolant level (low).	Check the level. See Also: Table 136. Coolant - Loss.
External radiator matrix blocked with dirt or chaff.	Clean exterior or radiator matrix.
Air flow to the radiator inadequate or restricted.	Check/repair fan shroud, anti-recirculation sealing, shutters, fan sensors, fan speeds as required.
Coolant pump or fan drive belts loose.	Check/correct belt tension.
Radiator hose collapsed, restricted or leaking.	Check/replace hose.
Oil level over filled.	Check oil level.
Cooling system pressure cap incorrect or faulty.	Replace cap with the correct rating for the system.

Cause	Remedy
Over concentration of antifreeze.	Remove part of the coolant from cooling system and replace with water.
Temperature sensor gauge faulty.	Check the electronic fault codes. Verify that the gauge and temperature sensor are accurate.
Thermostat faulty, incorrect or missing.	Check/replace the thermostat.
Air or combustion gases in the cooling system.	Make sure the fill rate is not exceeded and the correct vented thermostat is installed. If aeration continued, check for a compression leak through the head gasket.
Coolant pump faulty.	Check/replace the coolant pump.
Vent line from engine and/or radiator blocked or incorrectly routed (sudden overheating).	Check routing and operation of vent line.
Leak between the top tank and the auxiliary tank (sudden overheating).	Check for coolant leakage between radiator auxiliary tank and radiator top tank.
Cooling passages in radiator, cylinder head, head gasket or block blocked.	Flush the system and fill with clean coolant.
ECM (Engine Control Module) (if installed) or electrical sensor fault.	Check the electronic fault codes. Check the electrical connections at the ECM and sensors.
One or more engine injector worn or malfunctioning.	Check the electronic fault codes. Check the electrical connections at the injectors.

Table 138. Coolant - Under Temperature.

Cause	Remedy
Air flow across the radiator excessive.	Check/repair fan shroud, anti-recirculation sealing, shutters, fan sensors, fan speeds as required.
Temperature sensor gauge faulty.	Check the electronic fault codes. Verify that the gauge and temperature sensor are accurate.
Thermostat faulty, (open - not sealing).	Check/replace the thermostat.
Coolant not flowing by temperature sensor.	Check/clean coolant passages. A total coolant loss may result in the gauge showing low temperature initially. In which case, check the level.

Table 139. Coolant - Contaminated.

Cause	Remedy
Coolant rusty, operation without correct mixture of antifreeze and water.	Drain and flush the cooling system. Fill with correct mixture of antifreeze and water. Review the coolant change interval.
Engine oil cooler, or cooler housing allowing cross contamination of coolant with engine oil.	Remove the oil cooler assembly and check relevant sealing elements for damage.
Transmission lubricating oil cooler leaking (if applicable).	Check/replace lubricating oil cooler. Refer to equipment manufacturer's procedures.
Lubricating oil leaks from lubricating oil cooler, head gasket, cylinder head and crankcase.	See Also: Table 136. Coolant - Loss.
SCR system leak. ⁽²⁾	See Also: Table 136. Coolant - Loss.

(2) If installed

Drain and Fill

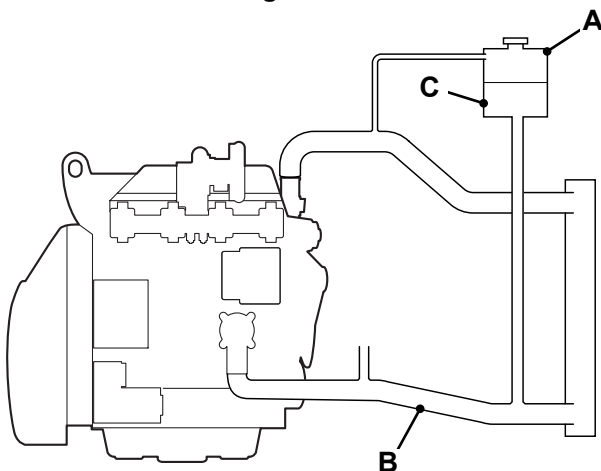
Consumables

Description	Part No.	Size
Antifreeze HP/ Coolant ASTM D6210	4006/1101	5 L
Concentrate	4006/1120	20 L
	4006/1103	200 L

The graphic shows a typical engine cooling system, the system you are working on may look slightly different.

1. Make the machine safe. Refer to (PIL 01-03).
 2. Stop the engine and let it cool down.
 3. Get access to the engine.
 4. Carefully loosen the cap just enough to let any pressure escape. Remove the cap when all pressure is released.
 5. Disconnect the bottom radiator hose and allow the coolant to drain into a suitable container.
 6. Flush the system by pouring clean water into the filler port.
 7. Connect the bottom radiator hose.
 8. Fill the expansion tank, using the necessary anti-freeze solution, to the level indicated.
- [Consumable: Antifreeze HP/Coolant ASTM D6210 Concentrate](#)
9. Run the engine for a while to raise the coolant to working temperature and pressure. Stop the engine and check for leaks. Check the level in the expansion tank and top up if necessary.

Figure 279.



- A** Cap
- B** Bottom radiator hose
- C** Expansion tank



03 - Cooling Pack

Contents	Page No.
21-03-00 General	21-13
21-03-03 Radiator	21-16
21-03-15 Fan	21-21



Notes:



00 - General

[Introduction](#) 21-13
[Component Identification](#) 21-14
[Clean](#) 21-15
[Check \(Condition\)](#) 21-15

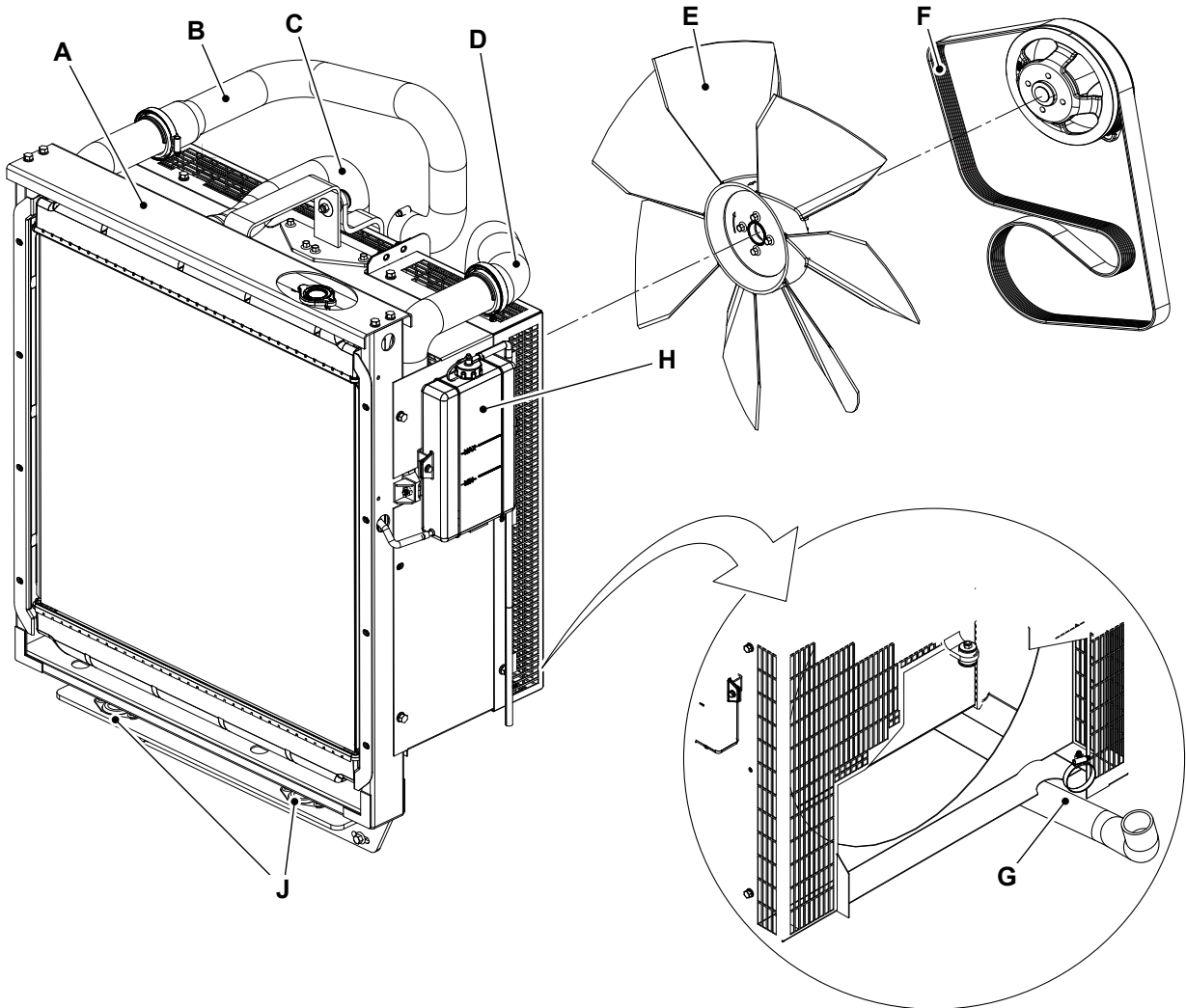
Introduction

The cooling pack of these machines has following two major components.

- Radiator. [Refer to: PIL 21-03-03.](#)
- Fan. [Refer to: PIL 21-03-15.](#)

Component Identification

Figure 280. Cooling pack



- A** Radiator
- C** Top radiator hose
- E** Fan assembly
- G** Bottom radiator hose
- J** Mounting (x2)

- B** Inlet Hose
- D** Outlet hose
- F** Drive belt
- H** Expansion tank

Clean

1. Make the machine safe.
2. Let the engine cool.
3. Get access to the cooling pack.
4. If necessary, use a soft bristle brush or compressed air to remove all debris from the cooling pack.

Check (Condition)

1. Make the machine safe.
2. Let the engine cool.
3. Get access to the radiator.
4. Check the condition of the coolant hoses.
5. Check the radiator and intercooler surfaces for signs of damage.
6. If necessary, contact your JCB dealer for any service requirements.



03 - Radiator

Introduction	21-16
Check (Condition)	21-17
Remove and Install	21-18

Introduction

The radiator is a device in the cooling system that removes heat from the coolant passing through it, allowing the coolant to remove heat from the engine.

Check (Condition)

Antifreeze

Never perform checks or maintenance on the cooling system when it is hot. Never remove radiator cap when engine is hot - severe risk of scalding. Never remove radiator cap when the engine is running. Antifreeze is toxic. If accidentally swallowed, medical advice must be sought immediately. Antifreeze is corrosive to the skin. If accidentally spilled on to skin, it must be washed off immediately. Protective clothing and eye protection must be worn when handling antifreeze.

WARNING! *Never remove the radiator cap when the cooling system is hot - severe risk of scalding.*

1. Check the condition of the radiator.
2. Clean the radiator fins and make sure that the fins are not damaged.
3. Remove any blockage from the air flow path of the radiator.

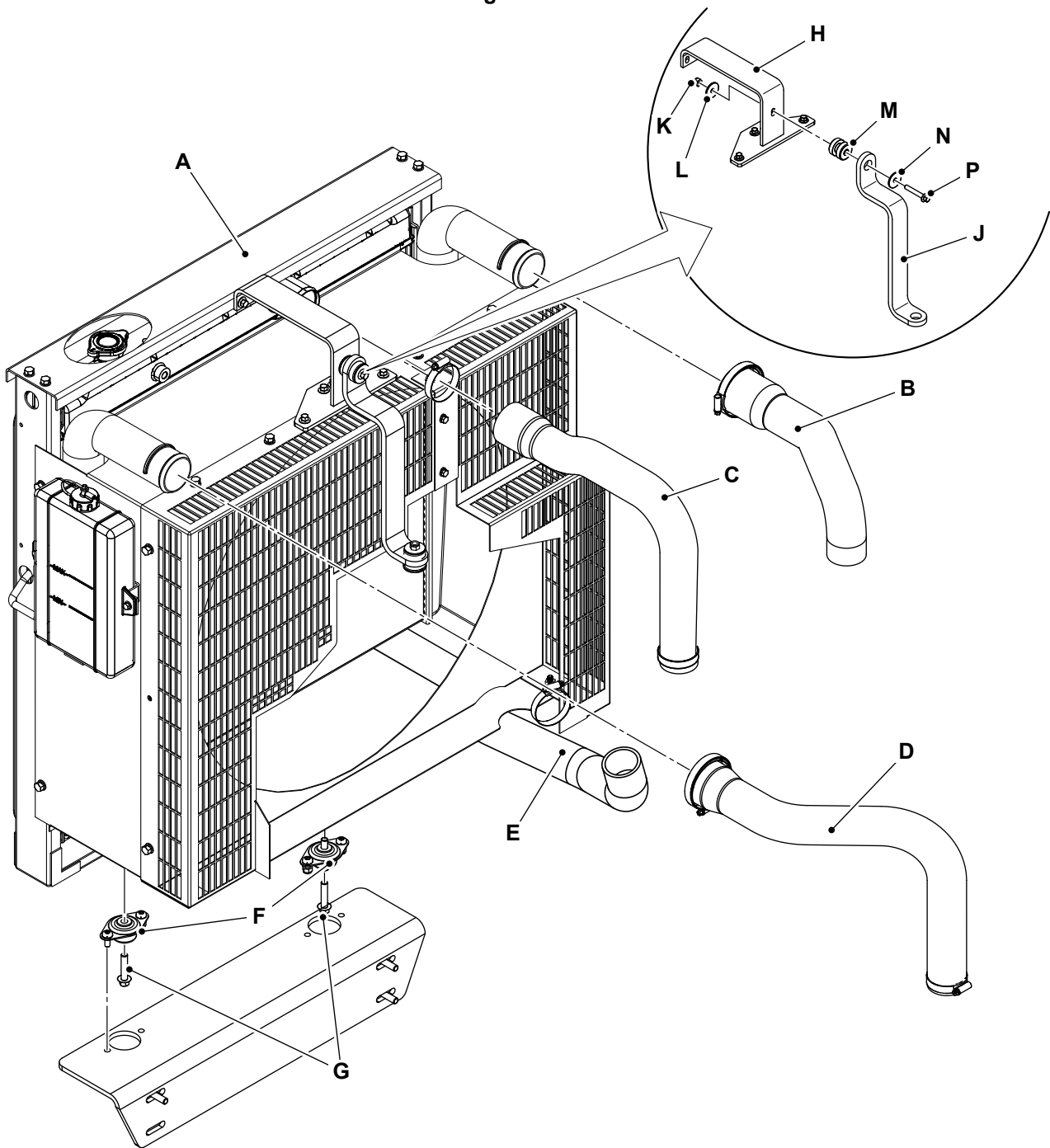
Remove and Install

▲ CAUTION This component is heavy. It must only be removed or handled using a suitable lifting method and device.

Remove

1. Make the machine safe.
[Refer to: PIL 01-03.](#)
2. Isolate the battery.
[Refer to: PIL 33-03-00.](#)
3. Remove the rear cover.
[Refer to: PIL 06-06-14.](#)
4. Drain the cooling system.
[Refer to: PIL 21-00-00.](#)
5. Remove the expansion tank.
[Refer to: PIL 21-06-00.](#)
6. If installed, loosen the worm drive clip and disconnect the inlet hose from the radiator.
7. If installed, loosen the worm drive clip and disconnect the outlet hose from the radiator.
8. Disconnect the top radiator hose and the bottom radiator hose from the radiator.
9. Put a label on the hoses to help installation.
10. Plug all the open ports and hoses to prevent contamination.
11. Remove the cooling pack stay from the cooling pack support bracket.
 - 11.1. Remove the locknut, washer 1, upper mounting rubber (x2), washer 2 and bolt 2.
12. Support the radiator with suitable lifting equipment.
13. Remove the radiator from the mountings.
 - 13.1. Remove the bolt 1 (x2) that attach the radiator to the mountings (x2).
14. Remove the radiator from the machine.

Figure 281.



- A Radiator
- C Top hose radiator
- E Bottom radiator hose
- G Bolt 1 (x2)
- J Cooling pack stay
- L Washer 1
- N Washer 2

- B Inlet hose (For aftercooled engine only)
- D Outlet hose (For aftercooled engine only)
- F Mounting (x2)
- H Cooling pack support bracket
- K Locknut
- M Upper mounting rubber (x2)
- P Bolt 2

Install

1. The installation procedure is the opposite of the removal procedure. Additionally do the following step.
2. Tighten the fasteners to the correct torque value.



15 - Fan

Introduction	21-21
Health and Safety	21-22
Remove and Install	21-23

Introduction

The engine cooling fan is a key component of the engine's cooling system. The cooling fan circulates air through the radiator to dissipate excess engine heat.



Health and Safety

Turning the Engine

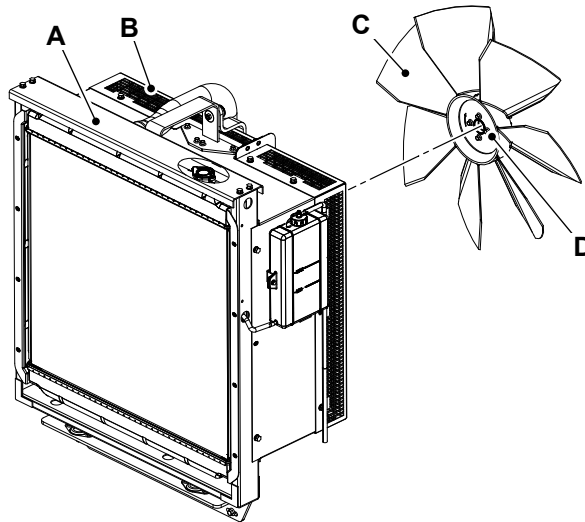
Do not try to turn the engine by pulling the fan or fan belt. This could cause injury or premature component failure.

Remove and Install

Remove

1. Make the machine safe.
[Refer to: PIL 01-03-27.](#)
2. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.
3. Open the access cover.
[Refer to: PIL 06-06-00.](#)
4. Remove the fan guard from the radiator.
5. Remove the fan drive belt.
6. Support the fan assembly.
7. Loosen the bolt (x4) that attaches the fan assembly to the fan drive.
8. Remove the fan assembly from the machine.

Figure 282.



A Radiator
C Fan assembly

B Fan guard
D Bolt (x4)

Install

1. The installation procedure is the opposite of the removal procedure. Additionally do the following steps.
2. Make sure that you install the spacer between engine pulley and metal disc of the fan.
3. Tighten the bolt (x4) to the correct torque value.

Table 140. Torque Values

Item	Nm
D	43



06 - Expansion Tank

Contents

Page No.

21-06-00 General	21-27
------------------------	-------



Notes:



00 - General

Introduction 21-27
Remove and Install 21-28

Introduction

The expansion tank retains coolant that has been forced out of the machines radiator under pressure.

As the machine runs, the temperature of the coolant circulating around the system increases, this causes an increase of pressure in the cooling system. When the pressure builds to a high enough point, the radiator cap allows that pressure to escape into the coolant tank through a rubber overflow tube that is connected from the neck of the radiator to the expansion tank.

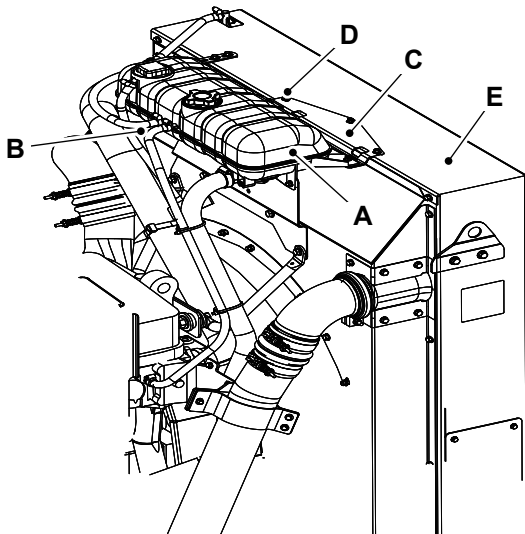
Most of the coolant that is forced into the expansion tank returns to the radiator naturally when the engine is cold.

Remove and Install

Remove

1. Make the machine safe.
[Refer to: PIL 01-03.](#)
2. Put a clean container underneath the expansion tank.
3. Disconnect the hoses from the expansion tank.
4. Put a label on the hoses to help installation.
5. Plug all the open ports and hoses to prevent contamination.
6. Remove the bolts that attach the expansion tank to the radiator.
7. Remove the expansion tank from mounting bracket.

Figure 283.



- A** Expansion tank
- B** Hose
- C** Mounting bracket
- D** Bolt
- E** Radiator

Install

1. The installation procedure is the opposite of the removal procedure. Additionally do the following step.
2. Tighten the bolts to the correct torque value.



09 - Pump

Contents

Page No.

21-09-00 General	21-31
------------------------	-------



Notes:



00 - General

Introduction	21-31
Component Identification	21-32
Operation	21-32
Remove and Install	21-33

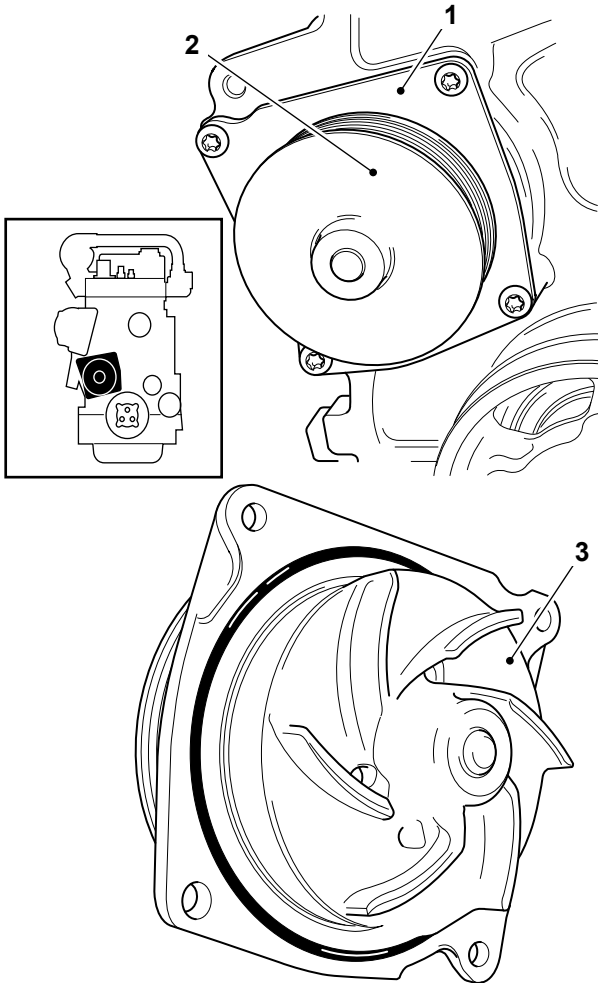
Introduction

The coolant pump is a centrifugal type located in the front of the crankcase, driven by the engine drive belt.

The impeller rotates to circulate the coolant through the cooling system. The pump shaft bearing and seal are not renewable.

Component Identification

Figure 284.



- 1 Coolant pump
- 2 Drive pulley
- 3 Impeller

Operation

The coolant pump is driven via a pulley and front end accessory drive belt, the pump draws coolant from the pump cavity. The coolant is pumped through the outlet gallery to the oil cooler cavity in the left side of the crankcase. As the coolant flows past the oil cooler matrix, heat is exchanged from the oil to the coolant. This enables the oil to function as a coolant as well as a lubricant.

Remove and Install

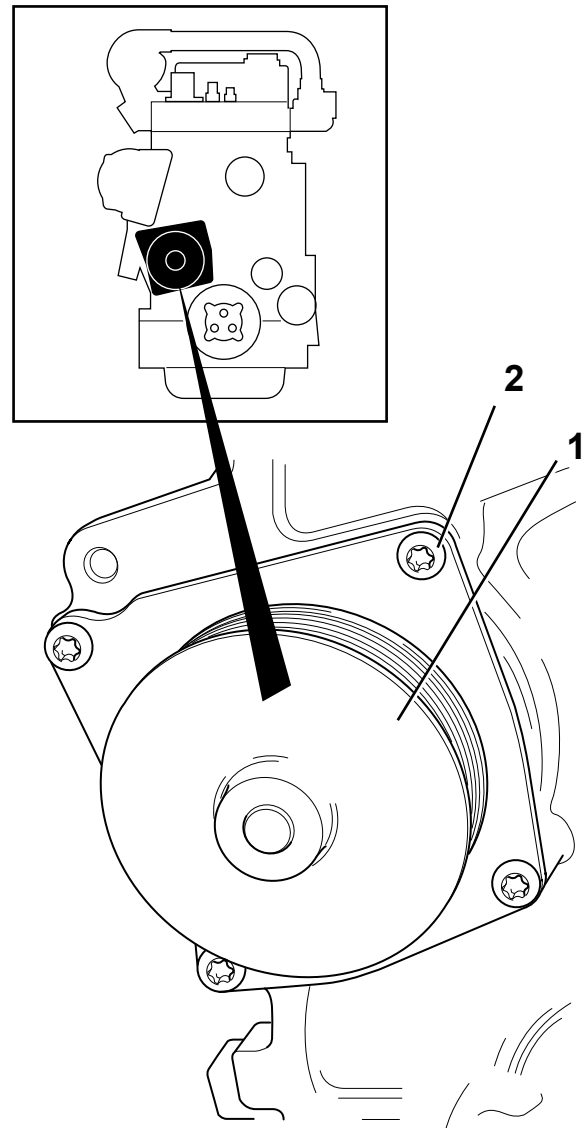
Before Removal

1. Make sure that the machine is safe. If the engine has been running, let it cool before you start the service work. Refer to (PIL 01-03).
2. Get access to the engine.
3. Drain the coolant.
4. Remove the coolant pump drive belt.

Remove

1. Remove the fixing screws.
2. Remove the coolant pump assembly.
3. Remove and discard the sealing O-ring.

Figure 285.

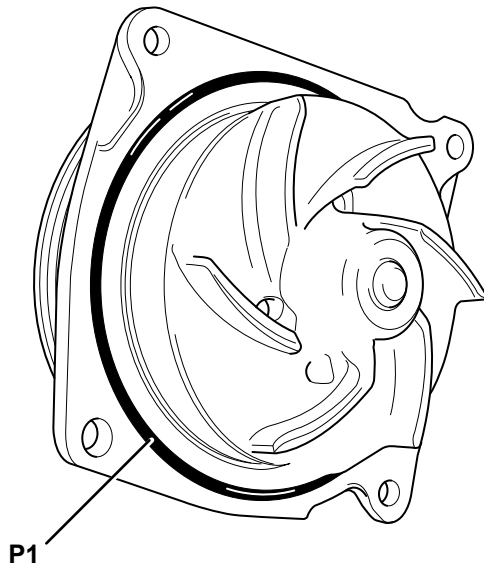


- 1 Coolant pump assembly
- 2 Fixing screws

The pump is a non-serviceable item. If the pump is faulty or damaged it must be renewed.

Install

1. The installation procedure is the opposite of the removal procedure. Additionally do the following steps.
2. Make sure that the mating face on the crankcase is clean and free from damage.
3. Install a new sealing O-ring.
4. Tighten the screws to the correct torque value.

Figure 286.


P1 Sealing O-ring

After Installation

1. Install the coolant pump drive belt.
2. Refill the engine with the recommended coolant mixture.
3. Start the engine and check for coolant leaks.

Table 141. Torque Values

Item	Nm
2	24



12 - Thermostat

Contents	Page No.
21-12-00 General	21-37



00 - General

Introduction	21-37
Component Identification	21-38
Operation	21-38
Check (Condition)	21-39
Check (Operation)	21-40
Remove and Install	21-40

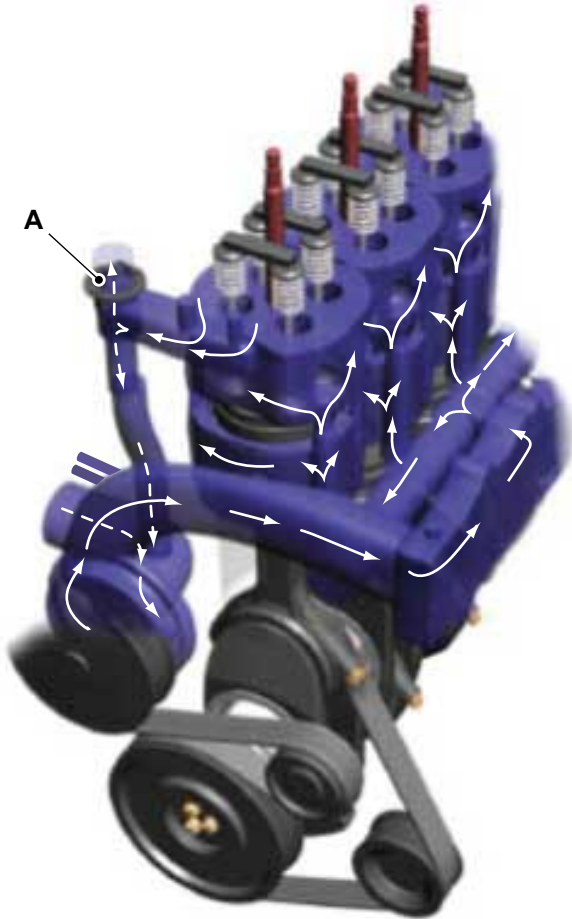
Introduction

The thermostat is located between the engine and the radiator. The function of the thermostat is to block the flow of coolant to the radiator until the engine has warmed up to a sufficient temperature.

When the engine is cold, no coolant flows through the engine. Once the engine reaches its operating temperature, generally about 95°C (203°F), the thermostat opens. By letting the engine warm up as quickly as possible, the thermostat reduces engine wear, deposits and emissions.

Component Identification

Figure 287.



A Thermostat

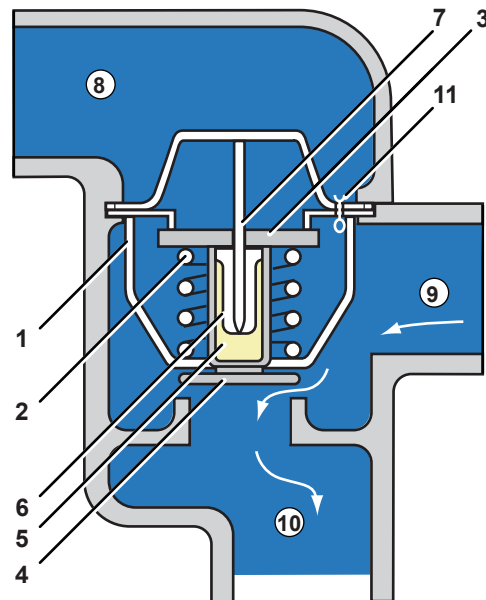
Operation

The thermostat is a wax element type and is configured for by-pass blanking. The thermostat functions as follows:

State A - Closed (Engine Cold)

When the engine is cold the wax pellet has contracted into its housing. This allows the spring to act against the thermostat body and move the valve plate up against its seat, closing the outlet port to the radiator. Since the bottom valve plate is connected to the top valve plate it also moves up, opening the bypass port. The coolant flows from the thermostat housing inlet port into the bypass gallery.

Figure 288.



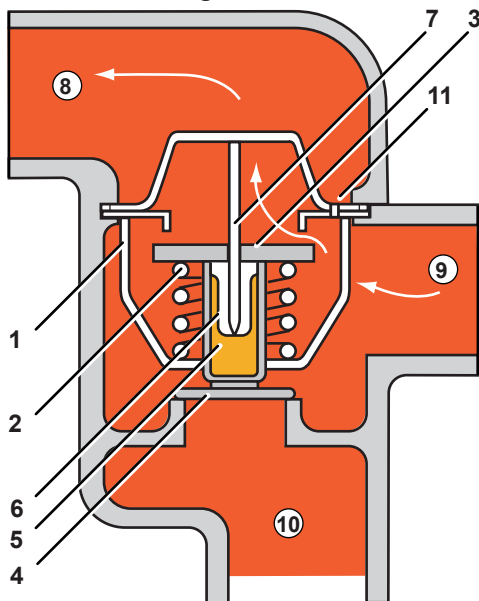
- 1 Thermostat
- 2 Spring
- 3 Top valve plate
- 4 Bottom valve plate
- 5 Wax pellet
- 6 Diaphragm
- 7 Actuating rod
- 8 Outlet port to the radiator top hose
- 9 Inlet port thermostat housing
- 10 Outlet port bypass gallery
- 11 1mm diameter orifice

State B - Open (Engine Hot)

When the engine is hot, the wax pellet melts, as it does so it expands and pushes against the diaphragm. The diaphragm reacts against the actuating rod and both the top and bottom valve plates move down into the thermostat body, compressing spring. The outlet port to the radiator is now open and the bypass port is closed. A 1mm

diameter orifice allows trapped air to be expelled from the system.

Figure 289.



- 1 Thermostat
- 2 Spring
- 3 Top valve plate
- 4 Bottom valve plate
- 5 Wax pellet
- 6 Diaphragm
- 7 Actuating rod
- 8 Outlet port to the radiator top hose
- 9 Inlet port thermostat housing
- 10 Outlet port bypass gallery
- 11 1mm diameter orifice

Check (Condition)

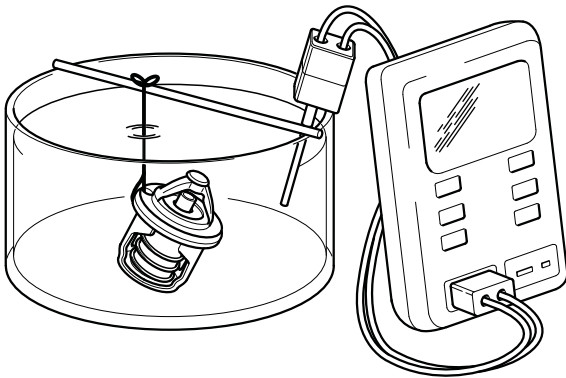
1. If the thermostat is suspected of being faulty, perform a thermostat test, refer to Thermostat - Check Operation to confirm its serviceability. Note that the thermostat is a non-serviceable item. If the thermostat is faulty or damaged it must be renewed.
2. Inspect the seal for damage or splits. If necessary renew the seal. Make sure that the seal is correctly located.

Check (Operation)

A period of 3–5min before the thermostat valve starts to operate is normal because of the time required to heat soak the thermostat.

1. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.
2. Remove the thermostat housing and the thermostat. Refer to (PIL 21-12).
3. Suspend the thermostat in a suitable container of coolant. Use an external heat source to gradually increase the temperature of the coolant. Note: When working with boiling water, all the necessary safety precautions must be taken. Refer to Figure 290.

Figure 290.



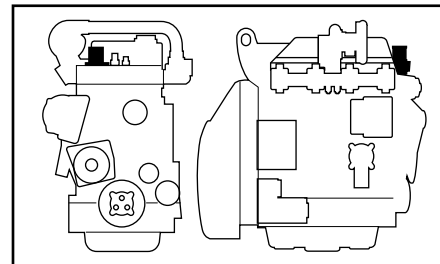
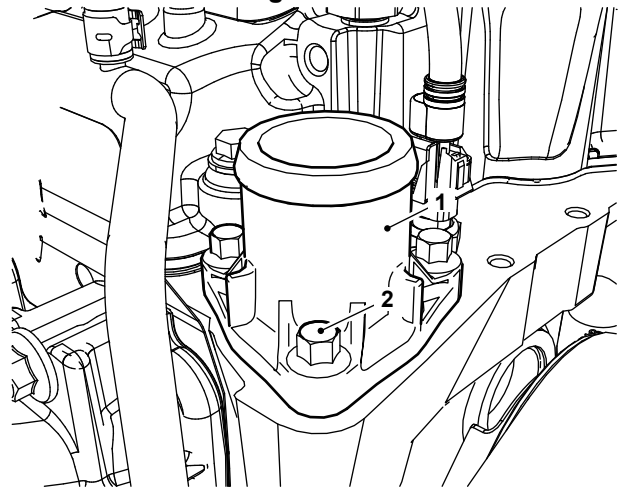
4. Use a thermometer to measure the temperature of the coolant.
5. When the coolant reaches the operating range of the thermostat the valve should start to open, the movement of the valve plate should be evident.
6. Record the start to open temperature, the fully open temperature and the amount of valve lift travel when fully open. Compare this with the data in Technical Data (PIL 21-00).

Remove and Install

Before Removal

1. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.
2. Get access to the engine.
3. Drain the coolant. Refer to (PIL 21-03-03).

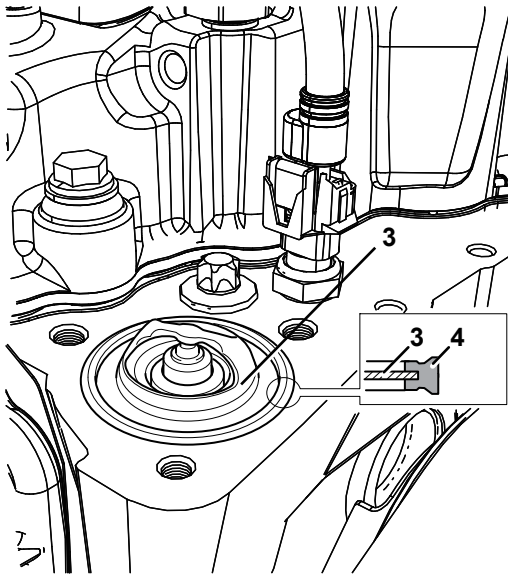
Figure 291.



- 1 Radiator hose
- 2 Fixing bolts

Remove

1. Disconnect the radiator hose at the thermostat housing.
2. Remove the fixing bolts and lift off the housing.
3. Lift out the thermostat.

Figure 292.


- 3 Thermostat
- 4 Seal

4. If the thermostat is suspected of being faulty, perform tests to confirm its serviceability.

Note The thermostat is a non-serviceable item. If the thermostat is faulty or damaged it must be renewed.

Install

1. The installation procedure is the opposite of the removal procedure. Additionally do the following steps.
2. Inspect the seal for damage or splits. If necessary renew the seal. Locate the seal correctly as shown.
3. Make sure you install the thermostat the right way up.
4. Tighten the bolts to the correct torque value.
5. Reconnect the radiator hose at the housing.

After Installation

1. Fill the cooling system with the recommended coolant mixture.
2. Start the engine and check for coolant leaks. Refer to (PIL 21-03-03).

Table 142. Torque Values

Item	Nm
2	24



21 - Inlet

Contents

Page No.

21-21-00 General 21-43

00 - General

Remove and Install

Before Removal

1. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.
2. Get access to the engine.
3. Drain the cooling system.

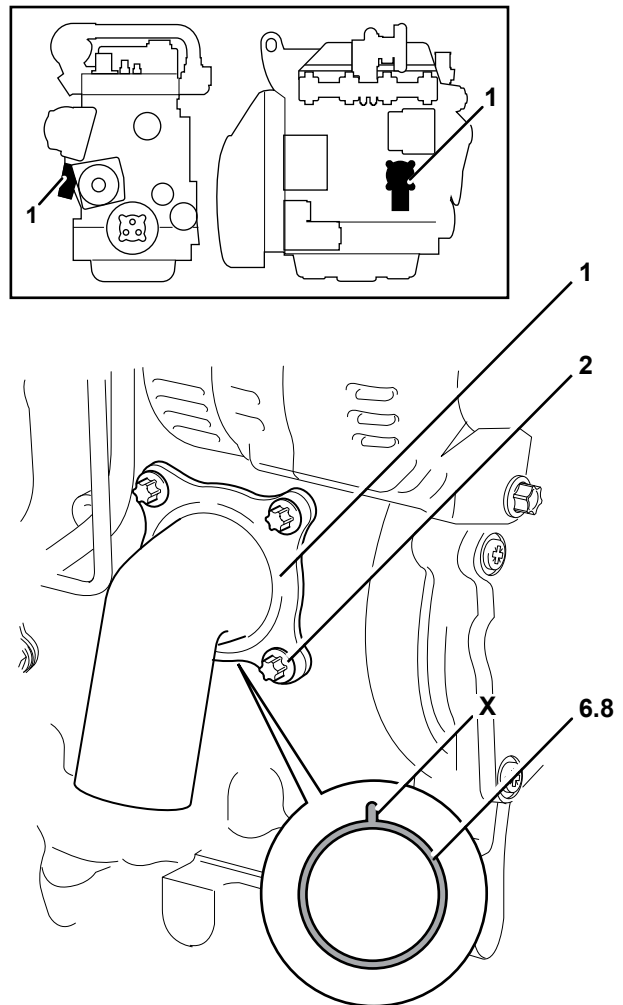
Refer to: [PIL 21-00-00](#).

The housing may be orientated differently to that shown in the illustration, depending on the engine installation.

Remove

1. Disconnect the radiator hose at the inlet housing.
2. Undo the bolts and lift off the housing.

Figure 293.



- 1 Inlet housing
- 2 Fixing bolts
- 6 Sealing Ring
- X Locating tab - sealing ring

Install

1. The installation procedure is the opposite of the removal procedure. Additionally do the following steps.
2. Make sure that the sealing ring is undamaged. If necessary install a new seal. Make sure that the seal is correctly located in its groove on the housing. Note the locating tab.
3. Tighten the bolts to the correct torque value.
4. Reconnect the radiator hose at the housing.

After Installation

1. Refill the engine with the recommended coolant mixture.
2. Start the engine and check for coolant leaks.



Table 143. Torque Values

Item	Nm
2	24



93 - Hose

Contents

Page No.

21-93-00 General	21-47
------------------------	-------



Notes:



00 - General

Introduction	21-47
Health and Safety	21-48
Check (Condition)	21-48

Introduction

The engine cooling hoses are essential parts of the cooling system. They carry the liquid coolant between the engine and the radiator/cooling pack.

Health and Safety

▲ **CAUTION** The cooling system is pressurised when the coolant is hot. When you remove the cap, hot coolant can spray out and burn you. Make sure that the engine is cool before you work on the cooling system.

Check (Condition)

1. Visually inspect the engine and related cooling components for:
 - 1.1. Leaks.
 - 1.2. Cracked, burnt or perished hoses.
 - 1.3. Hose clips are in good condition and tightened to the correct torque value.



33 - Electrical System

Contents	Page No.
Acronyms Glossary	33-2
33-00 Electrical System	
33-00-00 General	33-3
33-00-50 Schematic Circuit	33-8
33-00-90 Earth Point	33-28
33-03 Battery	
33-03-00 General	33-31
33-03-03 Isolator Switch	33-40
33-03-24 Tray	33-42
33-08 Power Alternator	
33-08-00 General	33-45
33-08-06 Voltage Regulator	33-58
33-08-15 Diode Bridge	33-61
33-09 Power Distribution	
33-09-00 General	33-67
33-12 Harness	
33-12-00 General	33-71
33-57 Electronic Diagnostic	
33-57-03 Servicemaster	33-81
33-57-12 LiveLink	33-95
33-57-90 Error Codes	33-104
33-78 Generator Control	
33-78-03 Control Panel	33-119



Acronyms Glossary

AVR	Alternator Voltage Regulator
CAN	Controller Area Network
DC	Direct Current
DCU	Dosing Control Unit
DEF	Diesel Exhaust Fluid
DLA	Data Link Adaptor
ECM	Engine Control Module
ECU	Electronic Control Unit
EGR	Exhaust Gas Recirculation
GPS	Global Positioning System
LCD	Liquid Crystal Display
LED	Light Emitting Diode
MCCB	Moulded Case Circuit Breaker
NOx	Nitrogen Oxide
RAM	Random Access Memory
RPM	Revolutions Per Minute
SCR	Selective Catalytic Reduction
SPP	Service Parts Pro
TMAP	Temperature Manifold Absolute Pressure
USB	Universal Serial Bus
VGT	Variable Geometry Turbocharger
VIN	Vehicle Identification Number
WIF	Water in Fuel



00 - Electrical System

Contents	Page No.
33-00-00 General	33-3
33-00-50 Schematic Circuit	33-8
33-00-90 Earth Point	33-28



Notes:



00 - General

Introduction 33-3
Health and Safety 33-4
Technical Data 33-5
Check (Condition) 33-7

Introduction

It is important that the electrical system on the machine is in a sound state of repair.

Make sure that all the health and safety warnings in this section are followed. Before working on any part of the electrical system ensure all correct isolation procedures have been implemented to allow safe working.

Health and Safety

Arc Welding

To prevent the possibility of damage to electronic components, disconnect the battery and the alternator before arc-welding on the machine or attached implements.

If the machine is equipped with sensitive electrical equipment, i.e. amplifier drivers, electronic control units (ECUs), monitor displays, etc., then disconnect them before welding. Failure to disconnect the sensitive electrical equipment could result in irreparable damage to these components.

Parts of the machine are made from cast iron, welds on cast iron can weaken the structure and break. Do not weld cast iron. Do not connect the welder cable or apply any weld to any part of the engine.

Always connect the welder earth (ground) cable to the same component that is being welded to avoid damage to pivot pins, bearings and bushes. Attach the welder earth (ground) cable a distance from the part being welded no more than 0.6 m.

Notice: *Do not disconnect the battery while the engine is running, otherwise the electrical circuits may be damaged.*

CAUTION! *Understand the electrical circuit before connecting or disconnecting an electrical component. A wrong connection can cause injury and/or damage.*



Technical Data

For: G70RS [HXN] Page 33-5

For: G125RS [HXN] Page 33-5

(For: G70RS [HXN])

Table 144.

Multi Switch Position	3	2	1
Frequency	60Hz	60Hz	60Hz
Phases	1	3	3
Output Voltage	240V/120V	208V/120V	480V/277V
Prime	37kW 37kVA	56kW 70kVA	56kW 70kVA
Amps	154A	194A	84A
Power factor	1	0.8	0.8
Rated Speed	1800 RPM (Revolutions Per Minute)	1800 RPM	1800 RPM
Alternator	ECP32-1L/4C	ECP32-1L/4C	ECP32-1L/4C
Alternator Maximum Instantaneous Fault Current	1,924A	1,924A	1,924A
Breaker	250A	250A	250A
Sensor Plug	250A	250A	250A
Overcurrent protection (I _r)	154A	194A	84A
Short circuit protection (I _{sd})	462A	582A	252A
Instantaneous current setting (I _i)	500A	750A	500A
Overcurrent protection time setting (t _r)	1s	1s	1s
Short circuit time delay (t _{sd})	0s	0s	0s

(For: G125RS [HXN])

Table 145.

Multi Switch Position	3	2	1
Frequency	60Hz	60Hz	60Hz
Phases	1	3	3
Output Voltage	240V/120V	208V/120V	480V/277V
Prime	66kW 66kVA	100kW 125kVA	100kW 125kVA
Amps	275A	347A	150A
Power factor	1	0.8	0.8
Rated Speed	1800 RPM	1800 RPM	1800 RPM
Alternator	ECP34-1M/4C	ECP34-1M/4C	ECP34-1M/4C
Alternator Maximum Instantaneous Fault Current	4,957A	4,957A	4,957A
Breaker	400A	400A	400A
Sensor Plug	400A	400A	400A
Overcurrent protection (I _r)	275A	347A	150A
Short circuit protection (I _{sd})	825A	1,050A	450A



33 - Electrical System

00 - Electrical System

00 - General

Instantaneous current setting (li)	1,200A	1,200A	800A
Overcurrent protection time setting (tr)	1s	1s	1s
Short circuit time delay (tsd)	0s	0s	0s

Check (Condition)

1. Switch OFF the generator.
2. Check all the electrical cables for damage.
3. Make sure that no cable terminals are loose. Tighten the terminal nuts to the correct torque value.
4. Check the condition of the cable terminals for corrosion and carbon build-up.
5. Make sure that all electrical cables are free from dirt, dust, oil and grease.
6. Check the condition of the power alternator.
[Refer to: PIL 33-08-00.](#)
7. Check the condition of the starter motor. Refer engine service manual.
8. Check the battery charging voltage.
9. Check readings of the engine sensors.
10. Check the controller for any faults.
11. Check the alternator voltage from phase to phase.
12. Check the alternator voltage from phase to neutral.
13. Check the neutral connection for any leakage in current.
14. Check the operation of the MCCB (Moulded Case Circuit Breaker).
15. If necessary, do the load test of the generator.
16. Check the earth connections for security and correct installation.



50 - Schematic Circuit

Introduction 33-8
Diagram 33-11

Introduction

A schematic wiring diagram is a simplified pictorial representation of the machines electrical circuit. It shows the components of the circuit as simplified electrical symbols, and the power and signal connections between the devices. The wiring diagram is used to troubleshoot problems and to make sure that all the connections have been made and that everything is present.

Use the schematics together with the correct electrical harness drawings to reference the connector pin details.

This section may contain more than one set of electrical schematics for different machine variants.

Understanding Electrical Schematics

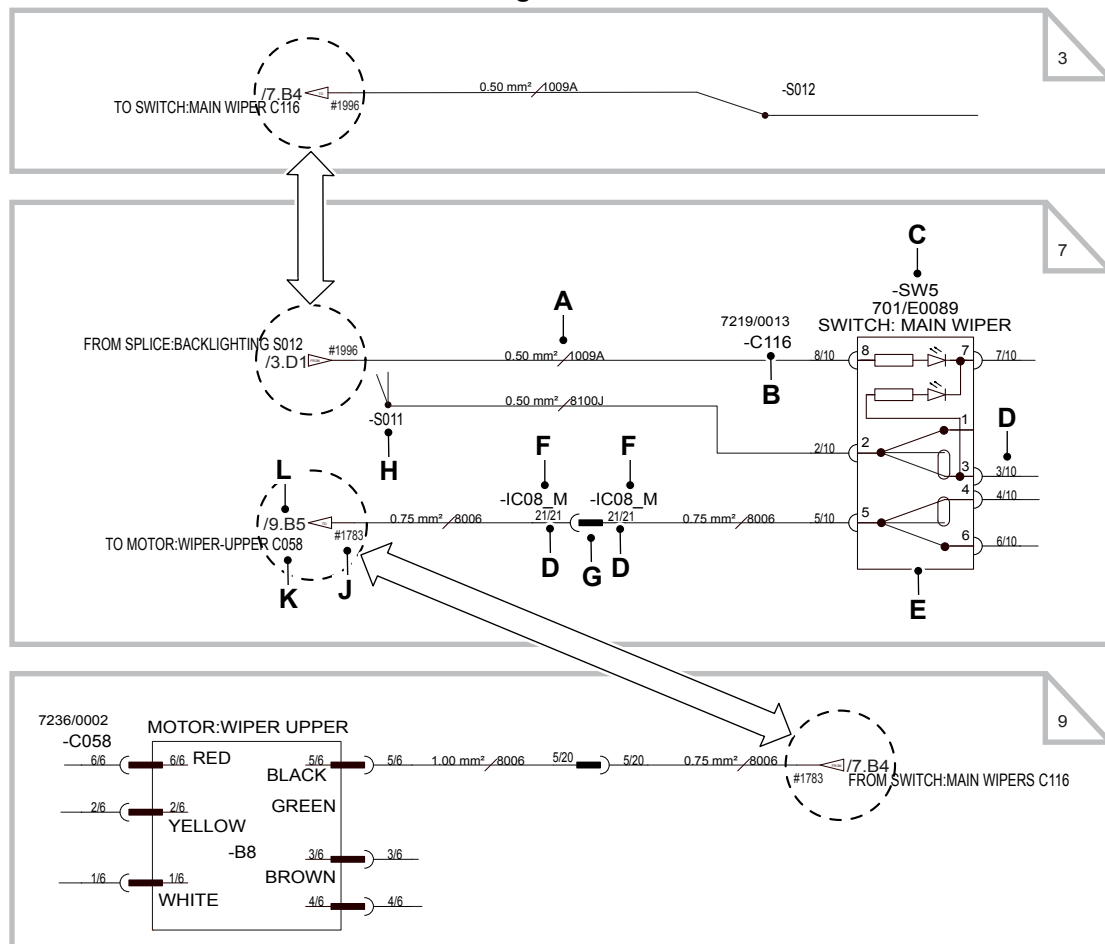
Use the applicable schematic set to trace wires and connections between electrical devices. In most cases it will be necessary to trace wires across more than one schematic sheet.

The example identifies the information contained on the diagrams. It also shows how to follow wires from one diagram sheet to another.

The harness inter-connector codes and device harness connector codes are the same as used on the applicable harness drawings.

Splices are not normally accessible. Splices are inside the harness sheath and not visible on the outside. Wires are welded together at a splice, there are no individual connector components.

Figure 294.



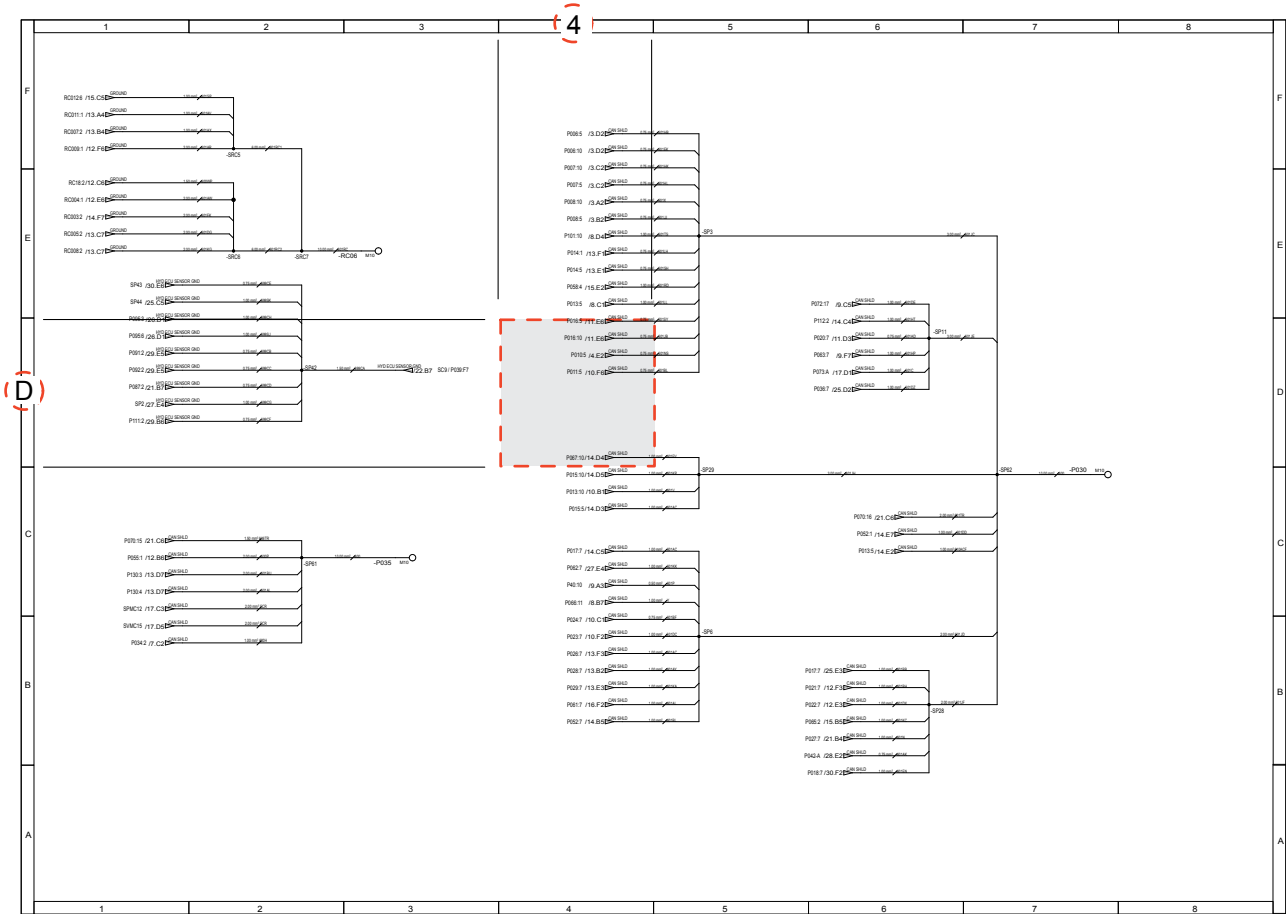
- A** Wire size (area) and number
- C** Device description
- E** Device internal schematic
- G** Harness inter-connector symbol
- J** Destination reference number
- L** Destination (diagram sheet and grid)

- B** Device harness connector code
- D** Connector pin number (wire location / total)
- F** Harness inter-connector codes
- H** Splice code and symbol
- K** Destination (harness connector code)

To help locate a wire destination from other diagram sheets use the grid reference. This identifies the applicable location zone on the sheet in a similar way to a map reference.

Due to space limitations, the grid is sometimes omitted.

Figure 295. Grid reference example (D4)





Diagram

For: G70RS [HXN] Page 33-11

For: G125RS [HXN] Page 33-20

(For: G70RS [HXN], BLAISE_PDF)

[Figure 296. G70 GA DEIF - 401/G9340 - Issue 4 \(Sheet 1 of 1\).....Page 33-13](#)

[Figure 297. G70 GA DSE - 401/S4355 - Issue 3 \(Sheet 1 of 1\).....Page 33-17](#)

Figure 296. G70 GA DEIF - 401/
G9340 - Issue 4 (Sheet 1 of 1)

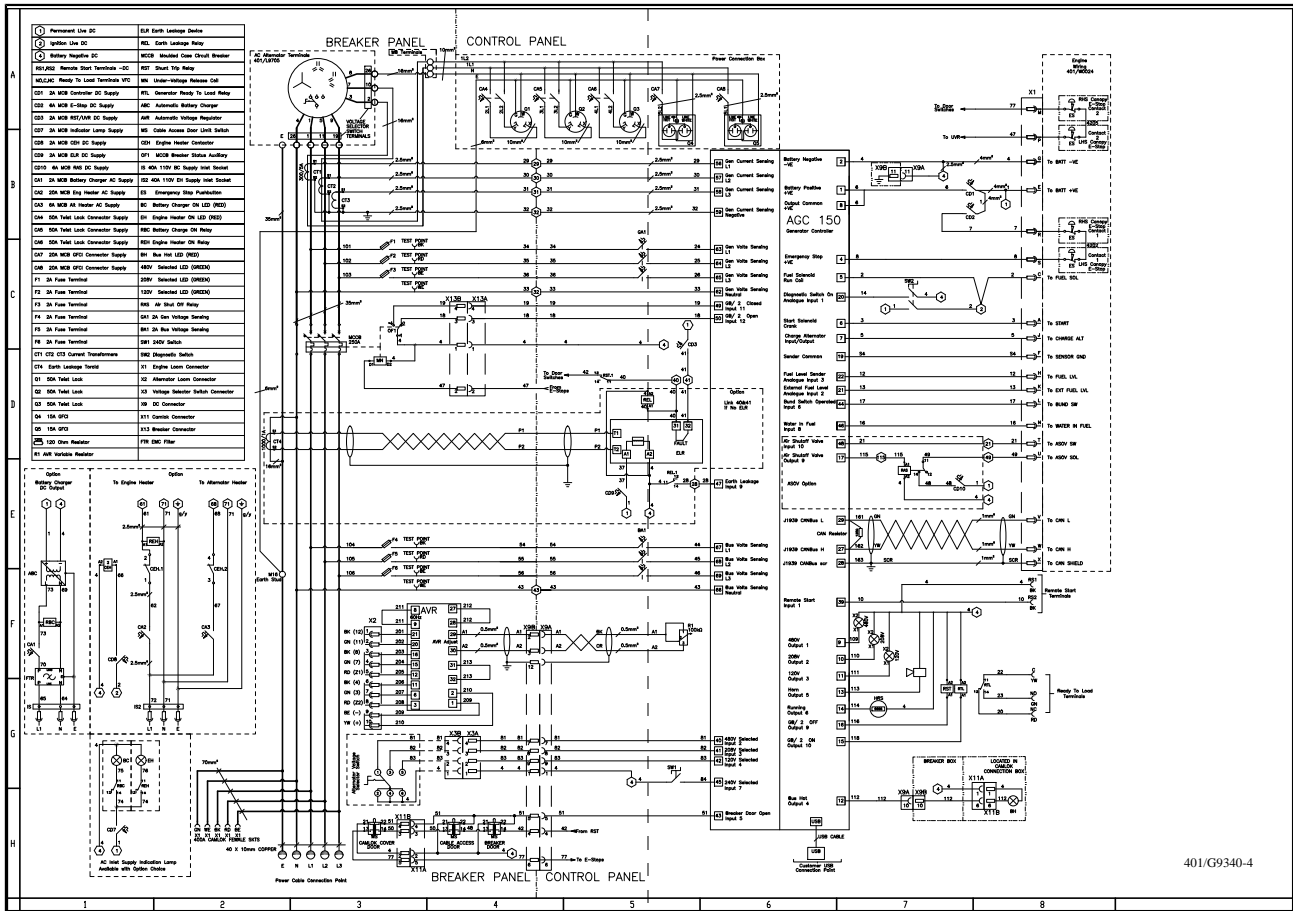
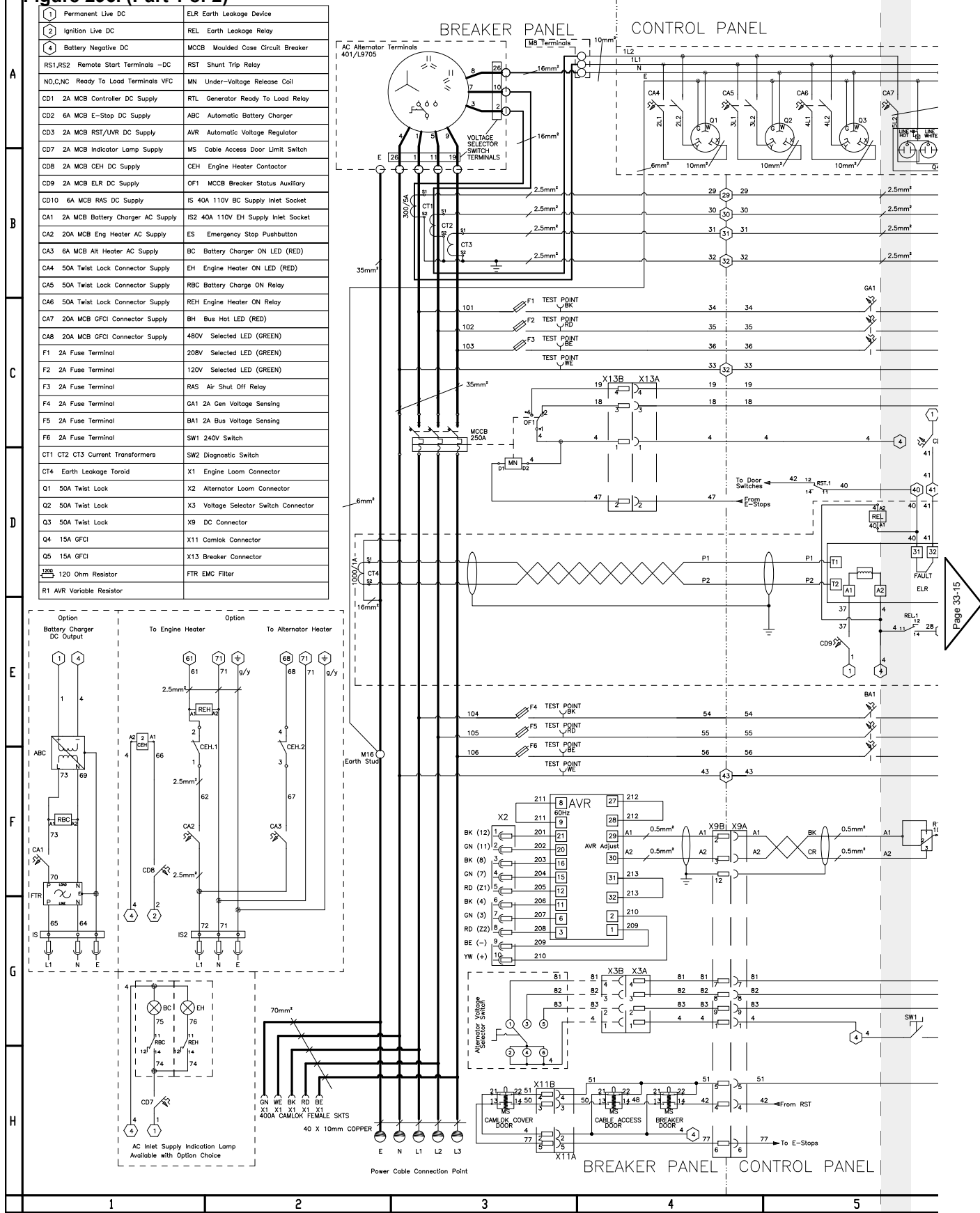
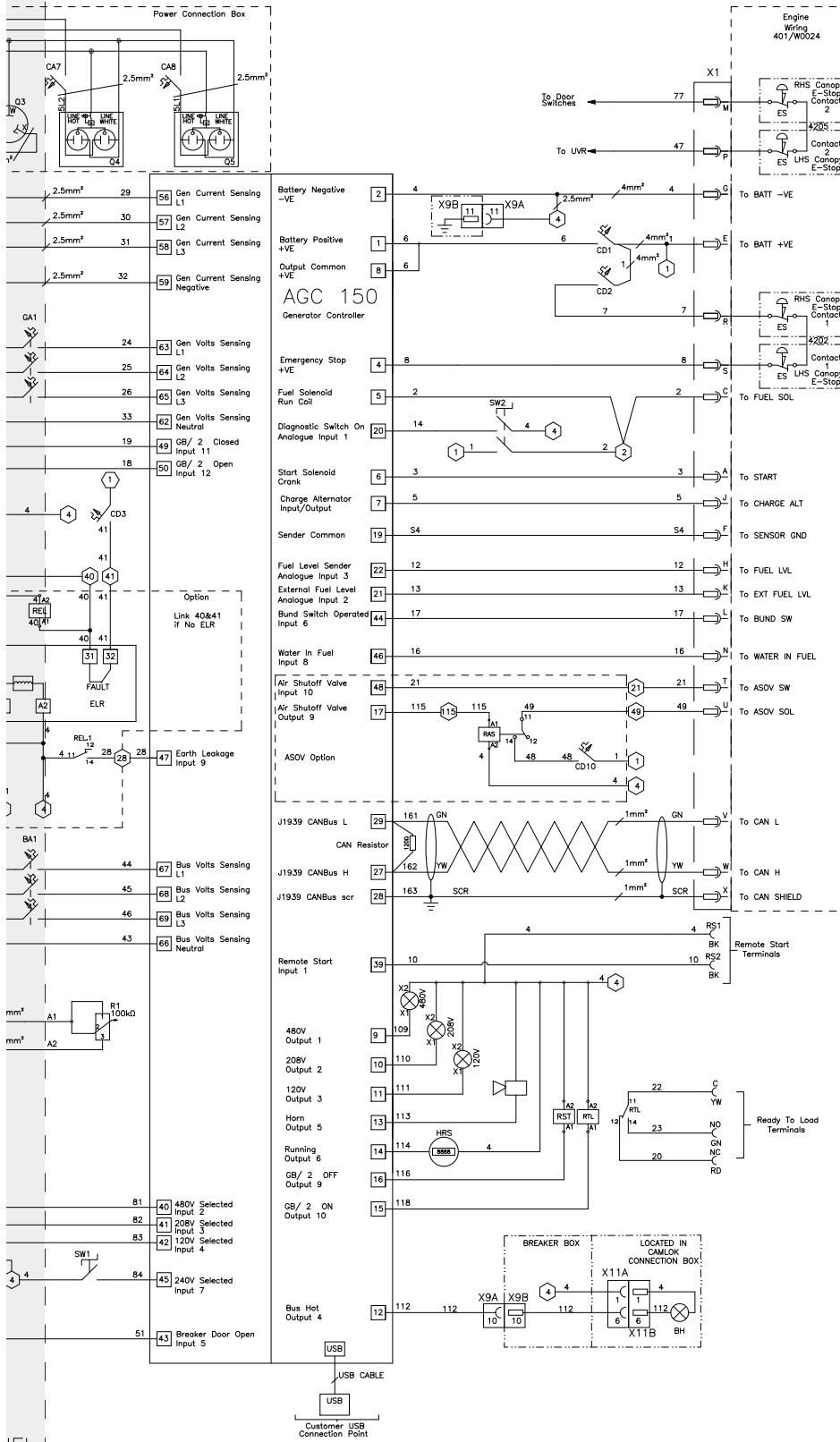


Figure 296. (Part 1 of 2)



Page 33-15

Figure 296. (Part 2 of 2)



401/G9340-4

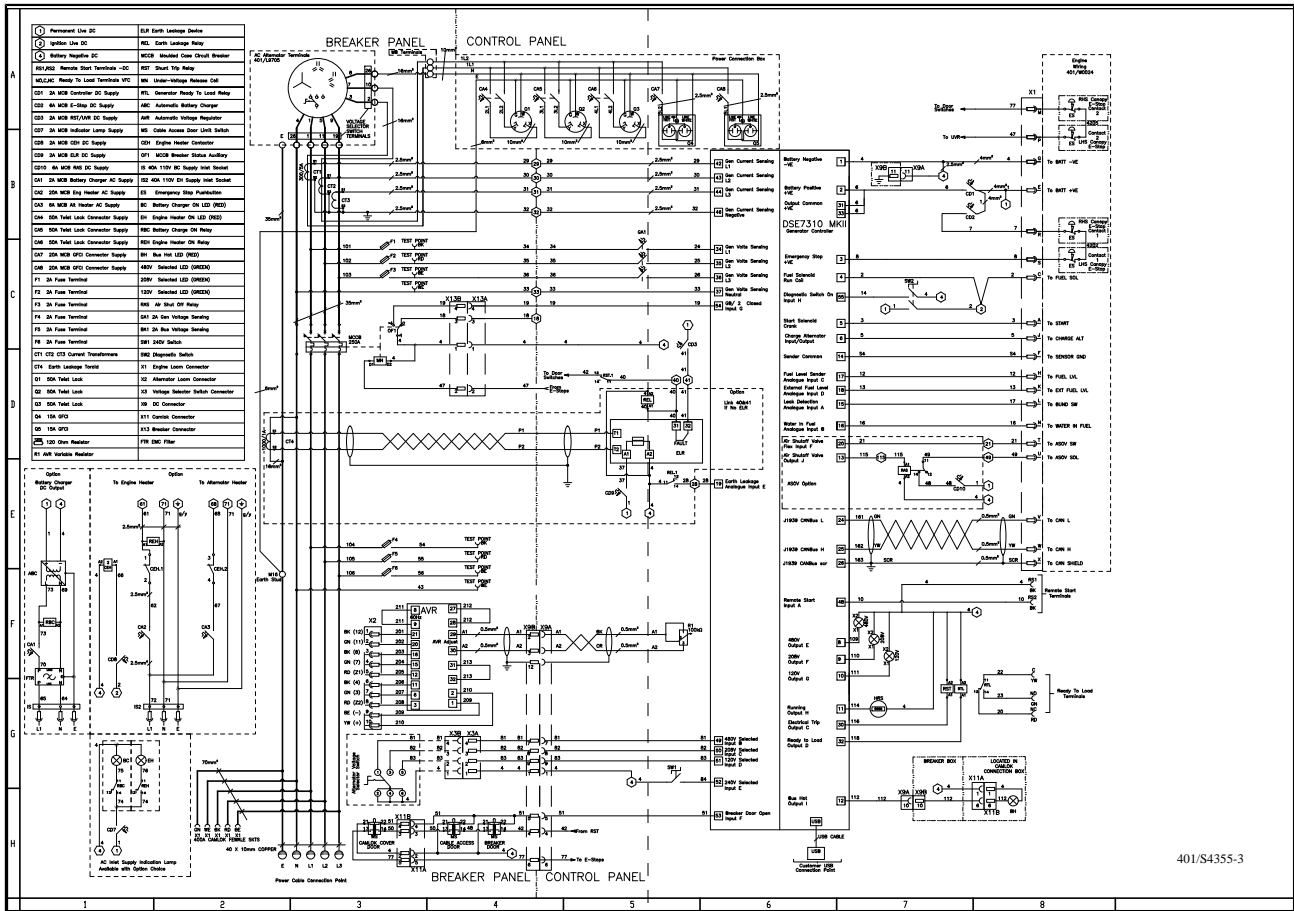


33 - Electrical System

00 - Electrical System

50 - Schematic Circuit

Figure 297. G70 GA DSE - 401/
S4355 - Issue 3 (Sheet 1 of 1)



401/S4355-3

Figure 297. (Part 1 of 2)

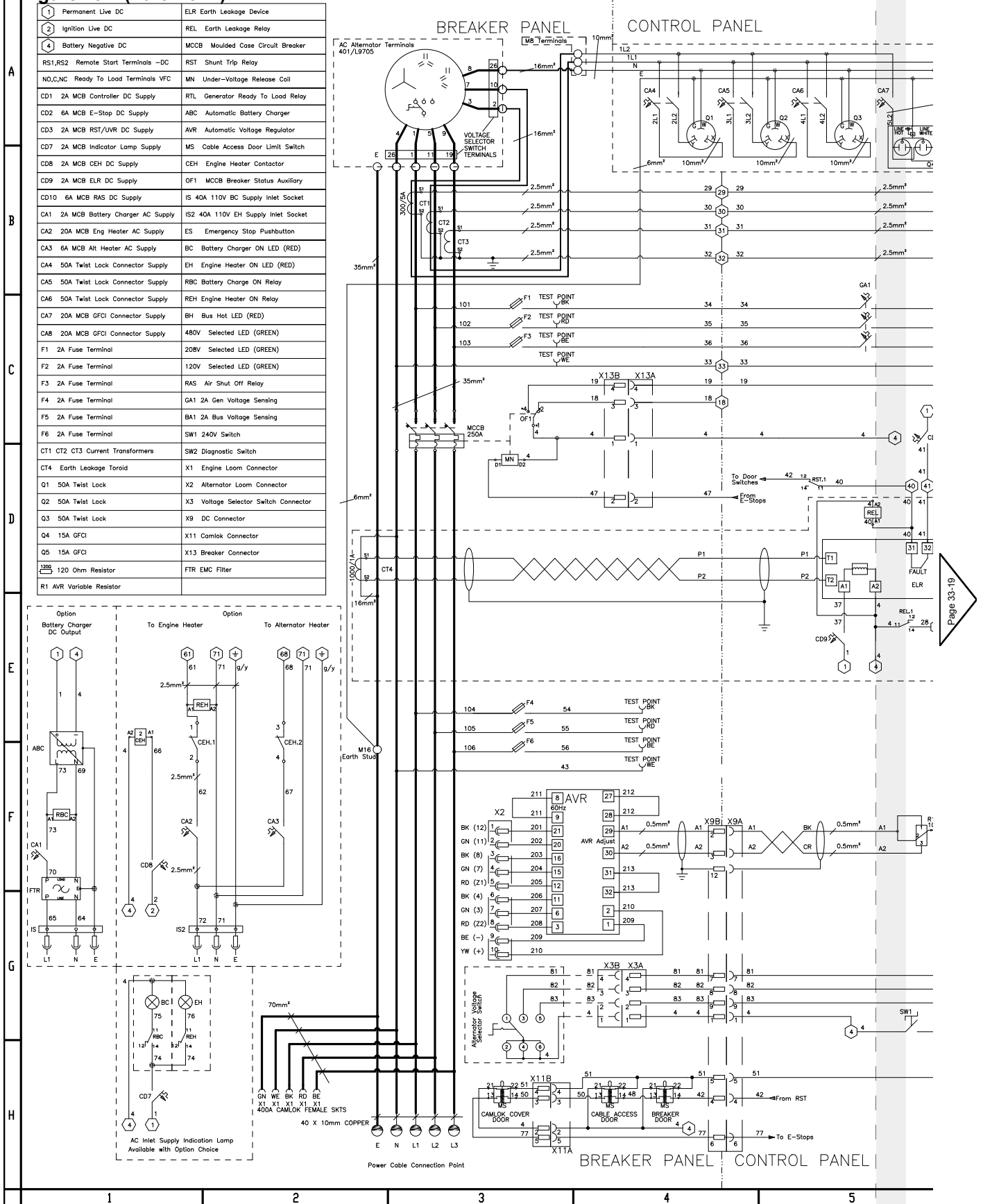
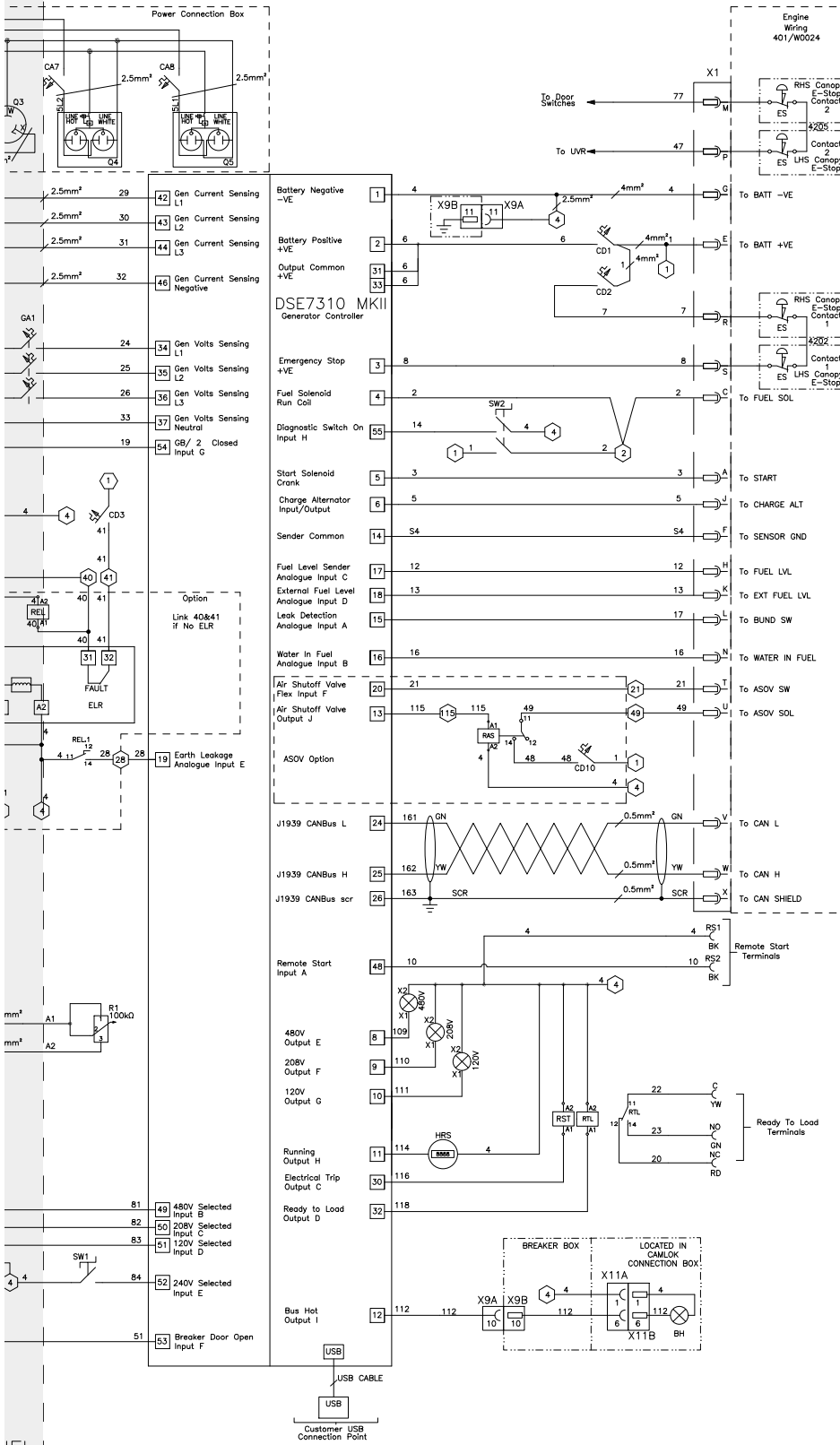


Figure 297. (Part 2 of 2)



401/S4355-3



(For: G125RS [HXN], BLAISE_PDF)

Figure 298. G125 GA DEIF - 401/G9342 - Issue 4 (Sheet 1 of 1).....Page 33-21

Figure 299. G125 GA DSE - 401/K4259 - Issue 3 (Sheet 1 of 1).....Page 33-25

Figure 298. G125 GA DEIF - 401/
G9342 - Issue 4 (Sheet 1 of 1)

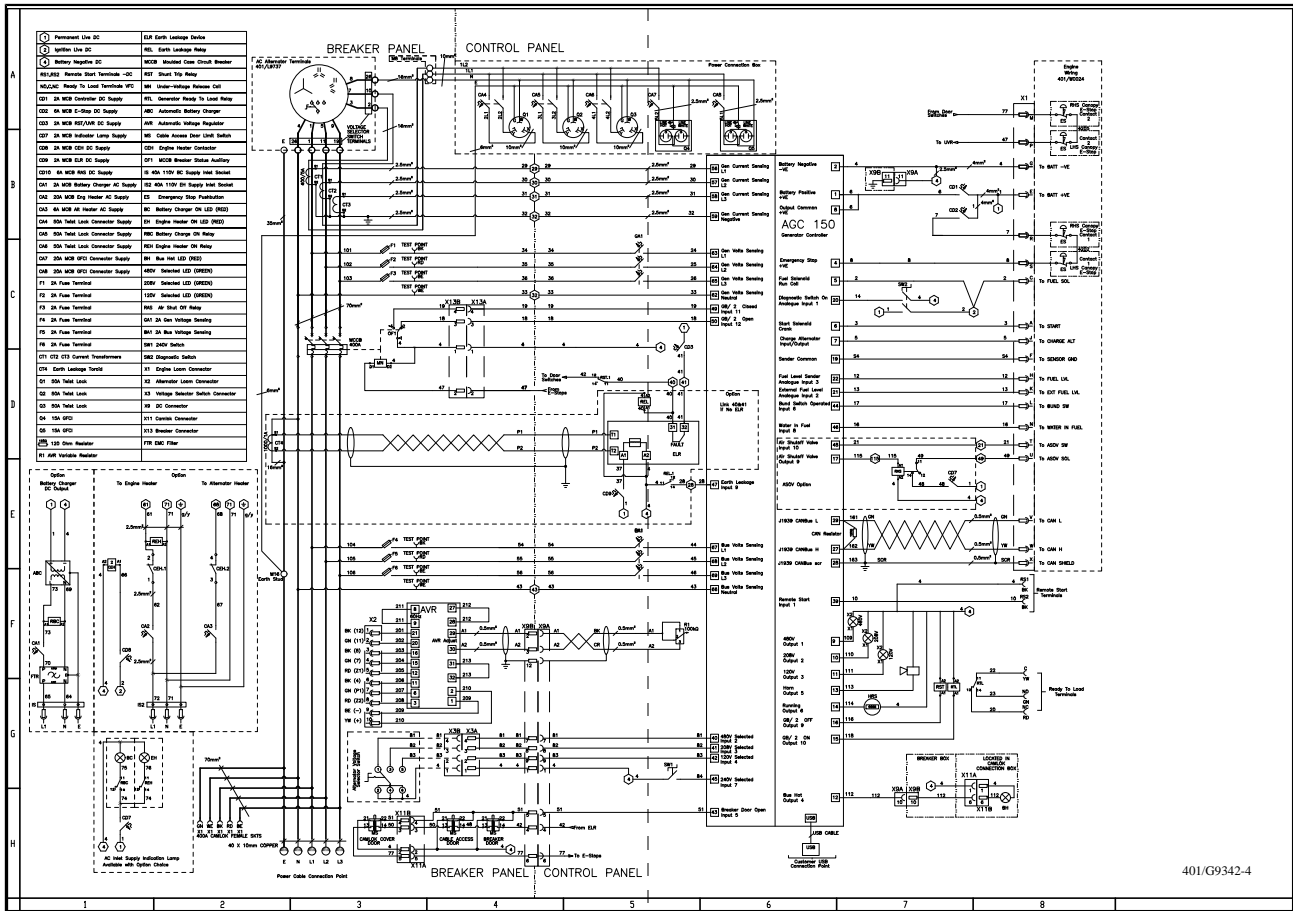
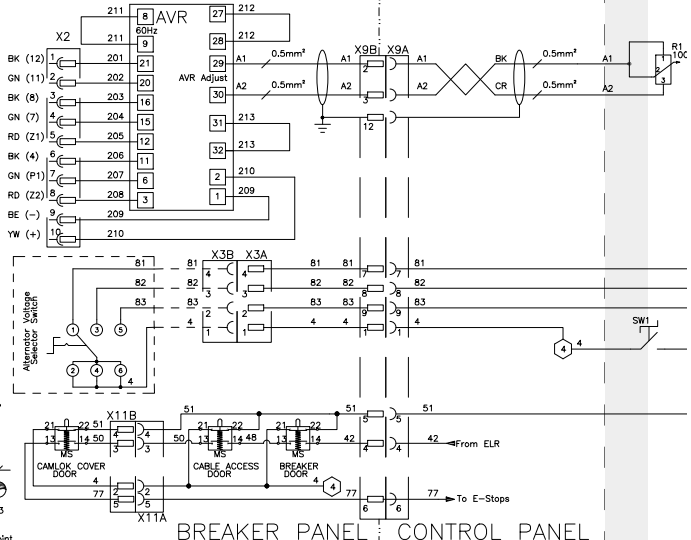
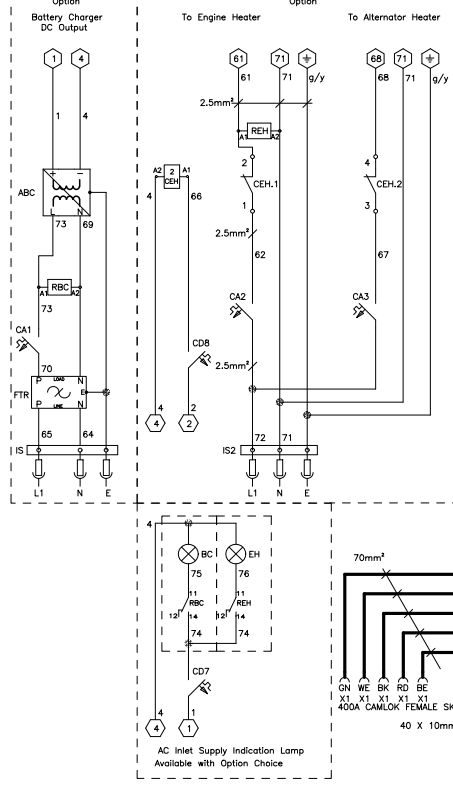
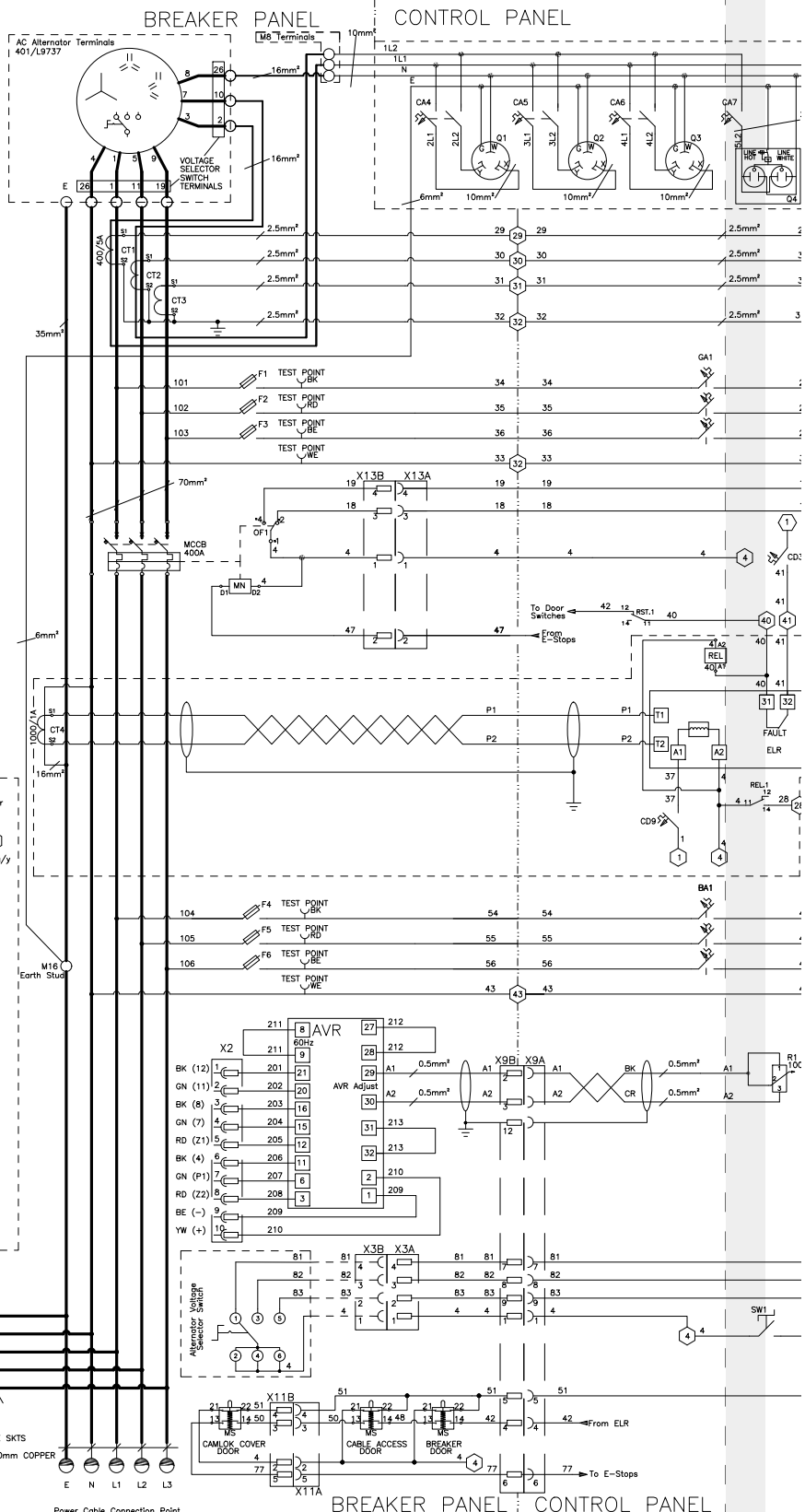


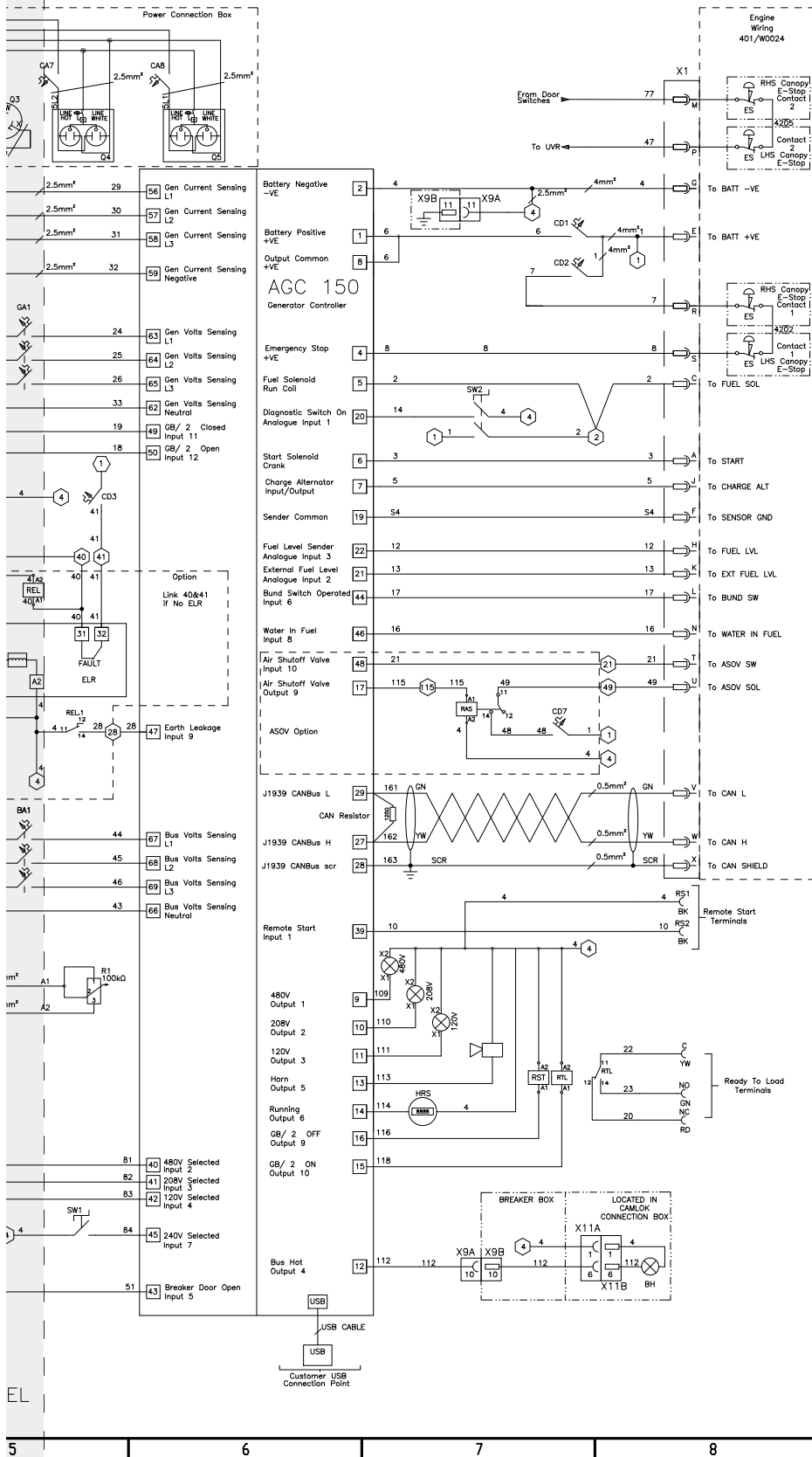
Figure 298. (Part 1 of 2)

1	Permanent Live DC	ELR Earth Leakage Device
2	Ignition Live DC	REL Earth Leakage Relay
4	Battery Negative DC	MCCB Moulded Case Circuit Breaker
RS1,RS2	Remote Start Terminals -DC	RST Shunt Trip Relay
NO,C,NC	Ready To Load Terminals VFC	MN Under-Voltage Release Coil
CD1	2A MCB Controller DC Supply	RTL Generator Ready To Load Relay
CD2	6A MCB E-Stop DC Supply	ABC Automatic Battery Charger
CD3	2A MCB RST/UVR DC Supply	AVR Automatic Voltage Regulator
CD7	2A MCB Indicator Lamp Supply	MS Cable Access Door Limit Switch
CD8	2A MCB CEH DC Supply	CEH Engine Heater Contactor
CD9	2A MCB ELR DC Supply	OF1 MCCB Breaker Status Auxiliary
CD10	6A MCB RAS DC Supply	IS 40A 110V BC Supply Inlet Socket
CA1	2A MCB Battery Charger AC Supply	IS2 40A 110V EH Supply Inlet Socket
CA2	20A MCB Eng Heater AC Supply	ES Emergency Stop Pushbutton
CA3	6A MCB Alt Heater AC Supply	BC Battery Charger ON LED (RED)
CA4	50A Twist Lock Connector Supply	EH Engine Heater ON LED (RED)
CA5	50A Twist Lock Connector Supply	RBC Battery Charge ON Relay
CA6	50A Twist Lock Connector Supply	REH Engine Heater ON Relay
CA7	20A MCB GFCI Connector Supply	BH Bus Hot Off Relay
CA8	20A MCB GFCI Connector Supply	480V Selected LED (GREEN)
F1	2A Fuse Terminal	208V Selected LED (GREEN)
F2	2A Fuse Terminal	120V Selected LED (GREEN)
F3	2A Fuse Terminal	RAS Air Shut Off Relay
F4	2A Fuse Terminal	GA1 2A Gen Voltage Sensing
F5	2A Fuse Terminal	BA1 2A Bus Voltage Sensing
F6	2A Fuse Terminal	SW1 240V Switch
CT1 CT2 CT3	Current Transformers	SW2 Diagnostic Switch
CT4	Earth Leakage Toroid	X1 Engine Loom Connector
Q1	50A Twist Lock	X2 Alternator Loom Connector
Q2	50A Twist Lock	X3 Voltage Selector Switch Connector
Q3	50A Twist Lock	X9 DC Connector
Q4	15A GFCI	X11 Camlok Connector
Q5	15A GFCI	X13 Breaker Connector
100	120 Ohm Resistor	FTR EMC Filter
R1	AVR Variable Resistor	



Page 33-23

Figure 298. (Part 2 of 2)



401/G9342-4



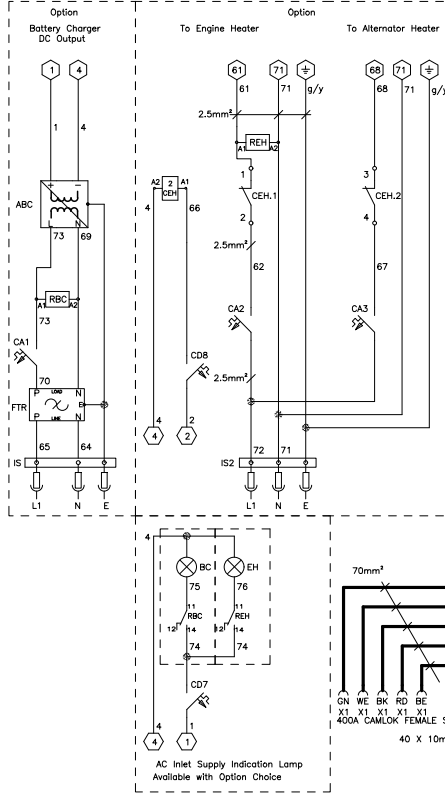
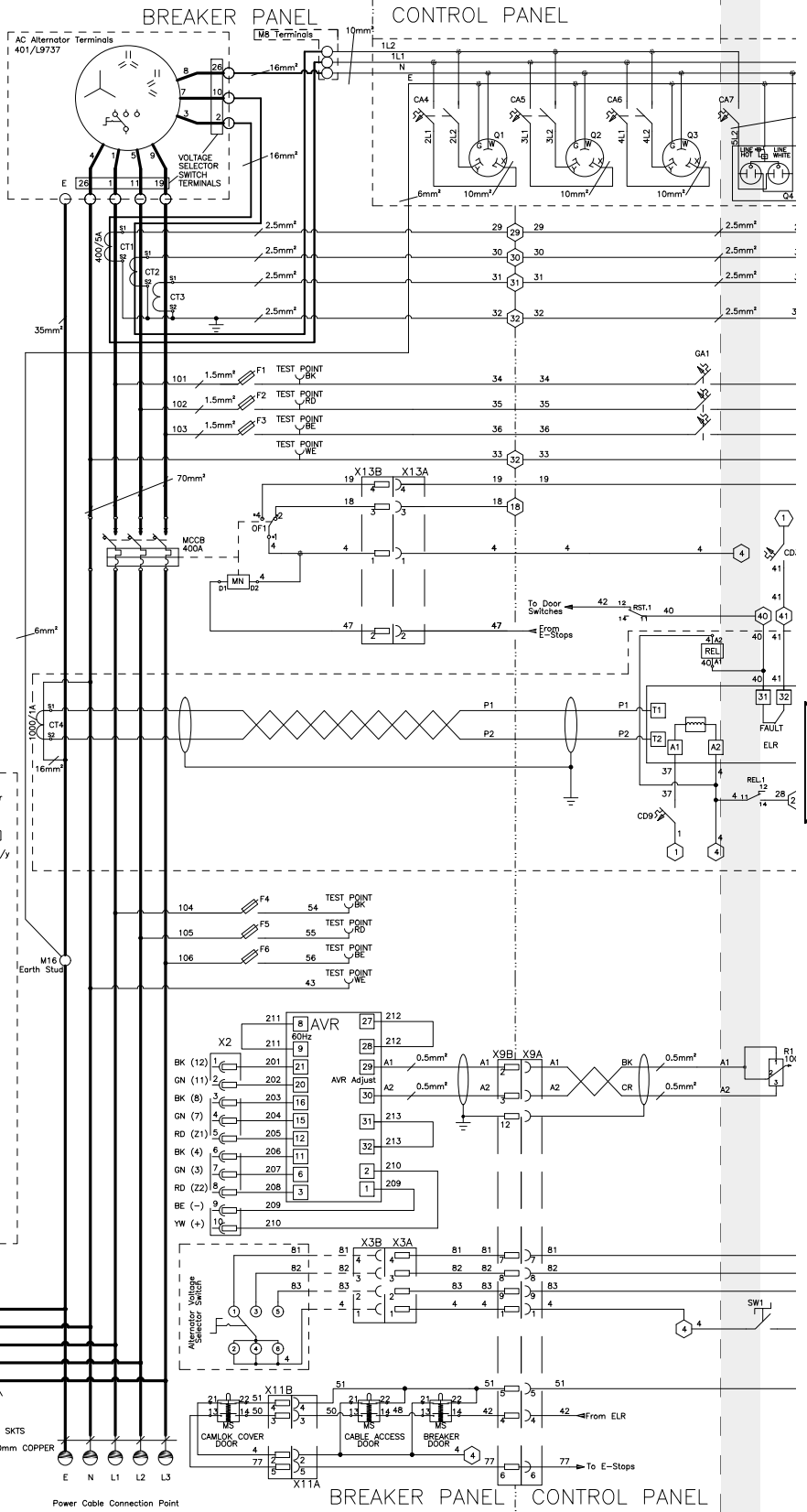
33 - Electrical System

00 - Electrical System

50 - Schematic Circuit

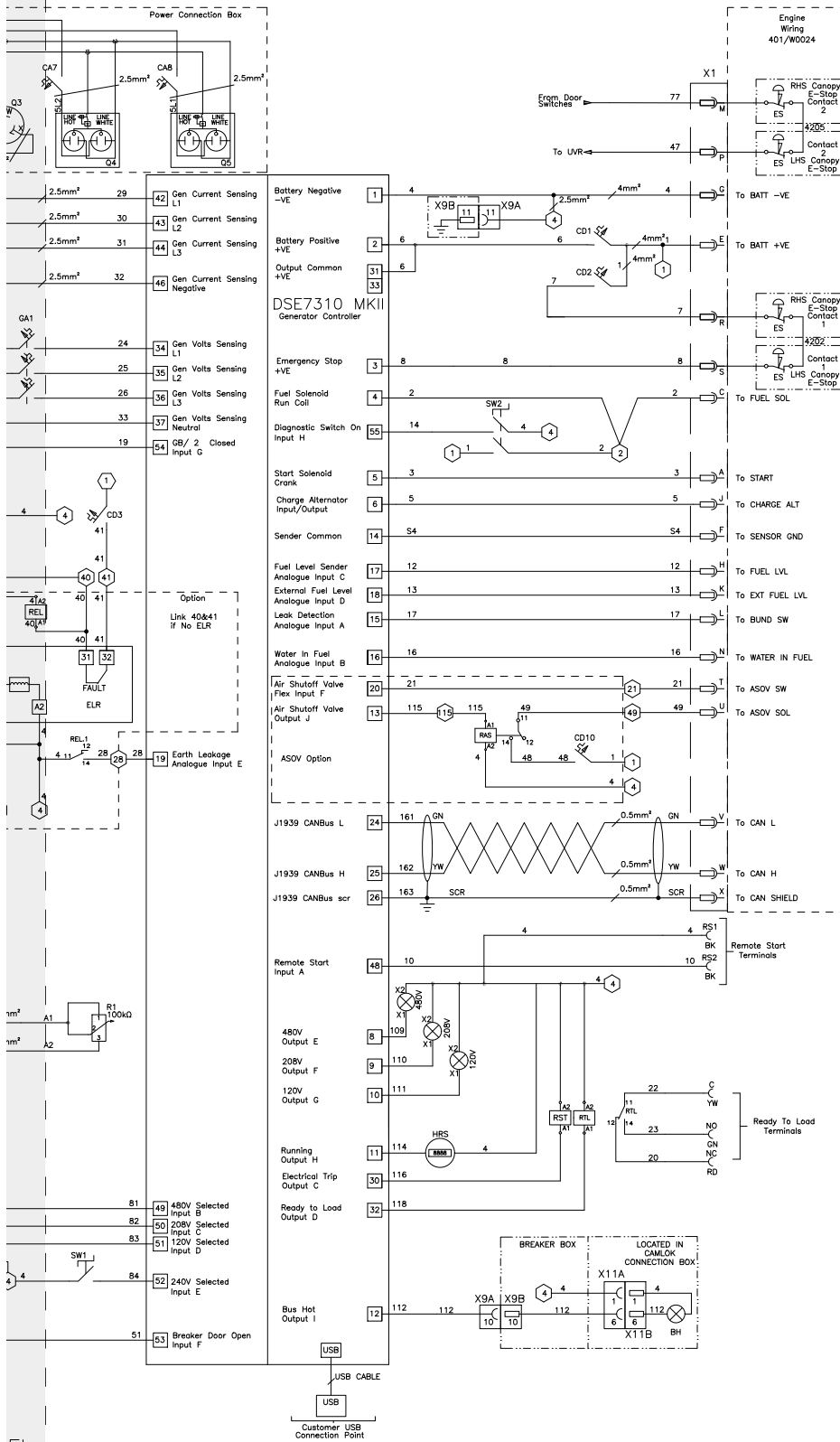
Figure 299. (Part 1 of 2)

1 Permanent Live DC	ELR Earth Leakage Device
2 Ignition Live DC	REL Earth Leakage Relay
4 Battery Negative DC	MCCB Moulded Case Circuit Breaker
RS1,RS2 Remote Start Terminals -DC	RST Shunt Trip Relay
NO,C,NC Ready To Load Terminals VFC	MN Under-Voltage Release Coil
CD1 2A MCB Controller DC Supply	RTL Generator Ready To Load Relay
CD2 6A MCB E-Stop DC Supply	ABC Automatic Battery Charger
CD3 2A MCB RST/UVR DC Supply	AVR Automatic Voltage Regulator
CD7 2A MCB Indicator Lamp Supply	MS Cable Access Door Limit Switch
CD8 2A MCB CEH DC Supply	CEH Engine Heater Contactor
CD9 2A MCB ELR DC Supply	OF1 MCCB Breaker Status Auxiliary
CD10 6A MCB RAS DC Supply	IS 40A 110V BC Supply Inlet Socket
CA1 2A MCB Battery Charger AC Supply	IS2 40A 110V EH Supply Inlet Socket
CA2 20A MCB Eng Heater AC Supply	ES Emergency Stop Pushbutton
CA3 6A MCB Alt Heater AC Supply	BC Battery Charger ON LED (RED)
CA4 50A Twist Lock Connector Supply	EH Engine Heater ON LED (RED)
CA5 50A Twist Lock Connector Supply	RBC Battery Charge ON Relay
CA6 50A Twist Lock Connector Supply	REH Engine Heater ON Relay
CA7 20A MCB GFCI Connector Supply	BH Bus Shut Off Relay
CA8 20A MCB GFCI Connector Supply	480V Selected LED (GREEN)
F1 2A Fuse Terminal	208V Selected LED (GREEN)
F2 2A Fuse Terminal	120V Selected LED (GREEN)
F3 2A Fuse Terminal	RAS Air Shut Off Relay
F4 2A Fuse Terminal	GA1 2A Gen Voltage Sensing
F5 2A Fuse Terminal	BA1 2A Bus Voltage Sensing
F6 2A Fuse Terminal	SW1 240V Switch
CT1 CT2 CT3 Current Transformers	SW2 Diagnostic Switch
CT4 Earth Leakage Toroid	X1 Engine Loom Connector
G1 50A Twist Lock	X2 Alternator Loom Connector
G2 50A Twist Lock	X3 Voltage Selector Switch Connector
G3 50A Twist Lock	X9 DC Connector
G4 15A GFCI	X11 Camlok Connector
G5 15A GFCI	X13 Breaker Connector
120 Ohm Resistor	FTR EMC Filter
R1 AVR Variable Resistor	



Page 33-27

Figure 299. (Part 2 of 2)



Page 33-26

EL

401/K4259-3

5	6	7	8
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90 - Earth Point

Introduction

The connection of the equipment to earth shall be the responsibility of the installer and configured to meet the requirements of the specific application and local regulations.



03 - Battery

Contents	Page No.
33-03-00 General	33-31
33-03-03 Isolator Switch	33-40
33-03-24 Tray	33-42

00 - General

Introduction	33-31
Health and Safety	33-32
Fault-Finding	33-33
Disconnect and Connect	33-33
Check (Condition)	33-34
Charge	33-39
Remove and Install	33-39

Introduction

Batteries used in normal temperate climate applications should not need topping up. However, in certain conditions (such as prolonged operation in high ambient temperatures or if the alternator overcharges) the electrolyte level should be checked frequently and topped up as necessary.

The electrolyte level should be checked in accordance with the routine maintenance schedule. Shorter maintenance intervals are required if the machine is operating at high ambient temperatures or continuously for long periods.

Later Machines may have the new type batteries installed which include a sight glass to check the condition of the battery. New batteries should be used as replacements if replacing the battery on earlier machines.

Figure 300.



A Maintenance free battery

Maintenance

To make sure that the battery provides optimum performance the following steps should be observed:

- Make sure that the electrical connections are clean and tight. Smear petroleum jelly on connectors to prevent corrosion.
- When applicable - never allow the electrolyte level to fall below the recommended level of 6mm above the plates. Use only distilled water for topping up.
- Keep the battery at least three quarters charged, otherwise the plates may become sulphated (hardened) - this condition makes recharging the battery very difficult.

Extra precautions must be taken when bench charging maintenance free batteries, they are more prone to damage by overcharging than the standard type of battery:

- Never boost charge a maintenance free battery (if installed).

- Never charge a battery at a voltage in excess of 15.8V.
- Never continue to charge a battery after it begins to gas.

Health and Safety

▲ DANGER Batteries give off an explosive gas. Do not smoke when handling or working on the battery. Keep the battery away from sparks and flames.

Battery electrolyte contains sulphuric acid. It can burn you if it touches your skin or eyes. Wear goggles. Handle the battery carefully to prevent spillage. Keep metallic items (watches, rings, zips etc) away from the battery terminals. Such items could short the terminals and burn you.

Set all switches to off before disconnecting and connecting the battery. When disconnecting the battery, take off the earth (-) lead first.

Re-charge the battery away from the machine, in a well ventilated area. Switch the charging circuit off before connecting or disconnecting the battery. When you have installed the battery in the machine, wait 5 min before connecting it up.

When reconnecting, attach the positive (+) lead first.

WARNING Keep metal watch straps and any metal fasteners on your clothes, clear of the positive (+) battery terminal. Such items can short between the terminal and nearby metal work. If it happens you can get burned.

WARNING Battery electrolyte is toxic and corrosive. Do not breathe the gases given off by the battery. Keep the electrolyte away from your clothes, skin, mouth and eyes. Wear safety glasses.

WARNING Do not top the battery up with acid. The electrolyte could boil out and burn you.

CAUTION Understand the electrical circuit before connecting or disconnecting an electrical component. A wrong connection can cause injury and/or damage.

Notice: Do not disconnect the battery while the engine is running, otherwise the electrical circuits may be damaged.

CAUTION The machine is negatively earthed. Always connect the negative pole of the battery to earth.

When connecting the battery, connect the earth (-) lead last.

When disconnecting the battery, disconnect the earth (-) lead first.

DANGER If you try to charge a frozen battery, or jump start and run the engine, the battery could explode. Do not use a battery if its electrolyte is frozen. To prevent the battery electrolyte from freezing, keep the battery at full charge.

CAUTION Damaged or spent batteries and any residue from fires or spillage must be put in a

suitable closed receptacle and must be disposed of in accordance with local environmental waste regulations.

Notice: Before carrying out arc welding on the machine, disconnect the battery and alternator to protect the circuits and components. The battery must still be disconnected even if a battery isolator is installed.

Fault-Finding

The most obvious sign of a battery problem is a machine not being able to start. However, because the battery is part of a larger electrical system connected to other parts of the machine, a flat battery may indicate another problem.

If something else is going wrong in the electrical system, for example, a weak alternator, corrosion or loose connections, cold weather starting, electrical equipment being left on without the engine running, interrogate the cause of the problem.

The best way to test the condition of the battery is with an electronic battery tester. Refer to Battery-Check Condition.

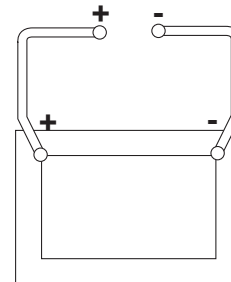
When the machine is not in use, make sure that the electrical system is not causing a drain on the battery. On machines with electronically controlled engines check the operation of the power hold relay. Refer to PIL 33-09-06.

Disconnect and Connect

The batteries leads will require connecting on initial installation.

When connecting the battery to the machine, always connect the positive terminal first followed by the negative terminal. When disconnecting, remove the negative first then the positive. These steps will ensure accidental shorting of the battery terminals cannot take place.

Figure 301. 12V System



Check (Condition)

Special Tools

Description	Part No.	Qty.
Battery Tester	400/G9956	1

Introduction

As of July 2019, this procedure must be used for all battery warranty claims. This procedure provides details on the new battery warranty claim criteria and details of how to test the batteries with the new battery tester kit.

To allow for the effective processing of battery warranty claims you must complete the battery test procedure specified in this document before you submit a warranty claim and in the event of claim submission, all the supporting criteria detailed in this procedure for approval should be made available.

Figure 302.



A Battery Tester Kit

Important Information.

- Any claims submitted without all the required criteria to support may be declined.
- All monthly test receipts and machine delivery test receipt should be kept with the machine or vehicle records and should be able to be evidenced in the event of a battery claim submission.

Battery Warranty Claim Adjudication.

Batteries are only warranted against the defects due to faulty workmanship or materials. Battery failures due to poor maintenance or a consequence of other

electrical issues on the machine are not separately claimable.

Note that damaged and leaking batteries are not considered as warrantable defects as such defects do not arise from faulty materials or workmanship. Claims must not be submitted if those are the identified defects. Such claims will get declined.

Batteries must only be returned to JCB Service when requested by the warranty adjudicator.

Important: Any claims submitted without all the below criteria may get declined.

Battery Claim Criteria.

- Images of the machine and battery
- Images of the battery test receipt deeming a 'failed' battery
- Images of the battery test receipt at delivery
- Images of monthly stock check health receipts.

All the criteria should be compiled using the attachment to bulletin (W228) and the pdf attached to the claim.

Battery Maintenance.

Batteries in stock require periodic checking and maintenance, whether on the shelf or in stock.

Dealer Lay-up.

- Upon arrival at your dealership, all machines must have their battery condition checked. The battery must be tested as per this battery test procedure. On the printed test receipt, write the machine serial number, date and sign.
- Important: As best practice for all machines, as of July 2019, the battery test receipt at point of delivery should be retained, even after machine retail.
- Machines in stock must have their batteries tested on a monthly basis. The battery must be tested as per this procedure. On the printed test receipt, write the machine serial number, date and sign.
- If the result deems recharge is required, the battery should be recharged and retested to show successful recharge. Again, on the printed test receipt, write the machine serial number, date and sign.

Important: All monthly battery test receipts should be kept with the machine or vehicle records and should be able to be evidenced in the event of a battery claim submission.

- If a battery is on a machine which is not going to be used for more than one month, it should be disconnected from the machine (Isolated or physically disconnected). Machines have electrical accessories which can slowly discharge the battery even when the ignition key has been removed.

Battery Stock Lay-up.

- Battery stock should be rotated (First in first out - FIFO) to make sure that the customer receives a good quality battery.
- The open circuit voltage of stock batteries should be checked every month (with the use of a digital voltmeter) and the voltage recorded on a ticket (date and voltage and signed) attached to the battery. The results of the test should be retained (by the dealer) upon battery retail for the duration of the battery warranty.
- If a stock battery has a voltage below 12.5V, a fresh recharge must be conducted.
- The battery condition must be checked before hand-over to the customer to make sure that its voltage is 12.5V or more.

Battery Test Procedure.

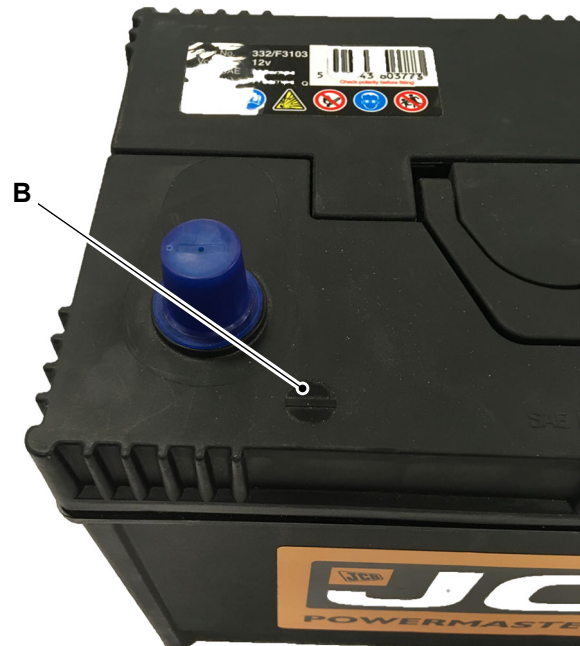
Note: All images are shown as examples. Some machines may require panels to be removed to get access to the battery. Refer to the respective service manual for information on the machine specific battery location to access.

All details on the battery test procedure can also be found in the battery test kit owner's manual. The engineer who completed this test must be familiar with the kit functionality and features.

The engineer who will carry out the procedure must have completed the JCB basic electrics training course to complete this procedure. They must be fully conversant in battery testing, a function of operation and battery lifting/handling.

1. Locate the negative terminal on the battery and identify the terminal by its symbol ('-'). Refer to Figure 303.

Figure 303.



B Negative battery-terminal identification

2. Connect the black clamp from the testing kit to the negative terminal. Make sure that the clamp is fully secured. Refer to Figure 305.
3. Locate the positive terminal on the battery and identify the terminal by its symbol ('+'). Refer to Figure 304.

Figure 304.



C Positive battery-terminal identification

4. Connect the red clamp from the testing kit to the positive terminal. Make sure that the clamp is fully secured. Refer to Figure 305.

Special Tool: Battery Tester (Qty.: 1)

Figure 305.



- D Black clamp
- E Red clamp

5. The display of the battery tester will light up when both cables are connected to the battery.
 - 5.1. If the cables have not been connected to the battery correctly, the test kit will recognise this and ask you to reconnect. Refer to Figure 306. Refer to Figure 307.

Figure 306.



Figure 307.



6. Press the 'Forward' or 'Back' button to select 'BATTERY TEST'. Refer to Figure 308.

Figure 308.



7. Press the 'Enter' button to proceed. Refer to Figure 309.

Figure 309.



8. Select the machine battery type. The JCB batteries are 'Flooded'. Move through the different types using the forward or back arrow buttons. Once selected press 'Enter'. Note: This procedure does not apply to 48V electric machines.
9. Select 'SAE' for the rating option and press 'Enter'.

Figure 310.



10. Set the battery capacity. Refer to Figure 313. This can be found on the battery labelled as 'CCA SAE'. Refer to Figure 311. Refer to Figure 312.

10.1. Press and hold the 'Forward' button until the desired value is selected and press 'Enter'.

Figure 311.

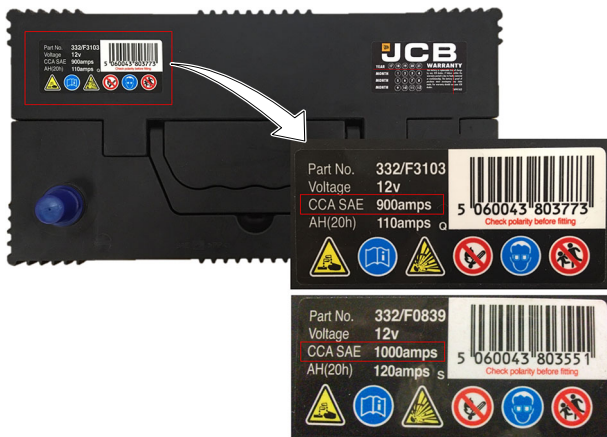


Figure 312.



Figure 313.



11. The battery tester will now perform the test. Once completed, the result will display on the screen. Refer to Table 146.

12. To print the test result, press the 'Enter' button. It will first display the battery resistance. Refer to Figure 314.

Figure 314.



13. Press 'Enter' again, and it will ask 'PRINT RESULT?'. Press the 'forward' button to display 'YES' and press 'Enter'. Refer to Figure 315.

Figure 315.



14. The battery tester should now print the test result. Refer to Figure 316.

Figure 316.

Table 146.

Results	Description
GOOD and PASS	The battery is good and capable of holding charge.
GOOD and RECHARGE	The battery is good but needs to be recharged.
RECHARGE and RETEST	The battery is discharged. The battery condition cannot be determined until it is fully charged. Recharge and retest the battery.
BAD and REPLACE	The battery will not hold a charge. It should be replaced immediately.
BAD CELLS and REPLACE	The battery will not hold a charge. It should be replaced immediately.

Charge

Precautions Before Charging

Follow all the precautions described below, to prevent damage to the alternator and battery.

1. Make the machine safe.
[Refer to: PIL 01-03.](#)
2. Make sure that the battery negative terminal is connected to the earth cable.
3. Do not connect or disconnect the battery or alternator connections, or any part of the charging circuit while the engine is in operation. If you disregard this instruction, the regulator or rectifying diodes will be damaged.
4. Main output cables are always in an active state of current flow even when the engine is not in operation. If the alternator connector is removed, do not earth the moulded plug.
5. When you do arc welding on the machine, remove the moulded plug (or if the separate output cables are installed, remove the cables) to protect the alternator.
6. If it is necessary to jump start the battery, do the following steps.
 - 6.1. Connect a secondary battery in parallel without disconnecting the vehicle battery from the charging circuit.
 - 6.2. Connect the batteries using suitable jump leads. Connect the positive lead to the positive terminals of both batteries. Connect the negative lead to the negative terminals of both batteries.
 - 6.3. After the jump start, safely disconnect the jump leads and remove the secondary battery.

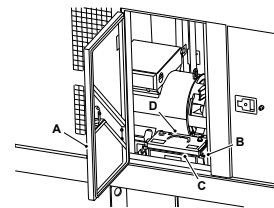
Remove and Install

▲ CAUTION This component is heavy. It must only be removed or handled using a suitable lifting method and device.

Remove

1. Obey all electrical system health and safety information.
[Refer to: PIL 33-00-00.](#)
2. Open the rear right side access panel.
[Refer to: PIL 06-06-00.](#)
3. Disconnect the battery cables.
4. Loosen the wing nut (x2).
5. Move the battery strap away from the battery.
6. Remove the battery from the machine.

Figure 317.



- A** Rear right side access cover
- B** Wing nut (x2)
- C** Battery strap
- D** Battery

Install

1. The installation procedure is the opposite of the removal procedure.



03 - Isolator Switch

Introduction	33-40
Disconnect and Connect	33-41
Remove and Install	33-41

Introduction

The battery isolator switch is used to disconnect the battery from the machine electrics. The switch must be turned to the OFF position if any maintenance work is to be performed on the machine.

Some machine systems perform shut down cycles after the engine stops. Wait until shut down cycles are complete before setting the battery isolator switch to the OFF position. For more information refer to Disconnect and Connect.

Disconnect and Connect

▲ Notice: Before carrying out arc welding on the machine, disconnect the battery and alternator to protect the circuits and components. The battery must still be disconnected even if a battery isolator is installed.

Notice: Do not isolate the machine electrics when the engine is running, this may cause damage to the machine electrics.

The control system is designed such that if the battery isolator is switched off then there is a 2min time delay to de-energise the ECU (Electronic Control Unit) to allow the DEF (Diesel Exhaust Fluid) purge to complete its shutdown cycle.

Disconnect the Machine Electrics:

1. Get access to the battery isolator.
2. Turn the battery isolator key in a counter-clockwise direction and remove.

Connect the Machine Electrics:

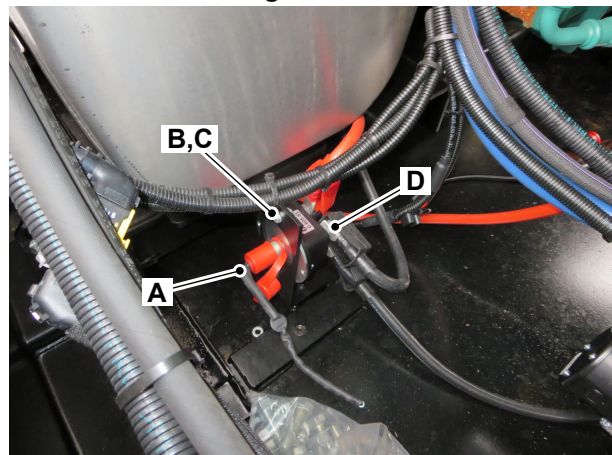
1. Insert the battery isolator key and turn in a clockwise direction.

Remove and Install

Removal

1. Make the machine safe.
[Refer to: PIL 01-03.](#)
2. Open the canopy door.
[Refer to: PIL 06-06.](#)
3. Disconnect the battery leads.
[Refer to: PIL 33-03-00.](#)
4. Remove the nut (x2) and the washer (x2) from the battery isolator switch.
5. Carefully pull out the battery isolator switch from its position.
6. Disconnect the harness (x2) from the battery isolator switch.
7. Remove the battery isolator switch.

Figure 318.



- A** Battery isolator switch
- B** Nut (x2)
- C** Washer (x2)
- D** Harness (x2)

Install

1. The installation procedure is the opposite of the removal procedure.

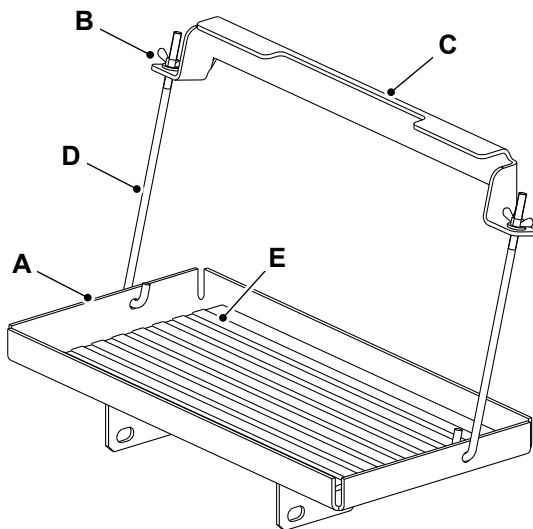
24 - Tray

Remove and Install

Remove

1. Obey all electrical system health and safety information.
[Refer to: PIL 33-00-00.](#)
2. Open the rear right side access panel.
[Refer to: PIL 06-06-00.](#)
3. Remove the battery.
[Refer to: PIL 33-03-00.](#)
4. Remove the wing nut (x2).
5. Remove the battery strap and the J bolt.
6. Remove the nut and bolts from the battery tray.
7. Remove the matt.
8. Remove the battery tray from the machine.

Figure 319.



- A Battery tray
- B Wing nut (x2)
- C Battery strap
- D J bolt (x2)
- E Matt

Install

1. The installation procedure is the opposite of the removal procedure.



08 - Power Alternator

Contents	Page No.
33-08-00 General	33-45
33-08-06 Voltage Regulator	33-58
33-08-15 Diode Bridge	33-61

00 - General

Health and Safety	33-45
Fault-Finding	33-46
Clean	33-48
Check (Condition)	33-49
Check (Operation)	33-51
Remove and Install	33-55

Health and Safety

▲ **WARNING** Suitable grounding of the product provides extra safety. The international electric code requires that the product is properly connected to an appropriate earth to help prevent electric shock. A suitable terminal is located on the generator for this purpose. For remote grounding connect a length of heavy gauge copper wire from the product terminal to a copper rod driven into the ground. (cable and rod not supplied). Never operate electrical equipment with damaged or defective cables.

WARNING Working with equipment that runs on Alternating Current (AC) could be dangerous. Any maintenance work on such equipment should be done by an authorised electrical engineer or a suitably trained person. All maintenance work must comply with ISO 60204-1 in Europe.

CAUTION You or others could be seriously injured by rotating parts if the alternator drive belt cover plate is not installed. Always install the cover plate before starting the engine.

Notice: Before carrying out arc welding on the machine, disconnect the battery and alternator to protect the circuits and components. The battery must still be disconnected even if a battery isolator is installed.

Notice: The engine or certain components could be damaged by high pressure washing systems; special precautions must be taken if the engine is to be washed using a high pressure system. Ensure that the engine air intake, alternator, starter motor and any other electrical components are shielded and not directly cleaned by the high pressure cleaning system.

Notice: The engine and other components could be damaged by high pressure washing systems. Special precautions must be taken if the machine is to be washed using a high pressure system.

Make sure that the alternator, starter motor and any other electrical components are shielded and not directly cleaned by the high pressure cleaning system. Do not aim the water jet directly at bearings, oil seals or the engine air induction system.

Fault-Finding

Fault

No voltage builds up while starting	Table 147.	Page 33-46
Voltage too low	Table 148.	Page 33-46
Voltage too high	Table 149.	Page 33-46
Unstable voltage	Table 150.	Page 33-46
Voltage correct at no load and too low when on load	Table 151.	Page 33-46
Voltage disappears during operation	Table 152.	Page 33-47
Faulty bearing	Table 153.	Page 33-47
Abnormal temperature	Table 154.	Page 33-47
Vibration	Table 155.	Page 33-47
Abnormal noise	Table 156.	Page 33-47

Table 147. No voltage builds up while starting

Cause	Remedy
Lack of residual magnetism	Connect a new battery of the specified voltage to terminals E+ and E-, respecting the polarity, for the specified time. Voltage: 4–12V
Faulty diodes	
Revolving field coil open circuit	
Faulty AVR	
Field winding open circuit	
Revolving field coil open circuit	

Table 148. Voltage too low

Cause	Remedy
Faulty DSR	Check the drive speed.
Field winding short circuited	
Rotating diode burn out	
Incorrect winding resistance	
Incorrect drive speed	

Table 149. Voltage too high

Cause	Remedy
Faulty DSR	Adjust the DSR voltage potentiometer.

Table 150. Unstable voltage

Cause	Remedy
Incorrect speed and irregular cycle	Adjust the DSR stability potentiometer.
Loose connections	
Faulty AVR	
Speed too low when on load	

Table 151. Voltage correct at no load and too low when on load

Cause	Remedy
Incorrect speed	Run at no load and check the voltage between E+ and E- on the DSR.
Faulty rotating diodes	
Short-circuit in the revolving field coil	
Faulty exciter armature	

Table 152. Voltage disappears during operation

Cause	Remedy
Exciter winding open circuit	Check the AVR, the surge suppressor and the rotating diodes. If necessary, replace them.
Faulty exciter armature	
Faulty AVR	
Revolving field coil open circuit or short-circuited	

Table 153. Faulty bearing

Cause	Remedy
Excessive temperature rise in one or both bearings (bearing temperature more than 80°C) with or without abnormal bearing noise	If the bearing has turned blue or if the grease has turned black, change the bearing.
	Make sure that the bearing is not fully locked (abnormal play in the bearing cage).
	Check the end shield alignment (flange is not properly installed).

Table 154. Abnormal temperature

Cause	Remedy
Excessive temperature rise in alternator case (more than 40°C above ambient temperature)	Air flow (intake-outlet) partially clogged or hot air is recycled from the alternator or the engine.
	Alternator operates at a high voltage (greater than the specified value of unload) Percentage: 105%
	Make sure that the alternator is not overloaded.

Table 155. Vibration

Cause	Remedy
Excessive vibration	Check for the coupling misalignment.
	Check for the defective mounting or play in the coupling.
	Check for the rotor balancing fault (Engine-Alternator).
Excessive vibration and humming noise coming from the machine	Check for the phase imbalance.
	Check for the stator short-circuit.

Table 156. Abnormal noise

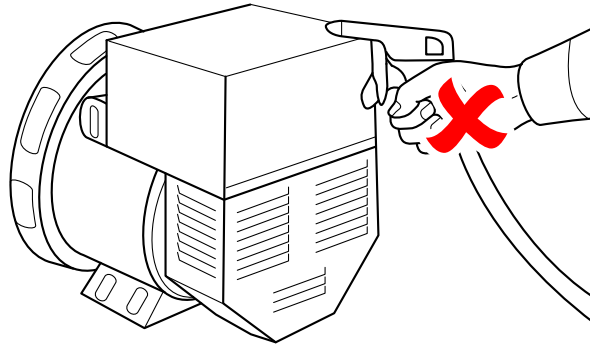
Cause	Remedy
Alternator damaged by a significant impact, followed by humming and vibration	Check for the system short-circuit.
	Check for the misalignment.
	Check for the broken or damaged coupling.
	Check for the broken or bent shaft extension.
	Check for the shifting and short-circuit of the revolving field winding.
	Check condition of the fan.
	Check condition of the rotating diodes or AVR.

Clean

Before you approach or touch the alternator, make sure that it is not live and it is at room temperature;

at this stage it is possible to clean the outside using compressed air.

Figure 320.

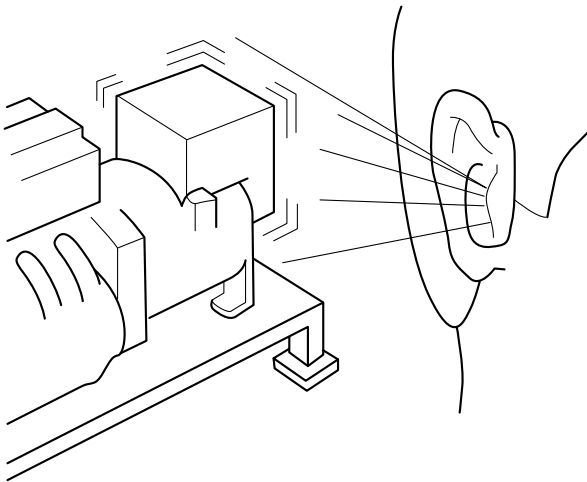


Never use liquids or water. Do not clean inside electrical components with compressed air, this may cause short circuits or cause damage.

Check (Condition)

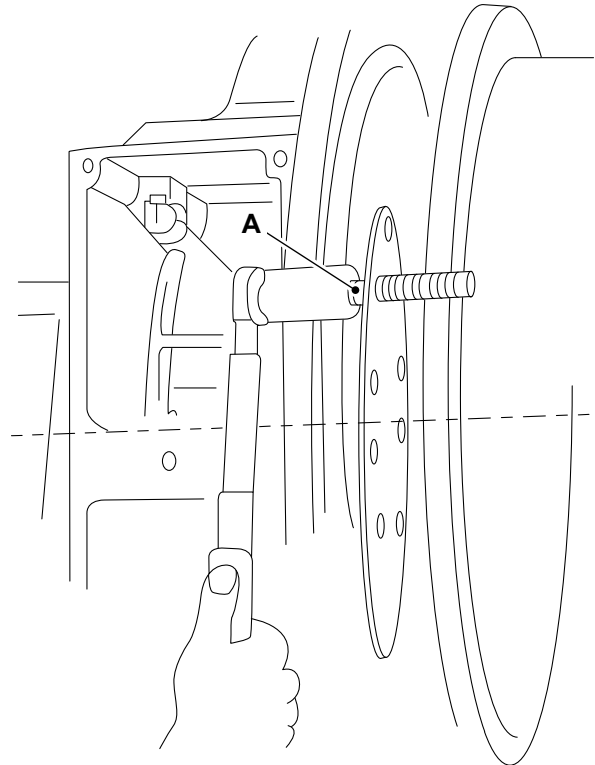
1. Check the machine for unusual noises and vibrations.
 - 1.1. If there are noises and vibrations then it indicates that the bearings are damaged.
 - 1.2. Make sure that the coupling is aligned correctly and it is not damaged.
 - 1.3. Make sure that there is no stress on the combustion engine.
 - 1.4. Make sure that the vibration mounts are not damaged.
 - 1.5. Check the performance data and make sure that it is similar to the data on the generator's plate.

Figure 321.



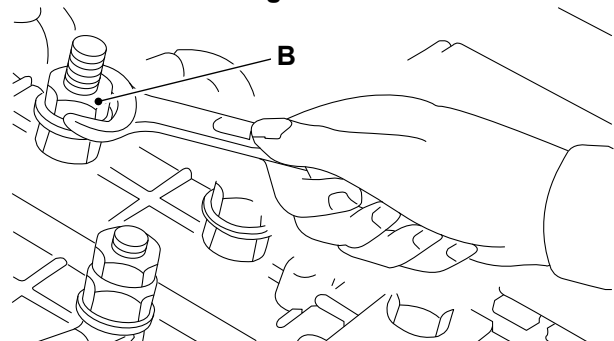
2. Check the electrical connections.

Figure 322.



A Bolt - Alternator to engine flywheel

Figure 323.



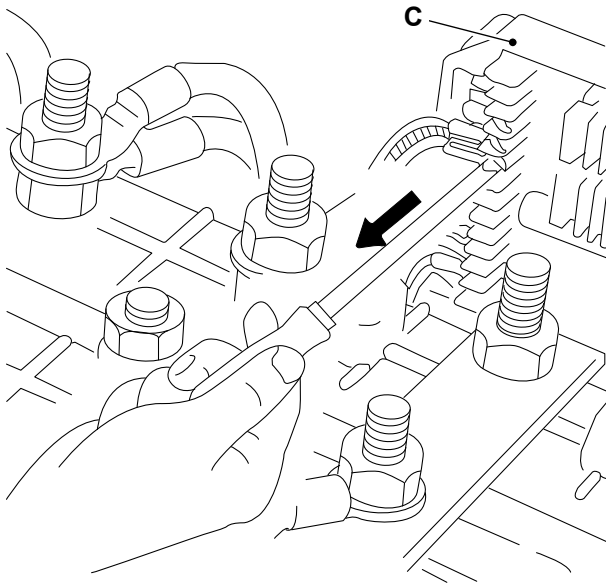
B Terminal nut

- 2.1. Make sure that there is no voltage when you check the electrical connections.

Check windings condition after long period of storage or inactivity.

1. Measure the insulating earth resistance with the megger device or a similar device to estimate the condition of the windings.
2. Disconnect the voltage regulator. Refer to Figure 324.

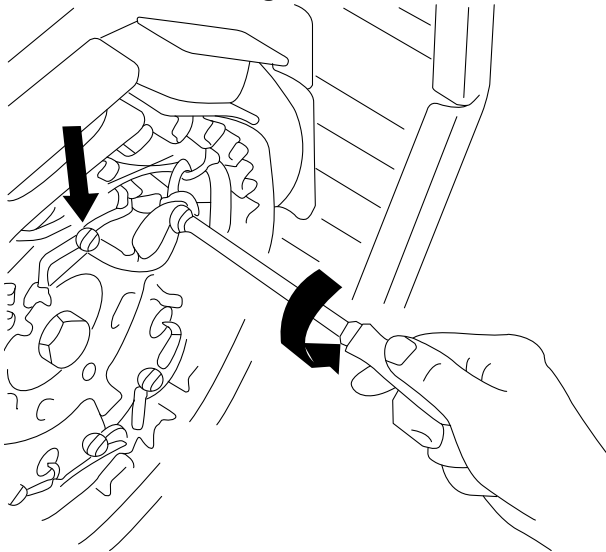
Figure 324.



C Voltage regulator

3. Disconnect the rotating diode bridge. Refer to Figure 325.

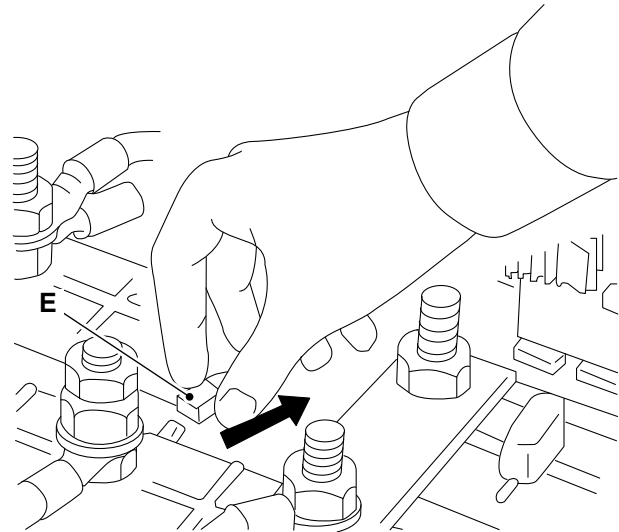
Figure 325.



D Rotating diode bridge

4. Disconnect the radio interference filter. Refer to Figure 326.

Figure 326.



E Radio-interference filter

5. Check if there is any other device connected to the windings before you get the measurements.
6. Make sure that the measured earth resistance of the windings is more than the specified value. If the resistance is less than the specified value then the windings must be sufficiently dried up.

Resistance: 10,000,000Ω

Check (Operation)

The following section involves testing of LIVE equipment and should only be carried out if the machine cannot be tested in a safer manner. Any testing should be in accordance with local site rules for testing LIVE systems.

1. Obey all electrical system health and safety information.

Refer to: PIL 33-00-00.

2. Test the main stator as follows:

- 2.1. Use a multimeter to check all the 3 phases.
- 2.2. Make sure that the voltage must be balanced phase to phase within the specified value.

Percentage: 1%

Figure 327.

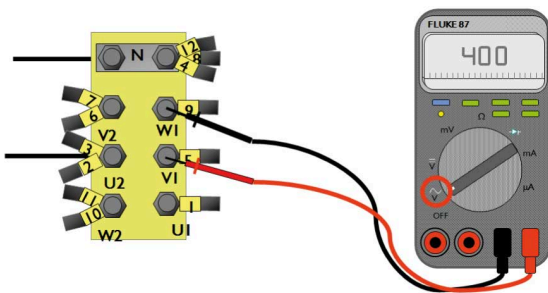


Figure 328.

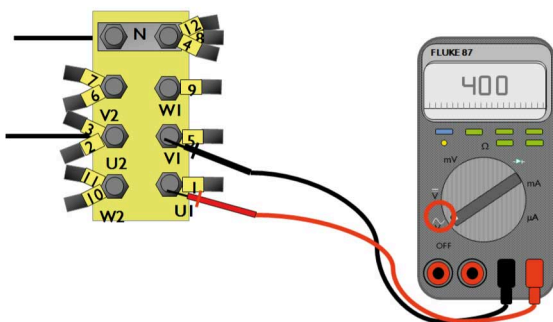
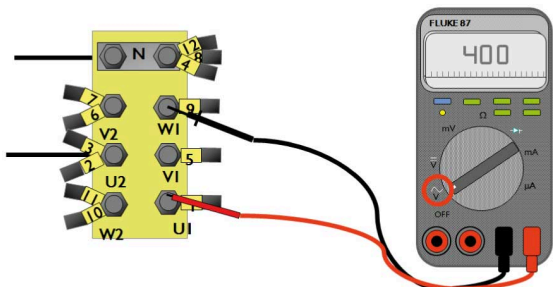


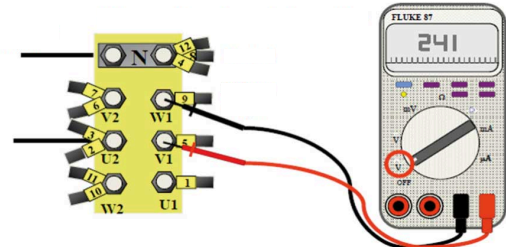
Figure 329.



- 2.3. If the voltage is unbalanced phase to phase at the specified value, it indicates a fault in the main stator windings.

Percentage: 10%

Figure 330.



- 2.4. Disconnect all the external leads from the generator and repeat the tests.

Figure 331.

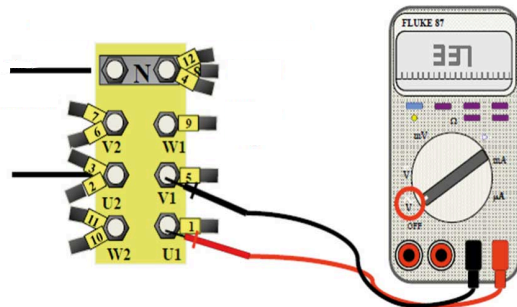
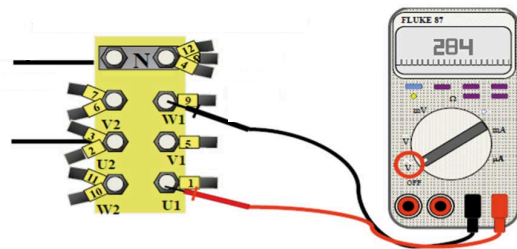


Figure 332.



- 2.5. Make a note that if the voltages are still unbalanced, it indicates that the main stator is faulty.

3. Make a note of the symptoms of the main stator failure as follows:

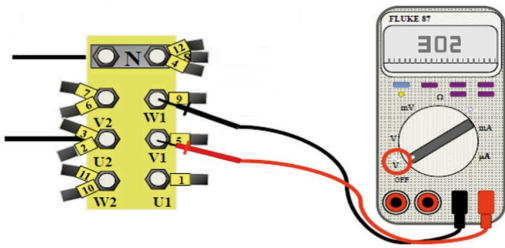
- 3.1. The output voltage will be unbalanced, phase to phase or neutral.
- 3.2. If separately excited with a battery, the engine will appear to be 'loaded'. This results from the short circuit current in the winding fault.
- 3.3. If the generator runs for a short period, the fault area in the windings area will become very hot. This can be detected by hand, or from the insulation burning (smell).

4. Test the windings and the main rectifier as follows:

- 4.1. If the voltages PH and -PH are balanced, it indicates that the main stator is ok.
- 4.2. If the voltages are lower than the specified value below the nominal, it indicates that there is a fault on the diodes or excitor rotor windings.

Percentage: 10%

Figure 333.



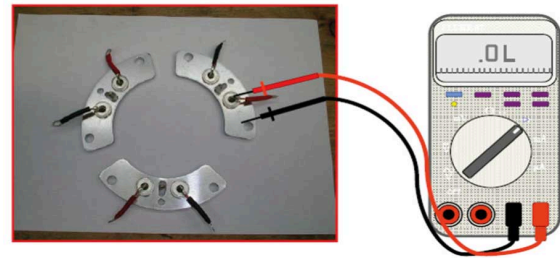
5. Make a note of the symptoms of the diode failure as follows:

- 5.1. The voltage will be low while separately exciting with a specified value battery.
Voltage: 12V
- 5.2. A self excited DSR system may not build up voltage or run up.
- 5.3. Auxiliary winding powered DSR system voltage starts to reduce gradually with continuous indication of overload indicator when the load is applied (depending on how many diodes have failed).
- 5.4. When faulty, diodes become short-circuit.
- 5.5. If two or more diodes short-circuit, it overheats the excitor rotor.
- 5.6. A short circuit diode melt its solder terminal.

6. Test the main rectifier diodes as follows:

- 6.1. Switch the multimeter to "diode" test position.
- 6.2. Make a note that with the positive test lead on the cathode side of the diode, the meter must give a reading that indicates the electron flow.

Figure 334.



7. Make a note of the symptoms of Varistor failure as follows:

- 7.1. If the Varistor fails, the device short-circuit.
- 7.2. The Varistor will fail catastrophically (explode).
- 7.3. On a self excited DSR system, a short circuit Varistor will prevent the voltage build up on the initial start-up.
- 7.4. On a auxiliary winding powered DSR system, the auxiliary winding can open circuit the varistor after failure.
- 7.5. The generator will function normally without the varistor.

8. Test the windings and the main rectifier as follows:

- 8.1. Make sure that you identify and correct any faults found with the main stator, diodes or the Varistor.
- 8.2. Make sure that the output voltage from the main stator must be balanced across the phases and within the specified value of the nominal voltage.

Percentage: 10%

- 8.3. If the step 8.2 is correct, it indicates that the windings and diodes are ok.
- 8.4. If the output voltage is low, more than the specified value below the nominal, it indicates a fault in one of the excitation windings.
- 8.5. Check condition of the exciter stator, rotor and the main rotor windings.
- 8.6. Make sure that you check the winding resistance values against the correct values given in the generator operator's manual.

9. Make a note of the symptoms of the excitor stator failure as follows:

- 9.1. If separately exciting with a specified value battery, the generator will produce residual

voltage only. This is due to an open circuit in the windings.

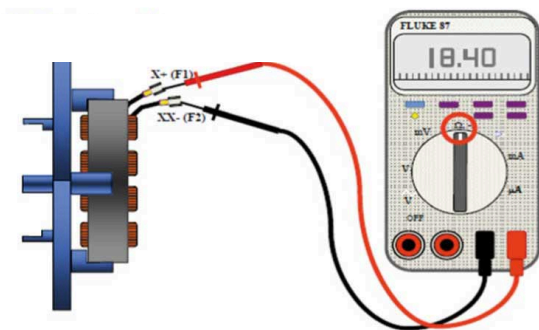
Voltage: 12V

- 9.2. The earth faults in the exciter stator can cause DSR instability, that results in the overheating of the auxiliary winding.
- 9.3. A severe earth fault cause the DSR power diodes to fail, due to excessive leakage current. This also burn out the auxiliary windings.

10. Test the excitor stator as follows:

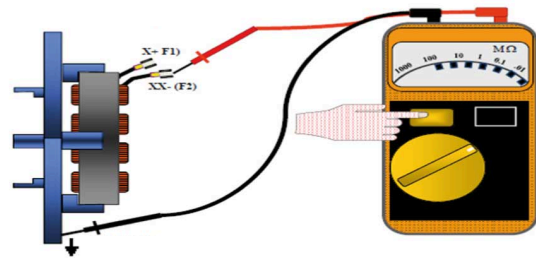
- 10.1. Check the exciter stator resistance across X+ and XX- with a multimeter set on the Ω range.
- 10.2. Make sure that you check for the correct resistance figures given in the operator's and maintenance manual supplied with the generator.

Figure 335.



- 10.3. Check the exciter stator insulation with the specified voltage insulation tester.
Resistance: 500 Ω
- 10.4. Make sure that the minimum insulation value must be of the specified value to earth (ground).
Resistance: 1,000,000 Ω
- 10.5. If the insulation value is less than the specified value, the windings must be cleaned, dried and re-coated with anti-track varnish. If necessary, replace the windings.
Resistance: 1,000,000 Ω

Figure 336.



11. Make a note of the symptoms of the excitor rotor failure as follows:

- 11.1. If separately excited with a specified voltage battery, the voltage is indicated as low.

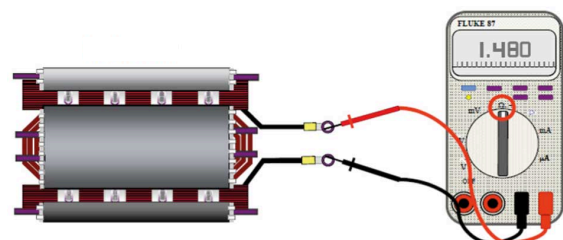
Voltage: 12V

- 11.2. If with a self excited DSR system, the generator may not be able to build up voltage on startup.
- 11.3. If with a auxiliary powered DSR, a short in the exciter rotor may cause repetitive alarming of the DSR overload protection circuit on load.
- 11.4. Make a note that the voltage gradually starts to reduce to protect the winding components.
- 11.5. Make a note that the short circuited diode can damage the exciter rotor windings on the main rectifier.

12. Test the main rotor as follows:

- 12.1. Make sure that you check the main rotor resistance with a multimeter set on the Ω range.
- 12.2. If the resistance readings are low, use a more accurate low resistance bridge meter to further test and confirm the results.
- 12.3. Make a note that the lower resistance will be proportional to the lower voltage.

Figure 337.



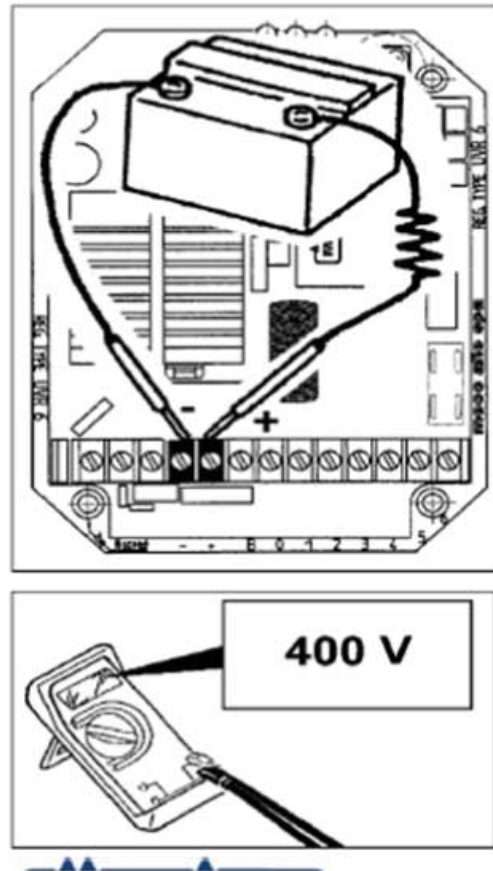
13. Make a note of the symptoms on the loss of residual magnetism as follows:

- 13.1. If separately excited with a specified voltage battery, the generator will appear to give normal voltage (balanced and within 10% of the nominal).
- 13.2. Make a note that the loss of residual magnetism affects self excited DSR control systems only.
- 13.3. Auxiliary winding powered DSR system supports voltage built up during initial start up more effectively than self excited system.
- 13.4. Residual magnetism is stored in the exciter stator core only.
- 13.5. Decay of the residual magnetism can be caused by long storage periods.
- 13.6. Residual magnetism can be destroyed by polarity reversal of the exciter stator (when separately excited with a battery).

14. Check the residual voltage as follows:

- 14.1. If the generator is switched off, remove the lid from the terminals case regulator.
- 14.2. Connect the two wires to a specified voltage battery with a specified value in series resistance.
Voltage: 12V
Resistance: 30Ω
- 14.3. Follow the electrical diagrams supplied by Mecc Alte, to locate the positive and negative terminals of the electronic regulator.
- 14.4. Start the generator.
- 14.5. Connect, only for a moment, the two wires to the previously located terminals.
- 14.6. Make sure to match the polarities (positive terminal of regulator with positive terminal of battery, negative terminal of regulator with negative terminal of battery).
- 14.7. Use a voltmeter or the right instrument panel, to check whether the generator produces the nominal voltage indicated on the plate.

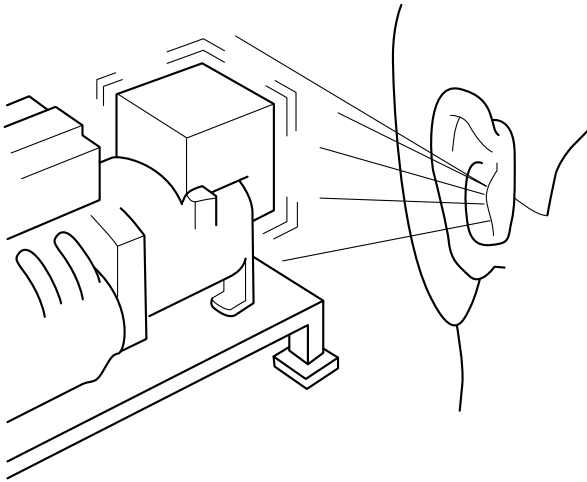
Figure 338.



15. Check the abnormal noise and vibration as follows:

- 15.1. Make sure that you regularly check the correct function of the generator.
- 15.2. Make sure that there are no anomalous noises or vibrations as their presence indicates damage of the bearings.
- 15.3. Make a note that the alternator itself has no particular vibration since the rotating parts are perfectly balanced.
- 15.4. Make a note that if the rotor balancing has not been altered and the rotor's bearings have not been damaged, vibrations in the generator set may occur due to alignment of the couplings, stress upon the combustion engine or due to the vibration mounts.
- 15.5. Make sure that you check the performance data which must comply with the data on the generator plate.

Figure 339.



Remove and Install

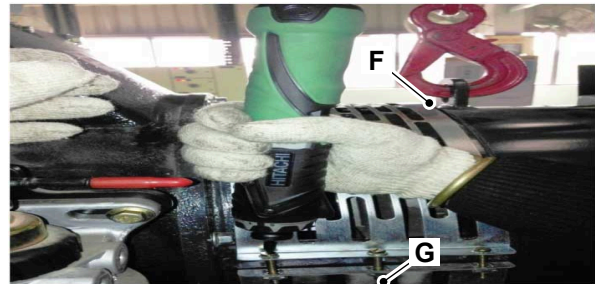
Hot Components

Touching hot surfaces can burn skin. The engine and machine components will be hot after the unit has been running. Allow the engine and components to cool before servicing the unit.

Remove

1. Make the machine safe.
[Refer to: PIL 01-03.](#)
2. Remove the canopy.
3. Make sure that the engine is safe to work on. If the engine has been running, let it cool before you start the service work.
4. Remove the voltage regulator.
[Refer to: PIL 33-08-06.](#)
5. Support the power alternator with suitable lifting equipment.
6. Remove the screw (x3) from the fan guard. Refer to Figure 340.
7. Remove the fan guard from the power alternator.

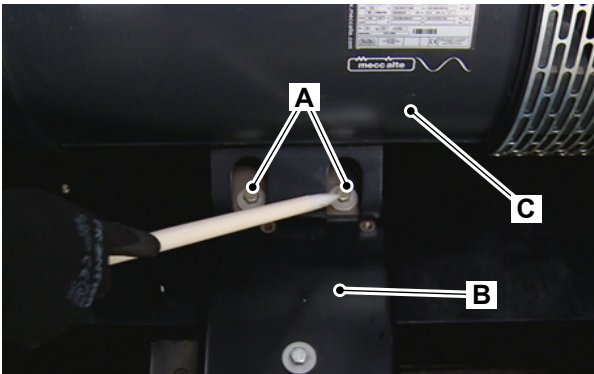
Figure 340.



- F** Fan guard
- G** Screw (x3)

8. Remove the alternator mounting bolt 1 (x4) that attaches the power alternator to the alternator mounting plate.

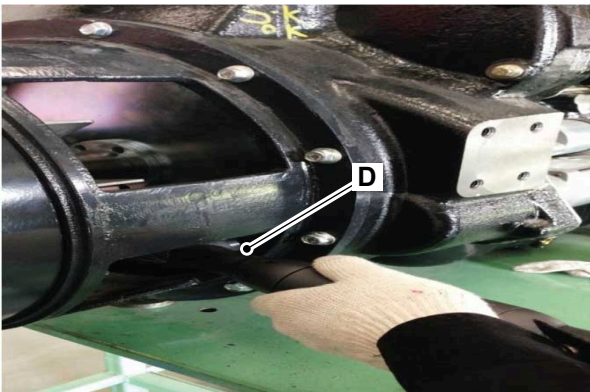
Figure 341.



- A** Alternator mounting bolt 1
- B** Alternator mounting plate
- C** Power alternator

9. Remove the bolt 2 (x8) that attaches the power alternator disc to the flywheel.

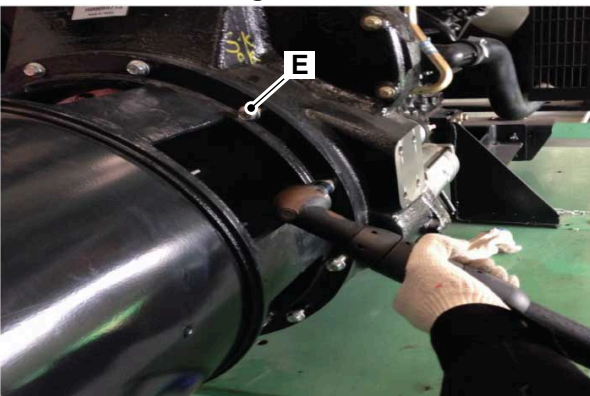
Figure 342.



- D** Bolt 2 (x8)

10. Remove the bolt 3 (x12) that attaches the power alternator to the flywheel housing.

Figure 343.



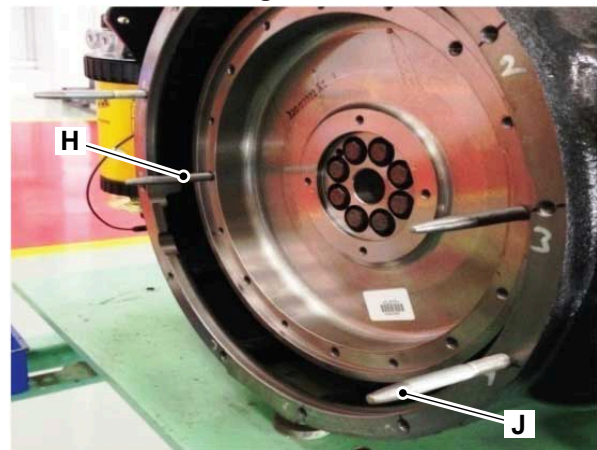
- E** Bolt 3 (x12)

11. Remove the power alternator from the machine.

Install

1. The installation procedure is the opposite of the removal procedure. Additionally do the following steps.
2. Make sure that the lifting equipment is properly engaged.
3. Position the power alternator at the correct location.
4. Align the power alternator with the flywheel housing through the housing guide pin (x2).
5. Align the power alternator disc with the flywheel through the disc guide pin (x2).

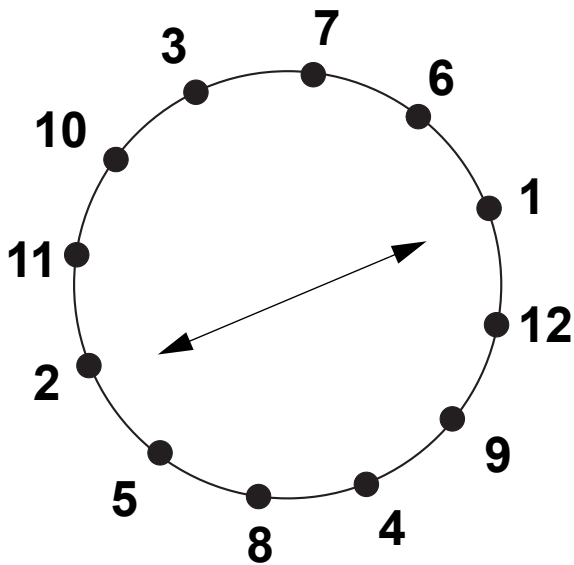
Figure 344.



- H** Disc guide pin (x2)
- J** Housing guide pin (x2)

6. Use a ratchet to diagonally engage and tighten the bolt 3 (x2) that attaches the power alternator to the flywheel housing. Refer to Figure 343.
7. Use the fan rotating tool and engage the bolt 2 (x8) that attaches the power alternator disc to the flywheel. Refer to Figure 342.
8. Remove all the guide pins.
9. Install the remaining bolt 3 (x10).
10. Tighten the bolt 3 (x12) to the correct torque value in the specified sequence. Refer to Figure 345.

Figure 345. Bolt tightening sequence (Power alternator to flywheel housing)



15. Tighten the screw (x3) to the correct torque value.

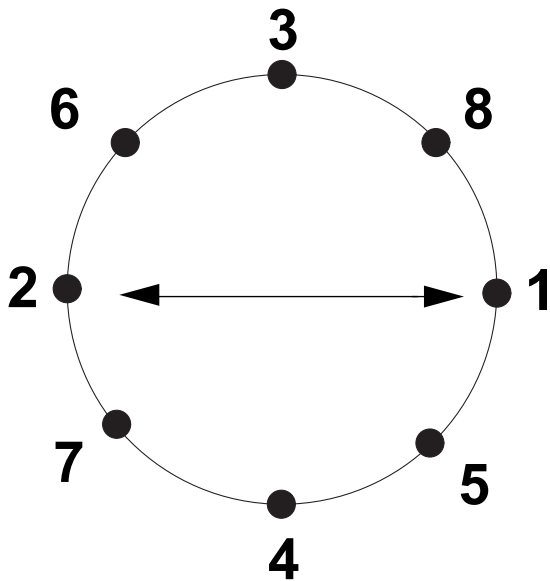
16. Check and mark the alternator mounting bolt 1 (x4).

Table 157. Torque Values

Item	Nm
A	83
D	40
E	47

11. Tighten the bolt 2 (x8) to the correct torque value in the specified sequence. Refer to Figure 346.

Figure 346. Bolt tightening sequence (Power alternator disc to the flywheel)



12. Install the alternator mounting bolt 1 (x4) that attaches the power alternator to the alternator mounting plate.

13. Tighten the alternator mounting bolt 1 (x4) to the correct torque value.

14. Install the fan guard to the power alternator and loosely engage the screw (x3).



06 - Voltage Regulator

Check (Condition) 33-58
Check (Operation) 33-59
Remove and Install 33-59

Check (Condition)

1. Make the machine safe.
[Refer to: PIL 01-03-27.](#)
2. Obey all electrical system health and safety information.
[Refer to: PIL 33-00-00.](#)
3. Visually inspect the voltage regulator for signs of contamination, dirt and dust.
4. Check condition of the electrical terminals for signs of contamination.
5. Tighten the electrical terminals as required.
6. Make sure that the mounting bolts are correctly tightened.

Check (Operation)

Residual Voltage Check

This check is to make sure that the generator is not over-excited (In such conditions the generator rotates at nominal velocity, the voltage will not be present in the generator's main terminal board).

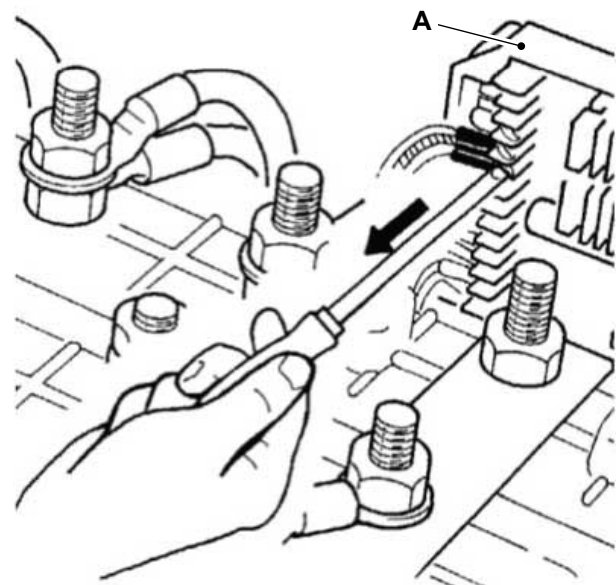
1. Make sure that the generator is switched off.
2. Remove the lid from the terminal case.
3. Connect the connecting wire (x2) to a battery of the specified DC (Direct Current) voltage with a specified in-series resistance.
Voltage: 12V
Resistance: 30Ω
4. Start the generator.
5. Connect the voltage regulator positive terminal with the positive terminal of the battery and the voltage regulator negative terminal with the negative terminal of the battery.
 - 5.1. Make sure you identify the positive and negative terminals of the voltage regulator correctly.
6. Use a voltmeter or the correct instrument panel and check if the voltage indicated on the plate is a nominal voltage.

Remove and Install

Remove

1. Make the machine safe. Refer to (PIL 01-03).
2. Obey all electrical system health and safety information.
3. Open the front right access panel.
4. Disconnect all the terminal board wires. Refer to Figure 347.

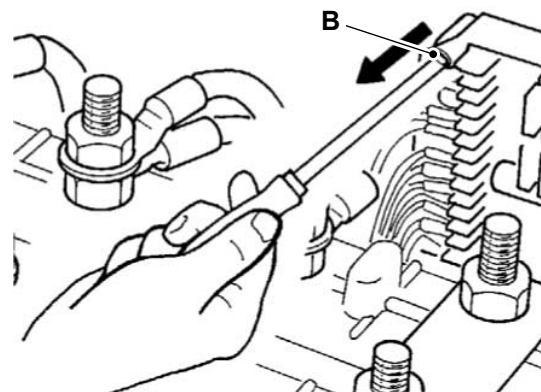
Figure 347.



A Voltage regulator

5. Put a label on the terminal board wires to help installation.
6. Remove the screws from the voltage regulator. Refer to Figure 348.
7. Remove the voltage regulator.

Figure 348.



B Screws



Install

1. The installation procedure is the opposite of the removal procedure.



15 - Diode Bridge

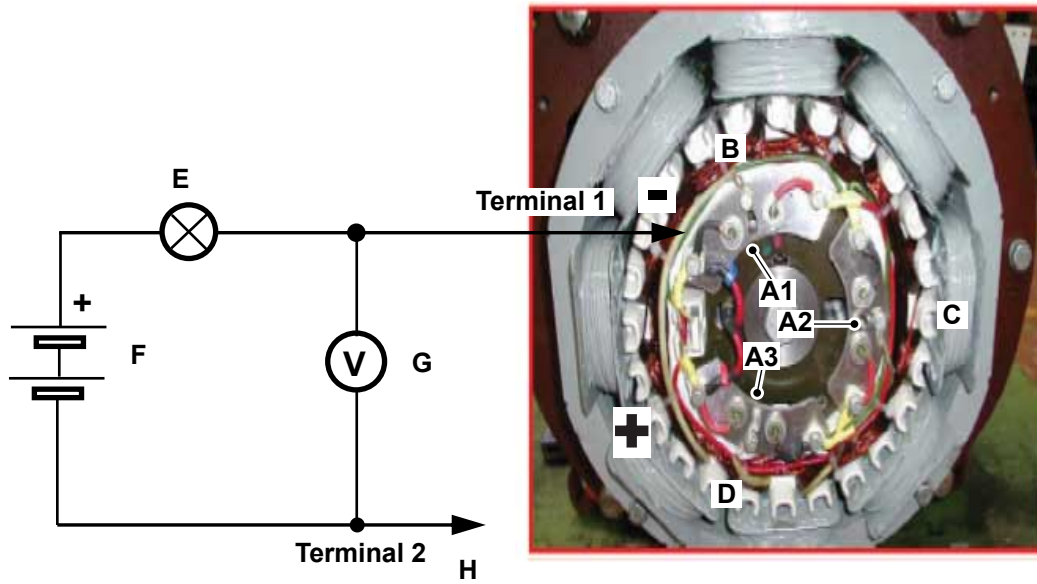
Check (Operation) 33-61
Remove and Install 33-64

Check (Operation)

Test of the diodes on the Negative Terminal

1. Disconnect the cables (x2) that connect the main rotor to the diode bridge.
2. Connect the battery, lamp and the voltmeter as shown in the figure. Refer to Figure 349.
 - 2.1. Use the specified voltage battery.
Voltage: 12V
 - 2.2. Use the lamp of specified value.
Voltage: 12V
Power: 21W
3. Connect the terminal 1 of the lamp to the negative terminal of the diode 1.
4. Connect the terminal 2 of the lamp to the point A1 of the diode 1.
5. Check the readings on the voltmeter.
6. If the voltage is within the specified value then the diode is in good condition.
Voltage: 0.8–1.2V
7. If the voltage is less than the specified value then the diode is in short circuit.
Voltage: 0.6V
8. If the voltage is more than the specified value then the diode is in open circuit.
Voltage: 1.3V
9. Do the step 3 to step 8 for the diode 2 and the diode 3.

Figure 349.



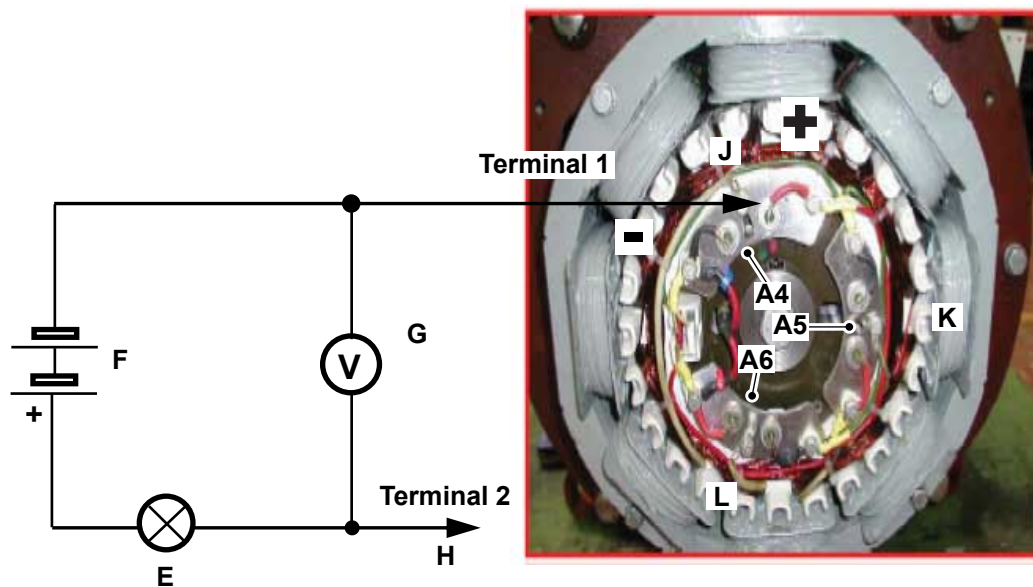
- B Diode 1
- D Diode 3
- F Battery
- H Probe

- C Diode 2
- E Lamp
- G Voltmeter

Test of the diodes on the Positive Terminal

1. Disconnect the cables (x2) that connect the main rotor to the diode bridge.
2. Connect the battery, lamp and the voltmeter as shown in the figure. Refer to Figure 350.
 - 2.1. Use the specified voltage battery.
Voltage: 12V
 - 2.2. Use a lamp of specified value.
Voltage: 12V
Power: 21W
3. Connect the terminal 1 of the battery to the positive terminal of the diode 1.
4. Connect the terminal 2 of the battery to the point A4 of the diode 1.
5. Check the readings on the voltmeter.
6. If the voltage is within the specified value then the diode is in good condition.
Voltage: 0.8–1.2V
7. If the voltage is less than the specified value then the diode is in short circuit.
Voltage: 0.6V
8. If the voltage is more than the specified value then the diode is in open circuit.
Voltage: 1.3V
9. Do the step 3 to step 8 for the diode 2 and the diode 3.

Figure 350.



E Lamp
G Voltmeter
J Diode 1
L Diode 3

F Battery
H Probe
K Diode 2

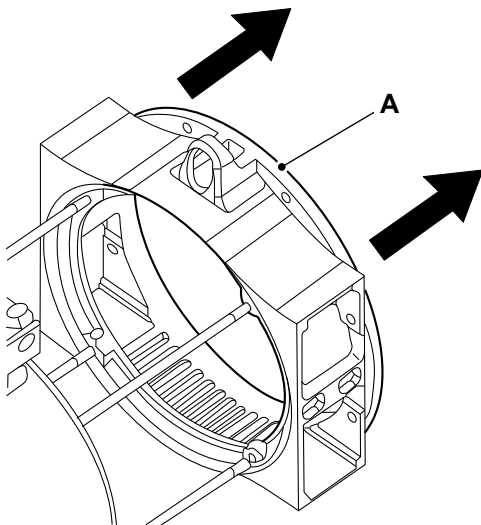
Remove and Install

It is necessary to install a new diode if the measured values indicate that the diode is damaged. While you install a new diode do not pull the rheophores out from their locations, cut the rheophores near to the body of the component. Install a new component of the correct polarity and soft solder it accurately with the remaining pieces of the rheophores.

Remove

1. Make the machine safe.
Refer to: [PIL 01-03](#).
2. Obey all the electrical health and safety information.
3. Remove the power alternator.
Refer to: [PIL 33-08-00](#).
4. Remove the drive end bracket. Refer to Figure 351.

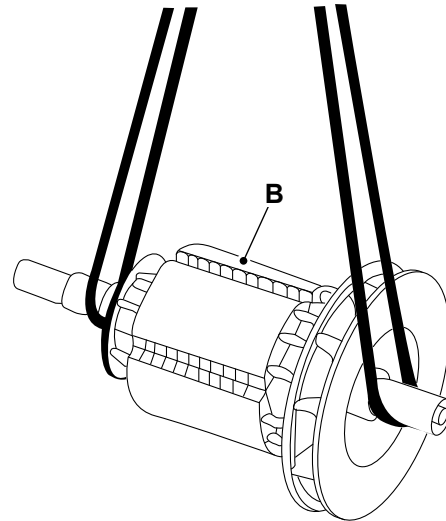
Figure 351.



A Drive end bracket

5. Support the rotor assembly with suitable lifting equipment. Refer to Figure 352.

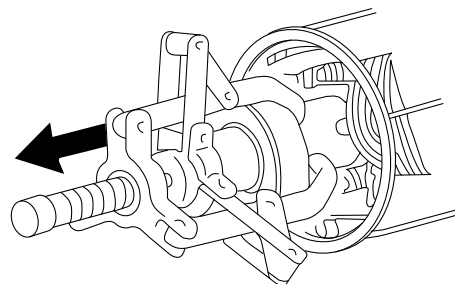
Figure 352.



B Rotor assembly

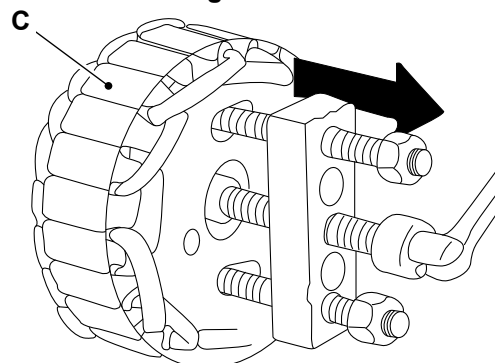
6. Use a suitable puller to remove the bearing. Refer to Figure 353.

Figure 353.



7. Use a suitable puller to remove the exciter armature. Refer to Figure 354.

Figure 354.



C Exciter armature

Install

1. The installation procedure is the opposite of the removal procedure.



09 - Power Distribution

Contents	Page No.
33-09-00 General	33-67



Notes:



00 - General

Introduction	33-67
Health and Safety	33-68

Introduction

The electrical circuits are protected by fuses. If a fuse blows, find out why and rectify the fault before installing a new one.

A full up to date list of fuses and relays and their locations can be found in the relevant operator manual, maintenance section.

Health and Safety

▲ **Notice:** Always replace fuses with ones of correct ampere rating to avoid electrical system damage.

Notice: When installing auxiliary electrical components always ensure that the additional load rating is suitable for that particular circuit. It is unacceptable to simply increase the fuse rating as this can cause overloading and consequential failure of wiring, along with failure of integral circuit components, which the fuse is protecting.



12 - Harness

Contents	Page No.
33-12-00 General	33-71



Notes:



00 - General

Introduction	33-71
Health and Safety	33-72
Component Identification	33-73
Diagram	33-75
Repair	33-75
Check (Condition)	33-76

Introduction

Harness Drawings

Drawings are reproduced from production electrical harness drawings. Each harness drawing includes tables showing wire connections and destinations for all the connectors on the harness. To identify the correct harness drawing for a particular machine refer to the relevant Harness Interconnection page for the machine serial number range.

Health and Safety

- ▲ **Notice:** When installing auxiliary electrical components always ensure that the additional load rating is suitable for that particular circuit. It is unacceptable to simply increase the fuse rating as this can cause overloading and consequential failure of wiring, along with failure of integral circuit components, which the fuse is protecting.

Harness Repair (Butane Heater)

- ▲ **WARNING** In addition to the warnings incorporated into this procedure, extreme care should be taken when handling the gas heating tool to ensure that the flame does not damage or set fire to any items in the vicinity of the repair, i.e. other wires, floor panels, floor mats, sound proofing, paintwork, etc. This tool should not be used in any restricted location prohibiting the use of "Naked Flames" or where risk of explosive gas or similar safety parameters apply. No other heat source should be used to attempt a sealed joint.

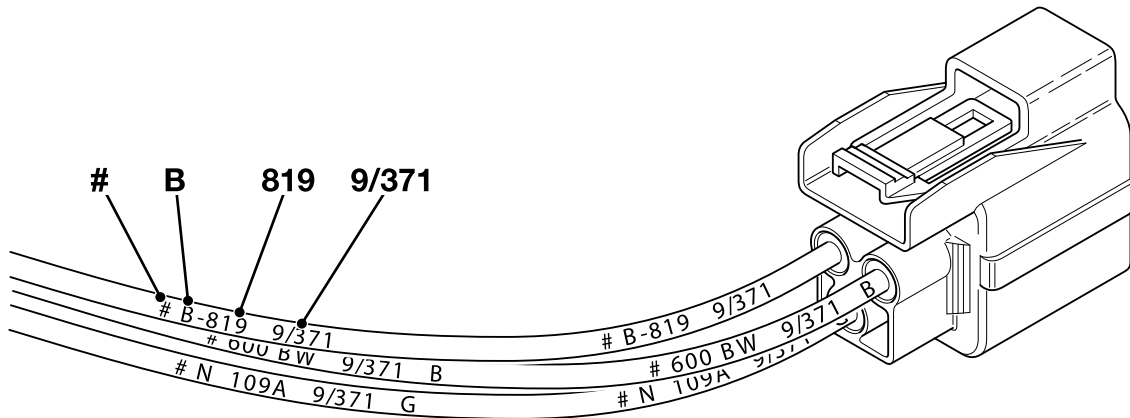
CAUTION When the heater is in use, the reflector and the air coming out are extremely hot. Keep away to avoid accidental burns. Do not touch the reflector until it has had time to cool down after switching off. If flame reappears at the reflector when the heater is in use, the catalytic element is damaged or used up. Stop work immediately and replace the heater.

Component Identification

Wire and Harness Number Identification

This section details the allocation of wire numbers and the identification of wires in the wiring harness.

Figure 355.



The illustration shows a typical connector and wires. Each wire has an individual identification number permanently marked on it, at regular intervals along its length. The number stamped on the wire identifies the following:

Table 158. Wire and Harness Number Identification

Identification Number	Description
#	The # indicates the start of the identification number. It is always printed to the left of the identification number.
B	If applicable - The colour of the flying lead that the harness wire should mate with. For instance, if wire 819 from harness 719/37100 mated with a flying lead coloured black (colour code B) then the number printed on the wire would be B-819 9/371.

Identification Number	Description
819	The wire's unique identification number. The wire functions and numbers allocated to them are consistent throughout the JCB range of products. Refer to Wire Numbers and Functions.
9/371	If applicable - The part number of the harness that the wire originates from. If the harness part number is 719/37100, the number printed on the harness wires will be 9/371 (71 and 00 are common numbers and therefore deleted).

Wire Numbers and Functions

Table 159. Wires 000-199, 1000-1999 (These numbers are reserved for ignition feeds, heater start circuits and start circuits)

Wire Number	Description
Wires 000 - 099	Unfused ignition feeds
Wires 100 - 199 and 1000 - 1999	Fused ignition feeds (feeds via ignition relays are also classed as ignition feeds). Power supplies output by a control module.

Table 160. Wires 200-399, 2000-3999 (These numbers are reserved for battery feeds)

Wire Number	Description
Wires 200-299 and 2000-2999	Unfused battery feeds. Power supplies output by a control module.
Wires 300-399 and 3000-3999	Fused battery feeds. Power supplies output by a control module.

Table 161. Wires 400-599, 4000-5999

Wire Number	Description
Wires 400-599 and 1000-5999	These numbers are reserved for instruments, sensors and variable input/output signal wires used in electronic systems. CAN wires also use numbers in this series.

Table 162. Wires 600-799, 6000-7999

Wire Number	Description
Wires 600-799 and 6000-7999	These numbers are used for earth wires. When the number is printed on to a wire it is prefixed by the Earth symbol. This symbol is printed onto the wire, it may however be omitted from harness drawings. Where a load is switched negative, the wire number from the load to the switch shall be different to that of the wire from the switch to the earth.

Figure 356.

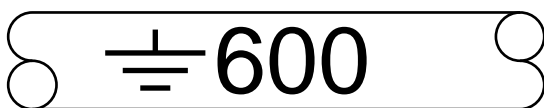


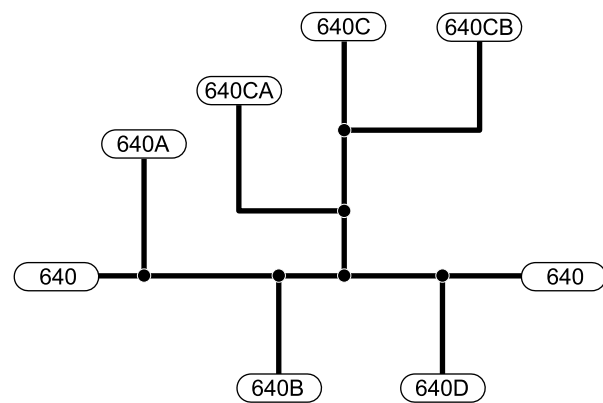
Table 163. Wires 800-999, 8000-9999

Wire Number	Description
Wires 800-999 and 8000-9999	These numbers are reserved for switched supplies to electrical loads, i.e. to lights, etc. Power supplies output by a control module.

Table 164. Wires In Splices

Wire Number	Description
Various	The main input wire is allocated with a wire number and a suitable description, i.e. Wire 640 earth splice to earth. The additional wires in the splice are allocated the same wire number and a postfix, i.e. 640A, 640B, etc.

Figure 357.



General Points

1. Wires continue to have the same number even after passing through a connector block to another harness.
2. The descriptions are applicable to JCB specification wiring harnesses. The machine may be installed with some wiring that does not conform to the JCB specifications, typically when it is part of equipment supplied by other manufacturers.

Diagram

A full set of harness drawings are available. Refer to: servicepro.jcb.com.

Repair

Special Tools

Description	Part No.	Qty.
Wiring Crimp Tool	892/00349	1

Consumables

Description	Part No.	Size
Wiring Splice (0.5-1.5mm Red, contains 50 off)	892/00351	-
Wiring Splice (1.5-2.5mm Blue, contains 50 off)	892/00352	-
Wiring Splice (3-6mm Yellow, contains 50 off)	892/00353	-

Instances occur where it is necessary to incorporate auxiliary electrical components into existing electrical circuits and although unlikely with present wiring harnesses, repair or replace specific individual wires within a harness. This will also apply to other machines in addition to those of manufacture.

To make sure that either the inclusion of an auxiliary electrical component or a repair within a harness is completed to an acceptable standard it is strongly recommended that the following tools, equipment and procedures are always used. Note that JCB harnesses have an Ingress Protection rating of 67 (I.P.67).

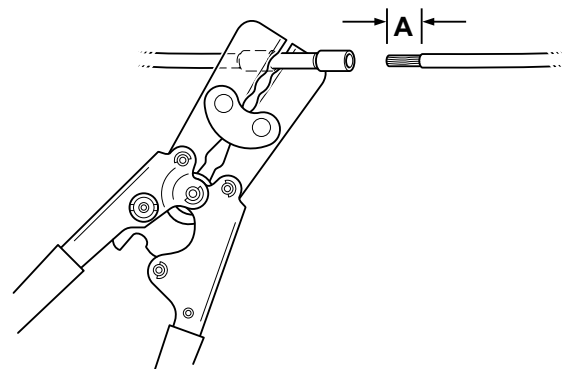
The sheath covering of the recommended splice is heat shrunk onto the original wire insulation. This results in a seal and corresponding joint to IP 67 specifications.

Procedure

1. Cut the wire and remove the protective insulation for a suitable distance dependent upon the size of wire and splice to be used.

Special Tool: Wiring Crimp Tool (Qty.: 1)

Figure 358.



A Distance for splice (check size)

- Using the correct sized splice, attach the new section of wire required or auxiliary flying lead to the existing harness and secure using the crimp tool. Note that each of the splices detailed is colour-coded to make size and range readily visible. They are secured using the corresponding size and matching colour-coded jaws of the crimp tool to ensure joint security. This tool also incorporates a ratchet closing mechanism which will not release until the splice is fully closed to the correct compression size.

Consumable: Wiring Splice (0.5-1.5mm Red, contains 50 off)

Consumable: Wiring Splice (1.5-2.5mm Blue, contains 50 off)

Consumable: Wiring Splice (3-6mm Yellow, contains 50 off)

- Seal the connection with insulation tape.

Check (Condition)

This section describes how to use electrical measuring devices that are used in electrical fault finding.

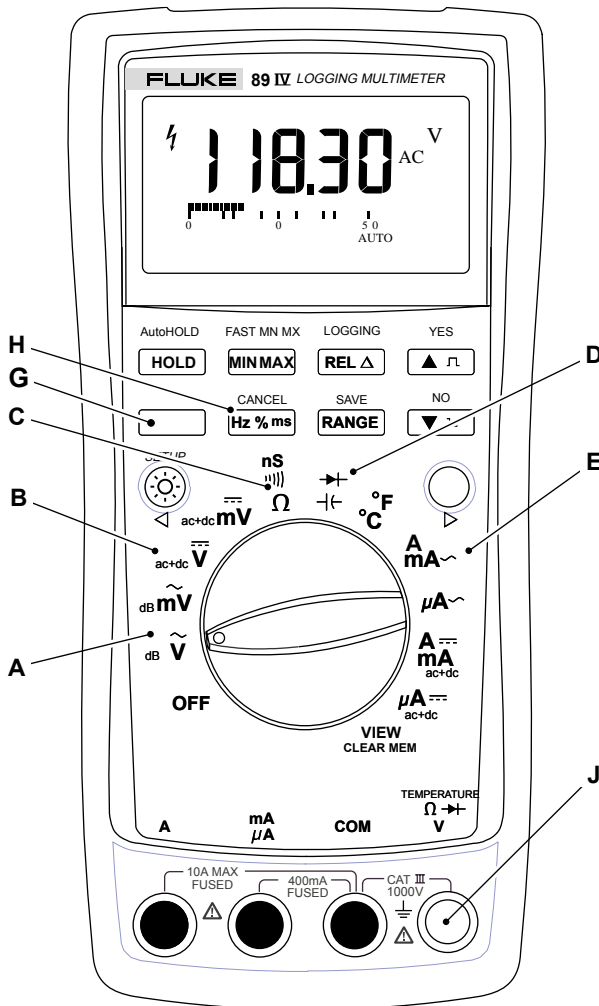
Use of Multimeters

In order to obtain the maximum benefit from the fault finding information contained in the Electrical Section, it is important that the technician fully understands the approach to fault finding and the use of the recommended test equipment, in this case a digital multimeter, or a moving pointer analogue multimeter. The approach is based on a fault finding check list. In tracing the fault from the symptoms displayed you will be directed to make measurements using a multimeter. These instructions are intended to cover the use of the recommended meters.

- Make sure that the test leads are plugged into the correct sockets. The black test lead should be plugged into the black socket (sometimes, this socket is also marked by a -, or E or marked as COMMON or COM). The red test lead should be plugged into the red socket marked with +, V or Ω .
- When you make a measurement, make sure that the test probes have a good clean contact with bare metal, free from grease, dirt, and corrosion as these can cause a false reading.
- When you measure a voltage, make sure that the correct range is selected, that it is set to the selector value equal to or greater than that you are about to measure. e.g. If asked to measure 12 Volts, set the selector to the 12V range. If there is no 12V range, set the selector to the next range higher, 20V for instance. If the meter is set to a range that is too low, it may be damaged. e.g. setting to the 2V range to measure 12V.

Measuring DC Voltage

- Select the correct range on the multimeter.
 - On the digital multimeter, turn the switch to position B.

Figure 359. Typical Digital Multimeter


2. Connect the black probe to the nearest available suitable earth point, usually this will be the starter motor earth, the battery negative, or the chassis. Connect the red probe to the wire or contact from which you are measuring the voltage.

Measuring Resistance

1. Make sure that there is no power to the part of the circuit you are about to measure.
2. Connect one probe at one end of the component or wire to be checked and the other probe at the other end. It does not matter which way round the two probes are placed.
3. Select the correct range on the multimeter.
 - 3.1. Turn the switch to position C and check that the W sign at the right hand side of the display window is on. If the F sign is on instead, press the blue button G to change the reading to Ω . Touch the meter lead probes together and press the REL3 key on

the meter to eliminate the lead resistance from the meter reading.

Measuring Continuity

1. Make sure that there is no power to the part of the circuit you are checking for continuity.
2. Connect one probe to one end of the component or wire to be checked and the other probe to the other end. It does not matter which way round the two probes are placed.
3. Select the correct range on the multimeter.
 - 3.1. On the digital multimeter, turn the switch to position C and check that the beeper symbol appears at the left hand side of the display window. If the F sign is on instead, press the button labelled F. If there is continuity in the circuit, the beeper will sound. If there is no continuity (open circuit), the beeper will not sound.

Measuring Frequency

1. Insert the black plug into the COM socket on the meter and attach the probe to the nearest suitable earth point on the chassis, for example, the battery negative terminal.
2. Insert the red probe into socket J.
3. Turn the selector switch to position A and depress G repeatedly until F is highlighted on the top row of the display.
4. Press button H once.
5. Touch or connect the red probe to the frequency source to be measured. Press and hold the button if an average reading is required.

Testing a Diode or a Diode Wire

A diode wire is a diode with male connector installed on one end and a female connector installed on the other end. The diode is sealed in heatshrink sleeving. To test a Diode or a Diode Wire.

1. On the digital multimeter:
 - 1.1. Turn the switch to position D.
 - 1.2. Press the HOLD button and check that the H sign appears at the top right hand side of the display window.
 - 1.3. Connect the black probe to the end of the diode with a band or to the male connector of the diode wire. Connect the red probe to the other end of the diode or diode wire. If the beeper does not sound the diode or diode wire is faulty.

- 1.4. Connect the red probe to the end of the diode marked with a band, or to the male connector of the diode wire, the black probe should be connected to the other end of the diode or diode wire. If the beeper sounds or the meter does not read O.L., the diode or diode wire is faulty.
- 1.5. Press the HOLD button and check that the H sign disappears from the right hand side of the display window.



57 - Electronic Diagnostic

Contents	Page No.
33-57-03 Servicemaster	33-81
33-57-12 LiveLink	33-95
33-57-90 Error Codes	33-104



Notes:

03 - Servicemaster

Introduction	33-81
Operation	33-87
Preparation	33-88
Disconnect and Connect	33-94

Introduction

JCB Servicemaster is an application to allow engineers to diagnose and set-up the various electronic control units ECU (Electronic Control Unit)'s within the JCB product range. The tools comprise of a front end generic user interface that allows the user to select the machine which they wish to work on as well as a number of various tools which allow:

- Programming ECU's.
- Diagnosing electronic issues.
- Set-up of various options.
- Checking the service history of the machine.

JCB Servicemaster is updated on a monthly basis by incorporating Web Update. This is a program which works alongside Servicemaster to let the user know and allow them to download an update as and when it becomes available.

JCB Servicemaster software is for use with Microsoft Windows and a laptop personal computer. The laptop computer is connected to the machine diagnostic socket using special cables and an adaptor.

Use Servicemaster software to:

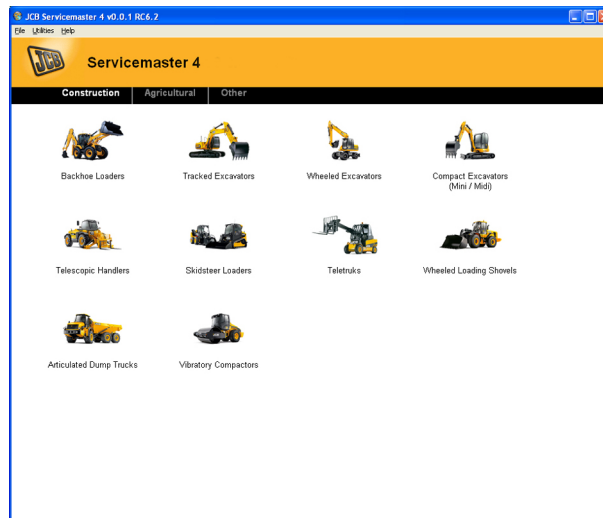
- Display data from a machine ECU.
- Change data stored in a ECU.

Servicemaster software communicates with the machine ECM (Engine Control Module) using the CAN (Controller Area Network)bus, refer to Control Modules (PIL 33-45).

Servicemaster Front Screen

The start-up page of Servicemaster is known as the front screen. This interface allows the user to easily and quickly navigate to the machine they are working on to ensure that they have the applicable tools for that machine.

Figure 360. Typical Front Screen



Once the user has clicked on the applicable machine type they will be able to select the tool they require from a list of the tools available for that machine range. Below are screen-shots showing the different machine tool sets.

Servicemaster Tools

Servicemaster tool sets are different for each machine range. When you have navigated to the correct machine type via the front end, you will be greeted with the relevant tools for that particular machine. These tools are accessed by a single click on the icon of the tool you require. There are 6 main tools within Servicemaster, these are:

Figure 361. Machine/Engine/LiveLink Set-up tool



View and change engine, machine or LiveLink specification data stored in the ECU. Settings include:

- Parameter settings.
- Option/Attachment control.
- Alternative Language Support.
- Model/Serial Number Identification.

Figure 362. LiveLink Diagnostics tool



View engine and machine operating parameters in real time. Perform system tests. View, save or clear ECU fault code log.

Figure 363. Flashloader tool



View ECU software file version. Upload and Reprogramme software updates to the ECU memory. Upload revisions to software.

Figure 364. Help



Comprehensive information about ECU connected devices.

Additional Service Tool

As well as the tools stated above there are also third party tools for some of the machine ranges which will

need to be installed. These tools are denoted by the following symbol:

Figure 365.



To install these applications you need to take the following steps:

1. On the front end, click the Other tab.
2. Click on General.
3. Click onto Extra applications.
4. Choose the relevant tool, which you require to be installed and run the installer.

Once the installer has been run, the icon should have changed within the machine tool page. e.g. the above icon has now become:

Figure 366.



Diagnostics Tool - User Guide

Introduction

The diagnostics software tool is part of the JCB Servicemaster software suite. The diagnostics software is designed to be an easy to use fault finding tool.

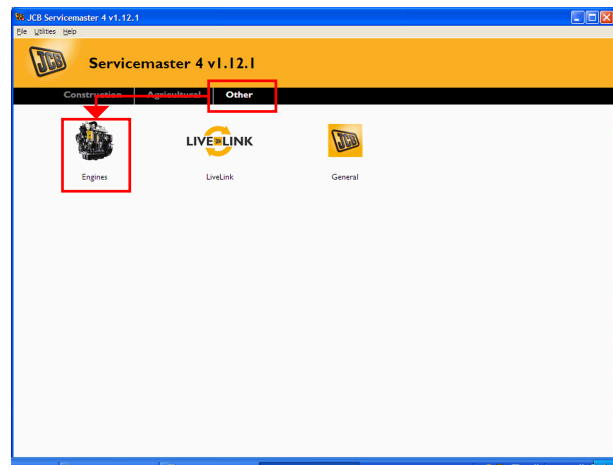
Connecting the Diagnostics

To use Diagnostics your laptop computer must be connected to the machine CAN bus.

Starting the Diagnostics

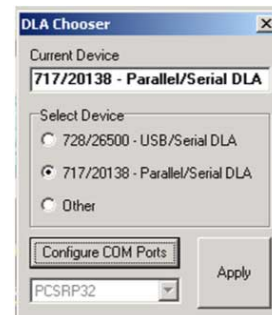
1. Turn ON the machine ignition and additionally start the engine if required (taking normal precautions).
2. Start JCB Servicemaster on the laptop computer.

Figure 367.



3. Make sure that the correct DLA (Data Link Adaptor) is selected in the chooser. Click on Utilities, DLA Set-up. The DLA Chooser window opens. Check the button to match to the Current Device. Click Apply.

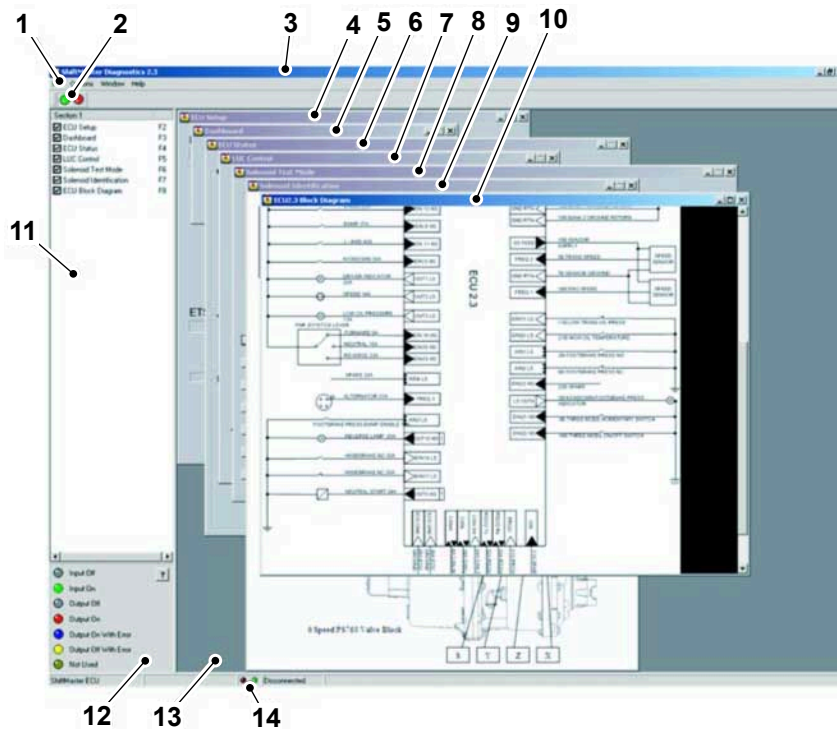
Figure 368.



Diagnostics Overview

There are several key elements to the diagnostics tool. These can be seen labelled below. Each element is explained in detail in later sections.

Figure 369.



- | | | | |
|----|-------------------------------|----|---------------------------------------|
| 1 | Menu bar | 2 | Start and stop buttons |
| 3 | Main window | 4 | ECU set-up page |
| 5 | Dashboard page | 6 | ECU status page |
| 7 | Lock-up torque converter page | 8 | Solenoid Test Mode Page |
| 9 | Solenoid Identification Page | 10 | ECU block diagram page |
| 11 | Page list | 12 | LED (Light Emitting Diode) status key |
| 13 | Page display area | 14 | Status bar |

The page list differs depending on the type of ECU connected.

The diagnostics software always displays the lock up torque converter page even if it is not applicable.

Flashloader Tool-User Guide

The Flashloader software tool is part of the JCB Servicemaster software suite. If the ECU is replaced and the data file in its flash memory is not applicable it will be necessary to flash the ECU memory with the correct data file. The Flashloader software tool can be used to access the data file name currently loaded in the ECU memory and is necessary upload a new data file to the ECU.

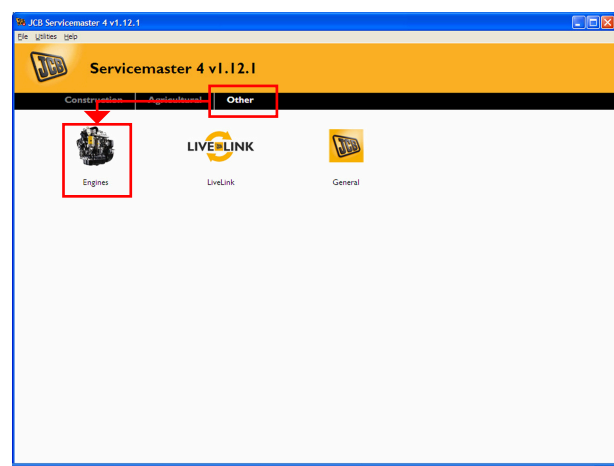
Connecting Flash Loader

To use Flashloader your laptop computer must be connected to the machine CANbus.

Starting Flashloader

1. Turn ON the machine ignition but DO NOT start the engine.
2. Start JCB Servicemaster on the laptop computer.

Figure 370.



3. Make sure that the correct DLA is selected in the chooser. Click on Utilities, DLA Set-up. The DLA Chooser window opens. Check the button to match to the Current Device. Click Apply.
4. Select the required machine range.

Figure 371.



5. The Flashloader tool will then open.

Figure 372.

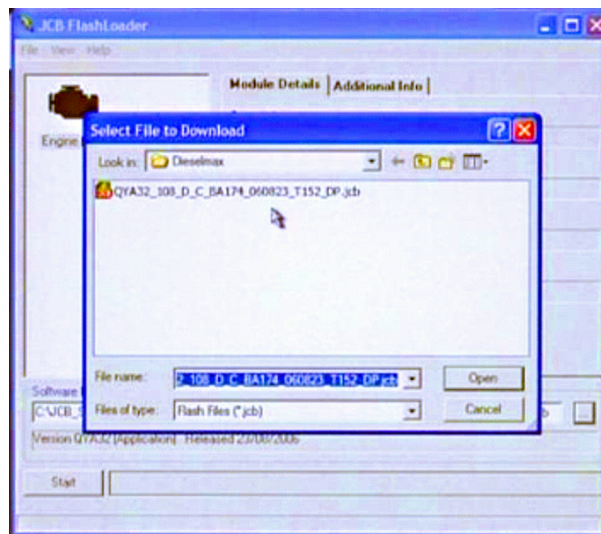


Using Flashloader

Important: Do not turn off the ignition or isolate the system by accidentally engaging the operators seat isolation switch when using the flashloader. This will interrupt the flash signal to the ECU and will irreparably damage the ECU.

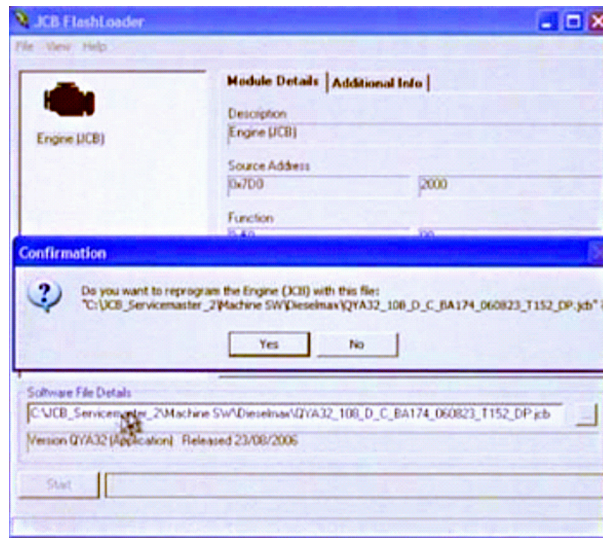
1. Make sure that the machine ignition switch is set to ON but do not start the engine.
2. Click on the ECU icon.
3. Click on the Browse button and select the correct data file. Click Open.

Figure 373.



4. Click on the Start button. A confirmation window will appear. Click on the Yes to start the reprogramming of the ECU. The progress bar is displayed.
5. When the programming is complete, switch the machine ignition to the OFF position.

Figure 374.



6. Before starting the machine, make sure that the machine set-up data is correct. You must check that all other relevant machine settings are correctly configured. Use the set-up software tool.

Changing the Language Set

1. To change the language, set proceed as follows:
2. Click on the language drop down list. Select the applicable language. Refer to Figure 375.
 - 2.1. Most language sets have three language default choices. The operator can select any language from the default choices.
3. Click on the Write button to change the language set stored in the instrument cluster.

Figure 375.



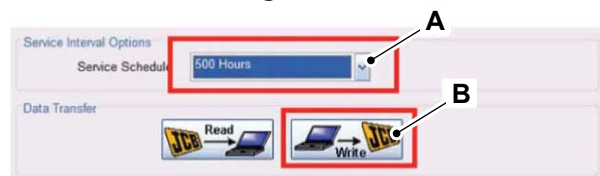
- A** Language drop down list
- B** Write button

Changing the Service Interval

1. To change the service interval proceed as follows:

2. Click on the service interval drop down list. Select the applicable service interval. Refer to Figure 376.
3. Click on the Write button to change the service interval stored in the instrument cluster.

Figure 376.



- A** Service interval drop down list
- B** Write button

Operation

Start Servicemaster

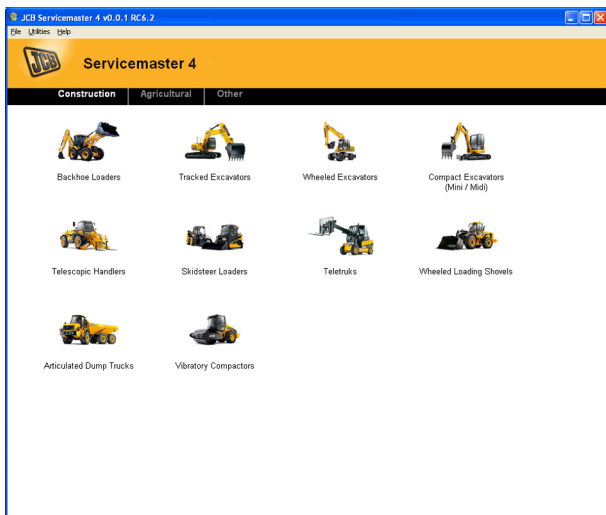
1. Set up Servicemaster, refer to Servicemaster - Refer to (PIL 57-03).
2. Double click on the Servicemaster icon. (The icon is found on the desktop or in the Start menu, Programs, JCB).

Figure 377.



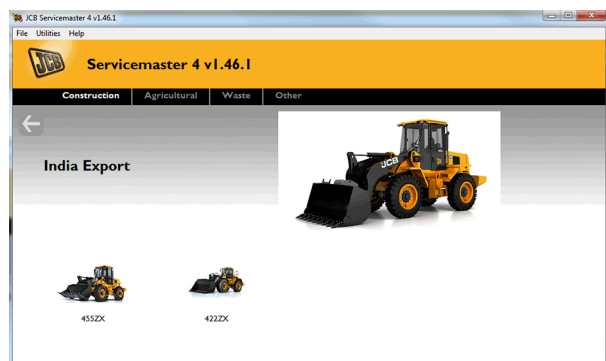
3. The Servicemaster window will open.

Figure 378.



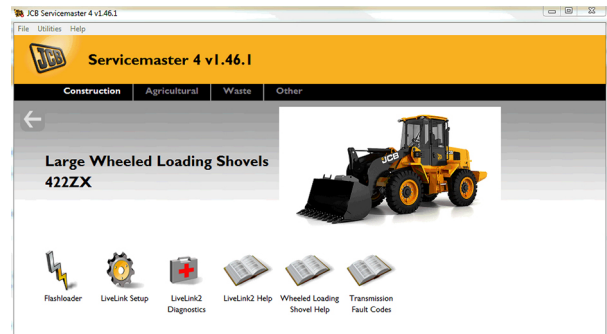
4. Double click the desired machine group.

Figure 379.



5. Select the applicable product.

Figure 380.



6. Access the relevant servicemaster tool to perform the operation. For full details of the Servicemaster tools, refer to Introduction, (PIL 33-57-03).

Preparation

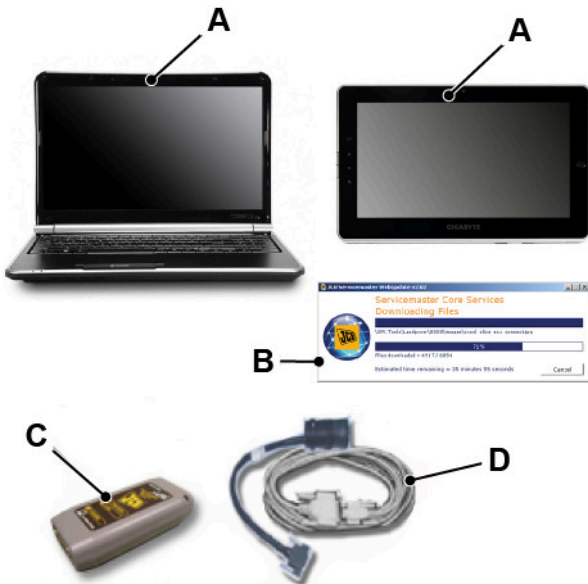
Set-up Servicemaster

The procedures below describe how to set up Servicemaster for USB (Universal Serial Bus) compatible equipment. There are other procedures and options. These are described in detail in the Servicemaster help files.

Before you start Servicemaster set up procedure make sure that you have the following:

- 1 A Microsoft Windows compatible laptop/PC with a USB port. Refer to Figure 381.
 - a Make a note that Servicemaster is compatible with Windows 98, 2000, ME, XP, Vista, and 7 operating systems (32 bit and 64bit).
- 2 The latest Servicemaster software (internet connection for web updates). Refer to Figure 381.
- 3 A JCB compatible DLA (Data Link Adaptor). Refer to Figure 381.
- 4 The correct connection cables. Refer to Figure 381.
 - a Do not connect any cables to the laptop, DLA or machine at this time.

Figure 381.



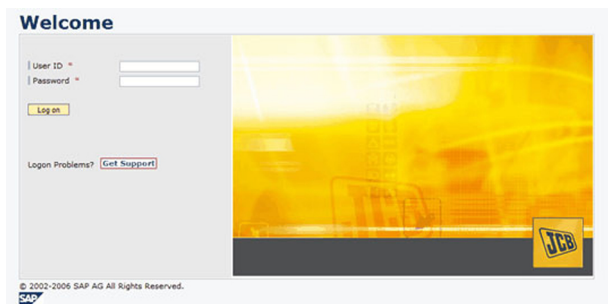
- A Laptop computer
- B Servicemaster software
- C DLA
- D Connection cables

JCB Servicemaster Web Update - New Installation

Once you install JCB Servicemaster on your laptop/PC you will need to keep it updated. JCB Servicemaster is updated through the "JCB Web Update" program. Do the below steps to download and install the JCB web update.

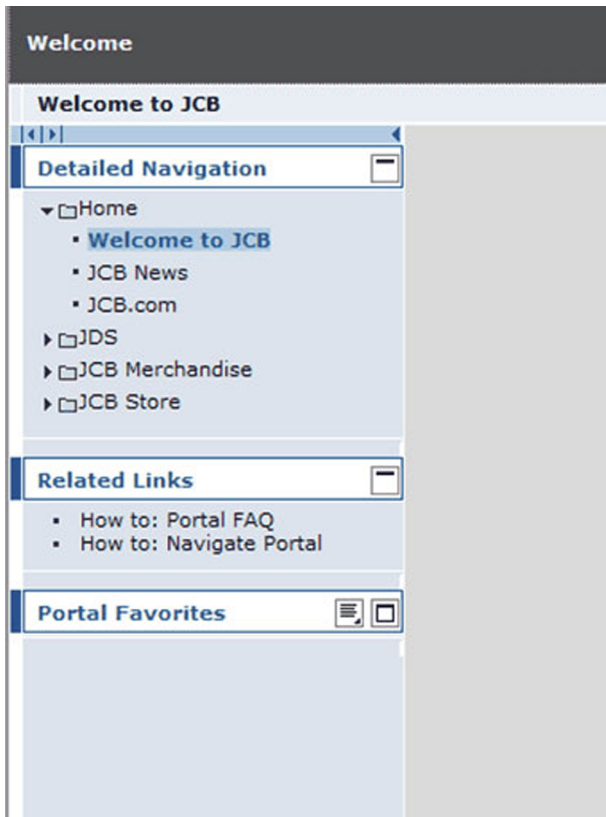
1. Use the web address www.business.jcb.com to install JCB web update.
2. A web page will open on the screen. Refer to Figure 382.

Figure 382.



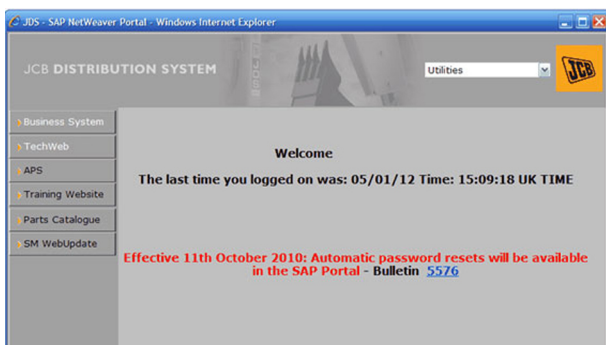
3. If you do not already have a User ID and Password, click the "Get Support" option.
 - 3.1. Apply for an account to get access to JDS (JCB Distribution System) and SPP (Service Parts Pro).
4. Once you are logged in, you will find a link "JDS" on the LH (Left Hand) tool bar. Refer to Figure 383.
 - 4.1. Click the "JDS" link.

Figure 383.



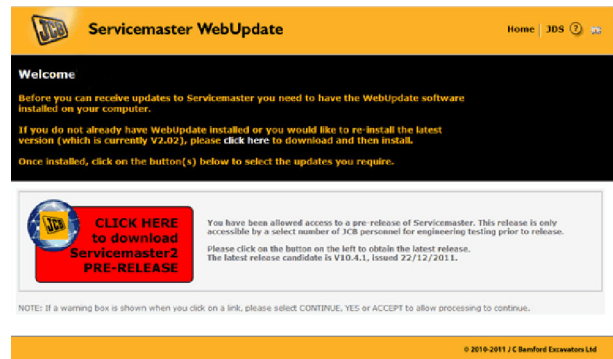
5. A new screen "JCB DISTRIBUTION SYSTEM" will open. Refer to Figure 384.

Figure 384.



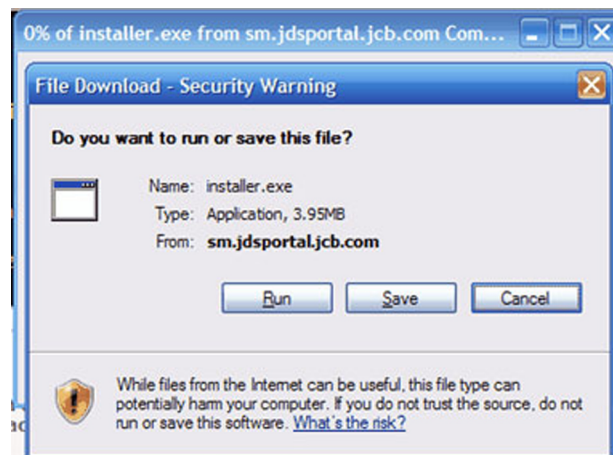
- 5.1. Click the "SM Web Update" link option of the LH tool bar.
6. A new "Servicemaster Web Update" screen will open. Refer to Figure 385.

Figure 385.



- 6.1. Click the "click here" link which is the orange colour text sentence to download JCB web update.
7. A new "File Download - Security Warning" window will appear on the screen. Refer to Figure 386.

Figure 386.



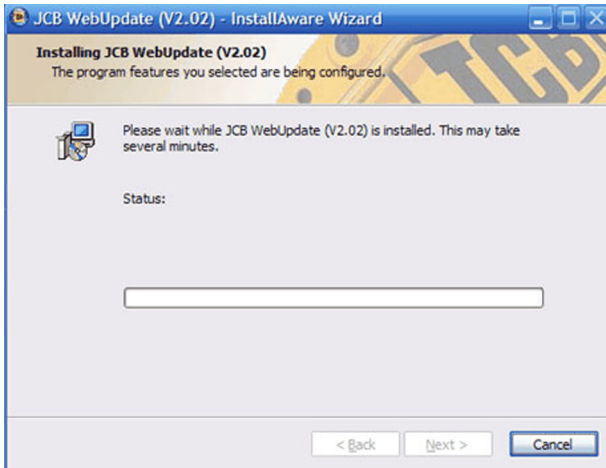
- 7.1. Click the "Run" option to start download.
8. Due to the computer system firewall, you may get a warning window "Internet Explorer - Security Warning". Refer to Figure 387.
- 8.1. Click the "Run" option to proceed.

Figure 387.



9. A new "JCB Web Update (V2.02) Installation Wizard" window will open. Refer to Figure 388.
 - 9.1. Once the download is finished, it will automatically run.

Figure 388.



10. The "JCB Web Update" program shortcut will be created on the computer desktop. Refer to Figure 389.

Figure 389.



11. Refer to the below section "JCB Web Update Downloads - Authorisation" to authorise your downloads.

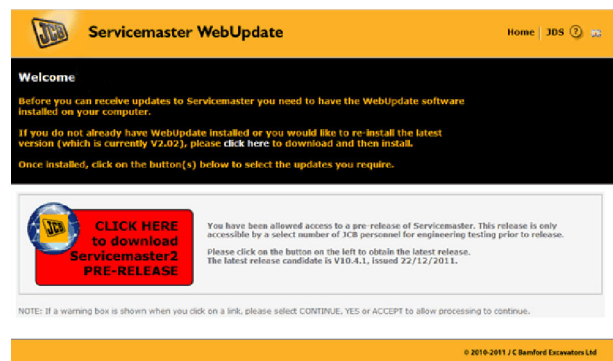
JCB Web Update Downloads - Authorisation

The below authorisation procedure is needed to access the downloads through the "JCB Web Update" on a laptop/PC.

1. It is necessary to authorise the download after the installation, to make sure that you get future updates.

2. After the installation you will need to authorise the download to ensure that you get future updates.
3. Get access to the "Servicemaster Web Update" screen. Refer to Figure 390.
4. The "Servicemaster Web Update" screen will have one of the red or orange dialogue box. Refer to Figure 390.
 - 4.1. The dialogue box depends on the download privileges attached to your name (red for pre-release and orange for full release only).

Figure 390.



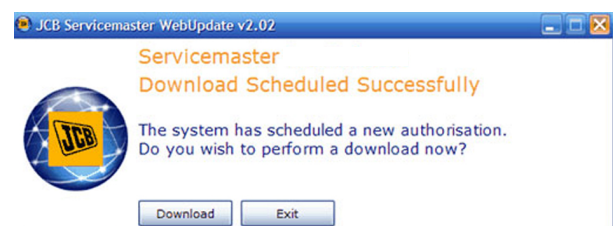
5. Click the dialogue box to start the authorisation process. Refer to Figure 391.
 - 5.1. A new window "Servicemaster Pre-Release Initiating New Authorisation" will open.

Figure 391.



6. After the system download authorisation process, "Download" option will reflect on the window. Refer to Figure 392.
 - 6.1. Click the "Download" option to download the JCB web update.

Figure 392.



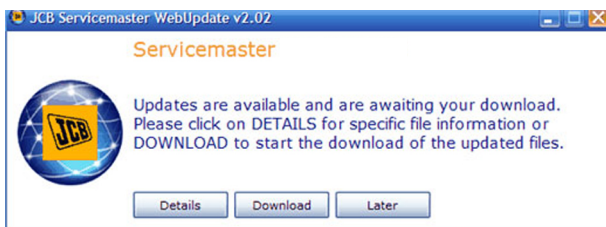
7. The authorisation process of "JCB Web Update" is now complete.

Servicemaster Updates - "JCB Web Update" Program

The updates for Servicemaster is downloaded through the "JCB Web Update" program on a laptop/PC. Refer to the below steps.

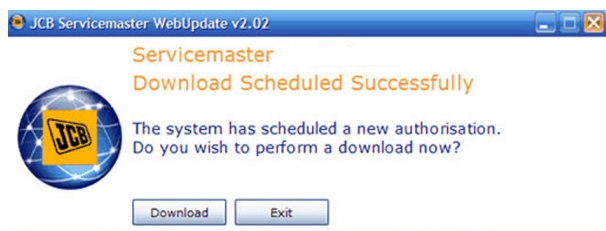
1. Run the "JCB WebUpdate" program either by using desktop shortcut or "Help" menu within Servicemaster, to do a Servicemaster update.
2. The "JCB WebUpdate" program will check for updates and inform you if there is any to download. Refer to Figure 393.

Figure 393.



- 2.1. You may click the "Details" option to check which files have been changed, added or removed.
- 2.2. Click the "Download" option to download the updates.
3. Once the updates downloaded, the "JCB Web Update" will give option to install them. Refer to Figure 394.
- 3.1. You may select options to install the updates immediately or at a later date.

Figure 394.

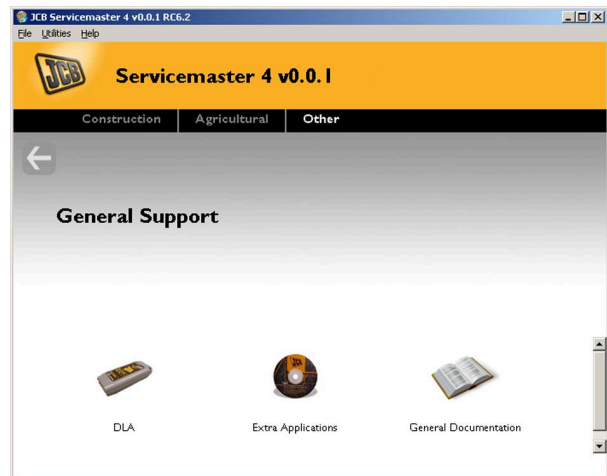


DLA Driver Software - Installation

When you use Servicemaster first time on your laptop/PC (which is newly installed with Servicemaster software), the DLA driver software is necessary to install first. Do the below steps to install the DLA driver software.

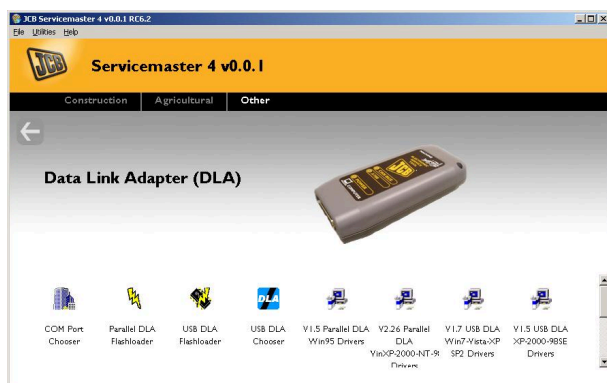
1. Once you complete the DLA driver software installation procedure, it will not require to do again on your laptop/PC.
2. Do not connect the DLA or cables to the machine or laptop/PC before to install the DLA driver software.
3. Open Servicemaster on your laptop computer.
4. Click the "Other" tab to get access to the "General Support" icon.
5. Click the "General Support" icon to get access to the "DLA" icon.
6. Click the "DLA" icon. Refer to Figure 395.

Figure 395.



7. Select and open the USB driver icon. Refer to Figure 396.
- 7.1. Make a note that the other drivers icon are also available for the computers with serial ports (no USB) and other versions of Microsoft Windows.
- 7.2. If your laptop does not have a USB port, select and open the correct driver icon.

Figure 396.



8. A new window "Driver Installer" will open. Refer to Figure 397.
 - 8.1. Obey the window instructions to the complete the DLA driver software installation.

Figure 397.



V1.7 USB DLA
 Win 7-Vista-XP
 SP2 Drivers

DLA Type and Communications Port - Configuration

When you use Servicemaster first time on your laptop/PC (which is newly installed with Servicemaster software) make sure that the correct DLA and laptop/PC port is selected to communicate with the DLA. Do the below steps to configuration the DLA with the laptop/PC.

1. Once you complete the DLA configuration, it will not require to do again on your laptop/PC.
2. Open Servicemaster on your laptop computer.
3. Click the "Other" tab to get access to the "General Support" icon.
4. Click the "General Support" icon to get access to the "DLA" icon.
5. Click the "DLA" icon.
6. Select and open the "COM Port Chooser" icon. Refer to Figure 398.

Figure 398.

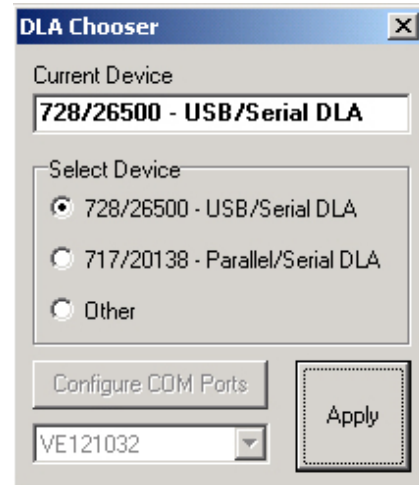


COM Port
 Chooser

7. A new "DLA Chooser" window will open. Refer to Figure 399.
 - 7.1. Select the USB /Serial DLA" device and click the "Apply" option to confirm.

- 7.2. Make a note that the older DLA and laptop computers may not be compatible with the USB ports. Select the "Parallel/Serial DLA" device in the DLA chooser.

Figure 399.



DLA Firmware File - Check

The DLA has software embedded in its own flash memory. This file must be replaced with a new one when new firmware is released. You will only have to Check the DLA firmware file version if you receive a new Servicemaster version or use a different DLA.

1. Make sure that the DLA is connected to the laptop computer.
2. Open Servicemaster on your laptop computer.
3. Click the "Other" tab to get access to the "General Support" icon.
4. Click the "General Support" icon to get access to the "DLA" icon.
5. Click the "DLA" icon.
6. Select and open the "USB DLA Flashloader" icon. Refer to Figure 400.
 - 6.1. Make a note that the older DLA and laptop computers may not be compatible with the USB ports. Select and open the "Flashloader for Serial/Parallel DLA" icon.

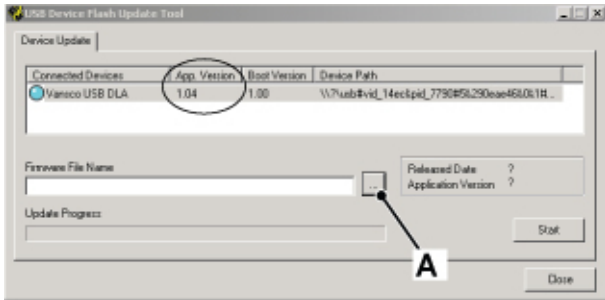
Figure 400.



USB DLA
 Flashloader

7. A window "USB Device Flash Update Tool" will open. Refer to Figure 401.
 - 7.1. The firmware details in the DLA are displayed with the application version (for example - 1.04). Refer to Figure 401.

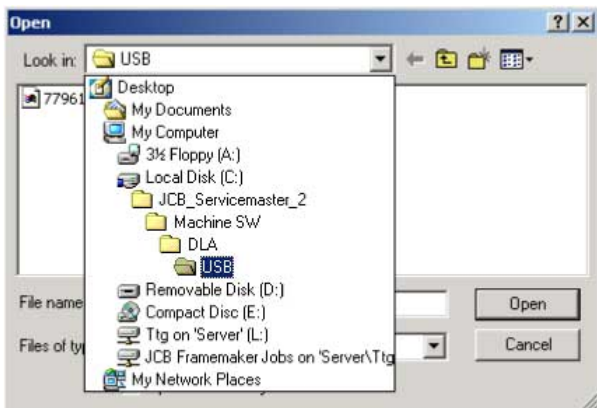
Figure 401.



A Browse option

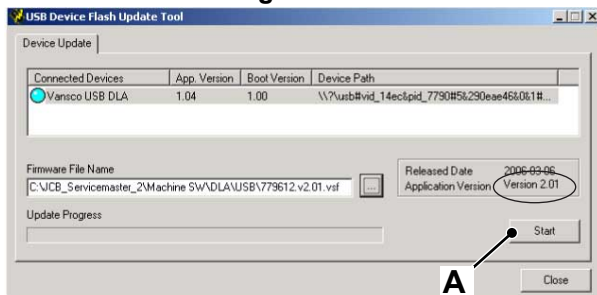
8. Check for a new firmware file.
 - 8.1. Click the "Browse" option and find the file stored within the JCB Servicemaster directory on your laptop hard drive. Refer to Figure 402.
 - 8.2. Select the file and click the "Open" option.

Figure 402.



- 8.3. The selected file appears in the firmware file name field together with its release date and application version (for example - 2.01). Refer to Figure 403.

Figure 403.



A Start option

9. Load a new firmware file.
 - 9.1. If the firmware in the DLA is not up to date, load the new file.
10. Click the "Start" option and obey the on-screen instructions.

Disconnect and Connect

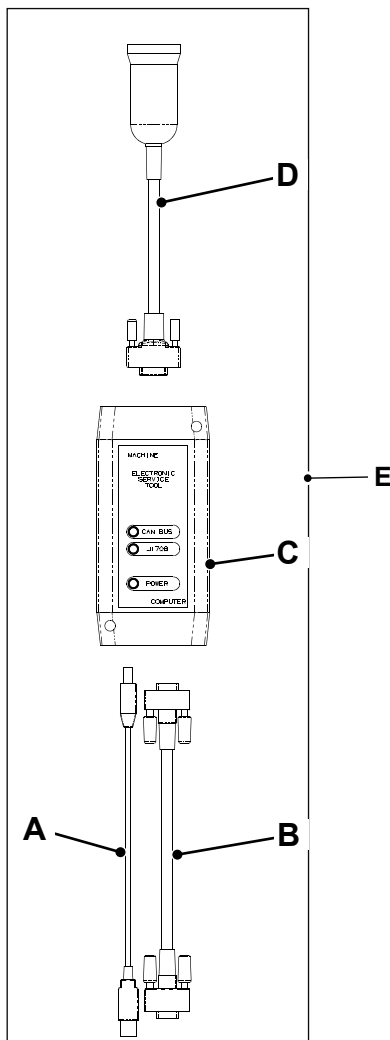
Special Tools

Description	Part No.	Qty.
Data Link Adaptor (DLA) Kit	892/01174	1*
Data Link Adaptor (DLA 2.0) Kit	728/H5409	

*Unless otherwise stated, you can use any of the tools shown.

To use Servicemaster, connect your laptop computer to the machine CAN (Controller Area Network) bus. Connection is made using the DLA (Data Link Adaptor) and the applicable cables.

Figure 404.



- A** USB PC Cable - 718/20235
- B** Serial PC Cable - 718/20236
- C** USB DLA - 728/26500
- D** Machine Cable - 718/20237
- E** Kit - 892/01174 (contains items A, B, C and D)

Note: Connect the USB cable directly to the laptop computer. Do not connect the cable via a USB hub.

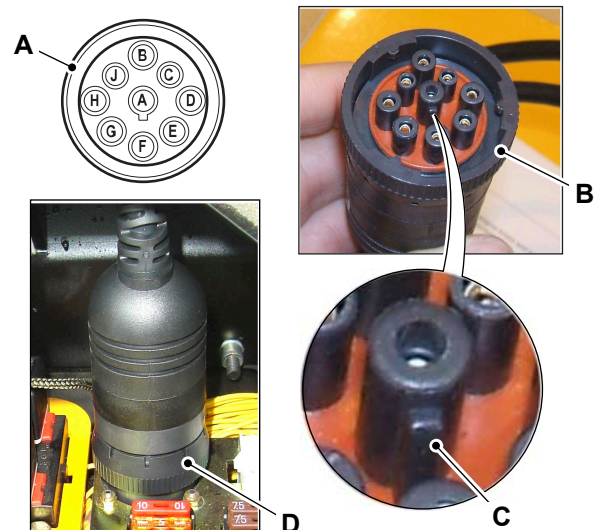
Note: Older DLA and laptop computers may not be compatible with USB ports. Use the serial PC cable to connect the DLA to the laptop serial port.

1. Make sure the machine ignition system is OFF.
2. To use the Servicemaster diagnostic tool, connect the laptop computer to the machine.

Special Tool: Data Link Adaptor (DLA) Kit / Data Link Adaptor (DLA 2.0) Kit (Qty.: 1)

3. Connect the USB PC Cable to the DLA and a free port on the laptop computer.
4. Connect the Machine Cable to the DLA. The Machine Cable has a 15-way D-type connector on one end and a 9-way CAN connector on the other. Plug the 15-way connector into the DLA and tighten the thumb screws.

Figure 405.



- A** USB PC Cable
- B** Serial PC cable
- C** Centre pin location tab
- D** Locking ring

5. Connect the 9-way CAN connector into the machines Diagnostics Connector as follows:
 - 5.1. Position the CAN connector to align the centre pin location tab with the diagnostics connector.
 - 5.2. Couple the connectors. Turn the locking ring clockwise to secure the connectors.



12 - LiveLink

[Introduction](#) 33-95
[Operation](#) 33-96

Introduction

JCB LiveLink is a web based application for storing, sharing, and distributing information. It provides a collaborative work environment that helps the organisation to improve business processes and share information.

Operation

Special Tools

Description	Part No.	Qty.
Data Link Adaptor (DLA) Kit	892/01174	1*
Data Link Adaptor (DLA 2.0) Kit	728/H5409	

*Unless otherwise stated, you can use any of the tools shown.

Start LiveLink Diagnostic

1. Open the ServiceMaster diagnostic tool.
2. Select the 'Generators' option in ServiceMaster. Refer to Figure 406.
 - 2.1. Click on the "TIER4 Final" icon.

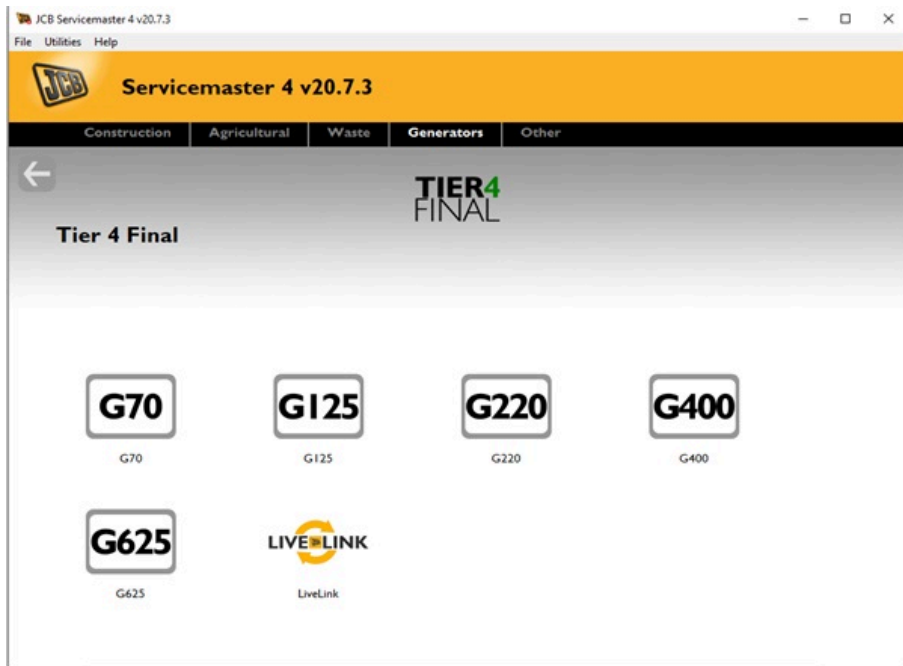
Figure 406.



3. Use the DLA (Data Link Adaptor) to connect ServiceMaster to the machine.

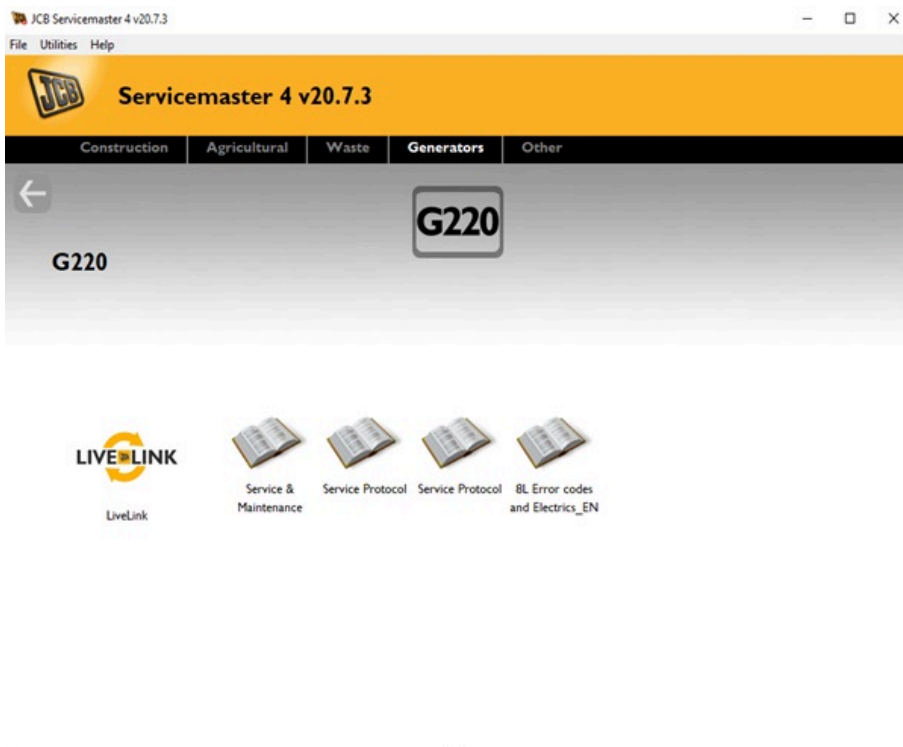
Special Tool: Data Link Adaptor (DLA) Kit / Data Link Adaptor (DLA 2.0) Kit (Qty.: 1)
4. Select your machine model icon. Refer to Figure 407.

Figure 407.



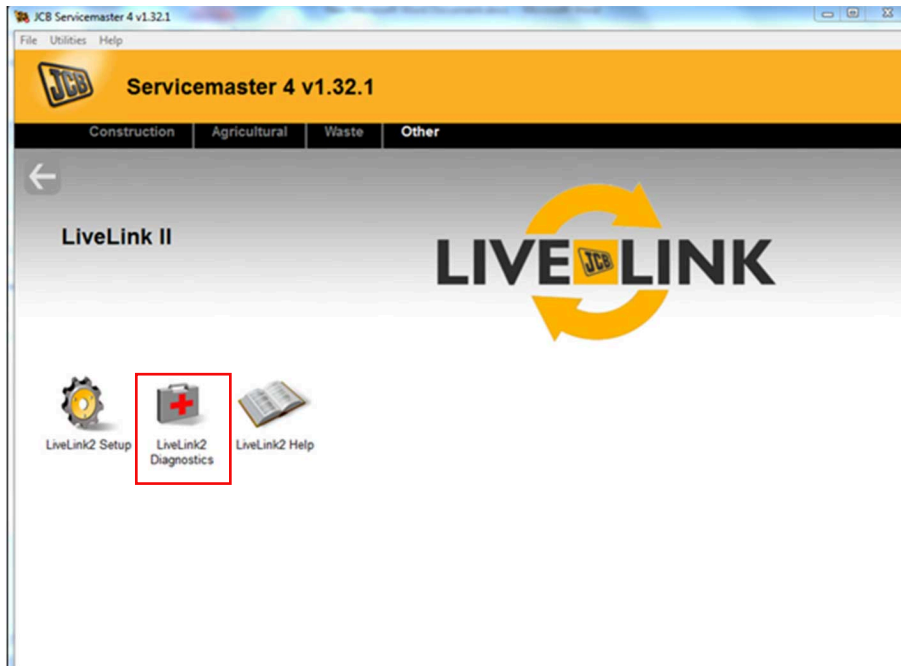
5. Select the 'LiveLink' icon. Refer to Figure 407.

Figure 408.



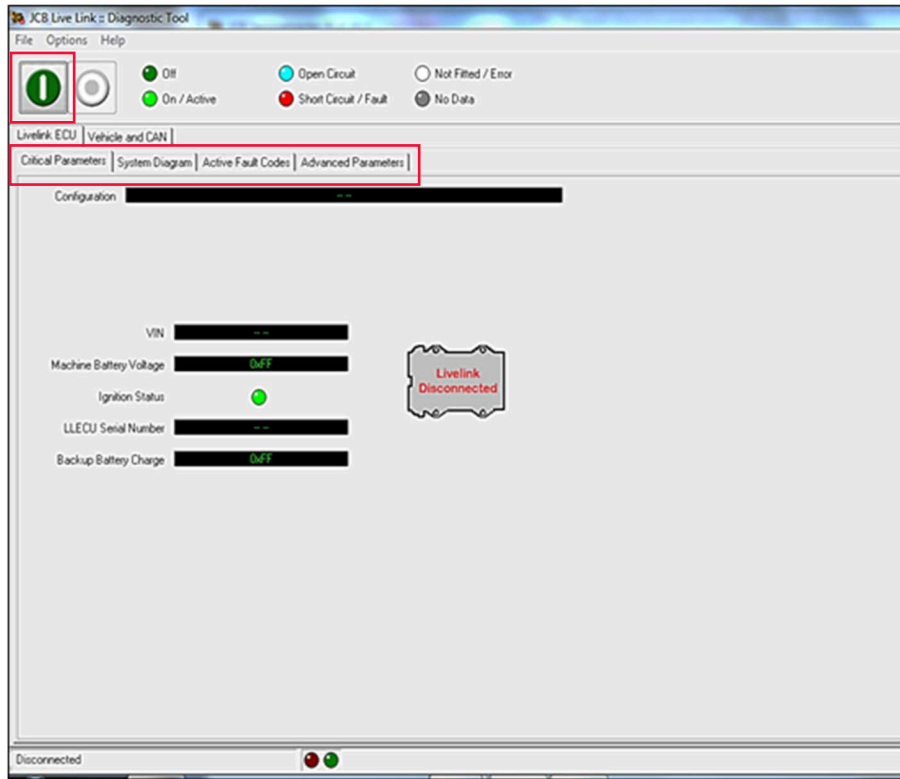
6. Select the 'LiveLink 2 Diagnostics' icon. Refer to Figure 409.

Figure 409.



- 6.1. Use 'Livelink 2 Diagnostics' to check the operation and diagnose the problem of JCB LiveLink ECU (Electronic Control Unit).
- 7. There are four program menus in the 'LiveLink 2 Diagnostics'. Refer to Figure 410.
 - 7.1. Critical parameters.
 - 7.2. System diagram.
 - 7.3. Active fault codes.
 - 7.4. Advanced parameters.

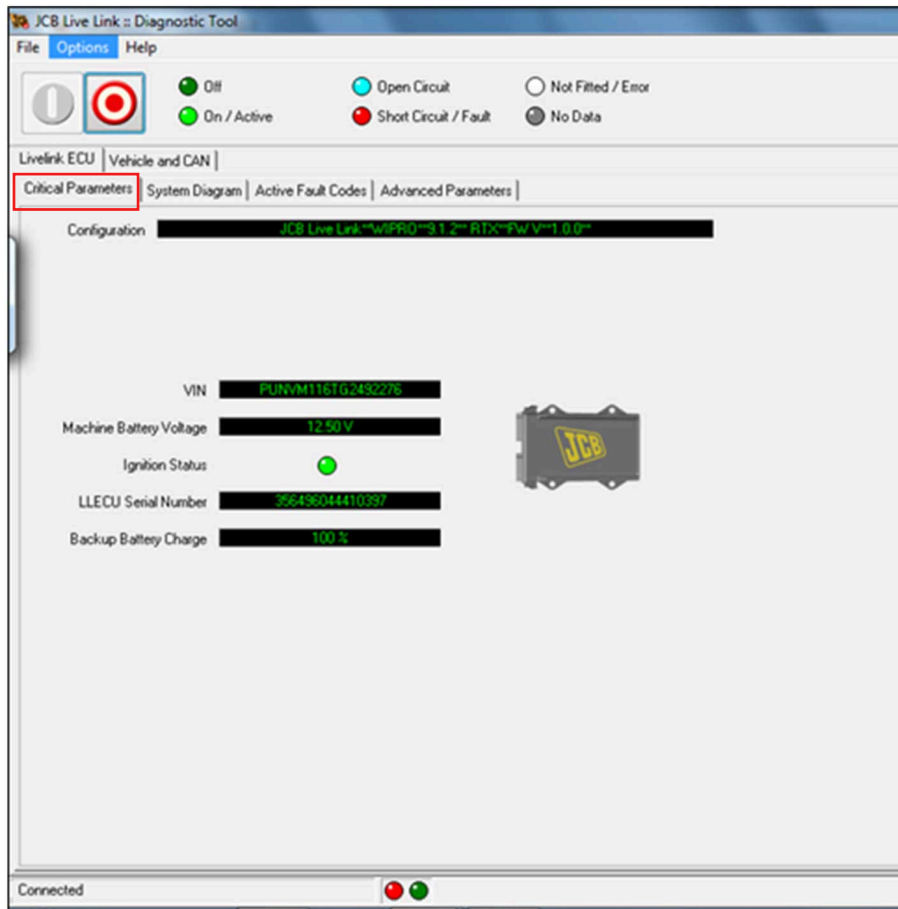
Figure 410.



8. Select the green 'Start' button at the top of the LiveLink 2 Diagnostics' screen. Refer to Figure 410.

The 'Critical Parameters' tab shows the following information: Refer to Figure 411.

Figure 411.

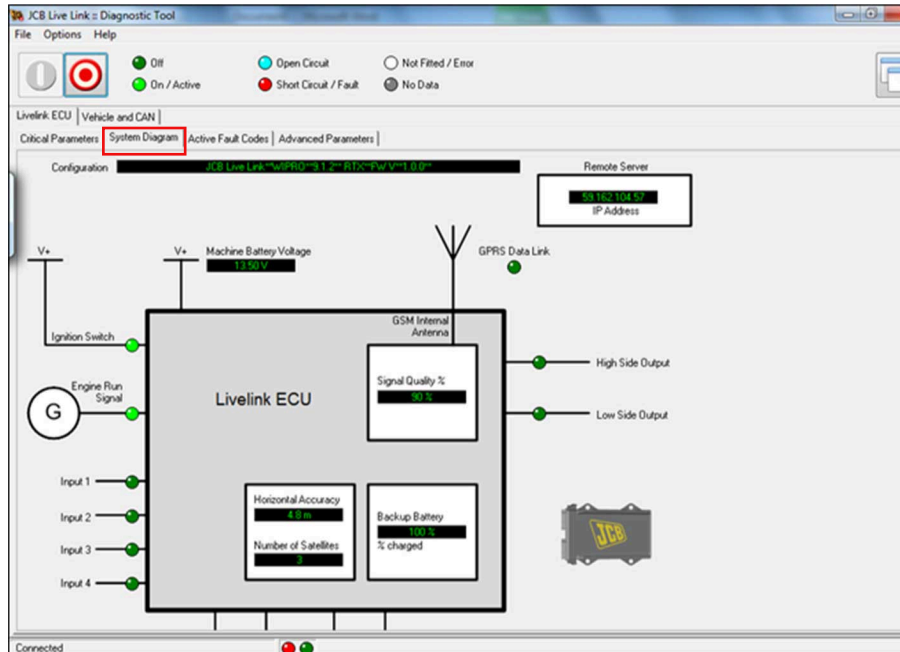


- Configuration: Configuration of software of the LiveLink.
- VIN (Vehicle Identification Number).
- Machine battery voltage.
- Ignition status.

- LLECU Serial number.
- Backup battery charge.

The 'System Diagram' tab shows following information: Refer to Figure 412.

Figure 412.

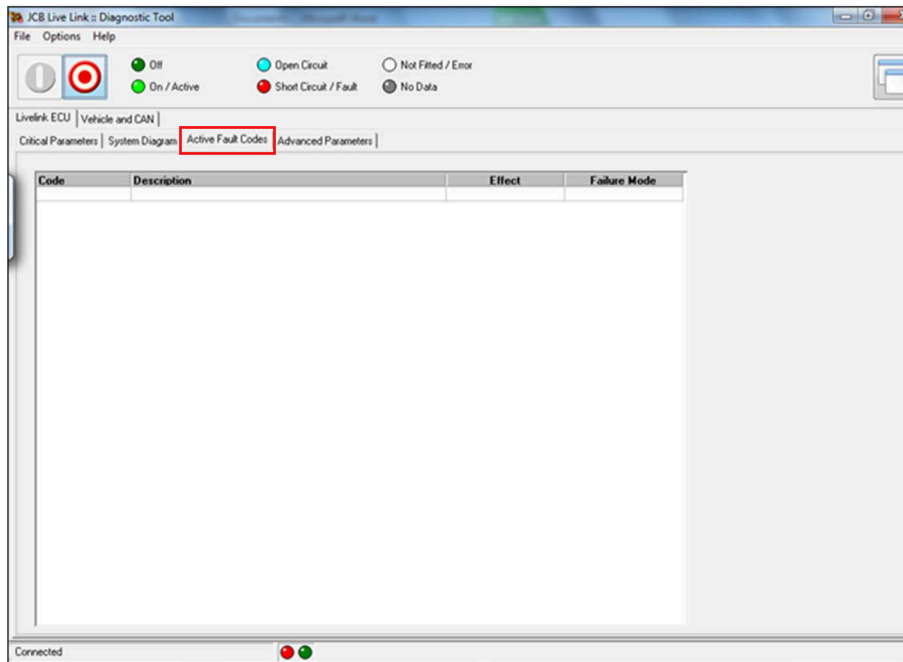


- Configuration.
- Machine battery voltage.
- Engine run signal.
- Input 1, Input 2, Input 3, Input 4: Status of the four hardwired input signals to LiveLink ECU.
- Signal quality of GPS (Global Positioning System).
- Horizontal accuracy of GPS.

- Number of satellites for GPS.
- Backup battery.
- GPRS data link.
- Remote server IP address.
- High side output.
- Low side output.

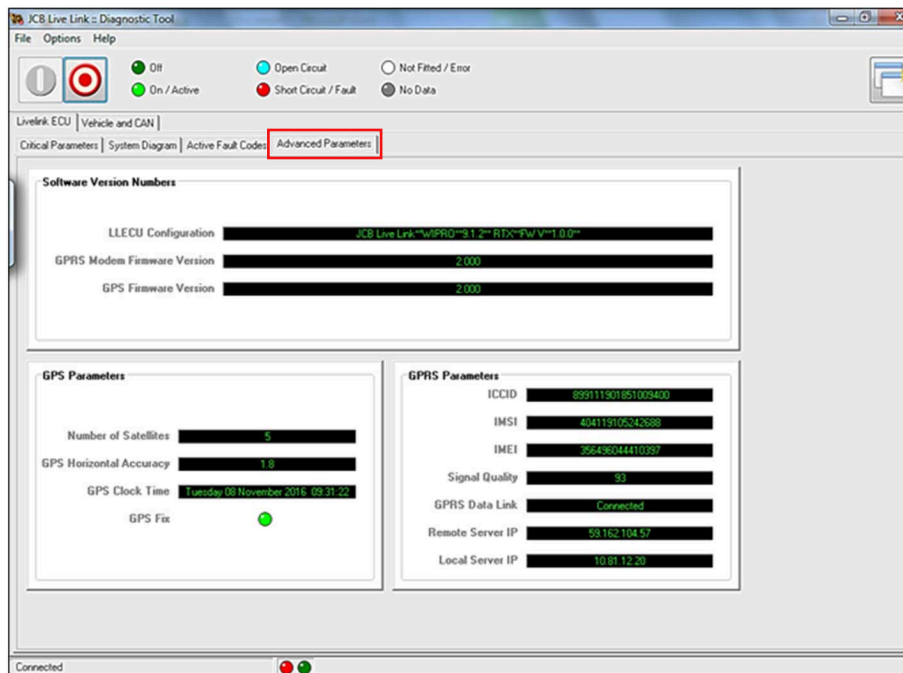
The 'Active Fault Codes' tab shows the present faults related to LiveLink: Refer to Figure 413.

Figure 413.



The 'Advanced Parameters' tab shows the following parameters: Refer to Figure 414.

Figure 414.



Software Version Numbers -

- LLECU configuration.
- GPRS Modem firmware version.

- GPS firmware version.

GPS Parameters -



- Number of satellites.
- GPS horizontal accuracy.
- GPS clock time.
- GPS fix.

GPRS Parameters -

- ICCID number.
- IMSI number.
- IMEI number.
- Signal quality.
- GPRS data link.
- Remote server IP address.
- Local server IP address.

90 - Error Codes

Technical Data

Table 165.

Fault code	Description
P0520	Low oil pressure Lamp/Gauge drive short circuit (SC)
P0520	Low oil pressure Lamp/Gauge drive short circuit to battery voltage (SC2V-BATT)
P0520	Low oil pressure Lamp/Gauge drive open circuit (OC)
P0520	Low oil pressure Lamp/Gauge drive short circuit to ground (SC2GND)
P0607	Throttle H-Bridge driver in ECU (Electronic Control Unit) fault: over temperature
P2103	Throttle H-Bridge driver in ECU fault: SC2VBATT
P2100	Throttle H-Bridge driver in ECU fault: open circuit (OC)
P2102	Throttle H-Bridge driver in ECU fault: SC2G
P0570	Cruise switch accelerate function fault detected
P060C	Functional safety fault
P060B	ADC circuit fault (Global)
P0602	RAM (Random Access Memory) corruption affecting injector C2I data
P0605	ECU memory integrity fault (code integrity)
P0602	C2I data not programmed
P0335	Crank signal over speed fault
P0371	Crank signal is too close to the previous one
P0340	Cam signal last learnt value is outside of limits
P0341	Cam signal drift higher than threshold
P0263	Cylinder balancing fault injector 2 stuck closed
P0262	Injector and wiring harness resistance drop (Inj 2)
P0201	Injector 2 open circuit fault (OC)
P0266	Cylinder balancing fault injector 1 stuck closed
P0265	Injector and wiring harness resistance drop (Inj 1)
P0202	Injector 1 open circuit fault (OC)
P0269	Cylinder balancing fault injector 3 stuck closed
P0268	Injector and wiring harness resistance drop (Inj 3)
P0203	Injector 3 open circuit fault (OC)
P0272	Cylinder balancing fault injector 0 stuck closed
P0271	Injector and wiring harness resistance drop (Inj 0)
P0204	Injector 0 open circuit fault (OC)
P0092	HPV current feedback high fault detected
P0089	Check that HPV is not stuck during IMV regulation.
P0092	Check HPV hardware current control trim high
P0091	HPV current feedback low fault detected
P0090	HPV driver in ECU fault detected
P0091	HPV driver in ECU fault detected
P2620	Throttle position feedback ADC fault
P2620	Throttle position feedback signal noisy fault
P2622	Throttle position feedback signal high fault
P2621	Throttle position feedback signal low fault
P0629	Lift pump global fault



Fault code	Description
P0627	Lift pump global fault
P0628	Lift pump global fault
P0252	Rail pressure control error (IMV current trim drift).
P0252	Rail pressure control error (IMV current trim drift).
P0252	Rail pressure control error (IMV current trim drift).
P0001	IMV driver fault is detected
P0003	IMV driver fault is detected
P0669	ECU internal temperature sensor high fault
P0668	ECU internal temperature sensor low fault
P0544	Turbo in temperature fault
P2080	Turbo in temperature count noise fault
P0546	Turbo in temperature count high fault
P0545	Turbo in temperature count low fault
P0473	Exhaust manifold pressure (P3) signal drifted high
P0472	Exhaust manifold pressure (P3) signal drifted low
P0470	Exhaust manifold pressure (P3) signal ADC fault
P0473	Exhaust manifold pressure (P3) signal high fault
P0472	Exhaust manifold pressure (P3) signal low fault
P061B	Functional safety fault
P2135	Foot pedal correlation track 1 over track 2 fault detected
P2138	Hand pedal signal correlation fault
P0685	Main ECU relay stuck
P0685	Main relay unexpected low state
P0088	Rail pressure control undefined error (over max calibrated system pressure)
P0087	Rail pressure control error positive
P0088	Rail pressure control error negative
P0089	Rail pressure control error
P2264	WIF (Water in Fuel) sensor feedback signal ADC fault
P2265	WIF sensor feedback signal 2 plausability fault
P2267	WIF sensor feedback signal high fault
P2266	WIF sensor feedback signal low fault
P250B	Oil level sensor signal global fault
P062D	Injector bank 0 fault shorted to ground (SC2VBAT)
P062D	Injector bank 0 fault shorted to ground (SC2GND)
P062E	Injector bank 1 fault shorted to ground (SC2VBAT)
P062E	Injector bank 1 fault shorted to ground (SC2GND)
P0235	Boosted air pressure sensor fault: ADC
P0096	Intake manifold temperature sensor (M2) signal noise fault (intake manifold 2 temp)
P007A	TMAP (Temperature Manifold Absolute Pressure) (Intake manifold 1 temp) temperature element sensor fault (ADC)
P007E	TMAP (Intake manifold 1 temp) temperature element sensor noise fault
P007D	TMAP (Intake manifold 1 temp) temperature element sensor high fault
P007C	TMAP (Intake manifold 1 temp) temperature element sensor low fault
P0106	Intake manifold absolute pressure (MAP) sensor signal plausibility fault
P0106	Intake Manifold Absolute Pressure (MAP) sensor signal drift high fault
P0106	Intake Manifold Absolute Pressure (MAP) sensor signal drift low fault
P2229	Atmosp sensor high fault
P2228	Atmosp sensor low fault



Fault code	Description
P0116	Coolant sensor fault (plausibility)
P0118	Coolant sensor signal high fault
P0117	Coolant sensor signal low fault
P1500	Foot pedal signal fault set (triggers limp home mode)
P1501	Foot pedal signal fault set (triggers reduced torque mode)
P1503	Hand pedal signal fault set (triggers limp home mode)
P1504	Hand pedal signal fault set (triggers reduced torque mode)
P1506	Pedal global limp home mode triggered
P0120	Foot pedal signal track 1 fault
P0220	Foot pedal signal track 2 fault
P2120	Hand pedal signal track 1 fault
P2125	Hand pedal signal track 2 fault
P1101	Rail pressure control error positive fault
P1102	Rail pressure control error negative fault
P0088	Rail pressure overpressure timeout
P1103	Rail pressure fault detected - not able to maintain pressure after a stop and start request
P2269	WIF sensor feedback signal setting fault
P250B	Oil level sensor signal global fault
P0521	Oil pressure sensor signal global fault
P0522	High oil pressure during engine stopped
P0523	Low oil pressure during engine running
P0095	Intake manifold temperature (M2) signal sensor ADC fault (Intake Manifold 2 temp)
P0096	Intake manifold temperature sensor (M2) signal plausibility fault (Intake Manifold 2 temp)
P0098	Intake manifold temperature sensor (M2) signal high signal fault (Intake Manifold 2 temp)
P0097	Intake manifold temperature sensor (M2) signal low fault (Intake Manifold 2 temp)
P0238	Boosted air pressure sensor high fault
P0237	Boosted air pressure sensor low fault
P0105	Intake manifold absolute pressure (MAP) sensor global fault
P0106	Intake manifold absolute pressure (MAP) sensor signal plausibility high fault
P0106	Intake manifold absolute pressure (MAP) sensor signal plausibility low fault
P0115	Coolant sensor signal fault
P0103	AMF electrical sensor high fault
P0102	AMF electrical sensor low fault
P0191	Rail pressure sensor fault. Exceeds threshold (out of range at key-on)
P0191	Rail pressure sensor fault. Above maximum threshold (out of range at key-on)
P0191	Rail pressure sensor fault. Below minimum threshold (out of range at key-on)
P0190	Rail pressure sensor signal grad fault
P0002	Rail pressure positive control error during 'IMV-Only' control. PID controller not able to stabilise the RPC value
P0002	Rail pressure negative control error during 'IMV-Only' control. PID controller not able to stabilise the RPC value
P0089	Rail pressure positive control error during 'RVD-Only' control. PID controller not able to stabilise the RPC value

Fault code	Description
P0089	Rail pressure negative control Error during 'RVD-Only' control. PID controller not able to stabilise the RPC value
P0087	RPC variable limit capacity (VLC) Torque reduction above its threshold
P0087	RPC variable limit capacity (VLC) Torque reduction clamped
P0196	Oil temperature sensor signal gradient fault
P0569	Cruise switch decelerate function fault detected
P0575	Cruise switch ADC fault detected
P0566	Cruise switch Off function fault detected
P0567	Cruise switch resume function fault detected
P0603	ECU memory integrity fault (data / cal integrity)
P0604	ECU memory integrity fault (RAM integrity)
P062F	ECU non volatile memory fault (APP)
P0374	Crank signal lost (no CPS signal seen in 1 Cam rotation)
P0372	Elapsed time between CPS events is too high
P0341	Cam signal lost (no Cam signal seen in 2 Crank rotations)
P0341	Cam signal fault (missing event within the expected window)
P0341	Cam signal fault (over speed detected)
U040B	CAN (Controller Area Network) communication error: EGR (Exhaust Gas Recirculation) obstruction
U040B	CAN communication error: EGR over temperature
U040B	CAN communication error: EGR over temperature
P1509	CAN communication error on TSC
U040D	CAN communication error: VGT (Variable Geometry Turbocharger) hardware
U040D	CAN communication error: VGT over temperature
U040D	CAN communication error: VGT span learn
P0261	Injector and wiring harness resistance too high/low (inj 2)
P0262	Injector and wiring harness resistance drop (Inj 2)
P0261	Injector and wiring harness resistance too high/low (inj 2)
P0201	Injector in cylinder 1 short circuit HSD to LSD
P029B	Fault which is set when the Injector 3 absolute MDP value is below a calibrated threshold
P1104	Fault which is set when no MDP updates occur on Injector 3 due to environmental conditions (as defined by the update strategy)
P1105	Fault which is set when no MDP updates occur on Injector 3 due to a fault within the update strategy
P029A	Injector drift fault detection on Injector 3. Fault which is set when the Injector 3 MDP trim exceeds the maximum calibrated threshold limit. Maximum APC raw trim at high rail pressure
P029A	Injector drift fault detection on Injector 2. Fault which is set when the Injector 2 MDP trim exceeds the maximum calibrated threshold limit. Max APC raw trim at low rail pressure
P029A	Injector drift fault detection on Injector 2. Fault which is set when Injector 2 MDP trim exceeds the maximum calibrated threshold limit. Max APC raw trim at medium rail pressure
P029B	Injector drift fault detection on Injector 2. Fault which is set when Injector 2 MDP trim exceeds the maximum calibrated threshold limit. Min APC raw trim at high rail pressure
P029B	Injector drift fault detection on Injector 2. Fault which is set when Injector 2 MDP trim exceeds the maximum calibrated threshold limit. Min APC raw trim at low rail pressure



Fault code	Description
P029B	Injector drift fault detection on Injector 2. Fault which is set when Injector 2 MDP trim exceeds the maximum calibrated threshold limit. Min APC raw trim at medium rail pressure
P0264	Injector and wiring harness resistance too high/low (inj 1)
P0265	Injector and wiring harness resistance drop (Inj 1)
P0264	Injector and wiring harness resistance too high/low (inj 1)
P0202	Injector in cylinder 2 short circuit HSD to LSD
P029F	Fault which is set when the Injector 2 absolute MDP value is below a calibrated threshold
P1106	Fault which is set when no MDP updates occur on Injector 2 due to environmental conditions (as defined by the update strategy)
P1107	Fault which is set when no MDP updates occur on Injector 2 due to a fault within the update strategy
P029E	Injector drift fault detection on Injector 1. Fault which is set when the Injector 1 MDP trim exceeds the maximum calibrated threshold limit. Maximum APC raw trim at high rail pressure
P029E	Injector drift fault detection on Injector 1. Fault which is set when the Injector 1 MDP trim exceeds the maximum calibrated threshold limit. Max APC raw trim at low rail pressure
P029E	Injector drift fault detection on Injector 1. Fault which is set when Injector 1 MDP trim exceeds the maximum calibrated threshold limit. Max APC raw trim at medium rail pressure
P029F	Injector drift fault detection on Injector 1. Fault which is set when Injector 1 MDP trim exceeds the maximum calibrated threshold limit. Min APC raw trim at high rail pressure
P029F	Injector drift fault detection on Injector 1. Fault which is set when Injector 1 MDP trim exceeds the maximum calibrated threshold limit. Min APC raw trim at low rail pressure
P029F	Injector drift fault detection on Injector 1. Fault which is set when Injector 1 MDP trim exceeds the maximum calibrated threshold limit. Min APC raw trim at medium rail pressure
P0267	Injector and wiring harness resistance too high/low (inj 3)
P0268	Injector and wiring harness resistance drop (Inj 3)
P0267	Injector and wiring harness resistance too high/low (inj 3)
P0203	Injector in cylinder 3 short circuit HSD to LSD
P02A3	Fault which is set when the Injector 4 absolute MDP value is below a calibrated threshold
P1108	Fault which is set when no MDP updates occur on Injector 4 due to environmental conditions (as defined by the update strategy)
P1109	Fault which is set when no MDP updates occur on Injector 4 due to a fault within the update strategy
P02A2	Injector drift fault detection on Injector 2. Fault which is set when the Injector 2 MDP trim exceeds the maximum calibrated threshold limit. Maximum APC raw trim at high rail pressure
P02A2	Injector drift fault detection on Injector 2. Fault which is set when the Injector 2 MDP trim exceeds the maximum calibrated threshold limit. Max APC raw trim at low rail pressure
P02A2	Injector drift fault detection on Injector 2. Fault which is set when Injector 2 MDP trim exceeds the maximum calibrated threshold limit. Max APC raw trim at medium rail pressure
P02A3	Injector drift fault detection on Injector 3. Fault which is set when Injector 3 MDP trim exceeds the maximum calibrated threshold limit. Min APC raw trim at high rail pressure

Fault code	Description
P02A3	Injector drift fault detection on Injector 3. Fault which is set when Injector 3 MDP trim exceeds the maximum calibrated threshold limit. Min APC raw trim at low rail pressure
P02A3	Injector drift fault detection on Injector 3. Fault which is set when Injector 3 MDP trim exceeds the maximum calibrated threshold limit. Min APC raw trim at medium rail pressure
P0270	Injector drift fault detection on Injector 2. Fault which is set when the Injector 2 MDP trim exceeds the maximum calibrated threshold limit. Max APC raw trim at low rail pressure
P0271	Injector and wiring harness resistance drop (Inj 0)
P0270	Injector drift fault detection on Injector 2. Fault which is set when Injector 2 MDP trim exceeds the maximum calibrated threshold limit. Max APC raw trim at medium rail pressure
P0204	Injector in cylinder 4 short circuit HSD to LSD
P02A7	Fault which is set when the Injector 1 absolute MDP value is below a calibrated threshold
P110A	Fault which is set when no MDP updates occur on Injector 1 due to environmental conditions (as defined by the update strategy)
P110B	Fault which is set when no MDP updates occur on Injector 1 due to a fault within the update strategy
P02A6	Injector drift fault detection on Injector 0. Fault which is set when the Injector 0 MDP trim exceeds the maximum calibrated threshold limit. Maximum APC raw trim at high rail pressure
P02A6	Injector drift fault detection on Injector 0. Fault which is set when the Injector 0 MDP trim exceeds the maximum calibrated threshold limit. Max APC raw trim at low rail pressure
P02A6	Injector drift fault detection on Injector 0. Fault which is set when Injector 0 MDP trim exceeds the maximum calibrated threshold limit. Max APC raw trim at medium rail pressure
P02A7	Injector drift fault detection on Injector 0. Fault which is set when Injector 0 MDP trim exceeds the maximum calibrated threshold limit. Min APC raw trim at high rail pressure
P02A7	Injector drift fault detection on Injector 0. Fault which is set when Injector 0 MDP trim exceeds the maximum calibrated threshold limit. Min APC raw trim at low rail pressure
P02A7	Injector drift fault detection on Injector 0. Fault which is set when Injector 0 MDP trim exceeds the maximum calibrated threshold limit. Min APC raw trim at medium rail pressure
P0092	HPV driver in ECU fault detected
P060B	HPV current feedback ADC fault detected
P0089	HPV open loop slope fault detected
P0325	Accelerometer fault (signal/noise ratio too low in idle)
P0002	Rail pressure control error (pressure error too high).
P0002	Rail pressure control error (pressure error too low).
P060B	-
P0004	Rail pressure control feedback high error
P0003	Rail pressure control feedback low error
P0004	IMV driver fault is detected
P061E	Functional safety fault
P061E	Functional safety fault
P0606	Functional safety fault
P0606	Functional safety fault
P061A	Functional safety fault



Fault code	Description
P0602	Functional safety fault
P0602	Functional safety fault
P061C	Functional safety fault
P1603	Functional safety fault
P060C	Functional safety fault
P060C	Functional safety fault
P060E	Functional safety fault
P0607	Functional safety fault
P060D	Functional safety fault
P060D	Functional safety fault
P060C	Functional safety fault
P060C	Functional safety fault
P060C	Functional safety fault
P060A	Functional safety fault
P060A	Functional safety fault
P060A	Functional safety fault
P060A	Functional safety fault
P060A	Functional safety fault
P060A	Functional safety fault
P060A	Functional safety fault
P1604	Functional safety fault
P1605	Functional safety fault
P060D	Functional safety fault
P060D	Functional safety fault
P0606	Functional safety fault
P0606	Functional safety fault
P0606	Functional safety fault
P0606	Functional safety fault
P0606	Functional safety fault
P062B	Functional safety fault
P062B	Functional safety fault
P062B	Functional safety fault
P062B	Functional safety fault
P062B	Functional safety fault
P062B	Functional safety fault
P062B	Functional safety fault
P062B	Functional safety fault
P062B	Functional safety fault
P062B	Functional safety fault
P062B	Functional safety fault
P062B	Functional safety fault
P060A	Functional safety fault
P060A	Functional safety fault
P060B	Functional safety fault
P060B	Functional safety fault
P060B	Functional safety fault
P060C	Functional safety fault
P1606	Functional safety fault
P0641	ECU Internal 5V Supply 1 fault
P0651	ECU Internal 5V Supply 2 fault
P0697	ECU Internal 5V Supply 2 auxiliary fault
P0697	ECU Internal 5V Supply 2 auxiliary fault

Fault code	Description
P2101	Throttle H-Bridge driver in ECU fault: SC
P2101	Throttle H-Bridge driver in ECU fault: Current limited
P2101	Throttle H-Bridge driver in ECU fault: Current reduced
P2100	Throttle H-Bridge driver in ECU fault: Under voltage
P2119	Throttle learning position fault S0
P2119	Throttle learning position fault S1
P2119	Throttle learning position fault S2
P2119	Throttle learning position fault S3
P2BAB	EGR Level 2 enacted
P2BAB	EGR Level 2 requested
P2BA8	Interruption Level 2 enacted
P2BA8	Interruption Level 2 requested
P2BAA	Consumption Level 2 enacted
P2BAA	Consumption Level 2 requested
P2BA9	Quality Level 2 enacted
P2BA9	Quality Level 2 requested
P2BAE	System tampering Level 2 enacted
P2BAE	System tampering Level 2 requested
P2BAB	EGR Level 1 requested
P2BAB	EGR Level 1 enacted
P2BAB	EGR Level 3 enacted
P2BAB	EGR Level 3 requested
P2BAB	EGR Warning requested
P2BA8	Interruption Level 1 requested
P2BA8	Interruption Level 1 enacted
P2BA8	Interruption Level 3 enacted
P2BA8	Interruption Level 3 requested
P2BA8	Interruption warning requested
P2BA7	Level warning requested
P2BAA	Consumption Level 1 requested
P2BAA	Consumption Level 1 enacted
P2BAA	Consumption Level 3 enacted
P2BAA	Consumption Level 3 requested
P2BAA	Consumption warning requested
P2BA9	Quality Level 1 requested
P2BA9	Quality Level 1 enacted
P2BA9	Quality Level 3 enacted
P2BA9	Quality Level 3 requested
P2BA9	Quality warning requested
P2BAE	System Tampering Level 1 requested
P2BAE	System Tampering Level 1 enacted
P2BAE	System Tampering Level 3 enacted
P2BAE	System Tampering Level 3 requested
P2BAE	Driver warning for system tampering
P2BA7	Level Level 1 requested
P2BA7	Level Level 1 enacted
P2BA7	Level level 2 enacted
P2BA7	Level Level 2 requested
P2BA7	Level Level 3 enacted

Fault code	Description
P2BA7	Level Level 3 requested
U010E	Inducement BAM TO
U010E	Engine rating TO
P0100	AMF electrical sensor fault (ADC)
P0100	AMF High side driver fault short circuit To Ground (SC2G)
P0194	Rail pressure sensor signal drop fault
P0089	Rail pressure positive control error during 'HPV-Only' control. PID controller not able to stabilise the RPC value
P0089	Rail pressure positive control error during 'IC & HVM' control. PID controller not able to stabilise the RPC value
P0089	Rail pressure positive control error during 'IC & HVM' control. PID controller not able to stabilise the RPC value
P0193	Rail pressure sensor signal high fault
P0192	Rail pressure sensor signal high fault
P0087	Rail pressure build normal fault
P0400	EGR flow reached its limit
P0563	Battery voltage monitoring signal high fault
P0562	Battery voltage monitoring signal low fault
P0110	Inlet Air Temperature (IAT) sensor signal ADC fault detected
P0113	Inlet Air Temperature (IAT) sensor signal high fault detected
P0112	Inlet Air Temperature (IAT) sensor signal low fault detected
P0180	Fuel temperature ADC fault
P0183	Fuel temperature sensor high fault
P0182	Fuel temperature sensor low fault
P0181	Fuel temperature sensor gradient fault
P2147	Injector supply voltage faulty
P2146	Injector supply voltage faulty
P0195	Oil temperature sensor signal external voltage (V-Ref) fault
P0196	Oil temperature sensor signal plausability fault
P0198	Oil temperature sensor signal high fault
P0197	Oil temperature sensor signal low fault
P0641	ECU Internal 5V Supply 1 fault
P0651	ECU Internal 5V Supply 2 fault
P0725	Engine RPM (Revolutions Per Minute) input missing /erratic / intermittent
P0523	Low oil pressure during engine running
P20E9	Over pressure error regardless of supply module state
P204B	Error while monitoring of pressure buildup
P204C	Error for pump pressure physical signal below lower limit
P20E9	Over pressure error in metering control state
P20E8	Under pressure error in metering control state
P204B	Error on rate of pressure reduction
P20AD	Error on supply module temperature
P20AD	Supply module temperature duty cycle above maximum range
P20AD	Supply module temperature duty cycle below minimum range
P20AD	Error on supply module temperature cold start
P20BB	Error for short to ground or open load on heater relay of back flow line
P20B9	Error for open load on heater relay of back flow line
P20BE	Error on relays for short to battery
P20BF	Error for short to ground or open load on heater relay of pressure line

Fault code	Description
P20BD	Error for open load on heater relay of pressure line
P20C3	Error for short to ground or open load on heater relay of suction line
P20C1	Error for open load on heater relay of suction line
P20BA	Error for over temperature of urea back flow line heater actuator power stage
P20BC	Error for short to battery of urea back flow line heater actuator power stage
P20BB	Error for short to ground of urea back flow line heater actuator power stage
P20B9	Open load error of urea back flow line heater actuator power stage
P20BE	Error for over temperature of urea pressure line heater actuator power stage
P20C0	Error for short to battery of urea pressure line heater actuator power stage
P20BF	Error for short to ground of urea pressure line heater actuator power stage
P20BD	Error for open load on heater relay of pressure line
P20C2	Error for over temperature of urea suction line heater actuator power stage
P20C4	Error for short to battery of urea suction line heater actuator power stage
P20C3	Error for short to ground of urea suction line heater actuator power stage
P20C1	Open load error of urea suction line heater actuator power stage
P20B6	Error for over temperature of supply module heater actuator power stage
P20B8	Error for over temperature of supply module heater actuator power stage
P20B7	Error for short to battery of supply module heater actuator power stage
P20B5	Error for short to ground of supply module heater actuator power stage
P242B	Error on catalyst temperature sensor plausibility above max threshold
P242B	Error on catalyst temperature sensor plausibility above max threshold
P242D	Exhaust catalyst temperature t4 voltage signal above maximum limit
P242C	Exhaust catalyst temperature t4 voltage signal below minimum limit
P242B	Error on SCR (Selective Catalytic Reduction) catalyst upstream temperature sensor static plausibility
P2000	Actual average conversion efficiency is below the threshold
P205B	Error on tank temperature sensor plausibility below minimum threshold
P205B	Error on tank temperature sensor plausibility exceeds maximum threshold
P20BE	Error on pressure line to perform after run
P203B	Error on tank level plausibility
P203B	Urea tank level signal is above maximum voltage limit
P203B	Urea tank level signal is above maximum voltage limit
P208B	Over temperature error of supply module pump motor
P208A	Supply module pump feedback error
P208D	Short circuit to battery error of supply module pump motor
P208C	Short circuit to battery error of supply module pump motor
P208A	Open load error of supply module pump motor
P208B	Error on supply module pump speed deviation
P208B	Error on supply module pump speed permanent deviation
P2000	Actual average conversion efficiency is below the threshold
P208B	Supply module motor speed duty cycle above maximum range
P208B	Supply module motor speed duty cycle below minimum range
U059E	CAN bus message error for heater ratio from upstream NOx (Nitrogen Oxide) sensor
U059E	CAN bus message error for no2 level from upstream NOx sensor
U059E	CAN bus message error for nh3 level from upstream NOx sensor
U059F	CAN bus message error for heater ratio from downstream NOx sensor
P2201	Downstream NOx offset max error detection

Fault code	Description
P2201	Downstream NOx offset min error detection
U059F	CAN bus message error for no2 level from downstream NOx sensor
U059F	CAN bus message error for nh3level from downstream NOx sensor
P2000	Actual average conversion efficiency is below the threshold
P2000	Actual average conversion efficiency is below the threshold
P202E	Error on dosing valve plausibility
P202E	Error on dosing valve plausibility at low voltage
P2671	Short circuit to battery of actuator relay 2
P2685	Short circuit to ground of actuator relay 3
P2670	Short circuit to ground of actuator relay 2
P0658	Short circuit to ground of actuator relay 1
P21A9	Short circuit to battery of actuator relay 4
P21AB	Short circuit to ground of actuator relay 4
P0659	Short circuit to battery of actuator relay 1
P2686	Short circuit to battery of actuator relay 3
P204B	Measured value of pressure sensor above the tolerable limit
P204B	Measured value of pressure sensor below the tolerable limit
P204D	Pump pressure signal above the maximum voltage limit
P204C	Pump pressure signal below the minimum voltage limit
P219D	Error for over temperature of urea heater relay actuator power stage
P2502	CAN bus message error for power management from engine ECU
P219E	Error for short to battery of urea heater relay actuator power stage
P219D	Open load error of urea heater relay actuator power stage
P219F	Error for short to ground of urea heater relay actuator power stage
P0562	Fault due to low or high battery voltage supply to DCU (Dosing Control Unit)
P060C	DCU software reset performed
P060C	DCU software reset performed
P060C	DCU software reset performed
P060C	Monitoring error on DCU
P0350	Error monitoring for system protection based on ignition switch input
U0105	CAN bus message error for fuel quantity from engine ECU
P0129	CAN bus message error for environment pressure from engine ECU
P203F	Reagent tank level low and below warning threshold
P203F	Reagent tank level low and empty
P203B	Tank head unit level physical signal above maximum limit
P203F	Tank head unit level physical signal below minimum limit
P203B	CAN bus message error for tank level from head unit
P00B7	CAN bus message error for coolant sensor from engine ECU
U059E	CAN bus off error from upstream NOx sensor
U059E	CAN bus message error from upstream NOx sensor
U059E	CAN bus message error from upstream nox sensor
U059E	CAN bus message error from upstream NOx sensor
U059F	CAN bus off error from downstream NOx sensor
U059F	CAN bus message error from downstream NOx sensor
U059F	CAN bus message error from downstream NOx sensor
U059F	CAN bus message error from downstream NOx sensor
U0029	CAN bus off error 250kbps
U0029	CAN bus off error 250kbps
U0401	CAN bus off error from engine ECU

Fault code	Description
U0401	CAN bus message error from engineECU
P2BAD	Inducement level 2 is active due to repeat offense error
P2413	Impeded EGR fault data or bus off for EGR faults from engine ECU
P2413	CAN bus message error for EGR faults from engine E
P060A	Monitoring error on DCU
P0606	Peripheral monitoring error on DCU
P207F	Adblue quality error during refill condition
P2BAD	Exceeded the limit value of long term adaptation factor
P2BAD	Undershoot the limit value of long term adaptation factor
P204B	Error on pressure line while monitoring for blockage
P204B	Error on pressure line & dosing valve while monitoring for blockage
P204B	Error while monitoring the stabilisation of pressure
P204F	Error to detect the clogged filter
P2BAD	Inducement level 1 is active due to repeat offense error
P2BAD	Inducement level 3 is active due to repeat offense error
P2428	Exhaust catalyst temperature T4 physical signal above maximum limit
P242B	Exhaust catalyst temperature T4 physical signal below minimum limit
P208B	Supply module internal duty cycle in invalid range
P208B	Supply module internal duty cycle below min range
P20A0	Open load error of back flow pump actuator power stage
P20A1	Error for over temperature of back flow pump actuator power stage
P20A3	Error for short to battery of back flow pump actuator power stage
P20A2	Error for short to ground of back flow pump actuator power stage
P20BE	Error on supply module heater
P20B6	Supply module heater temperature duty cycle above maximum range
P20B6	Supply module heater temperature duty cycle below minimum range
P20BE	Error on supply module heater temperature cold start
P20BE	Error on supply module heater temperature sensor
P204F	Error to detect leakage during no dose
P2BAD	Inducement override active
P2A00	Upstream NOx sensor not mounted or loose
P2A01	Downstream NOx sensor not mounted or loose
P2200	Invalid signal from upstream NOx sensor after heater release
P2201	Invalid signal from downstream NOx sensor after heater release
P1400	Erroneous signal from override switch
P1401	CAN bus message error from override switch
P1402	CAN bus off error from override switch
P3401	Excessive ambient/operating temperature error for after treatment 1 SCR catalyst reagent property
P3402	Concentration too high for after treatment 1 SCR catalyst reagent properties
P3403	Concentration too low for after treatment 1 SCR catalyst reagent properties
P3404	excessive ambient/operating temperature error for after treatment 1 SCR catalyst reagent property
P3405	Temperature too high for after treatment 1 SCR catalyst reagent properties
P3406	Temperature too low for after treatment 1 SCR catalyst reagent properties
P3407	Sensor open circuit error after treatment 1 SCR catalyst reagent temperature
P3408	Sensor short circuit error after treatment1 SCR catalyst reagent temperature

Fault code	Description
P3409	Excessive ambient/operating Level error for after treatment 1 SCR catalyst reagent property
P3410	Level too high for after treatment 1 SCR catalyst reagent properties
P3411	Level too low for after treatment 1 SCR catalyst reagent properties
P3412	Tank level open circuit error after treatment 1 SCR catalyst reagent temperature
P3413	Tank level short circuit error after treatment 1 SCR catalyst reagent temperature
P3414	Erroneous signal for engine boost pressure
P3415	Data length error for IC1 frame
P3416	Time out error for IC1 frame
P3417	Erroneous signal for Intake manifold temperature
P3418	Erroneous signal for operating mode request
P3419	Error for particulate inlet pressure
P3420	Data length error for PROSCR3 frame received for regeneration
P3421	Timeout error for PROSCR3 frame received for regeneration
P3422	Erroneous signal for soot load message
P3423	Erroneous signal for engine exhaust gas temperature.
P2200	Upstream NOx sensor self diagnostic timeout
P2201	Downstream NOx sensor self diagnostic timeout
P203B	Tank level signal error.
P20EB	DCU relay stuck
P20EA	DCU relay early opening
P0563	High battery voltage
P0562	Low battery voltage
P0070	CAN bus off error from engine ECU
P0071	CAN bus message error for environment temperature from engine ECU
P0070	CAN bus message error from engine ECU
P0181	CAN bus message error for fuel temperature from engine ECU
P0196	CAN bus message error for oil temperature from engine ECU
P205B	Tank head unit temperature physical signal above maximum limit
P205B	Tank head unit temperature physical signal below minimum limit
P205E	CAN bus message error for tank temperature from head unit
P205B	Error in increase of urea tank temperature
P205D	Tank temperature signal voltage above maximum limit
P205C	Tank temperature signal voltage below minimum limit
P205B	Error to indicate overheating of adblue tank
P205E	Tank temperature signal error on CAN
P0321	CAN bus message error for engine speed from engine ECU
P2200	Upstream NOx sensor self diagnostic
U059E	CAN bus message error for NOx level from upstream NOx sensor
P2200	Upstream NOx sensor short circuit to gnd or batt
P2203	Upstream NOx sensor reading exceeds above maximum threshold
P2202	Upstream NOx sensor reading below minimum threshold
P2200	Upstream NOx sensor open circuit
P2200	Upstream NOx sensor self diagnostic abort
U059E	CAN bus message error for o2 level from upstream NOx sensor
P2200	Upstream NOx sensor wire diagnosis-error in voltage supply
U059E	CAN bus message error for power signal status from upstream NOx sensor

Fault code	Description
U059E	CAN bus message error for temp signal status from downstream NOx sensor
U059E	CAN bus message error for NOx signal status from upstream NOx sensor
U059E	CAN bus message error for o2 signal status from upstream NOx sensor
P2209	Upstream NOx sensor heater not available
P2209	Upstream NOx sensor heater not heated quickly
U0401	CAN bus message error for modelled NOx from engine ECU
P2200	Lambda signal above maximum limit for upstream NOx sensor
P2200	Lambda signal below minimum for upstream NOx sensor
P2201	Downstream NOx sensor self diagnostic
U059F	CAN bus message error for NOx level from downstream NOx sensor
P2201	Downstream NOx sensor short circuit to gnd or batt
P2203	Downstream NOx sensor reading exceeds above maximum threshold
P2202	Downstream NOx sensor reading below minimum threshold
P2201	Downstream NOx sensor open circuit
P2201	Downstream NOx sensor self diagnostic abort
U059F	CAN bus message error for o2 level from downstream NOx sensor
U059F	CAN bus message error for power signal status from downstream NOx sensor
P2201	Downstream NOx sensor wire diagnosis-error in voltage supply
U059F	CAN bus message error for temp signal status from upstream NOx sensor
U059F	CAN bus message error for NOx signal status from downstream NOx sensor
U059F	CAN bus message error for o2 signal status from downstream NOx sensor
P2208	Downstream NOx sensor heater not available
P2208	Downstream NOx sensor heater not heated quickly
P2201	Lambda signal above maximum limit for downstream NOx sensor
P2201	Lambda signal below minimum limit for downstream NOx sensor
P2413	CAN bus message error from engine ECU
P202E	Error on dosing valve driver over temperature
P202E	Error on dosing valve short circuit to battery
P202E	Error on dosing valve short to ground or open circuit
P202E	Error on dosing valve short circuit to battery on high side or open load
P202E	Error on dosing valve short circuit
P209F	Error for over temperature of urea tank heater actuator power stage
P202C	Error for short to battery of urea tank heater actuator power stage
P202A	Open load error of urea tank heater actuator power stage
P202B	Error for short to ground of urea tank heater actuator power stage
P207F	AdBlue quality message error from head unit
P06A7	Sensor supply monitoring error through DCU
P2043	Adblue temperature message error from head unit
P207F	Adblue concentration message error from head unit
P203B	CAN bus off error from head unit
P203B	CAN bus message error from head unit
P2043	CAN bus off error from head unit
P2043	CAN bus message error from head unit
U0401	CAN bus message error from engine ECU



78 - Generator Control

Contents

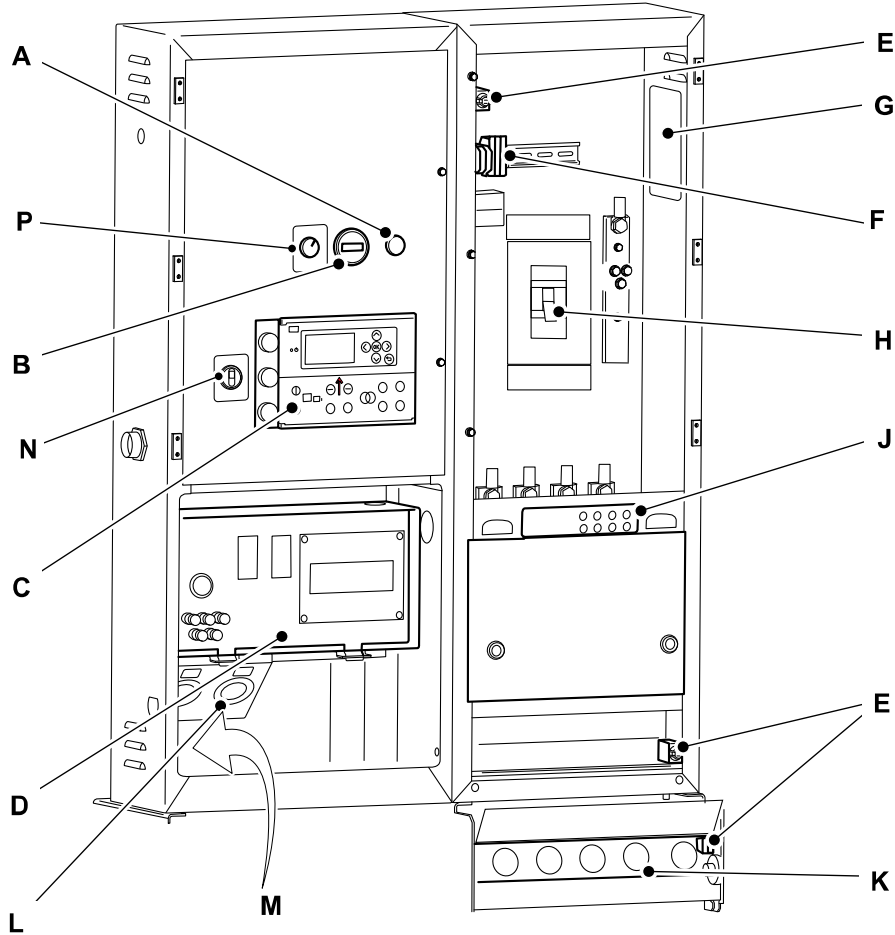
Page No.

33-78-03 Control Panel 33-119

03 - Control Panel
Introduction

Introduction 33-119

Operation 33-120

Figure 415.


- A** Panel mount buzzer
- C** Generator controller
- E** Limit switches
- G** AVR (Alternator Voltage Regulator)
- J** Test point
- L** Coolant heater and battery charger sockets
- N** 208/240 3 phase selector switch

- B** Analogue hour counter
- D** Connection box
- F** DIN rail terminal
- H** MCCB (Moulded Case Circuit Breaker)
- K** Camlock connections
- M** ECU (Electronic Control Unit) override switch
- P** Voltage adjustment

Operation

For: Control Panel DEIF AGC 150
..... Page 33-120

For: Control Panel 7310 Page 33-130

(For: Control Panel DEIF AGC 150)

Low Load Running

This machine should not be run at low load levels for extended periods of time: Alarms are activated if load running persists. Low load running will eventually result in excessive contamination of the SCR (Selective Catalytic Reduction). If this reaches an unacceptable level then the machine will shutdown. At this point the user shall either increase the site load or by use of a load bank increase the load level for the machine to perform an active refresh. If the user does not adhere to this then permanent damage to the SCR unit may occur.

Controller Overview

General Description

The DEIF AGC 150 is an easy-to-use control unit containing all necessary functions for protection and control of a genset.

DEIF AGC 150 contains all necessary 3-phase measuring circuits, and all values and alarms are presented on the sun-shine proof LCD (Liquid Crystal Display) display.

Main Features

User Levels in Settings

Configure three user levels with a password for each level: Customer, Service and Master. Configure each parameter for a user level, and only the parameters relevant for the user are shown.

Shortcut Menu

Configurable shortcuts gives the user easy access to commonly used functions.

PLC functions

Programmable functions (M-Logic) in a user-friendly environment.

Alarm and Event Logging

View historical alarms and events on the display and with the Utility Software (up to 500 alarms and 500 events).

Graphical Display

View important genset and/or system information on the easy to read graphical display, shown as text, symbols, numbers, and even a graphical synchroscope. View important genset and/or system information on the easy to read graphical display, shown as text, symbols, numbers, and even a graphical synchroscope. View important genset and/or system information on the easy to- read graphical display, shown as text, symbols, numbers, and even a graphical synchroscope.

Built-in Analogue AVR and GOV Control

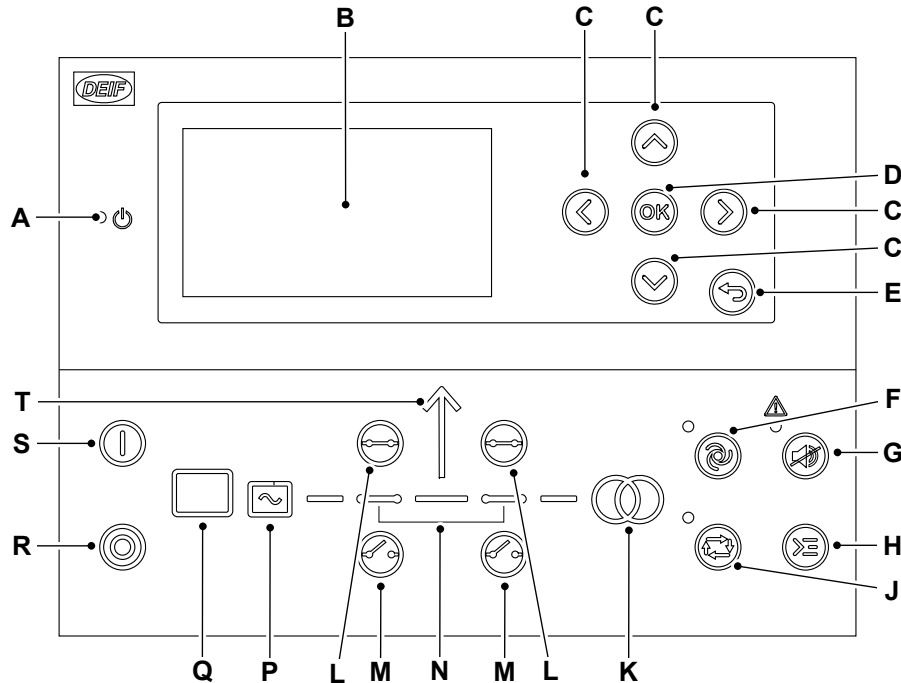
Eliminates the need for external equipment (voltage and PWM).

CIO Support

DEIF AGC 150 supports CAN (Controller Area Network)bus based I/Os, which increases the number of inputs and outputs.

Tier 4 Final Support

DEIF AGC 150 can be used with the latest electrical Tier 4 Final engines, and show values requested by the standard.

Front Overview
Figure 416.

Table 166.

S. No.	Item	Function
A	Power on	Green: The controller power is on. Off: The controller power is off.
B	Display screen	Resolution: 240 x 128. Viewing area: 88.50 x 51.40mm. Six lines, each with 25 characters.
C	Navigation	Move the selector up, down, left and right on the screen.
D	Ok	Enter the menu system. Confirm the selection on the screen.
E	Back	Go to the previous page.
F	Auto mode	The controller automatically starts and stops gensets according to the system settings. No operator actions are needed.
G	Silence horn	Turns off an alarm horn (if configured) and enters the alarm menu.
H	Shortcut menu	Gives access to: Jump menu, mode selection, test and lamp test.
J	Semi-auto mode	The controller cannot automatically start, stop, connect or disconnect the genset. The operator can start, stop, connect or disconnect the genset.

S. No.	Item	Function
		The controller automatically synchronises before closing a breaker, and automatically de-loads before opening a breaker.
K	Mains symbol	Green: The mains voltage and frequency are ok, and the controller can synchronise and close the breaker. Red: Mains failure.
L	Close breaker	Press to close the breaker.
M	Open breaker	Press to close the breaker.
N	Breaker symbols	Green: Breaker is On. Green flashing: Synchronising or de-loading. Red: Breaker failure.
P	Generator	Green: The generator voltage and frequency are Ok, and the controller can synchronise and close the breaker. Green flashing: The generator voltage and frequency are Ok, but the V&Hz Ok timer is still running. The controller cannot close the breaker. Red: The generator voltage is too low to measure.
Q	Engine	Green: There is running feedback. Green flashing: The engine is getting ready. Red: The engine is not running, or there is no running feedback.
R	Stop	Stops the genset if semi-auto or Manual is selected.
S	Start	Starts the genset if semi-auto or Manual is selected.
T	Load symbol	Off: Power management application. Green: The supply voltage and frequency are Ok. Red: Supply voltage/frequency failure.

Display Settings

settings under Settings > Basic settings > Controller settings > Display > Display control.

It is possible to adjust the settings for the display to compensate for ambient lighting. Configure these

Table 167.

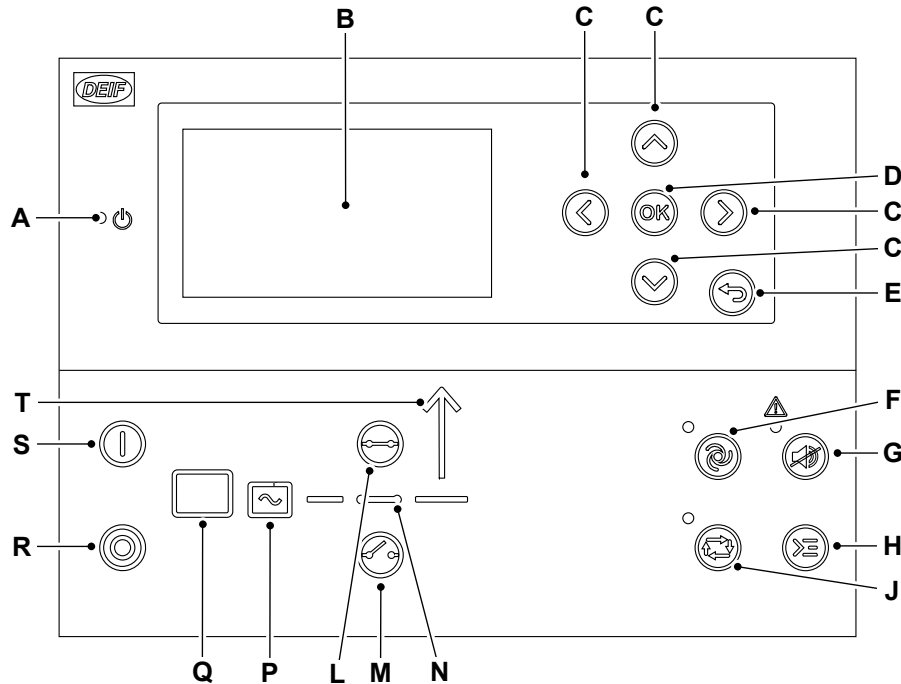
Parameter No.	Text	Range	Default
9151	Backlight dimmer	0 to 15	12
9152	Green LED (Light Emitting Diode)'s dimmer	1 to 15	15
9153	Red LED's dimmer	1 to 15	15
9154	Contrast level	-20 to +20	0
9155	Sleep mode timer	1 to 1800 s	60 s

Parameter No.	Text	Range	Default
9156	Enable (Sleep mode timer)	Off	On
		On	

Controller Types

Genset Controller Layouts

Figure 417. Single Genset Controller in Island Mode



- A Power on
- C Navigation
- E Back
- G Silence horn
- J Semi-auto mode
- M Open breaker
- P Generator
- R Stop
- T Load symbol

- B Display screen (monochrome)
- D Ok
- F Auto mode
- H Short cut menu for commands
- L Close breaker
- N Breaker symbols
- Q Engine
- S Start

Mimic Function

With the Mimic function the operator can choose how the control buttons and LED's are shown on DEIF

AGC 150, and thereby get a better overview of the controller in different applications.

Configure the Mimic function under Settings > Basic settings > Controller settings > Display > LED mimic.

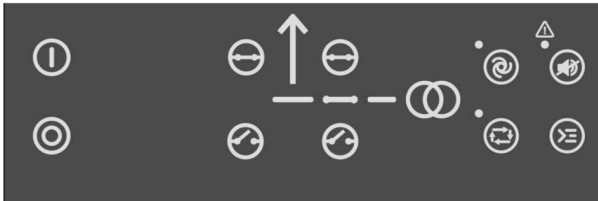
Table 168.

Parameter No.	Item	Range
6082	LED mimic	Standard with genset
		Standard
		Guided with genset
		Guided

Standard

Control buttons and LED's are continuously visible. If the genset is stopped, the motor/generator symbols are in off condition. Refer to Figure 418.

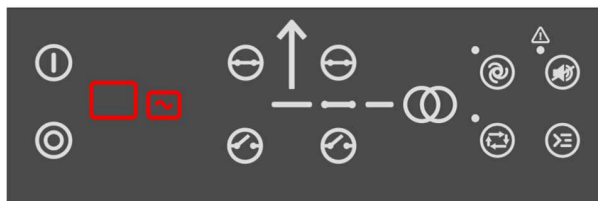
Figure 418.



Standard with Genset

Control buttons and LED's are continuously visible. If the genset is stopped, the motor/generator symbols are shown in red color. Refer to Figure 419.

Figure 419.



Guided

Active control buttons and LED's are visible, inactive items are not shown. Example: DEIF AGC 150 is in semi-auto mode. The generator is stopped. The only possible action is to start the generator, and so only the Start button is visible. Refer to Figure 420.

Figure 420.

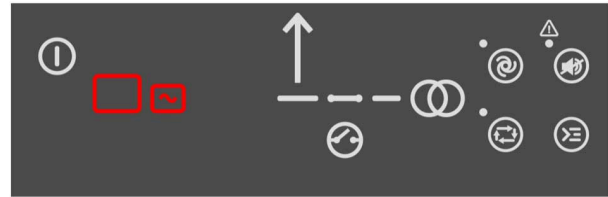


Guided with Genset

Active control buttons, LED's and motor/generator symbols are visible, inactive items are not shown.

Example: DEIF AGC 150 is in semi-auto mode. The generator is stopped. The only possible action is to start the generator, and so only the Start button and the red motor/generator symbols are visible. Refer to Figure 421.

Figure 421.

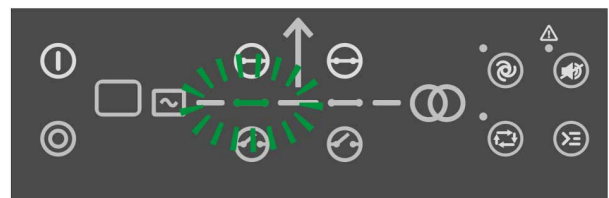


All Mimic Settings

The breaker symbol flashes green color: Refer to Figure 422.

- Controller is synchronising.
- Controller is de-loading.

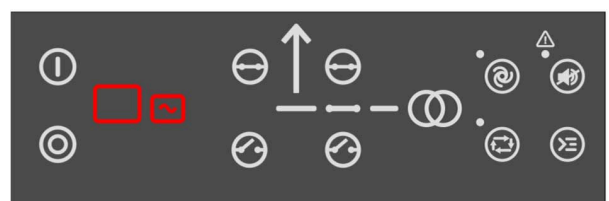
Figure 422.



The breaker symbol turns red color: Refer to Figure 423.

- Breaker position failure.
- Breaker close failure.

Figure 423.



Menu Structure

About Display and Menu Structures

The DEIF AGC 150 has two menu systems, which can be used without password entry:

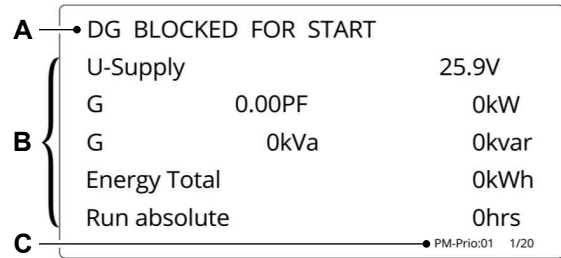
- View Menu System: The commonly used menu system, with 20 configurable windows that can be entered with the arrow push buttons.
- Setup Menu System: The menu system for setting up the controller, and to see detailed information that is not available in the view menu system.

Changes to the parameter settings are password protected.

The View Menu

When DEIF AGC 150 is powered up, the View menu appears. It is the daily use menu for the operator, which shows various measured values. If an alarm is present, the event and alarm list is shown at power-up. Refer to Figure 424.

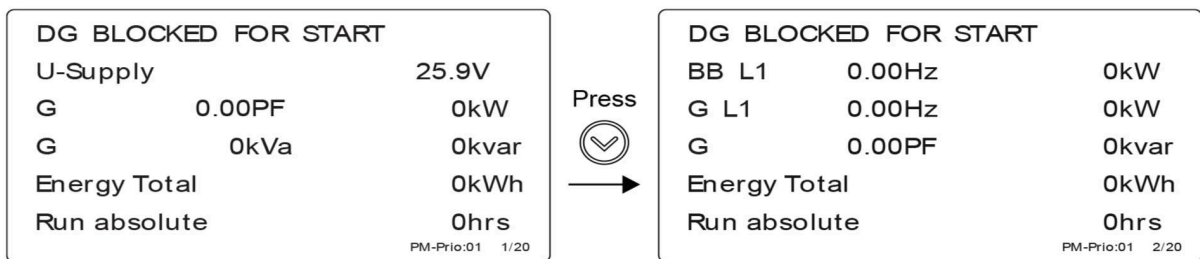
Figure 424. Example: The View Menu



- A** Status line
- B** Operational status or measurements
- C** View page number, Power management priority (if available) or Engine DEF (Diesel Exhaust Fluid) level (if available).

The View menu contains up to 20 different pages. Navigate through the pages with the Up and Down push-buttons. Refer to Figure 425.

Figure 425. Example: Navigating the View Menu

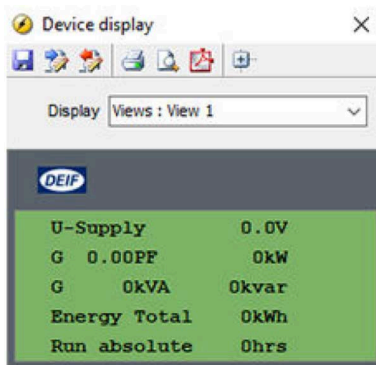


Available Display Texts

The display views can be configured to apply with the user's wishes. This is made with the Utility Software:

- In the taskbar, select configuration of the user views. Refer to Figure 426.

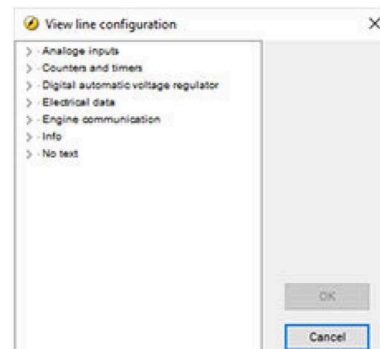
Figure 426.



- In the pop-up box, select the display view to be changed.
- Select the display line to be changed.

- In the new pop-up box, navigate to the desired text line, then select Ok. Refer to Figure 427.

Figure 427.

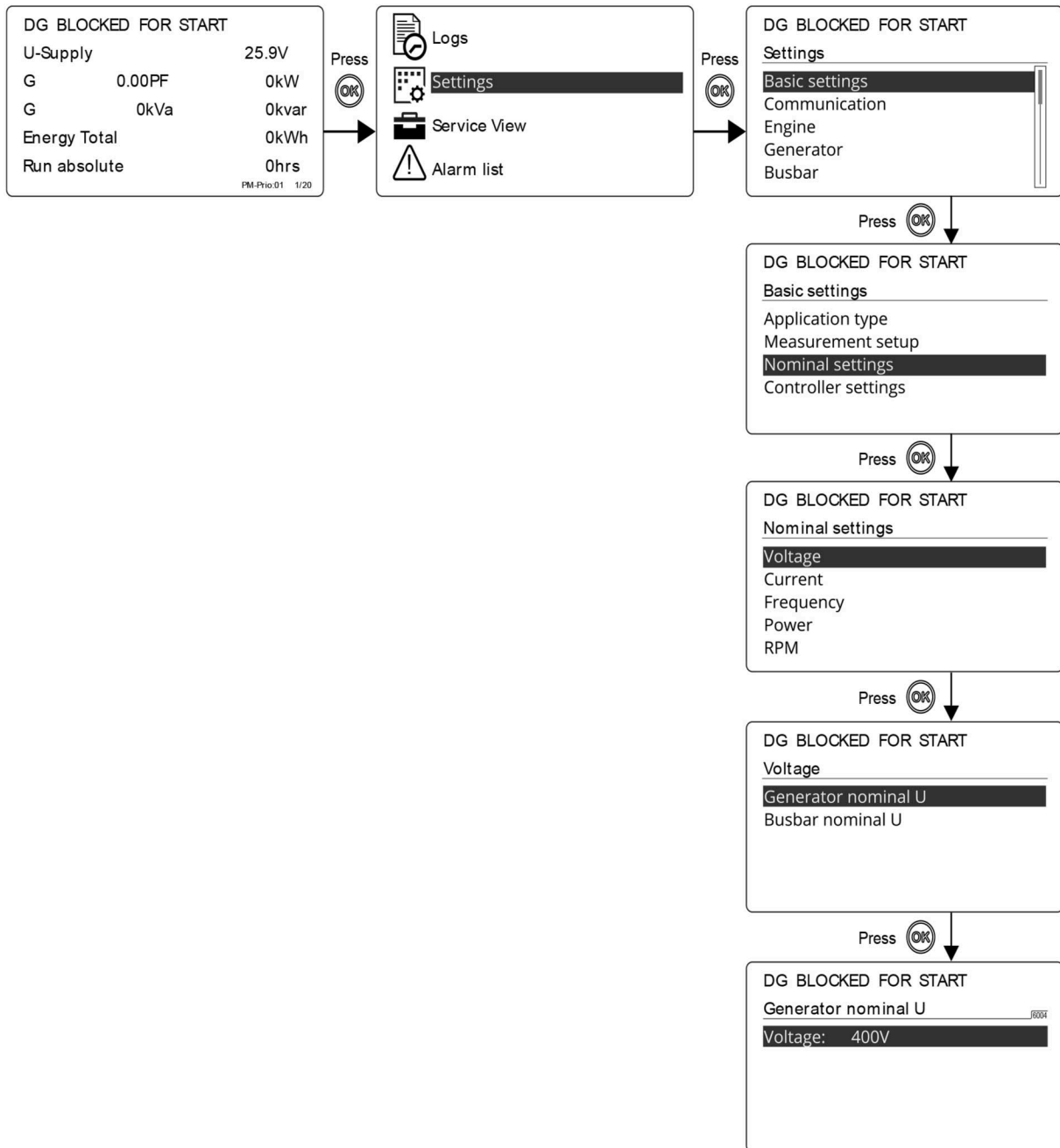


Settings Menu

The Settings menu is used for setting up the controller, and if the operator needs detailed information that is not available in the view menu system.

Navigate through the different setup parameters with the Up, Down and Ok push-buttons.

Figure 428. Example: Navigating the Settings Menu



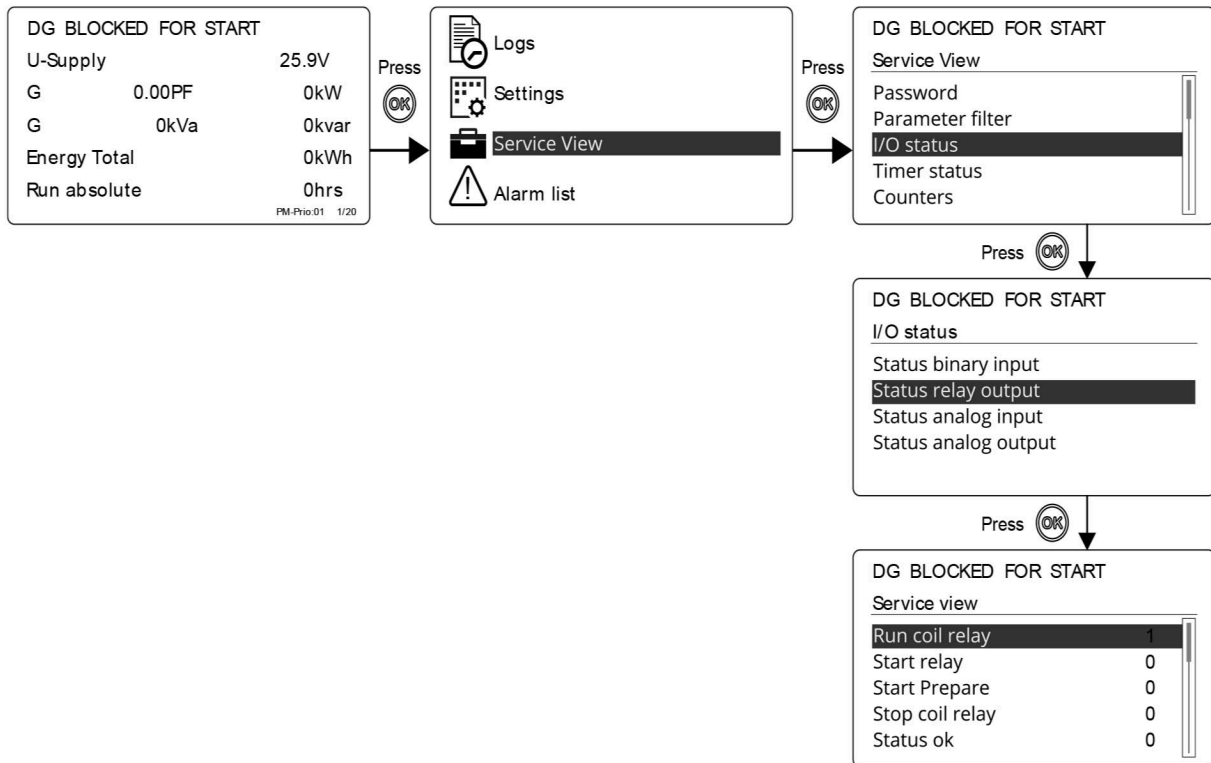
Service View

The Service View is used to view the status of the controller. The controller settings can not be changed

through the Service View, except for changing the Passwords.

Navigate through the different status views with the Up , Down and Ok push-buttons.

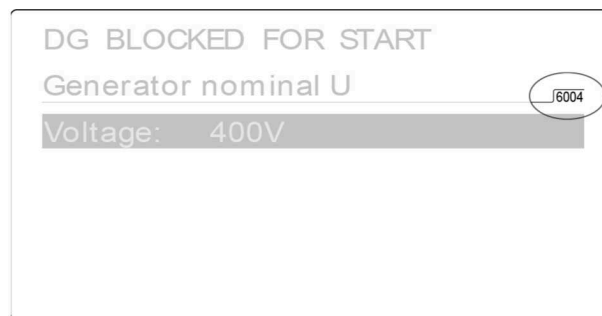
Figure 429. Example: Navigating the Service View



Menu Numbers

In DEIF AGC 150 each setting or parameter has a unique menu number. On the display screen, the menu number can be seen in the upper right corner:

Figure 430.



Menu numbers can also be found in the Utility Software:

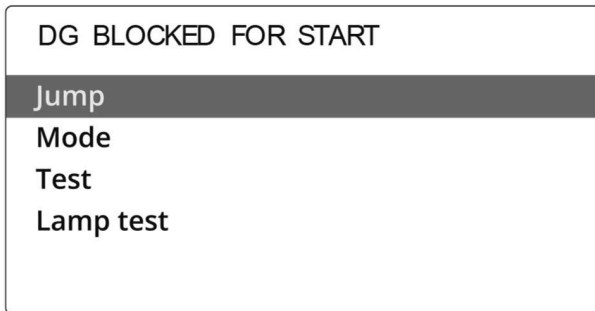
1. From the toolbar, select the Parameters page.
2. In View mode, choose the List view.
3. The menu numbers are shown in the Channel column.

Jump Function

If you know the menu number for a setting, you can use the Jump function to select and display settings without navigating through the menus.

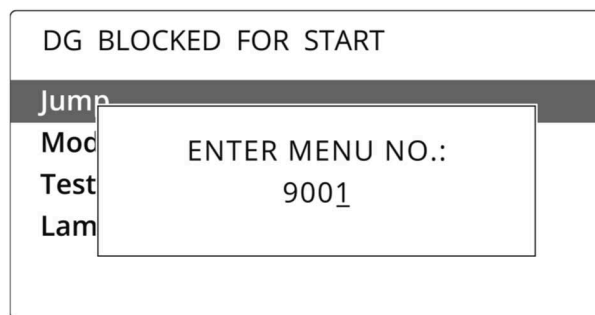
To activate the Jump function from the controller, press the Shortcut menu push-button.

Figure 431.



Scroll to the Jump menu with the Up and Down push-buttons, and select the menu with the Ok push-button.

Figure 432.



Enter the menu number and select with the Ok push-button.

To activate the Jump function in the Utility Software, select the Parameter page and then the Jump menu.

Mode Overview

DEIF AGC 150 has four different running modes and one block mode:

- Auto: In Auto mode, the controller will operate automatically, and the operator cannot initiate any sequences manually
- Semi-auto: In Semi-auto mode, the operator has to initiate all sequences. This can be done via the push-button functions, Modbus commands or digital inputs. When started in Semi-auto mode, the genset will run at nominal values.
- Test: The test sequence will start when the test mode is selected

- Manual: When Manual mode is selected, the digital increase/decrease inputs can be used (if they have been configured) as well as the Start and Stop push-buttons. When starting in Manual mode, the genset will start without any subsequent regulation.
- Block: When the block mode is selected, the controller is not able to initiate any sequences, for example the start sequence. Block mode must be selected when maintenance work is carried out on the genset.

Important: The genset will shut down if block mode is selected while the genset is running.

Alarm Handling and Log List

Alarm Handling

If the function Alarm Jump is On, the controller will automatically show the Alarm list on the display screen, when an Alarm occurs. Activate the function under Service View > Display > Alarm Jump.

Table 169.

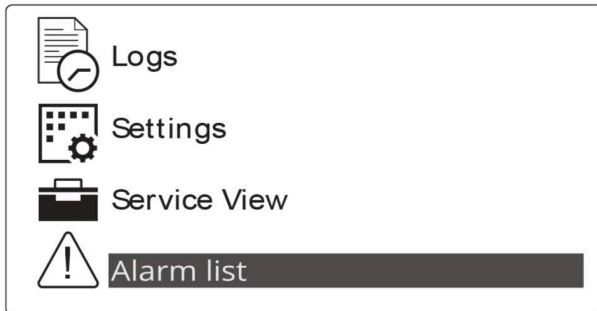
Parameter	Text	Range	Default
9157	Alarm jump	Off	On
		On	

Access the Alarm list from the display unit:

1. From the View menu, press the button.

2. Scroll to the Alarm list with the and buttons.

Figure 433.



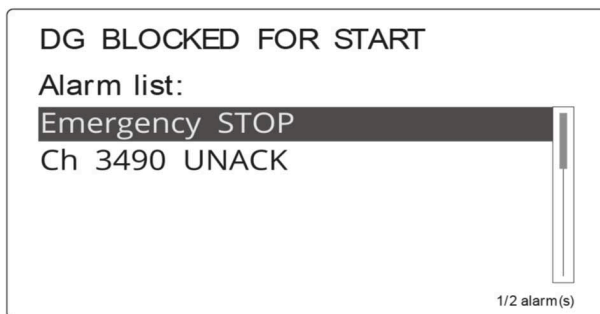
3. Press the button to select the Alarm list.
4. Press the button to leave the Alarm list.

The Alarm list contains both acknowledged and unacknowledged alarms that are active (that is, the alarm condition is still present). Once an alarm is acknowledged and the condition has disappeared, the alarm will no longer be displayed in the Alarm list.

If no alarms are present, the alarm list will read No alarms.

The display screen can show only one alarm at a time. The number of alarms is shown in the bottom line.

Figure 434. Example of an Unacknowledged Alarm



To see the other alarms, scroll with the Up and Down buttons.

To acknowledge an alarm, select the alarm and press the Ok button.

Access the Alarm list with the Utility Software

To open the Alarm list with the Utility Software, press the Alarms icon.

Important: If an alarm is blocking a genset in Auto mode from starting, the genset will automatically start and close the breaker if the condition that triggered the alarm has disappeared and the alarm has been acknowledged.

Logs Menu

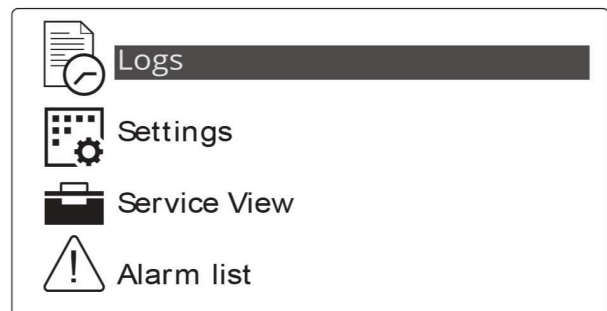
The log shows three menus:

1. Event log: Shows up to 500 events, for example: Auto Mains Failure.
2. Alarm log: Shows up to 500 alarms, for example: Emergency Stop. Only the latest 100 alarms are shown on the display unit, while the remaining alarms is shown in the Utility Software.
3. Battery test log: Shows up to 52 tests, either Test Ok or Test failed.

Access the Log Menu from the Display Unit

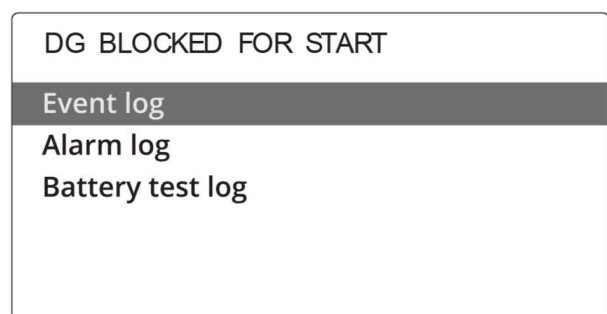
1. From the View menu, press the Ok button.
2. Scroll to Logs with the Up and Down buttons.

Figure 435.



3. Press the Ok button to select Logs.
4. Choose the preferred Log list.

Figure 436.



5. Press the Ok button to select the preferred Log list.
6. Press the back button to leave the Log list.

Access the Log list with the Utility Software

Open the Log menu with the Utility Software:

1. In the left menu, press the Logs icon.
2. In the task bar, press the Read logs icon.

3. Choose the preferred Log list.

(For: Control Panel 7310)

▲ WARNING Electric shock hazard. High voltage can cause serious injury or death. Make sure that all work is performed by qualified personnel. All cabling to the load must comply with the applicable laws and electrical standards.

Notice: Possibility of equipment damage. Proper sizing is critical to the operation and performance of the generator. Make sure that the load is sized correctly for the capacity of your generator and cables.

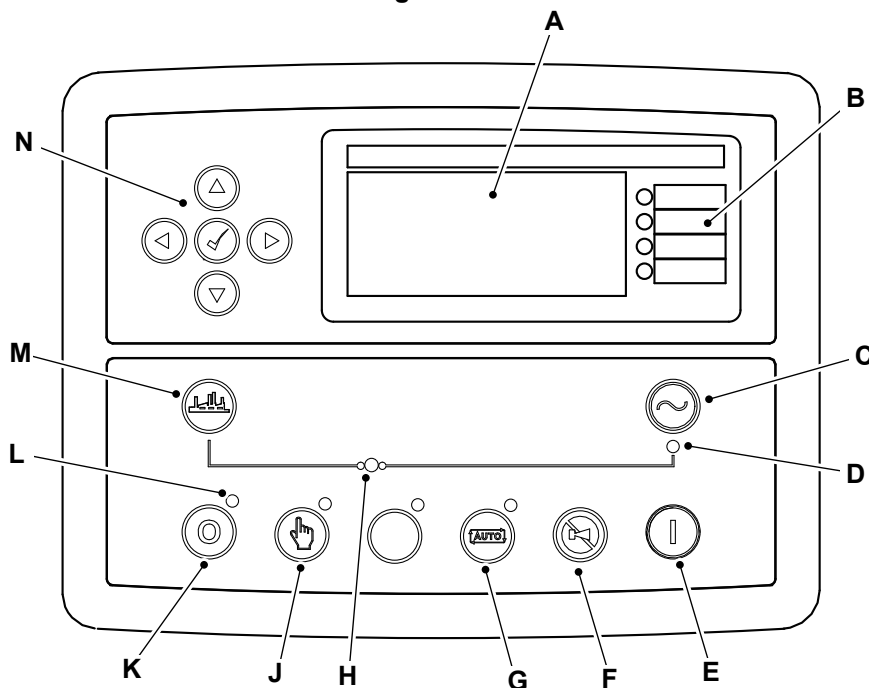
This is the stand alone generator controller. DSE 7310 can not synchronise.

The following description details the sequences followed by a module containing the standard 'factory configuration'. Always refer to your configuration source for the exact sequences and timers observed by any particular module in the field.

Control of the module is via push buttons mounted on the front of the module which need to be operated for the normal operation. Refer to Table 170.

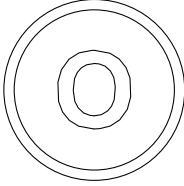
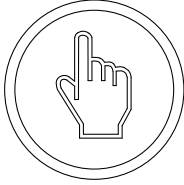
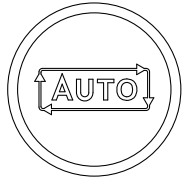
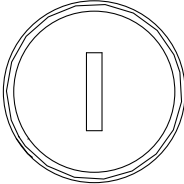
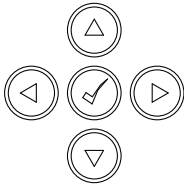
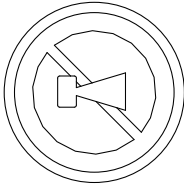
The module may instruct an engine start event due to external influences. Therefore, it is possible for the engine to start at any time without warning when it is set to Auto Mode. Prior to performing any maintenance on the system, it is recommended that steps are taken to remove the battery and isolate supplies.

Figure 437.



- | | |
|---|--|
| A Module display | B Four configurable status LED |
| C Close generator | D Generator available LED |
| E Start button | F Alarm mute and lamp test |
| G Auto mode | H Generator breaker LED (not used) |
| J Manual mode | K Stop/reset button |
| L Selected mode indication LED | M Open generator (manual mode only) |
| N Module display Menu navigation buttons | |

Control Push-Buttons
Table 170. Control panel 7310

	This button places the module into its STOP/RESET mode. This will clear any alarm conditions for which the triggering criteria have been removed. If the engine is running and the module is put into STOP/RESET mode, the module will automatically instruct the generator to unload ('Close Generator output' becomes inactive). In STOP/RESET mode the generator remains at rest.
	This button places the module into its MANUAL mode. Once in MANUAL mode, the module responds to the start button to start the generator and run it off load. The MCCB (Moulded Case Circuit Breaker) need to be closed manually.
	This button places the module into its AUTO MODE. This mode allows the module to control the function of the generator automatically. The module monitors numerous start requests via digital input, PLC and MSC link and when one has been made, the set is automatically started. Once the generator is available, the module automatically instructs the generator to synchronise and once in sync, to be place the generator on load ('Close Generator Output' becomes active). Upon removal of the starting signal, the module starts the Return Delay Timer and once expired, the load is automatically ramped off the generator and then it is taken off load ('Close Generator Output' becomes inactive). The generator then continues to run for the duration of the Cooling Timer until it stops. The module then waits for the next start event.
	This button is only active in the STOP/RESET mode, MANUAL mode. Pressing the Start button in Stop/Reset Mode powers up the engine's ECU (Electronic Control Unit) but does not start the engine. This can be used to check the status of the CAN communication and to prime the fuel system.
	Used for navigating the instrumentation, event log and configuration screens.
	Used to silences the audible alarm in the controller, de-activates the audible alarm output (if configured) and illuminates all of the LED on the module's fascia as a lamp test function.



Notes:



72 - Fasteners and Fixings

Contents	Page No.
72-00 Fasteners and Fixings	
72-00-00 General	72-3
72-03 Screws	
72-03-00 General	72-7
72-06 Bolts	
72-06-00 General	72-11



Notes:



00 - Fasteners and Fixings

Contents

Page No.

72-00-00 General 72-3

00 - General

Introduction

JCB Fasteners (Before September 2017)

Some external fasteners on JCB machines are manufactured using an improved type of corrosion resistant finish. This type of finish is called Dacromet and replaces the original Zinc and Yellow Plating used on earlier machines. The two types of fasteners can be readily identified by colour and part number suffix. Refer to Table 1. Fastener Types.

Table 171.

Fastener Type	Colour	Part Number Suffix
Zinc and Yellow	Golden Finish	Z (e.g. 1315/3712Z)
Dacromet	Mottled Silver Finish	D (e.g. 1315/3712D)

Note: As the Dacromet fasteners have a lower torque setting than the Zinc and Yellow fasteners, the torque figures used must be relevant to the type of fastener.

A Dacromet bolt should not be used in conjunction with a Zinc or Yellow plated nut, as this could change the torque characteristics of the torque setting further. For the same reason, a Dacromet nut should not be used with a Zinc or Yellow plated bolt.

All bolts used on JCB machines are high tensile and must not be replaced by bolts of a lesser tensile specification.

Dacromet bolts, due to their high corrosion resistance are used in areas where rust could occur. Dacromet bolts are only used for external applications. They are not used in applications such as gearbox or engine joint seams or internal applications.

JCB Fasteners (After September 2017)

Table 172.

Fastener Type	Colour	Part Number Suffix
Zinc flake-silver	White aluminium (silver-grey), Dull	D (e.g. 1315/3712D)
Zinc and heavy trivalent passivated with seal	Silver (Bright iridescent)	V (e.g. 1315/3712V)
Zinc Nickel - silver/grey	Dark, dull silver grey	Not assigned

Fastener Type	Colour	Part Number Suffix
Zinc Nickel - black	Black, chalky texture	N (e.g. 1315/3712N)
Zinc flake - black	Black, slight gloss	B (e.g. 1315/3712B)

Torque and Angle Tightening

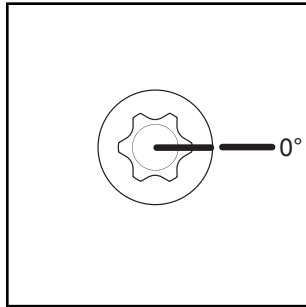
Insufficient pre-load of a bolted joint can cause major problems, such as cylinder head warp, leaking gasket joints etc. There are several methods of achieving an accurate pre-load of a bolted joint, the two main methods used on the JCB engine are:

- Torque Control Tightening - Using a torque meter to control the torque is the most popular means of controlling pre-load, and in the majority of instances this method is adequate. It should be noted that with this process, the majority of the torque is used to overcome friction, therefore slight variations in the frictional conditions can lead to large changes in the bolt pre-load.
- Angle Control Tightening - Where a more precise pre-load is required, the torque and angle tightening method is used. The bolt is tightened to a predetermined torque (this may be done in stages), and then as a final sequence, the bolt is tightened to a predetermined angle - this method of tightening the bolts results in a smaller variation in the final pre-load. It is critical that the predetermined tightening angle is accurately achieved, failure to tighten accurately to the specified angle could result in the bolt pre-load being incorrect - this will lead to eventual failures. It is good practice to replace all bolts that have been tightened using the torque + angle procedure.

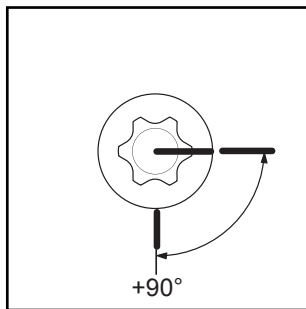
Tightening Method

The following example explains the recommended torque and angle procedure. A torque angle gauge should be used for accuracy, but as a visual check, the bolts can be match marked as described below.

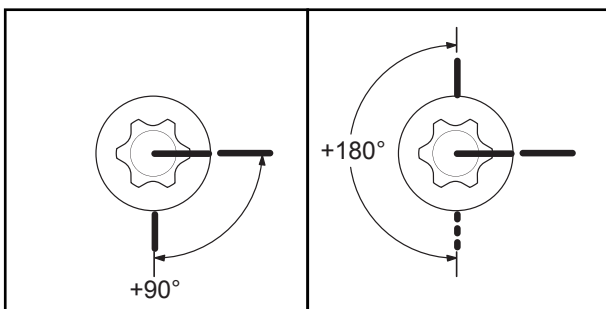
1. Tighten the bolt to the specified torque (specified torque values will be detailed in the relevant PIL sections).
2. Mark a line across the centre of the bolt, and a second line on the part to be clamped - the two lines should be aligned. Refer to Figure 438.

Figure 438.


3. Mark a third line at the specified torque angle - in this instance the additional torque angle is 90° . This line must be marked the specified angle in a clockwise direction (to further tighten the bolt). Refer to Figure 439.

Figure 439.


4. In some instances, angle torque tightening can be specified in two stages, for instance in this example, the first angle quoted is 90° and then a second angle of 180° . The additional 180° angle is from the LAST tightened position. Refer to Figure 440.

Figure 440.


5. Tighten the bolt so that the line on the bolt aligns with the angle(s) marked on the item to be clamped - remember, to ensure complete accuracy an angle gauge should be used.



03 - Screws

Contents

Page No.

72-03-00 General	72-7
------------------------	------



Notes:

00 - General

Introduction	72-7
Technical Data	72-8

Introduction

Use the torque setting tables (Technical Data) only where no torque setting is specified in the text. Note: Dacromet fasteners are lubricated as part of the plating process, do not lubricate. Torque settings are given for the following conditions:

Table 173. Up to September 2017

Type	Condition 1	Condition 2
no coating	Unlubricated fasteners	Zinc flake silver (Dacromet) fasteners.
2 (obsolete from September 2017).	Zinc fasteners	Lubricated zinc and yellow plated fasteners.
3, 4 (obsolete from September 2017).	Yellow plated fasteners	Where there is a natural lubrication. For example, cast iron components.

Table 174. From September 2017

Type	Condition 1	Condition 2
no coating	Unlubricated fasteners	Dacromet) fasteners.
1	Zinc flake - silver	Zinc flake silver (Dacromet) fasteners.
5	Zinc and heavy trivalent with seal	
7	Zinc nickel - silver	
8	Zinc nickel - black	
9	Zinc flake - black	

Technical Data

Table 175. Torque Settings - Internal Hexagon Headed Capscrews (Zinc)

Bolt Size	
mm	N·m
3	2
4	6
5	11
6	19
8	46
10	91
12	159
16	395
18	550
20	770
24	1,332



06 - Bolts

Contents

Page No.

72-06-00 General	72-11
------------------------	-------

00 - General

Introduction 72-11
 Technical Data 72-12

Introduction

Use the torque setting tables (Technical Data) only where no torque setting is specified in the text. Note: Dacromet fasteners are lubricated as part of the plating process, do not lubricate. Torque settings are given for the following conditions:

Table 176. Up to September 2017

Type	Condition 1	Condition 2
no coating	Unlubricated fasteners	Zinc flake silver (Dacromet) fasteners.
2 (obsolete from September 2017).	Zinc fasteners	Lubricated zinc and yellow plated fasteners.
3, 4 (obsolete from September 2017).	Yellow plated fasteners	Where there is a natural lubrication. For example, cast iron components.

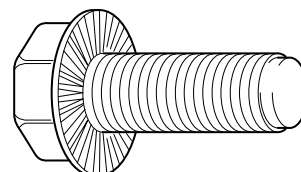
Table 177. From September 2017

Type	Condition 1	Condition 2
no coating	Unlubricated fasteners	Dacromet) fasteners.
1	Zinc flake - silver	Zinc flake silver (Dacromet) fasteners.
5	Zinc and heavy trivalent with seal	
7	Zinc nickel - silver	
8	Zinc nickel - black	
9	Zinc flake - black	

Verbus-Ripp Bolts

Torque settings for these bolts are determined by the application. Refer to the relevant procedure for the required settings.

Figure 441.



Technical Data

From JCB standard STD00019 issue 15.

1. This information does not apply to:-
 - 1.1. Hydraulic fittings (i.e. BSP, SAE O-ring boss, UNF, four bolt split flange and JIC).
 - 1.2. Locking type fasteners (those with a nylon insert, or with distorted thread nuts such as Cleveloc).
2. For information on fastener conditions, refer to fasteners and fixings, bolts, general, introduction.

Table 178. Torque Settings - UNF S Fasteners

Bolt Size	Treads per Inch	Hexa-gon (A/F)	Condition 1	Condition 2
in	in	in	N·m	N·m
(1/4 in)	28	7/16	11.2	10
(5/16 in)	24	1/2	22.3	20
(3/8 in)	24	9/16	40	36
(7/16 in)	20	5/8	64	57
(1/2 in)	20	3/4	98	88
(9/16 in)	18	13/16	140	126
(5/8 in)	18	15/16	196	177
(3/4 in)	16	1 1/8	343	309
(7/8 in)	14	1 15/16	547	492
(1 in)	12	1 1/2	814	732
(1 1/8 in)	12	1 7/8	1,181	1,063
(1 1/4 in)	12	2 1/4	1,646	1,481

Table 179. Torque Settings - UNF X Fasteners

Bolt Size	Treads per Inch	Hexa-gon (A/F)	Condition 1	Condition 2
in	in	in	N·m	N·m
(1/4 in)	28	7/16	17.6	15.9
(5/16 in)	24	1/2	35.2	31.6
(3/8 in)	24	9/16	64	57
(7/16 in)	20	5/8	101	91
(1/2 in)	20	3/4	155	139
(9/16 in)	18	13/16	221	199
(5/8 in)	18	15/16	310	279
(3/4 in)	16	1 1/8	542	488
(7/8 in)	14	1 15/16	864	777
(1 in)	12	1 1/2	1,285	1,156
(1 1/8 in)	12	1 7/8	1,865	1,679
(1 1/4 in)	12	2 1/4	2,598	2,339

Table 180. Torque Settings - Coarse Metric Grade 8.8 Fasteners

Bolt Size	Tread Pitch	Hexa-gon (A/F)	Condition 1	Condition 2
mm	mm	mm	N·m	N·m
4	0.7	7	2.9	2.6
5	0.8	8	5.8	5.2
6	1	10	9.9	9
8	1.25	13	24	22
10	1.5	17	47	43
12	1.75	19	83	74
14	2	22	132	119
16	2	24	205	184
20	2.5	30	400	360
24	3	36	690	621
30	3.5	46	1,372	1,235
36	4	55	2,399	2,159

Table 181. Torque Settings - Coarse Metric Grade 10.9 Fasteners

Bolt Size	Thread Pitch	Hexa-gon (A/F)	Condition 1	Condition 2
mm	mm	mm	N·m	N·m
4	0.7	7	4	3.6
5	0.8	8	8.1	7.3
6	1	10	13.9	12.5
8	1.25	13	34	30
10	1.5	17	67	60
12	1.75	19	116	104
14	2	22	185	167
16	2	24	288	259
20	2.5	30	562	506
24	3	36	971	874
30	3.5	46	1,930	1,737
36	4	55	3,374	3,036

Table 182. Torque Settings - Coarse Metric Grade 12.9 Fasteners

Bolt Size	Thread Pitch	Hexa-gon (A/F)	Condition 1	Condition 2
mm	mm	mm	N·m	N·m
4	0.7	7	4.8	4.4
5	0.8	8	9.8	8.8
6	1	10	16.6	15
8	1.25	13	40	36
10	1.5	17	80	72
12	1.75	19	139	125
14	2	22	223	200
16	2	24	345	311

Bolt Size	Thread Pitch	Hexagon (A/F)	Condition 1	Condition 2
mm	mm	mm	N·m	N·m
20	2.5	30	674	607
24	3	36	1,165	1,048
30	3.5	46	2,316	2,084
36	4	55	4,049	3,644

Table 183. Torque Settings - Rivet Nuts / Bolts

Bolt Size	
mm	N·m
3	1.2
4	3
5	6
6	10
8	24
10	48
12	82



Notes:



75 - Consumable Products

Contents	Page No.
Acronyms Glossary	75-2
75-00 Consumable Products	
75-00-00 General	75-3
75-00-03 Parts List	75-7
75-03 Oil	
75-03-00 General	75-9
75-03-03 Engine	75-10
75-09 Fluids	
75-09-00 General	75-13
75-09-03 Antifreeze	75-14
75-09-12 Diesel Exhaust Fluid (DEF)	75-16
75-18 Fuel	
75-18-00 General	75-19



Acronyms Glossary

DEF	Diesel Exhaust Fluid
SCR	Selective Catalytic Reduction



00 - Consumable Products

Contents	Page No.
75-00-00 General	75-3
75-00-03 Parts List	75-7



Notes:



00 - General

Introduction	75-3
Health and Safety	75-4
Technical Data	75-6

Introduction

JCB recommend that you use the JCB lubricants shown as they have been verified by JCB for use on JCB machines. However, you could use other lubricants that are equivalent to the JCB standards and quality or offer the same machine component protection.

Before you start work, make sure that:

- All safety precautions are observed in accordance with the information contained within the relevant support documentation.
- The consumables are used in accordance with the manufacturer's recommendations.
- The consumables shown are available in the correct quantity.

Consumables other than those listed may be required. It is expected that general consumables will be available in any well equipped workshop or be available locally.

Health and Safety

Oil

Oil is toxic. If you swallow any oil, do not induce vomiting, seek medical advice. Used engine oil contains harmful contaminants which can cause skin cancer. Do not handle used engine oil more than necessary. Always use barrier cream or wear gloves to prevent skin contact. Wash skin contaminated with oil thoroughly in warm soapy water. Do not use petrol, diesel fuel or paraffin to clean your skin.

Fluid Under Pressure

Fine jets of fluid at high pressure can penetrate the skin. Keep face and hands well clear of fluid under pressure and wear personal protective equipment. Hold a piece of cardboard close to suspected leaks and then examine the cardboard for signs of fluid. If fluid penetrates your skin, get medical help immediately.

Fuel

Fuel is flammable, keep naked flames away from the fuel system. Stop the engine immediately if a fuel leak is suspected. Do not smoke while refuelling or working on the fuel system. Do not refuel with the engine running. Completely wipe off any spilt fuel which could cause a fire. There could be a fire and injury if you do not follow these precautions.

Hygiene

JCB lubricants are not a health risk when used correctly for their intended purposes.

However, excessive or prolonged skin contact can remove the natural fats from your skin, causing dryness and irritation.

Low viscosity oils are more likely to do this, so take special care when handling used oils, which might be diluted with fuel contamination.

Whenever you are handling oil products you must maintain good standards of care and personal and plant hygiene. For details of these precautions we advise you to read the relevant publications issued by your local health authority, plus the following.

Storage

Always keep lubricants out of the reach of children.

Never store lubricants in open or unlabelled containers.

Waste Disposal

▲ CAUTION It is illegal to pollute drains, sewers or the ground. Clean up all spilt fluids and/or lubricants.

Used fluids and/or lubricants, filters and contaminated materials must be disposed of in accordance with local regulations. Use authorised waste disposal sites.

CAUTION Damaged or spent batteries and any residue from fires or spillage must be put in a suitable closed receptacle and must be disposed of in accordance with local environmental waste regulations.

All waste products must be disposed of in accordance with all the relevant regulations.

The collection and disposal of used oil must be in accordance with any local regulations. Never pour used engine oil into sewers, drains or on the ground.

Handling

New Oil

There are no special precautions needed for the handling or use of new oil, beside the normal care and hygiene practices.

Used Oil

Used engine crankcase lubricants contain harmful contaminants.

Here are precautions to protect your health when handling used engine oil:

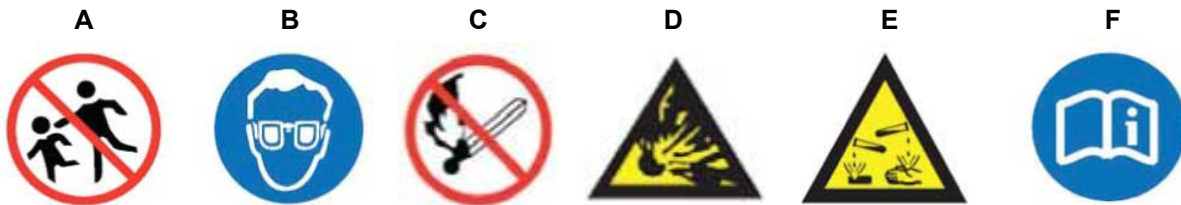
- Avoid prolonged, excessive or repeated skin contact with used oil
- Apply a barrier cream to the skin before handling used oil. Note the following when removing engine oil from skin:
 - Wash your skin thoroughly with soap and water
 - Using a nail brush will help
 - Use special hand cleansers to help clean dirty hands
 - Never use petrol, diesel fuel, or paraffin for washing
- Avoid skin contact with oil soaked clothing
- Don't keep oily rags in pockets
- Wash dirty clothing before re-use
- Throw away oil-soaked shoes

Battery

Warning Symbols

The following warning symbols may be found on the battery.

Figure 442.



- A** Keep away from children
C No smoking, no naked flames, no sparks
E Battery acid

- B** Shield eyes
D Explosive gas
F Note operating instructions

First Aid - Oil

Eyes

In the case of eye contact, flush with water for 15min. If irritation persists, get medical attention.

Swallowing

If oil is swallowed do not induce vomiting. Get medical advice.

Skin

In the case of excessive skin contact, wash with soap and water.

Spillage

Absorb with sand or a locally approved brand of absorbent granules. Scrape up and remove to a chemical disposal area.

Fires

- ▲ WARNING** Do not use water to put out an oil fire. This will only spread it because oil floats on water.
 Extinguish oil and lubricant fires with carbon dioxide, dry chemical or foam.

First Aid - Electrolyte

Eyes

In the case of eye contact, flush with water for 15min. always get medical attention.

Swallowing

Do not induce vomiting. Drink large quantities of water or milk. Then drink milk of magnesia, beaten egg or vegetable oil. Get medical help.

Skin

Flush with water, remove affected clothing. Cover burns with a sterile dressing then get medical help.

First Aid - DEF (if applicable)

Do not drink or inhale DEF (Diesel Exhaust Fluid). If large quantities of DEF have been swallowed a doctor should be called immediately. Do not induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person.

Avoid prolonged or repeated skin contact. After contact with skin wash thoroughly with plenty of soap and water. If irritation develops seek medical advice.

Avoid contact with eyes, skin and clothing. Wear chemical resistant gloves, overalls and safety goggles complying with an approved standard. If in contact with eyes, rinse immediately with plenty of clean water. If irritation occurs seek medical attention. Always wash hands and arms thoroughly after handling before eating, drinking, smoking or using the lavatory.

Technical Data

New engines DO NOT require a running-in period. The engine/machine should be used in a normal work cycle immediately, glazing of the piston cylinder bores, resulting in excessive oil consumption, could occur if the engine is gently run-in. Under no circumstances should the engine be allowed to idle for extended periods; (e.g. warming up without load).

A minimum API CJ-4 grade oil must be used. Superior grade oils may be more appropriate for heavy duty applications (such as sustained high loads and operation at elevated temperatures).

The choice of lubricant viscosity should be made based the lowest ambient temperature at which the machine will be started and the maximum ambient temperature at which it will operate.

The following table provides guidance as to the temperature range that can be accommodated by standard oil viscosities and can be used to select an appropriate grade. Refer to Table 184.

When selecting the oil viscosity grade make sure the oil conforms with or exceeds the recommended specification. Refer to Table 185.

Table 184.

Oil Viscosity	Minimum Temperature °C (°F)	Maximum Temperature °C (°F)
SAE 5W30	-30°C (-22.0°F)	30°C (86.0°F)
SAE 5W40	-30°C (-22.0°F)	46°C (114.7°F)
SAE 10W30	-15°C (5.0°F)	46°C (114.7°F)

Recommended Oils

Table 185. With exhaust after treatment

Engine Oil	Specification
JCB 5W/30 (Part 4001/3100)	CJ-4
JCB 5W/40 (Part 4001/3400)	CJ-4
JCB 10W/30 (Part 4001/3000)	CJ-4

Engine Oil Capacity

Choose the grade of oil to suit the temperature range as detailed. Refer to Table 184.

The engine oil capacity, including filter and clean sump is 11.5L MIN and 14L MAX mark on the dipstick. Refer to Table 186.

Table 186.

Item	Capacity L	
	Minimum	Maximum
Engine	11.5L	14L

DEF System

Table 187.

Item	Specification
DEF filter 'O' rings	deionised/demineralised water or DEF (Diesel Exhaust Fluid)



03 - Parts List



03 - Oil

Contents

Page No.

75-03-00 General	75-9
75-03-03 Engine	75-10

00 - General

Introduction

New Oil

There are no special precautions needed for the handling or use of new oil, besides the normal health and safety practices mentioned in the relevant section of this service manual.

Used Oil

Used engine crankcase lubricants contain harmful contaminants. Here are precautions to protect your health when handling used engine oil:

1. Avoid prolonged, excessive or repeated skin contact with used oil.
2. Apply a barrier cream to the skin before handling used oil.
3. Note the following when removing engine oil from skin:
 - 3.1. Wash your skin thoroughly with soap and water.
 - 3.2. Using a nail brush will help.
 - 3.3. Use special hand cleansers to help clean dirty hands.
 - 3.4. Never use petrol, diesel fuel, or paraffin for washing.
4. Avoid skin contact with oil soaked clothing.
5. Don't keep oily rags in pockets.
6. Wash dirty clothing before re-use.
7. Throw away oil-soaked shoes.

First Aid

EYES - In the case of eye contact, flush with water for 15 minutes. If irritation persists, get medical attention.

SWALLOWING - If oil is swallowed do not induce vomiting. Get medical advice.

SKIN - In the case of excessive skin contact, wash with soap and water.

SPILLAGE - Absorb on sand or a locally approved brand of absorbent granules. Scrape up and remove to a chemical disposal area.

FIRES - Extinguish with carbon dioxide, dry chemical or foam. Firefighters should use self-contained breathing apparatus.



03 - Engine

Introduction 75-10
Technical Data 75-11

Introduction

New engines DO NOT require a running-in period. The engine/machine should be used in a normal work cycle immediately, glazing of the piston cylinder bores, resulting in excessive oil consumption, could occur if the engine is gently run-in. Under no circumstances should the engine be allowed to idle for extended periods; (e.g. warming up without load).

The choice of lubricant viscosity should be made based on the lowest ambient temperature at which the machine will be started and the maximum ambient temperature at which it will operate.

The technical data section provides guidance as to the temperature range that can be accommodated by standard oil viscosities and can be used to select an appropriate grade.

When selecting the oil viscosity grade, make sure that the oil conforms with or exceeds the recommended specification.

Technical Data
Table 188.

Engine Code	Oil API Specification	Viscosity	Minimum Temperature °C (°F)	Maximum Temperature °C (°F)
SA, SB, SC, SK, SG, SD, SE, SF, DA, DB, DC, DE, DG, DD, DK, DF, DR, EC, EE, EF, EK	CF/ CH-4	SAE 5W30	-30°C (-22.0°F)	30°C (86.0°F)
	CH-4	SAE 15W40	-5°C (23.0°F)	50°C (121.9°F)
	CH-4	SAE 10W40	-15°C (5.0°F)	46°C (114.7°F)
	CH-4	SAE 5W40	-30°C (-22.0°F)	46°C (114.7°F)

Table 189.

Engine Code	Oil API Specification	Viscosity	Minimum Temperature °C (°F)	Maximum Temperature °C (°F)
SL, SH, DH, DM, SM	CH-4	SAE 5W40	-30°C (-22.0°F)	46°C (114.7°F)
	CJ-4	SAE 5W40	-30°C (-22.0°F)	46°C (114.7°F)
	CH-4	SAE 15W40	-5°C (23.0°F)	50°C (121.9°F)

Table 190.

Engine Code	Oil API Specification	Viscosity	Minimum Temperature °C (°F)	Maximum Temperature °C (°F)
SJ, DJ, DP, FL, FN	CJ-4	SAE 5W40	-30°C (-22.0°F)	46°C (114.7°F)
	CJ-4	SAE 5W30	-30°C (-22.0°F)	30°C (86.0°F)
	CJ-4	SAE 10W30	-15°C (5.0°F)	46°C (114.7°F)

Table 191.

Engine Code	Oil API Specification	Viscosity	Minimum Temperature °C (°F)	Maximum Temperature °C (°F)
SS	CI-4+	SAE 15W40	-10°C (14.0°F)	50°C (121.9°F)
ST, DT, KG	CK-4	SAE 10W30	15°C (59.0°F)	46°C (114.7°F)

Table 192. Capacity

Engine Code	Minimum	Maximum
SA, SB, SC, SK, SG, SD, SE, SF, DA, DB, DC, DE, DG, DD, DK, DF, DR, SL, SH, SM, DH, SJ, SS, ST, DJ, DM, DP, DT	11.5L	14L
EC, EE, EF, EK	20L	24L
FL, FN	12.3L	14.5L
SS, ST, DT, KG	12L	15L



09 - Fluids

Contents	Page No.
75-09-00 General	75-13
75-09-03 Antifreeze	75-14
75-09-12 Diesel Exhaust Fluid (DEF)	75-16

00 - General

Introduction

It is most important that you read and understand this information and the publications referred to. Make sure all your colleagues who are concerned with lubricants read it too.

Hygiene

JCB lubricants are not a health risk when used properly for their intended purposes.

However, excessive or prolonged skin contact can remove the natural fats from your skin, causing dryness and irritation.

Low viscosity oils are more likely to do this, so take special care when handling used oils, which might be diluted with fuel contamination.

Whenever you are handling oil products you should maintain good standards of care and personal and plant hygiene. For details of these precautions we advise you to read the relevant publications issued by your local health authority, plus the following.

Storage

Always keep lubricants out of the reach of children. Never store lubricants in open or unlabelled containers.

Waste Disposal

All waste products should be disposed of in accordance with all the relevant regulations.

The collection and disposal of used oil should be in accordance with any local regulations. Never pour used engine oil into sewers, drains or on the ground.



03 - Antifreeze

Introduction 75-14
 Health and Safety 75-15

Introduction

Coolant Mixtures

Check the strength of the coolant mixture at least once a year, preferably at the start of the cold period. Do not use solutions of more than 60% or damage to the engine may occur. Replace the coolant mixture according to the intervals shown in the machine's maintenance schedule.

You must dilute full strength antifreeze with clean water before use. Use clean water of no more than a moderate hardness (pH value 8.5). If this cannot be obtained, use de-ionized water. For further information advice on water hardness, contact your local water authority.

The correct concentration of antifreeze protects the engine against frost damage in winter and provides year round protection against corrosion. Always renew the antifreeze every two years.

The protection provided by High Performance Antifreeze and Inhibitor is shown below. If any other antifreeze is used, refer to the manufacturer's instructions and make sure that a corrosion inhibitor is included.

Table 193.

Solution	Maintains circulation down to:	Protects against damage down to:
50% Concentration (Standard)	-33°C (-27.4°F)	-40°C (-39.9°F)
60% Concentration (Standard)	-42°C (-43.5°F)	-56°C (-68.7°F)

Important: Do not exceed a 60% concentration, as the freezing protection provided reduces beyond this point.

If you use any other brand of antifreeze:

- Make sure that the antifreeze complies with International Specification ASTM D6210.
- Always read and understand the manufacturer's instructions.
- Make sure that a corrosion inhibitor is included. Serious damage to the cooling system can occur if corrosion inhibitors are not used.
- Make sure that the antifreeze is ethylene glycol based and does not use Organic Acid Technology (OAT).

Health and Safety

▲ **CAUTION** The cooling system is pressurised when the coolant is hot. When you remove the cap, hot coolant can spray out and burn you. Make sure that the engine is cool before you work on the cooling system.

CAUTION Antifreeze can be harmful. Obey the manufacturer's instructions when handling full strength or diluted antifreeze.



12 - Diesel Exhaust Fluid (DEF)

[Introduction](#) 75-16
[Health and Safety](#) 75-17

Introduction

Details of the DEF (Diesel Exhaust Fluid) are given in the Fuel and Exhaust System section. Refer to (PIL 18-30-00).

Health and Safety

Diesel Exhaust Fluid (DEF)

If large quantities of DEF have been swallowed a doctor should be called immediately. Do not induce vomiting unless directed to do so by medical personnel. Never give anything by mouth to an unconscious person. Avoid prolonged or repeated skin contact. After contact with skin wash thoroughly with plenty of soap and water. If irritation develops seek medical advice. Avoid contact with eyes, skin and clothing. Wear chemical resistant gloves, overalls and safety goggles complying with an approved standard. If in contact with eyes, rinse immediately with plenty of clean water. If irritation occurs seek medical attention. Always wash hands and arms thoroughly after handling before eating, drinking, smoking or using the lavatory. DEF is corrosive to some metals such as copper and its alloys. Use only recommended storage and dispensing systems. DEF solution is very polluting to surface water and groundwater. DEF may not be removed by oil separators so it is important to isolate drainage from the dispensing area to prevent pollution in the event of a spill. Store below 30 degrees C in a segregated, approved and labelled area. Keep container closed.

Notice: *No warranty liability whatsoever will be accepted for failure of the emissions control system where the failure is attributed to the quality and grade of the diesel exhaust fluid (DEF) used.*

Notice: *No warranty liability whatsoever will be accepted for failure of the emissions control system where the failure is attributed to contamination of the diesel exhaust fluid (DEF).*



18 - Fuel

Contents

Page No.

75-18-00 General	75-19
------------------------	-------

00 - General

Introduction 75-19
Health and Safety 75-22

Introduction

Acceptable and Unacceptable Fuels

▲ WARNING Do not use petrol in this machine. Do not mix petrol with the diesel fuel. In storage tanks the petrol will form flammable vapours.

Notice: No warranty liability whatsoever will be accepted for failure of fuel injection equipment where the failure is attributed to the quality and grade of the fuel used.

Notice: Sulphur can be detrimental to the emissions performance of your engine and it is in your interest to ensure Ultra Low Sulphur Diesel (ULSD) is used. Failure to adhere to local emissions regulations will result in no support and no warranty liability being accepted on any engine.

Fuel Groups

The major world fuels standards are divided into four categories. Those that are fully accepted as suitable fuels, those that are acceptable from a "warranty" point of view, but may have undesirable affects on the expected life of the engine performance, those that will reduce the expected life, and lastly those that are viewed as unacceptable for use (fuels shown on the same line as each other are considered equivalents).

The lists below are not exhaustive of all diesel fuel standards encountered in the marketplace. If comment is required on the suitability of fuel standards not on the list, requests with, if possible, specification details showing at least the key characteristics described above should be forwarded to JCB Service for assessment and comment.

Table 194. Group 1

Fuel	Advice	Service Requirements
EN590 Diesel fuel types - Auto/C0/C1/C2/C3/C4 Sulphur < 10ppm.	Preferred and may be used with no restrictions or conditions.	For fuel with unspecified parameters, EN590 values apply. Fuel grades within each standard must be appropriate to the ambient temperature. The appropriate level of fuel cleanliness at the FIE inlet after filtration has to be ensured by the customer.
BS2869 Class A2 Sulphur < 10ppm		
ASTM D975-076 2-D, US DF1, US DF2, US DFA Sulphur < 15ppm		
JIS K2204 Grades 1, 2, 3 and Special Grade 3 Sulphur < 10ppm		

Table 195. Group 2

Fuel	Advice	Service Requirements
Group1 fuels with HFFR WSD in the range 460 to 520	Not preferred and may be used but may lead to reduced FIE life and / or loss of performance.	
ASTM D975-91 Class 1-1DA		

(1) See your JCB dealer for advice on service requirements.

Table 196. Group 3

Fuel	Advice
AVTUR FS11 (NATO F34, JP8, MIL T83133, DEF STAN 91-87, DERD 2463)	Not preferred and may be used only with appropriate additives and will lead to reduced FIE life and / or loss of performance.
AVCAT FS11 (NATO F44, JP5, MIL T5624, DERD 2452, AVTOR))	
JET A1 (NATO F35, DEF STAN 91-91, DERD 2494)	
AVCAT (NATO F43, JP5 without additives)	
JET A (ASTM D1655)	
ASTM D3699 Kerosene	
JP7 (MIL T38219 XF63)	
NATO F63	

Table 197. Group 4

Fuel	Advice
Unmodified Vegetable Oils and Biodiesels over 20% concentration	Unacceptable

Additives

The additives listed below are advertised as being suitable for bringing the lubricity levels of kerosene/ low sulphur fuels up to those of diesel fuels.

These products are given as examples only. The information is derived from the manufacturers data. The products are not recommended or endorsed by JCB. Contact your JCB dealer for further advice.

- Elf 2S 1750. Dosage 1000-1500 ppm (0.1% to 0.15%), specifically for Indian Superior Kerosene (SKO) but may be applicable to other fuels.
- Lubrizol 539N. Dosage (on Swedish low sulphur fuel) 250 ppm.
- Paradyne 7505 (from Infineum). Dosage 500 ppm (0.05%).

Warranty

JCB have shown a commitment to support the environment by approving the use of biodiesel blended fuels.

Using a B5 blend of biodiesel requires caution and additional servicing of the engine is required.

Failure to follow the additional recommended service requirements may lead to a warranty claim being declined.

Failures resulting by the incorrect use of biodiesels or other fuel additives are not defects of the engine workmanship and therefore will not be supported by JCB Warranty.

Usage and Effects of Fuels

The information that follows indicates types of fuel that are acceptable or unacceptable.

Acceptable Fuels

Ultra Low Sulphur Diesel (EN590)

Available throughout the UK, Europe and North America since March 1999. This fuel has a maximum sulphur content of 0.001% (0.0015% in North America) by weight and a further reduction in the natural lubricity and aromatic content than experienced with low sulphur diesel. Major oil producers will add lubrication improvers and also maintain the total aromatic content to an acceptable level.

Unacceptable Fuels

B20 Biodiesel

Biodiesel refers to pure fuel before it is blended with diesel fuel. When biodiesel is blended with diesel fuel it is referred to as B5, B20 etc., where the number indicates the percentage of biodiesel in the fuel, for example B5 contains 5% biodiesel.

Biodiesel has different characteristics than mineral based fuels, this could lead to seals swelling, fuel system corrosion and seal damage.

Using B20 biodiesel can result in poisoning of the SCR (Selective Catalytic Reduction) system.

The natural properties of biodiesel make it a good medium for micro bacterial growth, these microbes

can cause fuel system corrosion and early fuel filter blocking.

B100 - Chemically Modified Vegetable Oils (FAME/ VOME)

These fuels have been derived from a wide range of vegetable oils and animal fats, resulting in better stability, viscosity and cetane number than those produced from unmodified vegetable oils, but it is recognised that there are potential problems associated with the finished fuel characteristics. These oils are less stable than mineral oil derived fuels when stored and they will readily degrade producing fatty acids, methanol and water, none of which are desirable in the FIE. These effects are known to be accelerated when the fuel is stored in the presence of air and water together.

An extract 'common statement' from the FIE manufactures specifies that "The fuel injection equipment manufacturers can accept no liability whatsoever for failure attributable to operating their products with fuels for which the products were not designed, and no warranties or representations are made as to the possible effects of running these products with such fuels".

Unmodified Vegetable Oils

Burned in diesel engines neat or used as an extender to mineral derived fuel. When these are subjected to heat in the fuel injection system they form sticky deposits that can be found inside the fuel pump and a hard lacquer in the injectors where exposure to even higher temperatures takes place.

Sulphur Content

▲ Notice: A combination of water and Sulphur will have a corrosive chemical effect on fuel injection equipment. Use of high Sulphur fuels will poison the Selective Catalytic Reduction (SCR) catalyst (if fitted) and must not be used. Ultra Low Sulphur Diesel (ULSD) should always be used. Ultra Low Sulphur Diesel (ULSD) has a Sulphur content of less than 10 ppm (US 15ppm).

Effects of Fuel Contaminates

The effect of dirt, water and other contaminants in diesel can be disastrous for injection equipment:

Dirt

A severely damaging contaminant. Finely machined and mated surfaces such as delivery valves and distributor rotors are susceptible to the abrasive nature of dirt particles - increased wear will almost inevitably lead to greater leakage, uneven running and poor fuel delivery.

Water

Water can enter fuel through poor storage or careless handling, and will almost inevitably condense in fuel tanks. The smallest amounts of water can result in effects that are just as disastrous to the fuel injection pump as dirt, causing rapid wear, corrosion and in severe cases, even seizure. It is vitally important that water is prevented from reaching the fuel injection equipment. The filter/water trap must be drained regularly.

Wax

Wax is precipitated from diesel when the ambient temperature falls below that of the fuel's cloud point, causing a restriction in fuel flow resulting in rough engine running. Special winter fuels may be available for engine operation at temperatures below 0°C (32.0°F). These fuels have a lower viscosity and limit wax formation.

Chemical Contamination

It should be noted that exposure of fuel to surfaces containing Copper (Cu), Zinc (Zn) or Lead (Pb) can adversely affect fuel quality and should be minimised.

JCB Power Systems - Use of HVO Fuels

Following market requests from JCB power systems customers to approve the use of HVO (hydro-treated vegetable oil) fuel as a diesel fuel alternative in JCB engines. JCB power systems have carried out extensive testing to make sure that this has no detrimental effect on the performance and reliability of the JCB engine.

JCB power systems confirm that HVO has been tested and approved for use with JCB 444 and 448, stage IIIB and stage IV engines. The testing has been conducted by JCB power systems and this approval does not constitute any recertification of any engine model by any third party notified body.

The JCB 444/448 engines can be operated on HVO or 'synthetic' fuels as long as these fuels meet EN15940 and any other local emissions legislation. Customers should note that engine performance may be lower than regular diesel due to the characteristics of HVO fuel. Customers make sure that any additional maintenance requirements, including but not limited to servicing periods, are identified to users.

Health and Safety

Fuel

Fuel is flammable, keep naked flames away from the fuel system. Stop the engine immediately if a fuel leak is suspected. Do not smoke while refuelling or working on the fuel system. Do not refuel with the engine running. Completely wipe off any spilt fuel which could cause a fire. There could be a fire and injury if you do not follow these precautions.

WARNING! *Do not use petrol in this machine. Do not mix petrol with the diesel fuel. In storage tanks the petrol will form flammable vapours.*



78 - After Sales

Contents	Page No.
Acronyms Glossary	78-2
78-24 Maintenance Schedules	
78-24-00 General	78-3
78-24-03 Maintenance Intervals	78-4
78-24-06 Pre-start Cold Checks, Service Points and Fluid Levels	78-5
78-81 Clothing and Personal Protective Equipment (PPE)	
78-81-00 General	78-9
78-93 Special Tools	
78-93-00 General	78-11
78-93-03 Parts List	78-12
78-96 Units of Measurement	
78-96-00 General	78-29



Acronyms Glossary

CCV	Crankcase Ventilation
DEF	Diesel Exhaust Fluid
FEAD	Front End Accessory Drive



24 - Maintenance Schedules

Contents	Page No.
78-24-00 General	78-3
78-24-03 Maintenance Intervals	78-4
78-24-06 Pre-start Cold Checks, Service Points and Fluid Levels	78-5

00 - General

Introduction

The schedules show the service tasks which must be done and their intervals.

The services must be done at either the hourly interval or the calendar equivalent, whichever occurs first.

The intervals given in the schedules must not be exceeded. If the machine is operated under severe conditions (high temperature, dust, water, etc.) shorten the intervals.

Table 198.

○	Service task can be completed by a competent operator. Details of how to complete the service task are given in the Operator's Manual.
□	We recommend that a Service Engineer completes the service task. Details of how to complete the service task are given in the Service Manual.



03 - Maintenance Intervals

Introduction

General

Table 199.

Interval (h)	Calendar Equivalent
10	Daily
50	Weekly
500	6 months
1000	Yearly
2000	2 Years
8000	8 Years



06 - Pre-start Cold Checks, Service Points and Fluid Levels

Introduction

Table 200.

Component	Task	10	50	500	1000	1500	2000	8000
Overall Machine								
Visual Inspection	Overall visual check	○	○	□	□	□	□	□
Control Panel	Check operation	○	○	□	□	□	□	□
Safety Decals	Check condition	○	○	□	□	□	□	□
Emergency Stop Switches	Check operation	○	○	□	□	□	□	□
Earth Leakage RCD and MCB ⁽¹⁾	Check operation		○	□	□	□	□	□
External Power Socket Box ⁽²⁾	Check condition		○	□	□	□	□	□
Battery Terminals and Voltage	Check			□	□	□	□	□
Control Panel Events History	Check			□	□	□	□	□
Bus Bar Cover Safety Switch	Check operation			□	□	□	□	□
Alternator and Engine Mounting Bolts	Check security			□	□	□	□	□
Bus Bar Terminals	Check security			□	□	□	□	□
Machine Earth Connections	Check condition			□	□	□	□	□
Engine and Controller Harness	Check condition and connections			□	□	□	□	□
Load Test (as per usage and applications) ⁽⁶⁾	Load Test @ 75% of maximum load							□
Engine								
Oil Level	Check	○	○	□	□	□	□	□
Coolant Quality and Level	Check	○	○	□	□	□	□	□
Coolant or Oil Leaks	Check	○	○	□	□	□	□	□
Water Sedimenter	Check for Contamination and Drain		○	□	□	□	□	□
Fuel Filters	Change			□	□	□	□	□
Oil and Filter ⁽⁴⁾	Change			□	□	□	□	□
All Hoses - Condition	Check			□	□	□	□	□
Radiator ⁽⁵⁾	Clean			□	□	□	□	□
FEAD (Front End Accessory Drive) Drive Belt Condition	Check			□	□	□	□	□



Component	Task	10	50	500	1000	1500	2000	8000
Air Cleaner Outer Element ⁽⁵⁾	Change				<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>
DEF (Diesel Exhaust Fluid) Filter ^(1, 7)	Change				<input type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>
CCV (Crankcase Ventilation) Filter	Change					<input type="checkbox"/>		
Air Cleaner Inner Element	Change						<input type="checkbox"/>	<input type="checkbox"/>
Valve Clearances ⁽⁶⁾	Check and Adjust						<input type="checkbox"/>	<input type="checkbox"/>
Oil Filler and Dipstick O-rings	Change						<input type="checkbox"/>	<input type="checkbox"/>
Cooling System	Drain and Fill						<input type="checkbox"/>	<input type="checkbox"/>
FEAD Belt	Change							<input type="checkbox"/>
Injectors ⁽⁶⁾	Change							<input type="checkbox"/>
Injectors Leak-Off Rail ⁽⁶⁾	Change							<input type="checkbox"/>
High Pressure Fuel Lines ⁽⁶⁾	Change							<input type="checkbox"/>
Main Alternator								
Generator Alternator cables ⁽³⁾	Check condition			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Generator Alternator Terminals	Check security			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Trailer								
Wheel nut torque	Check condition		○	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Brakes	Check operation	○	○	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

- (1) If installed.
- (2) Check seals and O-rings are in place, check covers close securely. Replace if there is any sign of wear.
- (3) Replace if there is any sign of wear.
- (4) If operating under arduous conditions, do an engine oil flush (use the normal recommended engine oil) every 250 hours. Change the engine oil and filter every 250 hours.
- (5) If operating in dusty adverse working environments, do these jobs more frequently.
- (6) These jobs must be done by a qualified engineer.
- (7) Change DEF filter more regularly under arduous conditions.
- (8) Annual check or 8000hrs, whichever first.

Table 201.

Component	Task	10	50	250 or 3,000 Miles	500 or 6,000 Miles	1000 or 12,000 Miles
Wheel nut torque ⁽¹⁾	Check condition	○	○	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Wheels	Check condition	○	○	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Tire inflation pressure	Check condition	○	○	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Tyres	Check condition	○	○	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Brakes	Check operation	○	○	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Trailer light	Check operation	○	○	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Breakaway system (battery charge and switch operation)	Check condition/operation	○	○	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Brakes adjustment	Check operation			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>



Component	Task	10	50	250 or 3,000 Miles	500 or 6,000 Miles	1000 or 12,000 Miles
Suspension parts (bending, loose fasteners, wear)	Check condition			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Brake magnets	Check operation				<input type="checkbox"/>	<input type="checkbox"/>
Electric brake controller	Check operation				<input type="checkbox"/>	<input type="checkbox"/>
Brake linings (wear)	Check condition					<input type="checkbox"/>
Hub/Drum (wear/scoring)	Check condition					<input type="checkbox"/>
Hydraulic brake cylinders (leaks, sticking)	Check condition/operation					<input type="checkbox"/>
Hydraulic brake hoses (cracks, leaks and kinks)	Check condition					<input type="checkbox"/>
E-Z Lube axles, wheel bearing and cups (corrosion or wear)	Check condition					<input type="checkbox"/>
E-Z Lube axles. Grease gun - pump until new grease displaces the old grease	Grease					<input type="checkbox"/>
Seals	Check condition					<input type="checkbox"/>
Springs (wear, cracked, loss of arch)	Check condition					<input type="checkbox"/>
Hangers (welds)	Check condition					<input type="checkbox"/>

(1) On first trip tighten wheel lugs at start and at 10, 25 and 50 miles. Thereafter, check wheel lugs before each trip, after excessive braking and following long periods of non-use.



81 - Clothing and Personal Protective Equipment (PPE)

Contents

Page No.

78-81-00 General	78-9
------------------------	------



00 - General

Introduction

Do not wear loose clothing or jewellery that can get caught on controls or moving parts. Wear protective clothing and personal safety equipment issued or called for by the job conditions, local regulations or as specified by your employer.



93 - Special Tools

Contents	Page No.
78-93-00 General	78-11
78-93-03 Parts List	78-12

00 - General

Introduction

The tools shown are the special tools required for completing the procedures described in this manual. These tools are available from JCB Service or in some instances can be manufactured locally.

The tools are divided into three categories:

- Special Tool = Only available from JCB.
- Recommended Tool = Available from JCB but other tool manufacturers/suppliers may offer a tool with the same characteristics.
- General Tool = A tool which is widely available.

Tools other than those listed will be required. It is expected that such general tools will be available in any well equipped workshop or be available locally from any good tool supplier.

Before you start work, make sure that all safety precautions are observed in accordance with the information contained within the relevant support documentation.

03 - Parts List

Introduction

Introduction 78-12
 Component Identification 78-15

15 - Engine

Tool Category	Part No.	Description	Qty.	Comments
Special Tool	320/09062	Front Lifting Eye	1	
Special Tool	320/09063	Rear Lifting Eye	1	
Special Tool	320/B0656	Crankshaft Rear Oil Seal Installation Tool (new type)	1	
Special Tool	892/00278	Pressure Gauge (0-40 Bar)	1	
Special Tool	892/00292	Oil Filter Removal Tool	1	
Special Tool	892/01147	Crankshaft Turning Tool (95.25mm PCD)- JCB 4 Cylinder Ecomax and Dieselmax	1	
Special Tool	892/01148	Crankshaft / Camshaft Timing Pin (444/448/672 Engine)	2	
Special Tool	892/01149	Template for Sealant Oil Sump - Pressed	1	
Special Tool	892/01150	Oil Sump Location Dowel	2	
Special Tool	892/01152	Valve Stem Seal Installation Tool (444/448/672 Engine)	1	
Special Tool	892/01156	Crankshaft Rear Oil Seal Installation Tool (old type)	1	
Special Tool	892/01157	Crankshaft Front Oil Seal Installation Tool	1	
Special Tool	892/01158	Crankshaft Rear Oil Seal Alignment Tool	1	
Special Tool	892/01174 728/H5409	Data Link Adaptor (DLA) Kit Data Link Adaptor (DLA 2.0) Kit	1	Unless otherwise stated, you can use any of the tools shown.
Special Tool	892/01176	Template for Sealant Gear Case to Cylinder Block (4 Cyl and 6 Cyl Elec)	1	
Special Tool	892/01380	Valve Clearance Service Kit	1	
Special Tool	892/01382	Engine Lifting Spreader Bar	1	
Special Tool	892/12347	Dummy Injector	1	
Special Tool	892/12349	Template for Sealant Flywheel Housing to Gear Case (4 Cyl Elec)	1	
Recommended Tool	892/12351	Deep Socket	1	

Tool Category	Part No.	Description	Qty.	Comments
Special Tool	892/12354	Template for Sealant Oil Sump (Cast)	1	
Special Tool	892/12356	Template for Sealant Bedplate to Crankcase (4 Cyl)	1	
Special Tool	892/12359	Fuel Injection Equipment Cap Kit (444/448 T4i/T4F/BS4/STV Engine)	1	
General Tool	993/70111	Torque Wrench (10-100Nm)	1	
Special Tool	998/11051	Digital Hydraulic Pressure Test Kit	1	

18 - Fuel and Exhaust System

Tool Category	Part No.	Description	Qty.	Comments
Special Tool	320/00925	C-Shaped Ring Spanner	1	
Special Tool	892/01147	Crankshaft Turning Tool (95.25mm PCD)- JCB 4 Cylinder Ecomax and Dieselmex	1	
Special Tool	892/01148	Crankshaft / Camshaft Timing Pin (444/448/672 Engine)	1	
Special Tool	892/01154	Tamper proof Cover Removal Tool	1	
Special Tool	892/01155	Pump Gear Removal Tool	1	
Special Tool	892/01174 728/H5409	Data Link Adaptor (DLA) Kit Data Link Adaptor (DLA 2.0) Kit	1	Unless otherwise stated, you can use any of the tools shown.
Recommended Tool	892/01267	Socket 17MM Offset - (HP Fuel pipes)	1	
Special Tool	892/12346	Injector Seal Installation Tool (Electronic Engine)	1	
Special Tool	892/12350	Injector Leak-off Test Kit ((Electronic Engine))	1	
Special Tool	892/12359	Fuel Injection Equipment Cap Kit (444/448 T4i/T4F/BS4/STV Engine)	1	
General Tool	993/70111	Torque Wrench (10-100Nm)	1	

33 - Electrical System

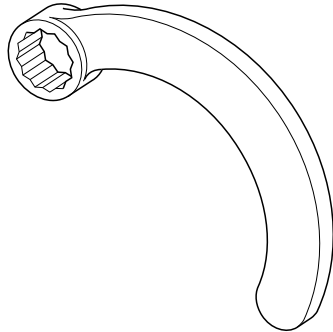
Tool Category	Part No.	Description	Qty.	Comments
General Tool	400/G9956	Battery Tester	1	
General Tool	892/00349	Wiring Crimp Tool	1	



Tool Category	Part No.	Description	Qty.	Comments
Special Tool	892/01174 728/H5409	Data Link Adaptor (DLA) Kit Data Link Adaptor (DLA 2.0) Kit	1	Unless otherwise stated, you can use any of the tools shown.

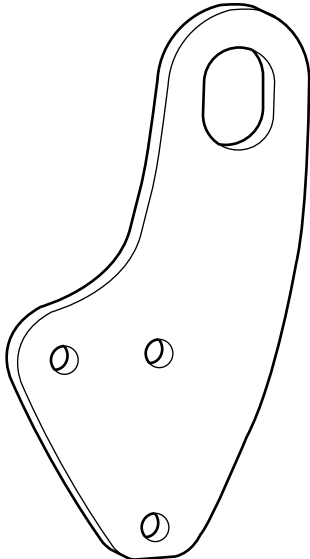
Component Identification

Special Tool - 320/00925 - C-Shaped Ring Spanner

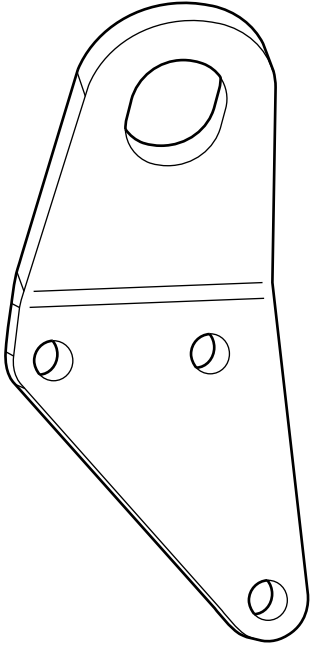


Use to access the inner mounting nut of the fuel injection pump.

Special Tool - 320/09062 - Front Lifting Eye

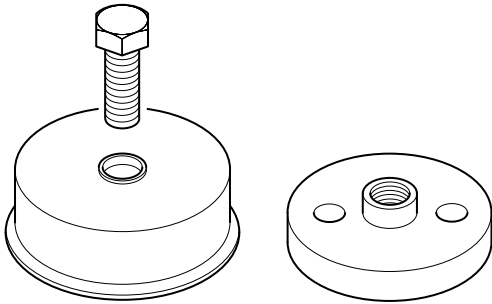


Special Tool - 320/09063 - Rear Lifting Eye



Special Tool - 320/B0656 - Crankshaft Rear Oil Seal Installation Tool (new type)

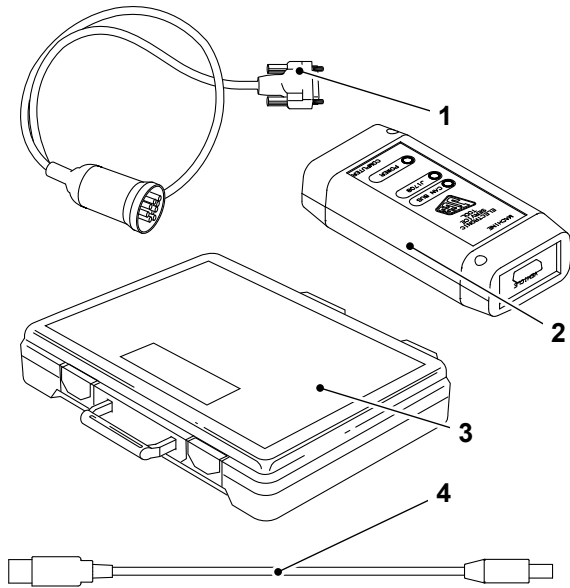
Use to correctly install the crankshaft rear oil seal.



General Tool - 400/G9956 - Battery Tester

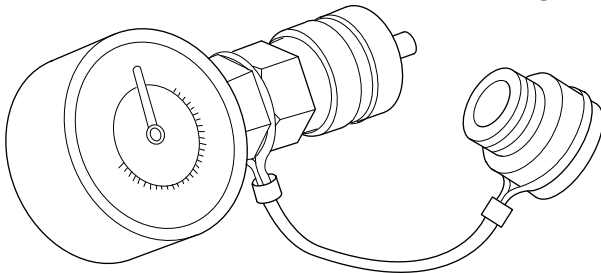


Special Tool - 728/H5409 - Data Link Adaptor (DLA 2.0) Kit



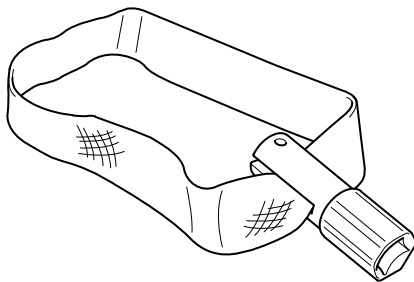
Item	Part No.	Description	Qty.
1		Interconnecting cable, DLA to machine ECU diagnostics socket.	1
2		Data Link Adaptor (DLA 2.0), enables data exchange between the machine ECU (Electronic Control Unit) and a laptop PC loaded with the applicable diagnostics software.	1
3		Kit carrying case.	1
4		Interconnecting cable, DLA to laptop PC.	1

Special Tool - 892/00278 - Pressure Gauge (0-40 Bar)

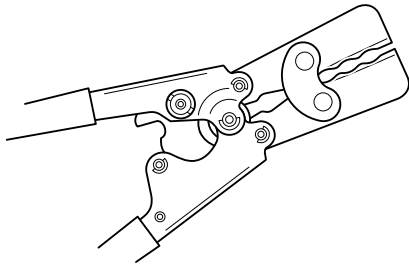


Special Tool - 892/00292 - Oil Filter Removal Tool

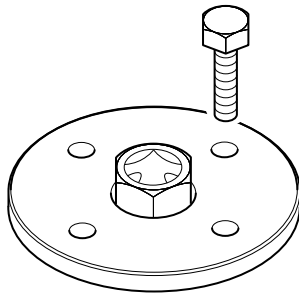
Use to remove and install spin-on filter canister.



General Tool - 892/00349 - Wiring Crimp Tool

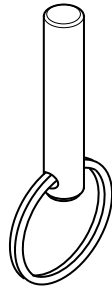


Special Tool - 892/01147 - Crankshaft Turning Tool (95.25mm PCD)- JCB 4 Cylinder Ecomax and Dieselmax



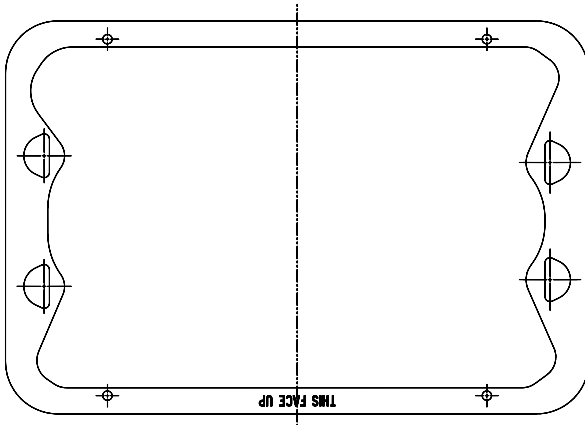
Use to manually turn the crankshaft, for instance when setting top dead centre (TDC). 4 x mounting holes to suit crankshaft pulley.

Special Tool - 892/01148 - Crankshaft / Camshaft Timing Pin (444/448/672 Engine)



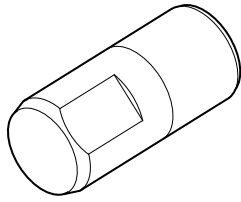
1. Use to correctly align the crankshaft at top dead centre (TDC). 2. Use to align the camshaft in the correct timed position when removing/fitting the fuel injection pump.

Special Tool - 892/01149 - Template for Sealant Oil Sump - Pressed



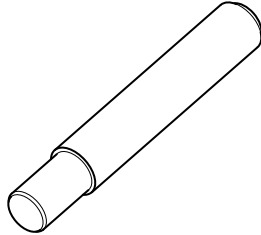
Use to ensure correct sealant application, correct positioning of the sealant is critical to prevent leaks.

Special Tool - 892/01150 - Oil Sump Location Dowel



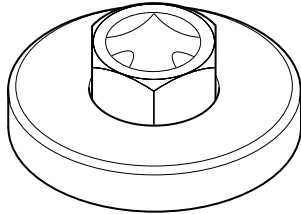
Use to correctly align the sump, prevent sump movement during fitting, correct positioning of the sump is critical to ensure a good joint and prevent leaks.

Special Tool - 892/01152 - Valve Stem Seal Installation Tool (444/448/672 Engine)



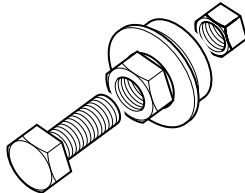
Use to ensure positive engagement of the valve stem seals.

Special Tool - 892/01154 - Tamper proof Cover Removal Tool



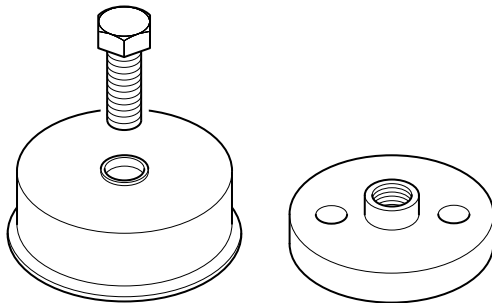
Use to gain access to the mechanical fuel injection pump gear retaining locknut. The tool is used to remove the tamperproof cover.

Special Tool - 892/01155 - Pump Gear Removal Tool



Use to remove the gear from the fuel injection pump shaft.

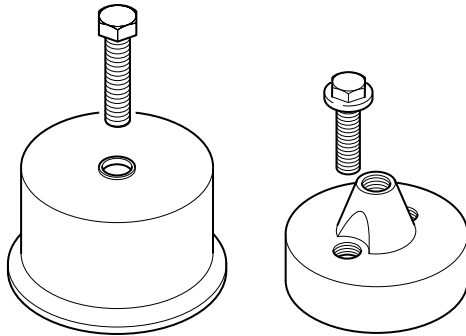
Special Tool - 892/01156 - Crankshaft Rear Oil Seal Installation Tool (old type)



Use to correctly install the crankshaft rear oil seal.

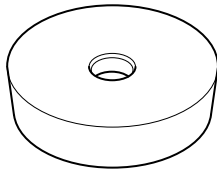
Special Tool - 892/01157 - Crankshaft Front Oil Seal Installation Tool

Use to correctly install the crankshaft front oil seal.



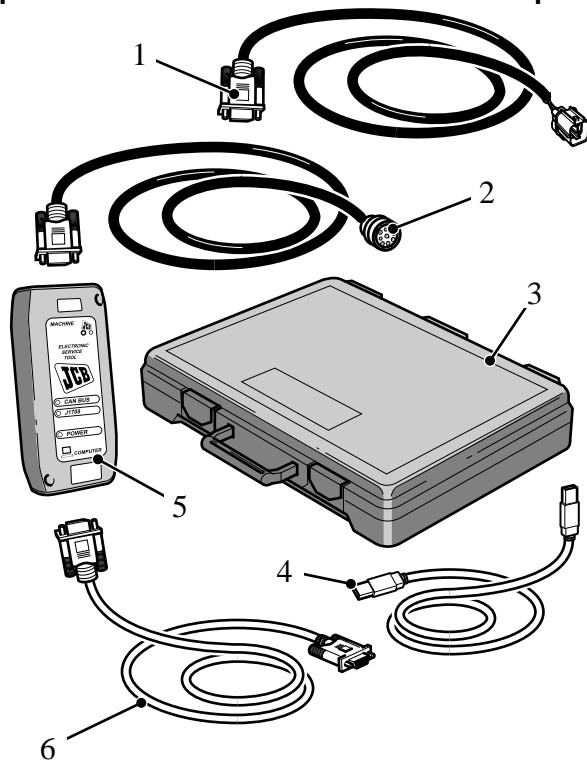
Special Tool - 892/01158 - Crankshaft Rear Oil Seal Alignment Tool

Use to position the crankshaft rear oil seal before using installation tool 892/01156. This tool must be used to position the seal, otherwise the lip of the seal may be inverted during the installation process - leading to potential oil leak.

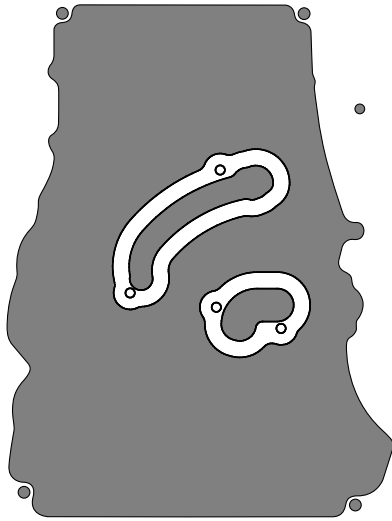


Special Tool - 892/01174 - Data Link Adaptor (DLA) Kit

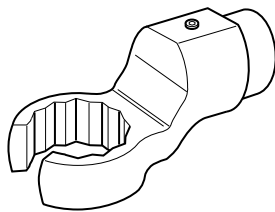
No longer available to order.
 Replaced by special tool 728/H5409 (Data Link Adaptor (DLA 2.0) Kit)



Item	Part No.	Description	Qty.
1		Interconnecting cable, DLA to machine ECU diagnostics socket.	1
2		Interconnecting cable, DLA to machine ECU diagnostics socket.	1
3		Kit carrying case.	1
4		Interconnecting cable, DLA to laptop PC.	1
5		Data Link Adaptor (DLA), enables data exchange between the machine ECU (Electronic Control Unit) and a laptop PC loaded with the applicable diagnostics software.	1
6		Interconnecting cable, DLA to laptop PC.	1

Special Tool - 892/01176 - Template for Sealant Gear Case to Cylinder Block (4 Cyl and 6 Cyl Elec)

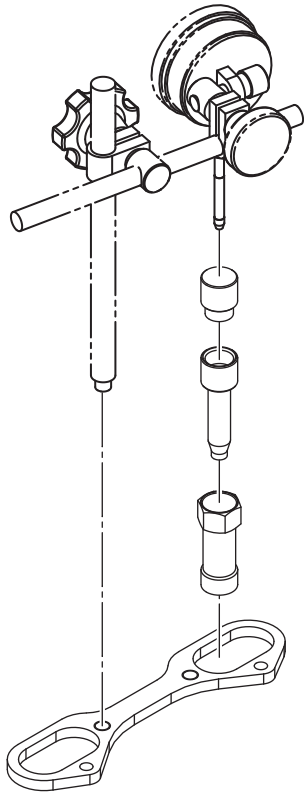
Use to ensure correct sealant application, correct positioning of the sealant is critical to prevent leaks.

Recommended Tool - 892/01267 - Socket 17MM Offset - (HP Fuel pipes)

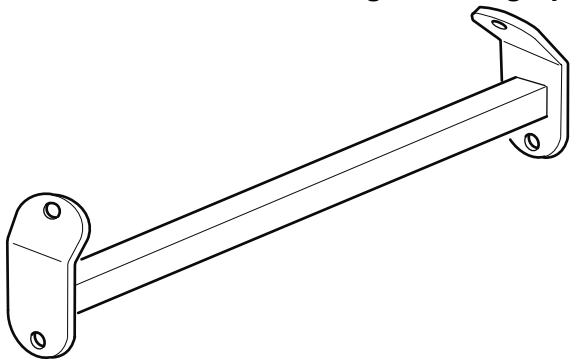
Use to remove and replace high pressure fuel pipes.
Use with 993/70111 torque wrench.

Special Tool - 892/01380 - Valve Clearance Service Kit

Use to measure and adjust valve clearances without removal of the rocker cover.

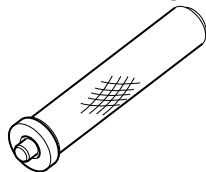


Special Tool - 892/01382 - Engine Lifting Spreader Bar

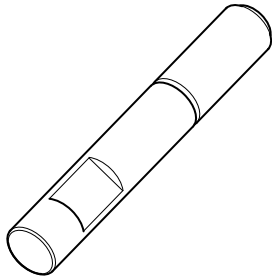


Special Tool - 892/12346 - Injector Seal Installation Tool (Electronic Engine)

Use to correctly set and install the rocker cover injector seals.

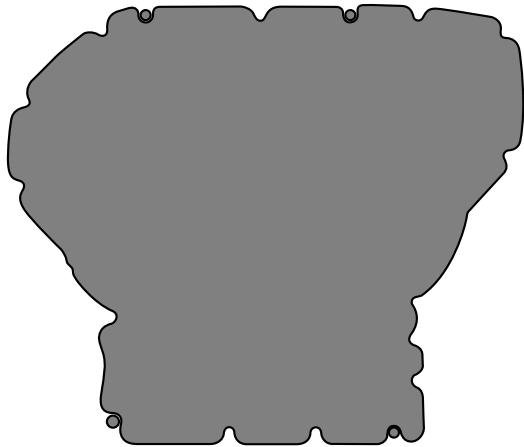


Special Tool - 892/12347 - Dummy Injector



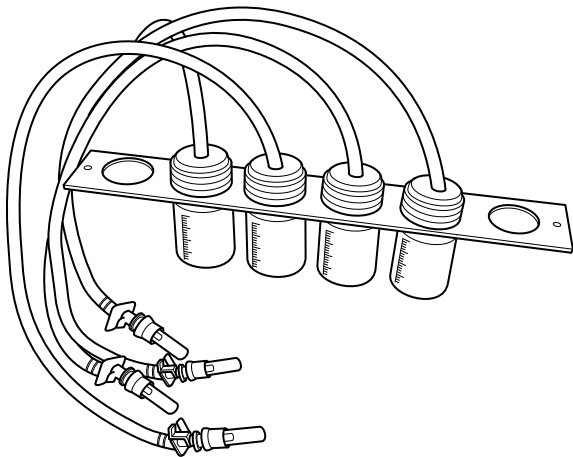
Use in place of the injector to check engine compression. End drilled and tapped 1/8-28 BSP to accept universal adaptor fitting.

Special Tool - 892/12349 - Template for Sealant Flywheel Housing to Gear Case (4 Cyl Elec)



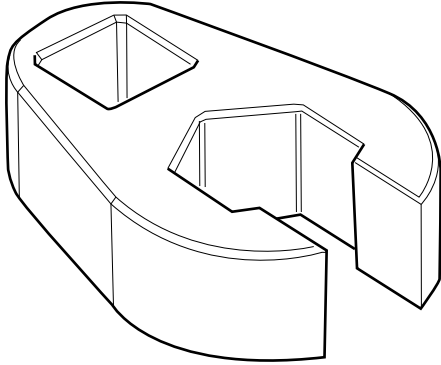
Use to ensure correct sealant application, correct positioning of the sealant is critical to prevent leaks.

Special Tool - 892/12350 - Injector Leak-off Test Kit ((Electronic Engine))

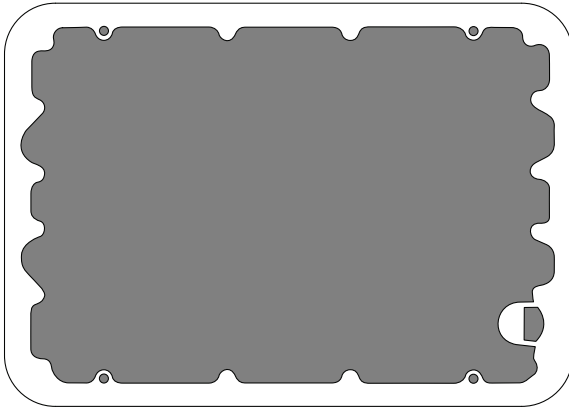


Use to confirm a defective injector. You need 2 of these kits for electronic 6 cylinder engines.

Recommended Tool - 892/12351 - Deep Socket

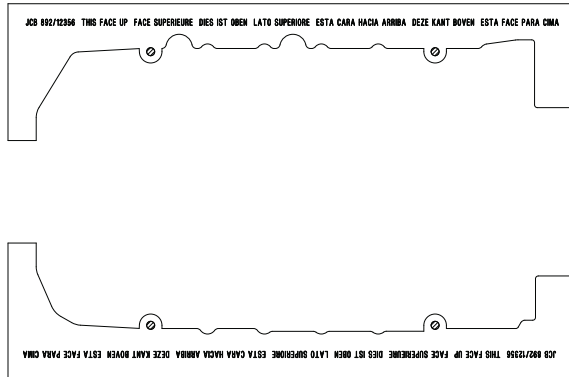


Special Tool - 892/12354 - Template for Sealant Oil Sump (Cast)



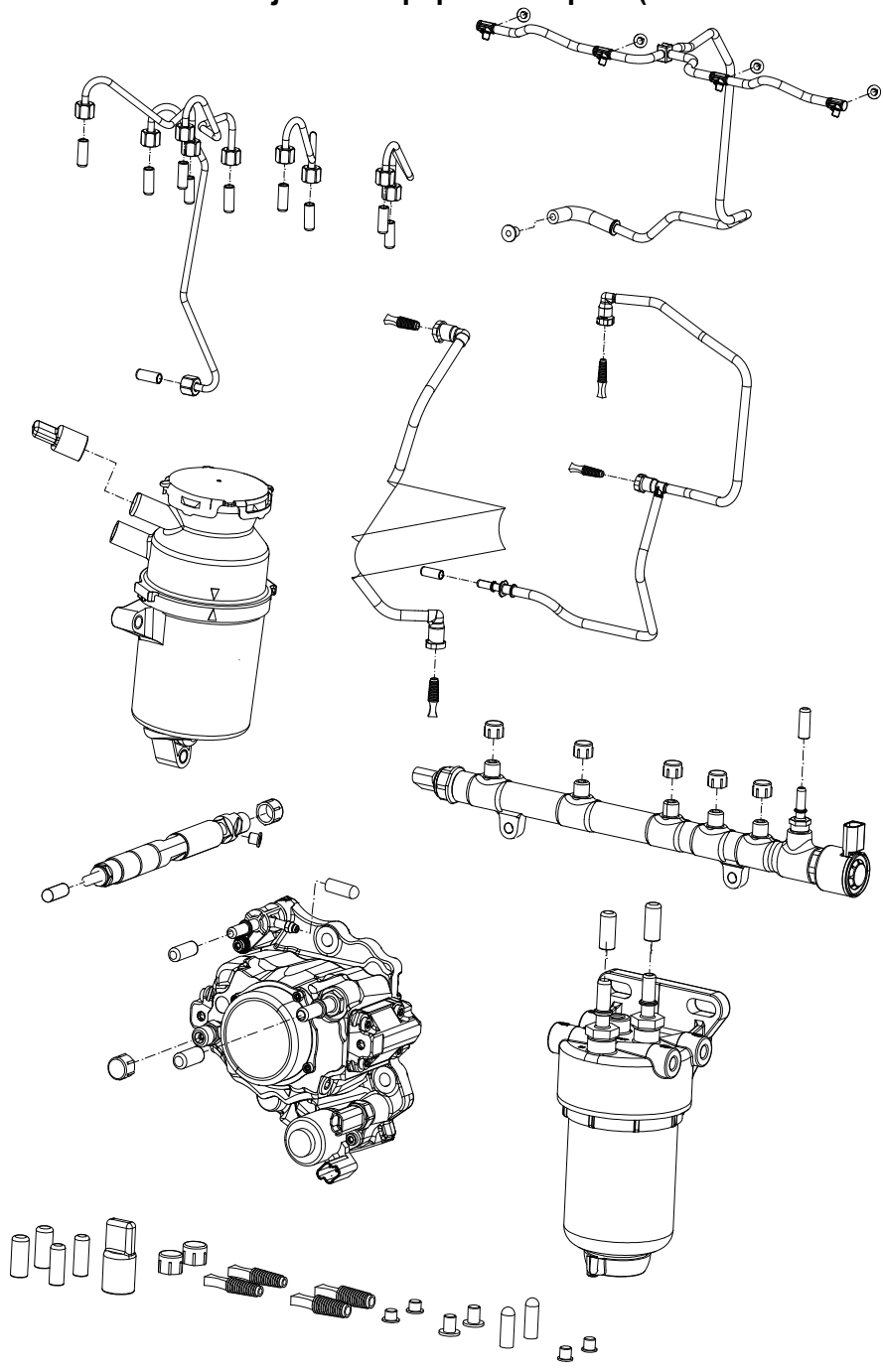
Use to ensure correct sealant application, correct positioning of the sealant is critical to prevent leaks.

Special Tool - 892/12356 - Template for Sealant Bedplate to Crankcase (4 Cyl)

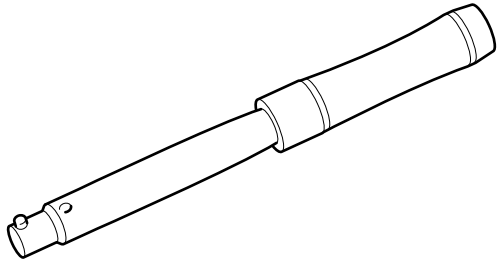


Use to ensure correct sealant application, correct positioning of the sealant is critical to prevent leaks.

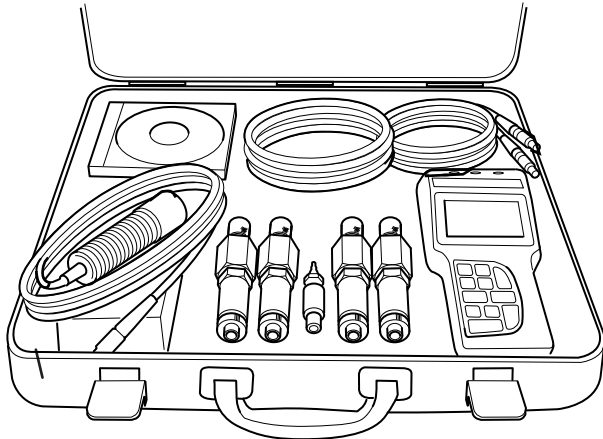
Special Tool - 892/12359 - Fuel Injection Equipment Cap Kit (444/448 T4i/T4F/BS4/STV Engine)



General Tool - 993/70111 - Torque Wrench (10-100Nm)



Special Tool - 998/11051 - Digital Hydraulic Pressure Test Kit



Item	Part No.	Description	Qty.
1	998/11052	Hand Held 4-Channel ServiceMaster Unit	1
2	998/11053	SensoWin Software Kit and PC Cable	1
3	998/11054	Equipment Case	1
4	998/11055	0-600 Bar Pressure Transducer	2
5	998/11056	0-100 Bar Pressure Transducer	2
6	998/11057	RPM Tachometer (includes fixed cable, 2 metres)	1
7	998/11058	5 Metre Connecting Cable	1
8	998/11059	M16 Metric Adaptors for Test Points	4
9	998/11060	400mm Test Hose 90° HSP to M16	2
10	998/11061	400mm Test Hose Straight HSP to M16	2



96 - Units of Measurement

Contents	Page No.
78-96-00 General	78-29



Notes:

00 - General

Technical Data

The standard units of measurement used by JCB are listed below together with the formula for conversion for countries using non metric standards.

Standard Units

Table 202. Force

Measurement (unit)	Convert to	Multiply by
Newton (N)	Kilogram force (kgf)	0.102
	Pound force (lbf)	0.225

Table 203. Length

Measurement (unit)	Convert to	Multiply by
Millimetre (mm)	Inch (in)	0.0394
Metre (m)	Feet (ft)	3.281
	Yard (yd)	1.094
Kilometre (km)	Mile (mile)	0.621

Table 204. Mass

Measurement (unit)	Convert to	Multiply by
Gram (g)	Ounce (oz)	0.035
Kilogram (kg)	Pound (lb)	2.205
Tonne	Ton	0.984

Table 205. Speed

Measurement (unit)	Convert to	Multiply by
Kilometre/Hour (km/h)	mile/hour (mph)	0.621
Metre/Second (m/s)	feet/second (ft/s)	3.281

Table 206. Volume

Measurement (unit)	Convert to	Multiply by
Cubic Centimetre (cm ³)	Cubic Inch (in ³)	0.061
Cubic Metre (m ³)	Cubic Foot (ft ³)	35.315
	Cubic Yard (yd ³)	1.308
Millilitre (ml)	Fluid ounce (fl oz)	0.035
Litre (l)	UK Gallon	0.220
	US Gallon	0.264

Table 207. Flow

Measurement (unit)	Convert to	Multiply by
Litre/Minute (L/m)	UK Gal- lon/Minute	0.220
	US Gal- lon/Minute	0.264

Table 208. Area

Measurement (unit)	Convert to	Multiply by
Square Millimetre (mm ²)	Square Inch (in ²)	0.0015
Square Metre (m ²)	Square Foot (ft ²)	10.764
	Square Yard (yd ²)	1.196

Table 209. Torque

Measurement (unit)	Convert to	Multiply by
Newton metre (Nm)	Pound force foot (lb f ft)	0.7376

Table 210. Pressure

Measurement (unit)	Convert to	Multiply by
Bar	Pound force/ inch ² (psi)	14.5

Table 211. Fuel Consumption

Measurement (unit)	Convert to	Multiply by
Kilometre/Litre (km/l)	Miles/Gallon (mpg)	2.825
	Miles/ US Gal- lon	2.352

Table 212. Temperature

Measurement (unit)	Convert to	Formula
Degrees Celsius (°C)	Degrees Fahrenheit (°F)	Multiply by 9, Divide by 5, Add 32

Table 213. Power

Measurement (unit)	Convert to	Multiply by
KiloWatt (kW)	Horsepower (hp)	1.341

Table 214. Time

Measurement (unit)
Second (s)
Minute (min)
Hour (h)



Table 215. Current

Measurement (unit)
Ampere (A)

Table 216. Voltage

Measurement (unit)
Volt (V)

Table 217. Noise Levels

Measurement (unit)
Sound pressure level (LpA)
Sound power level (LwA)