



# CORMORANT

## 20kVA DIESEL GENERATOR OPERATION AND MAINTENANCE MANUAL

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By Command of the Defence Council

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Ministry of Defence

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Army Equipment Support Publication



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Annex E	Deep Sea Electronics plc - Engine Management System

**PREFACE**

1 Each initial issue leaf bears the date of issue. Each leaf of a subsequent amendment bears the date of issue and the number of the amendment with which the subsequent leaf was issued.

2 New or amended technical matter will be indicated by triangles positioned outside the type area thus: > < to show the extent of amended text. When a Part, Section or Chapter is issued in a completely revised form, the triangles will not appear and the material will carry the note '(Completely revised)'.

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**LIST OF RELATED PUBLICATIONS**

- 012-01K Isuzu Diesel Engine Instruction Manual (Industrial) - 4LB1, 4LC1, 4LE1
- 107-04K Isuzu Diesel Engine Workshop Manual (Industrial) - 4LB1, 4LC1, 4LE1  
Isuzu L-Series Diesel Engine Technician Guide
- BCH-018 Ed 12 Newage Alternator - Installation, Service and Maintenance Manual
- DSE 520 Issue 4 Deep Sea Electronics Engine Management System - Model 520

The commercial publications associated with the Harrington 20 kVA Diesel Generator system are located in Annexes A, B, C, D and E of this Operation and Maintenance Manual.

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## WARNINGS

**PERSONAL INJURY.** ALWAYS READ THE HAZARD NOTICES ASSOCIATED WITH OPERATING AND MAINTAINING THIS MACHINE. IF IN DOUBT ABOUT THE SAFE OPERATION OF THE EQUIPMENT, CONSULT THE MANUFACTURER OR A QUALIFIED OPERATOR.

**PERSONAL INJURY.** DO NOT REMOVE THE RADIATOR CAP WHILST THE ENGINE IS RUNNING OR HOT.

**LETHAL VOLTAGE.** DO NOT CARRY OUT HIGH VOLTAGE INSULATION TESTS ON THE GENERATOR OR ON THE DISTRIBUTION SYSTEM WHILST THE GENERATOR IS CONNECTED.

**PERSONAL INJURY.** BEFORE COMMENCING ANY SERVICE OR REPAIR WORK, ENSURE THAT THE CONTROL MODULE IS IN THE 'OFF/RESET' POSITION. OPERATE THE EMERGENCY STOP PUSHBUTTON. DISCONNECT THE NEGATIVE TERMINAL ON THE BATTERY. ENSURE THAT THERE IS NO CONNECTION TO THE 24V INTER-VEHICLE SOCKET.

**PERSONAL INJURY.** EACH BATTERY WEIGHS 40Kg AND THE BATTERIES SHOULD BE LIFTED BY TWO PEOPLE.

**DAMAGE TO HEARING.** OPERATORS SHOULD WEAR EAR DEFENDERS WHILST THE 20KVA GENERATOR IS IN OPERATION WITH DOORS/PANELS OPEN.

**PERSONAL INJURY.** 20KVA GENERATOR COOLANT - ETHYLENE GLYCOL IS HARMFUL IF SWALLOWED. IN CASE OF CONTACT WITH EYES, RINSE IMMEDIATELY WITH PLENTY OF WATER AND SEEK MEDICAL ADVICE. ALWAYS WEAR PROTECTIVE CLOTHING, GLOVES AND EY/FACE PROTECTION. IF YOU FEEL UNWELL, SEEK MEDICAL ADVICE IMMEDIATELY.

**PERSONAL INJURY.** EXHAUST EXTENSIONS MUST BE DEPLOYED OUTSIDE CAMOUFLAGE NETTING WHILST THE GENERATOR IS RUNNING. WHEN DEPLOYING GENERATORS ENSURE EXHAUSTS AND EXHAUST EXTENSIONS ARE POINTED AWAY FROM THE VEHICLE.

## CAUTIONS

**EQUIPMENT DAMAGE.** Caution should be exercised when using the 'Emergency Start' feature as damage may be caused whilst it is in use and the generator is allowed to exceed its normal operational parameters.

**EQUIPMENT DAMAGE.** All PERSONNEL in the vicinity should be made aware that the emergency stop is inoperable whilst using the 'Emergency Start' feature.

**EQUIPMENT DAMAGE.** Caution should be exercised when refueling and using the fuel gauge to monitor the contents of the fuel tank. The fuel gauge is damped so it does not register changes in fuel level instantaneously.

**LIST OF ABBREVIATIONS**

COTS	Commercial Off The Shelf
EC	Emission Control
IRR	Infra-Red Reflective
Kg	Kilogramme
Mcb	Miniature circuit breaker
PCLM	Pilot Circuit Line Monitor
RCD	Residual Current Device

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**CATEGORY 1            PLANNING AND SUPPORT INFORMATION**  
**SUB-CATEGORY 1.0    PURPOSE AND PLANNING INFORMATION**

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## SUB-CATEGORY 1.0

### PURPOSE AND PLANNING INFORMATION

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#### INTRODUCTION

- 1 The Cormorant 20kVA Generator consists of a four-cylinder diesel engine close-coupled to a 1-phase brushless alternator, housed within an acoustic/weatherproof canopy.
- 2 The self-contained unit has the capability to operate autonomously for 12 hours, utilising the on-board fuel, batteries and a control and monitoring system.
- 3 The canopy (Fig 1) houses the exhaust silencer and provides shielding.
- 4 The compact, integral control system monitors critical performance parameters of the engine, alternator and electrical output, reporting indications, warnings and shutdowns.
- 5 The electrical power output interface is via two connectors. The 230V, 1-phase, 50Hz output is protected against overload, short-circuit and earth leakage.

#### Canopy

- 6 The canopy is fabricated from steel and aluminium alloy and is finished with an Infra-Red Reflective (IRR) powder coating. The function of the canopy is to provide mechanical and weather protection and to restrict noise and heat emissions.

**Generator**

7 The engine is an Isuzu 4LE1, 4-cylinder water-cooled diesel engine, naturally aspirated. The engine has mechanical speed governing with 5% regulation. The electrical system is 24 volt and includes a belt-driven battery charge alternator. The alternator is a Newage BCI182J 2-pole machine of rotating field, brushless construction.

**Generator control module**

8 The generator control module monitors the operational status of the generator and checks engine, alternator and control system parameters against pre-programmed levels. The LED display indicates operational sequences, warning and fault conditions.

**SAFETY****WARNING**

**PERSONAL INJURY. ALWAYS READ THE HAZARD NOTICES ASSOCIATED WITH OPERATING AND MAINTAINING THIS MACHINE. IF IN DOUBT ABOUT THE SAFE OPERATION OF THE EQUIPMENT, CONSULT THE MANUFACTURER OR A QUALIFIED OPERATOR.**

9 Observe the following instructions and precautions before attempting to operate or maintain the 20kVA diesel generator.

- (1) READ the associated engine and alternator operation manuals.
- (2) ENSURE that you know how to stop the engine in an emergency.
- (3) BE AWARE that the generator has the facility to be started remotely.
- (4) BEFORE commencing any service, maintenance or repair work, ensure that the control module is in the OFF/RESET position. Operate the emergency stop pushbutton.
- (5) DO NOT operate the generator in confined areas. Exhaust fumes are poisonous and can KILL.
- (6) ENSURE that the surrounding area of the machine has no restrictions that would prevent an adequate flow of clean, ambient air.
- (7) DO NOT operate the generator with the canopy doors open.
- (8) DO NOT smoke when refuelling.
- (9) AVOID overfilling when refuelling.
- (10) WIPE up any fuel spilt on the machine and move the equipment away from the area where fuel has been spilt.
- (11) OPERATE the equipment at least 1 metre from other equipment and buildings. The area should be clear of any combustible materials, ie cardboard, dried grass, timber etc.
- (12) DO NOT use the equipment with loose or missing components or guards.

(13) REMEMBER that parts of the engine and particularly the exhaust system remain hot for some time after the generator has stopped.

(14) EARTHING is the responsibility of the persons installing the generator and its distribution system.

### SPECIFICATIONS

10 Table 1 details the specifications of the Cormorant 20kVA generator.

**TABLE 1 CORMORANT 20kVA GENERATOR SPECIFICATIONS**

Generator Component	Specification
Output (Main)	20kVA 230V 50 Hz 1-phase. 10% overload capacity 1 hour in 10.
Power Factor	0.8 lag.
Output Power	16.0 kW
Rated Current	87.0 Amps (0.8pf). 69.6 Amps (1.0pf).
Voltage Regulation	+/- 2.5%
Engine	Isuzu 4LE1 4 cylinder, water-cooled. 3000 rev/min, nominal. 24 volt electric start.
Alternator	Newage BCI182J 2-pole, rotating field. Brushless, Class H insulation.
Fuels	Dieso (Ambient temperatures -5°C to +44°C). AVTUR (Ambient temp below -5°C). 100 litre tank. 12 hours operation at full load.
Lubricating Oil	Multi-viscosity diesel engine oil. SAE 15W-40 (Ambient temp -15°C to +49°C). SAE 5W-30 (Ambient temp below -15°C).
Coolant	Ethylene glycol (50%) and water mixture (50%) with inhibiting coolant additives.
Battery	UK 6TN FV546133. 12 volt lead acid 100 Ah rating. Two in series.
Output Connectors	2 x 50A max rating 4 pin. Mcb protection 45A per connector.
Inter-vehicle Connector	24 Volt FV634300. NATO No. 4910997234625. (ABPC20352806SFOO).
Operating Conditions	Ambient temperatures -31°C to +44°C. Altitude up to 3000 masl.
Dimensions	1990L x 870W x 1325H (millimetres).
Weight	890kg maximum (fully loaded).

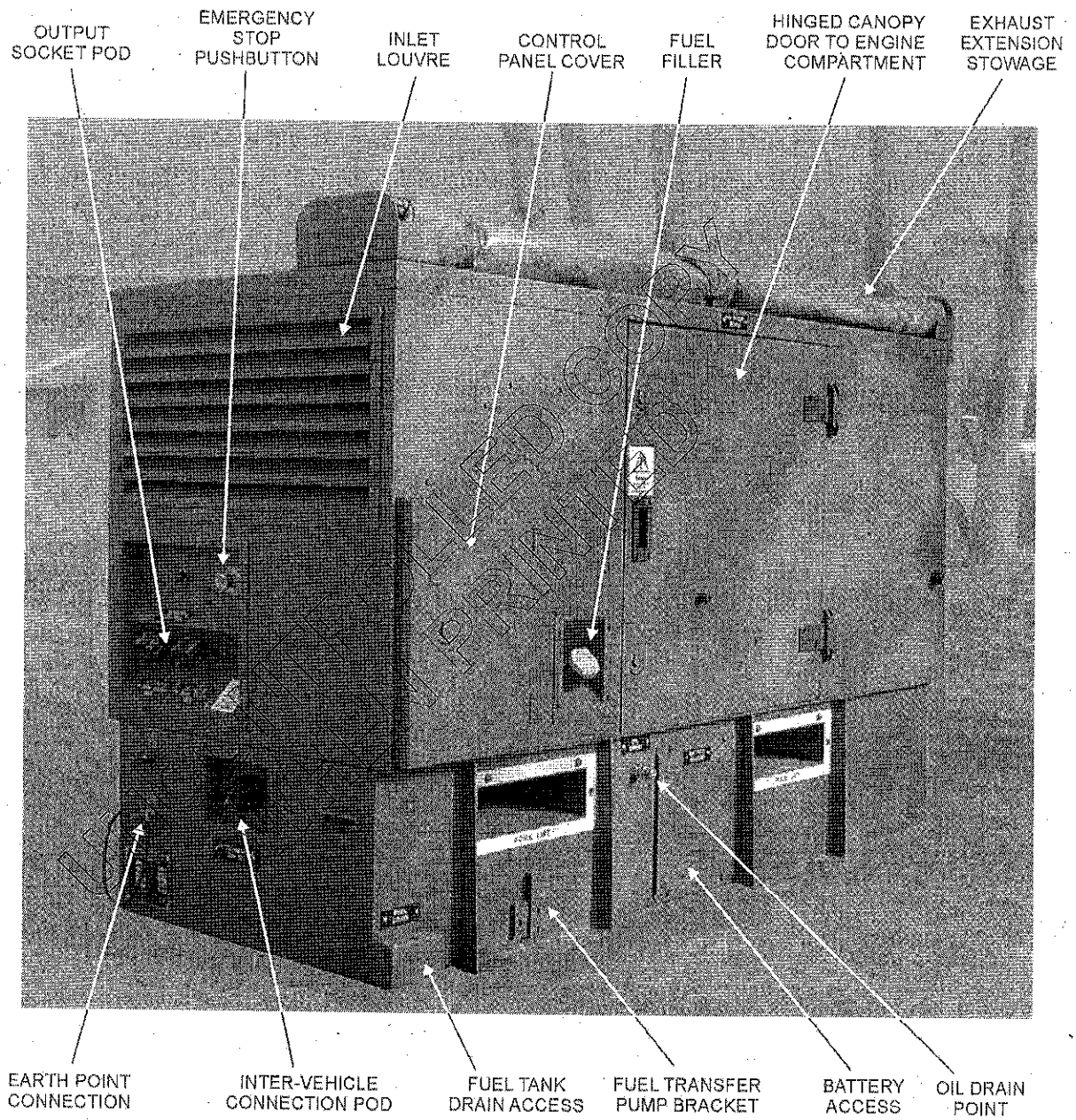


Fig 1 Cormorant 20kVA generator canopy front view

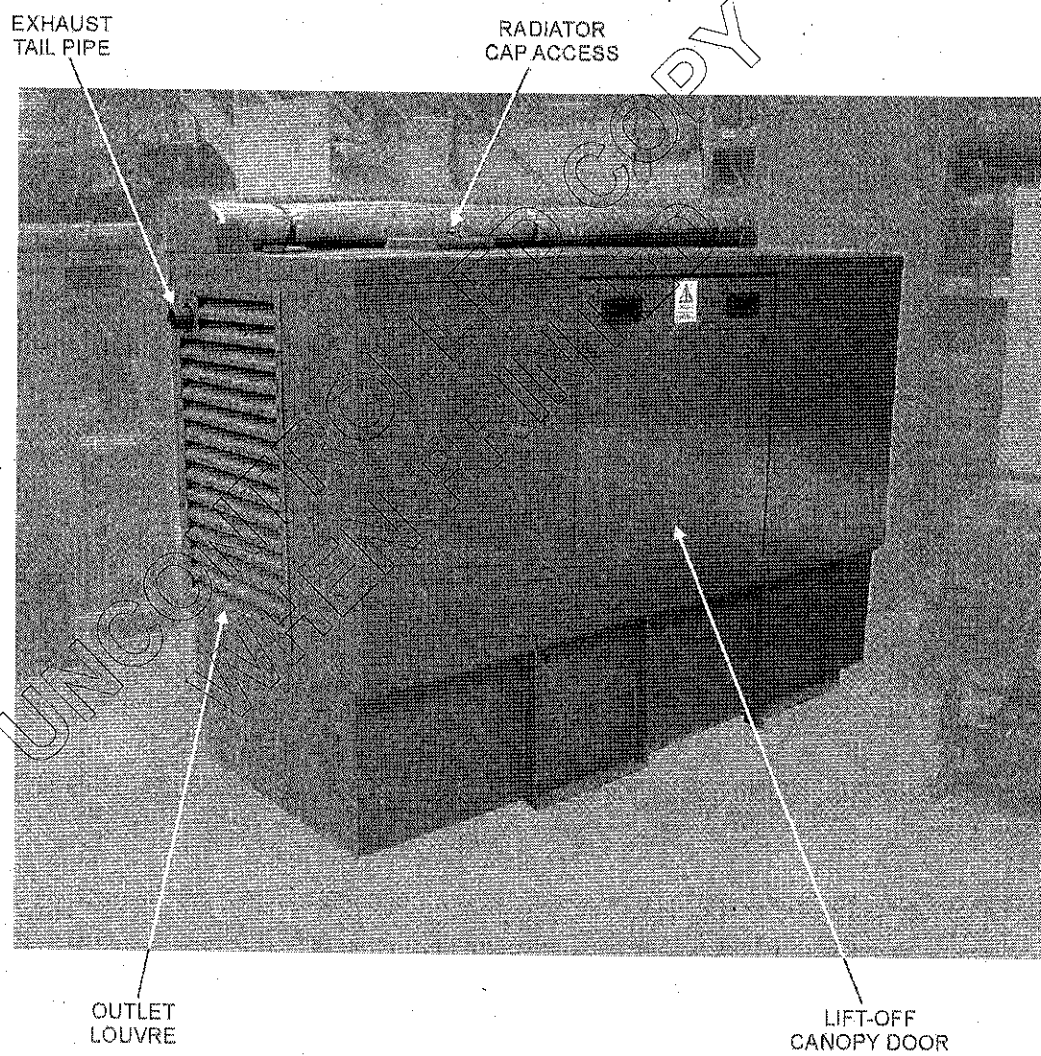


Fig 2. Cormorant 20kVA generator canopy rear view

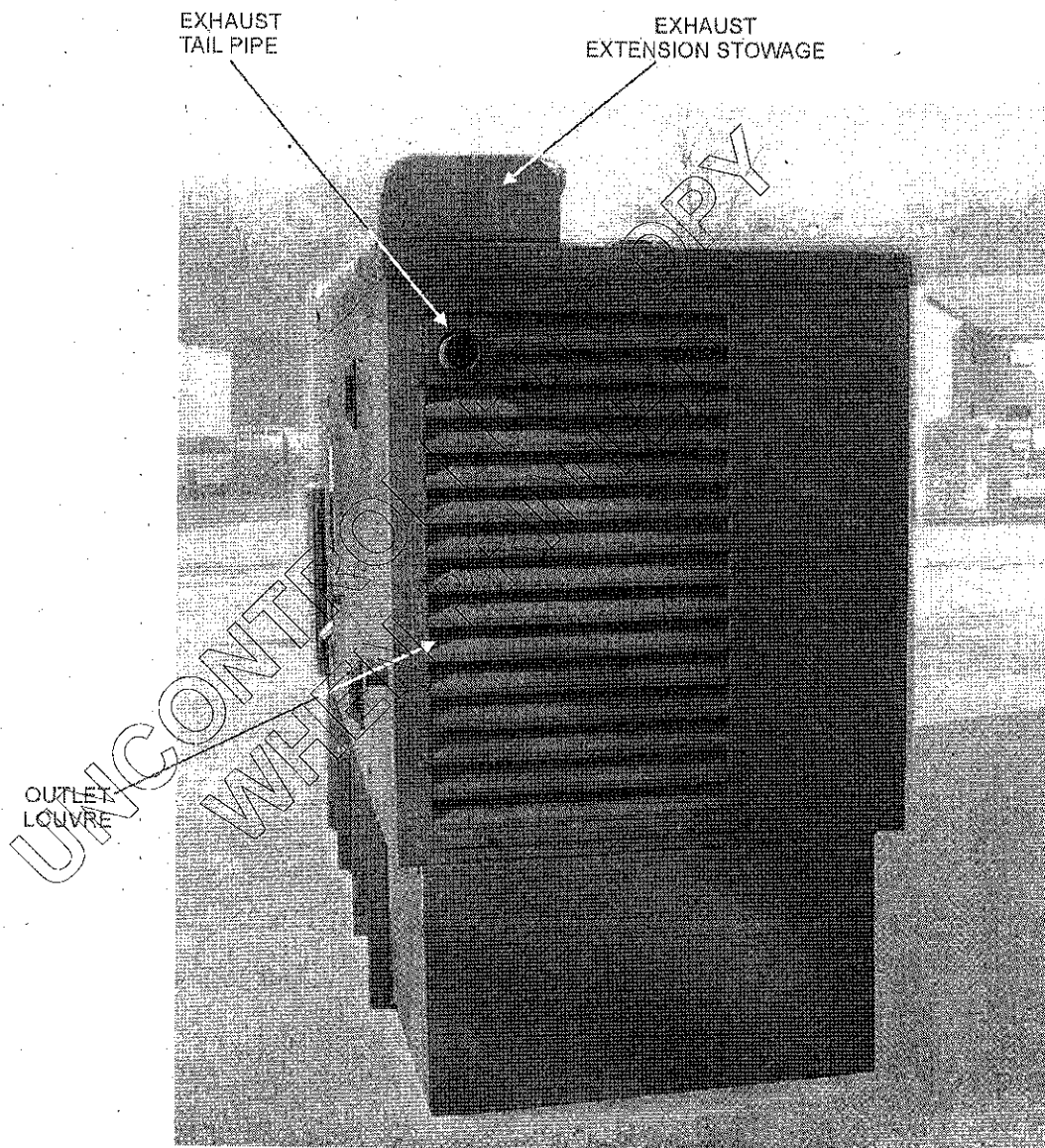


Fig 3 View on hot air louvre end

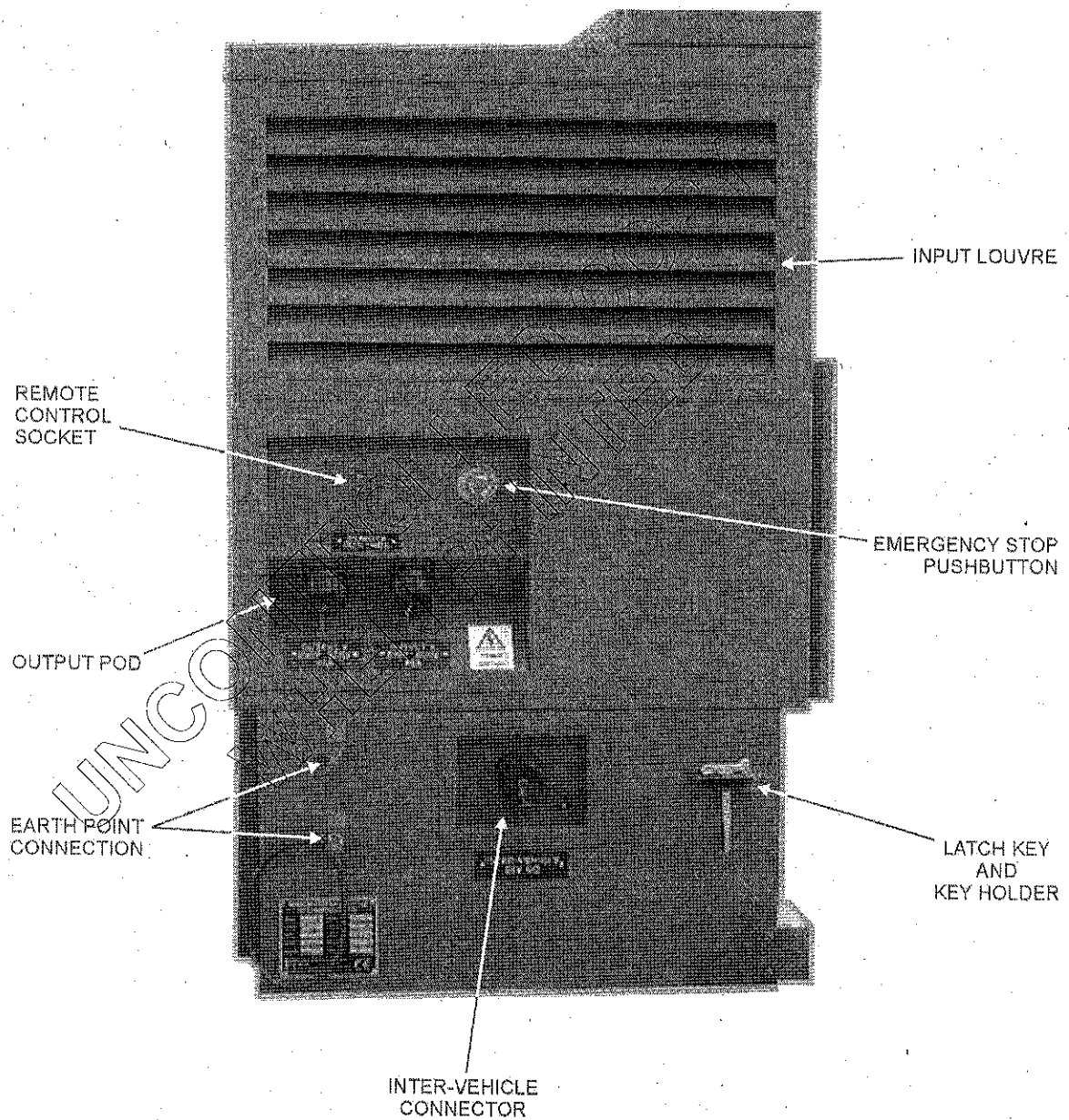


Fig 4 View on output panel end

**CATEGORY 2            OPERATING AND TRAINING INFORMATION**

**SUB-CATEGORY 2.0    OPERATING INFORMATION**

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**SUB-CATEGORY 2.0**

**OPERATING INFORMATION**

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- 2 Checking the service status
- 3 Starting
- 4 Checking the output
- 6 Connecting load
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- 9 Shutdown
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- 16 Cormorant 20kVA management module program

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**PRE-START CHECKS**

1. Reference should be made to Fig 1 Control Module and Fig 2 Control Panel throughout the operating instructions. Pre-start checks are as follows:

- (1) Check that the generator is stood on reasonably level ground.
- (2) Check the generator earthing arrangements. Earthing is the responsibility of the persons installing the generator and its distribution system.
- (3) Open the hinged access door to the engine compartment. Check the lubricating oil level in the engine. (Refer also to the Engine Instruction Manual at Annex A, Para 29.) Add oil as necessary using the grade according to the site conditions (refer to Sub-cat 1.0).
- (4) Check there is sufficient fuel in the tank using the Fuel/Hours status switch. Add fuel as necessary using the fuel type according to the site conditions (refer to Sub-cat 1.0).

**WARNING**

**PERSONAL INJURY. DO NOT REMOVE THE RADIATOR CAP WHILST THE ENGINE IS RUNNING OR HOT.**

- (5) Check the coolant level in the expansion bottle (Fig 3). Coolant may be added to the expansion bottle (only if there is already water in the bottle) or via the radiator filler cap (Sub-cat 5.3, Fig 4). Add coolant as necessary so that the level touches the bottom of the radiator filler neck. Use 50% ethylene glycol and water mixture with supplemental coolant additives. (Refer also to Annex A, Para 37.)

- (6) Check that the canopy inlet and outlet louvres are not blocked. Brush away any heavy sand or dust deposits that have collected at the bottom of the louvres.
- (7) Squeeze the dust unloader valve on the engine air cleaner to remove dust deposits. If clogged, remove and clean the dust unloader valve. Replace if damaged.
- (8) When operating in extremely dusty/sandy conditions, check the air restriction indicator. If this shows restriction in the air intake system, remove and inspect the primary air cleaner element. Service as necessary. (Refer also to the Engine Instruction Manual at Annex A, Para 108.)

### CHECKING THE SERVICE STATUS

2 Operate the Fuel/Hours Status switch and check the recorded 'hours run'. Check this against the service/maintenance program for the generator and take the appropriate measures if attention is due. (See the Maintenance Schedule summary in Sub-cat 5.3.)

### STARTING

- 3 To start the 20kVA generator:
  - (1) Ensure that the DC selector is ON.
  - (2) Turn the generator mode selector switch to the 'RUN' position.
  - (3) Check that there are no warning lamps illuminated. If warning lamps are lit, refer to Sub-cat 5.1, Fault Diagnosis.
  - (4) Press the engine 'Start' button and release.
  - (5) If the ambient temperature is below  $-12^{\circ}\text{C}$ , the cold start system will be activated. The 'Cold Start' LED will illuminate for 20 seconds whilst the induction air heater operates.
  - (6) Following the 20 second cold start period, or immediately if the temperature is above  $-12^{\circ}\text{C}$ , the 'Pre-heat' (Glow) LED will illuminate. The engine cylinder head glow plugs will heat for 10 seconds before cranking begins.

### NOTE

When the starting sequence has begun, the 'Stop' button will not halt the procedure until the generator has run up to speed.

- (7) To abort the start sequence, turn the mode selector switch to 'STOP/RESET'.
- (8) The control system will automatically start the generator and disconnect the starter. The system will make up to three attempts to start with a short rest between each crank period to allow the batteries to recover and prevent starter burn-out.
- (9) If the generator fails to start after three attempts, the 'Fail to Start' warning lamp will illuminate and the 'Common alarm' lamp will flash. Refer to Sub-cat 5.1, Fault Diagnosis.

### NOTE

In an **EMERGENCY**, press the Emergency Stop pushbutton.

### CHECKING THE OUTPUT

4 Before connecting equipment to the generator, it is advisable to check that the off-load voltage is stable and within limits.

5 The voltage can be checked using the voltmeter. The voltage should be 230 Volts +/- 6V. If the voltage is not within this range, DO NOT PROCEED with connection of the load.

### CONNECTING LOAD

6 To connect the load:

- (1) Remove the cap(s) on the output socket(s) marked '230V 50Hz'. (Refer to Fig 4).
- (2) Push the power lead connector firmly into the socket and tighten the locking ring.
- (3) Operate the relevant Mcb, ie Mcb Output 1 or Mcb Output 2, to connect the generator to the load.
- (4) If the Mcb will not set, it may be due to a pilot wire incontinuity or an earth leakage in the distribution system. (See Sub-cat 5.1, Fault Diagnosis.)

### CHECKING THE GENERATOR LOADING

7 The amount of load supplied by the generator can be monitored using the ammeter.

8 The load current should not exceed 87 amperes as a continuous load. A 10% overload, ie 96 amperes, is allowable for 1 hour in every 10 hours.

### SHUTDOWN

9 To shutdown the generator:

- (1) Switch off the power at the Mcb(s).
- (2) Press the engine 'Stop' button.
- (3) When the generator has come to a halt, turn the control module mode selector switch to 'STOP/RESET'.
- (4) There is no requirement to disconnect cabling.

### EARTHING

#### WARNING

**LETHAL VOLTAGE. DO NOT CARRY OUT HIGH VOLTAGE INSULATION TESTS ON THE GENERATOR OR ON THE DISTRIBUTION SYSTEM WHILST THE GENERATOR IS CONNECTED.**

10 The neutral of the generator winding is electrically bonded to the metalwork of the generator and to the Earth Point connection on the generator canopy (see Fig 4 in Sub-cat 1.0).

11 The generator is fitted with over-current protection, residual current protection and pilot wire monitor devices. The operation of these devices is described in Sub-cat 3.0 of this manual.

12 Tests should be carried out on new installations and at appropriate intervals thereafter to ascertain that earth fault (loop) impedances are low enough to ensure that electrical protection devices operate in the event of a breakdown of insulation leading to an 'earth fault'

13 Further advice on earthing can be found in the following Health & Safety Executive publications (available from HMSO):

Guidance note	GS27	Protection Against Electric Shock
	GS24	Electricity on Construction Sites

## CONTROL MODULE

14 The control module (Fig 2) is a microprocessor-based unit and is the hub of the dc and ac control system. The module is programmed during manufacture. To assist in understanding the operation of the control system, refer to the DSE 520 Engine Management System manual at Annex E, the programme configuration in Para 16, and to the wiring diagrams in Sub-cat 3.0.

15 Operation is as follows:

(1) The module uses a 24V dc supply at Terminals 1 and 2. The supply positive is protected by a single-pole miniature circuit breaker, 35A.

(2) The engine fuel control solenoid and starter motor solenoid are supplied via Terminal 3 and the emergency stop pushbutton.

### NOTE

This complies with CE Safety Machinery legislation that dictates that emergency shutdown systems are not associated with microprocessor circuits.

(3) The generator start sequence commences when a supply negative is connected to Terminal 13 and the module is in 'RUN' mode. This is initiated when the 'Start' button is pressed momentarily. An auxiliary output signal at Terminal 17 latches the start interlock relay.

(4) If the ambient temperature is below  $-12^{\circ}\text{C}$ , the cold start timer is energised. This holds off the signal to Terminal 13 for 20 seconds whilst the induction air heater operates.

(5) As soon as the signal is received at Terminal 13, the pre-heat timer commences. Auxiliary output at Terminal 6 energises the pre-heat slave relay. This energises the cylinder head glow plugs. Following the pre-heat time (10 seconds), the fuel relay is energised via Terminal 4 and the engine fuel solenoid operates.

(6) The start relay is energised via Terminal 5 for the duration of the first crank period (10 seconds).

### NOTE

All LEDs are extinguished during cranking.

- (7) If the engine does not start during this time, there follows a crank rest period (1 second). Three crank attempts are made with a rest period between each. If the engine has still not started after three attempts, the fail to start alarm is latched and the 'Fail to start' LED is lit. The 'Common alarm' LED flashes.
- (8) When the engine starts, the main alternator voltage is monitored at Terminals 14 and 15 via circuit breaker Mcb2. When the frequency reaches 21.0Hz, cranking is stopped.
- (9) Monitoring of the oil pressure, engine temperature and charge alternator are held off for the safety on delay time (10 seconds).
- (10) The generator is running and available to supply the load. While the fuel solenoid is energised, an auxiliary output at Terminal 17 energises the fuel gauge.
- (11) During operation, the following parameters are monitored:
- |                                 |                        |
|---------------------------------|------------------------|
| Low oil pressure                | (N/O switch).          |
| High engine temperature         | (N/O switch).          |
| Underspeed/Frequency            | (Limit 42Hz).          |
| Overspeed/Frequency             | (Limit 55Hz).          |
| Battery charge alternator       | (Limit 8.0V).          |
| Low fuel alarm 1.5 hrs          | (20 litres remaining). |
| Low fuel alarm 0.5 hrs          | (6 litres remaining).  |
| Pre-heaters energised.          |                        |
| Cold start circuit operational. |                        |

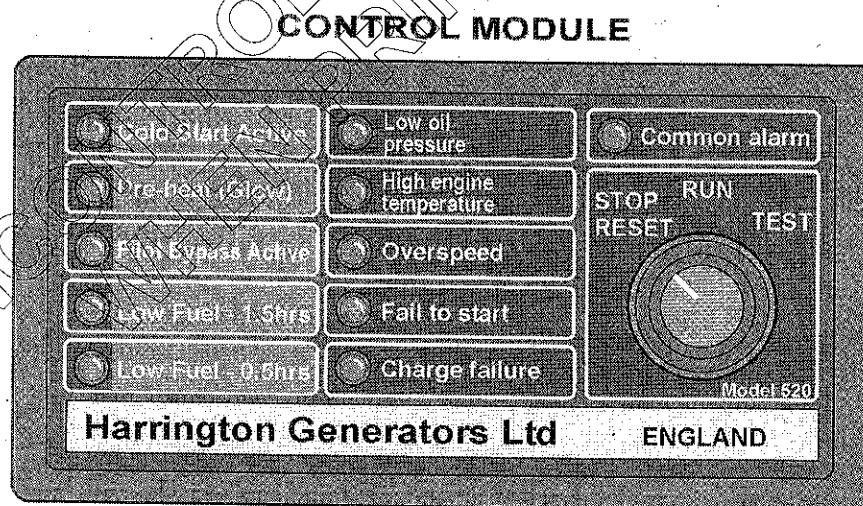


Fig 1 Control module

- (12) In normal operation, generator shutdown is initiated by pressing the 'Stop' button momentarily. This removes the supply negative at Terminal 13. The remote start signal is removed and the auxiliary output at Terminal 17 is de-energised along with the start interlock relay.
- (13) The fuel relay is de-energised from Terminal 4 and the engine stops.
- (14) At this point, the fail to stop timer is initiated for 30 seconds.
- (15) If oil pressure or alternator frequency are detected after this time, a fail to stop alarm is generated. The 'Common alarm' LED flashes.

### **CORMORANT 20kVA MANAGEMENT MODULE PROGRAM**

16 Pre-programmed parameter levels as shown at Para 15(11) are entered during commissioning of the Control Module.

17 Refer to the Model 520 Engine Management System manual at Annex E for control module factory default configuration details. The configuration for a standard module, if no configuration interface is available, gives values and details of the following:

- (1) Miscellaneous items.
- (2) Configurable inputs.
- (3) Relay outputs.
- (4) Front panel LEDs.
- (5) System timers.
- (6) Analogue levels.

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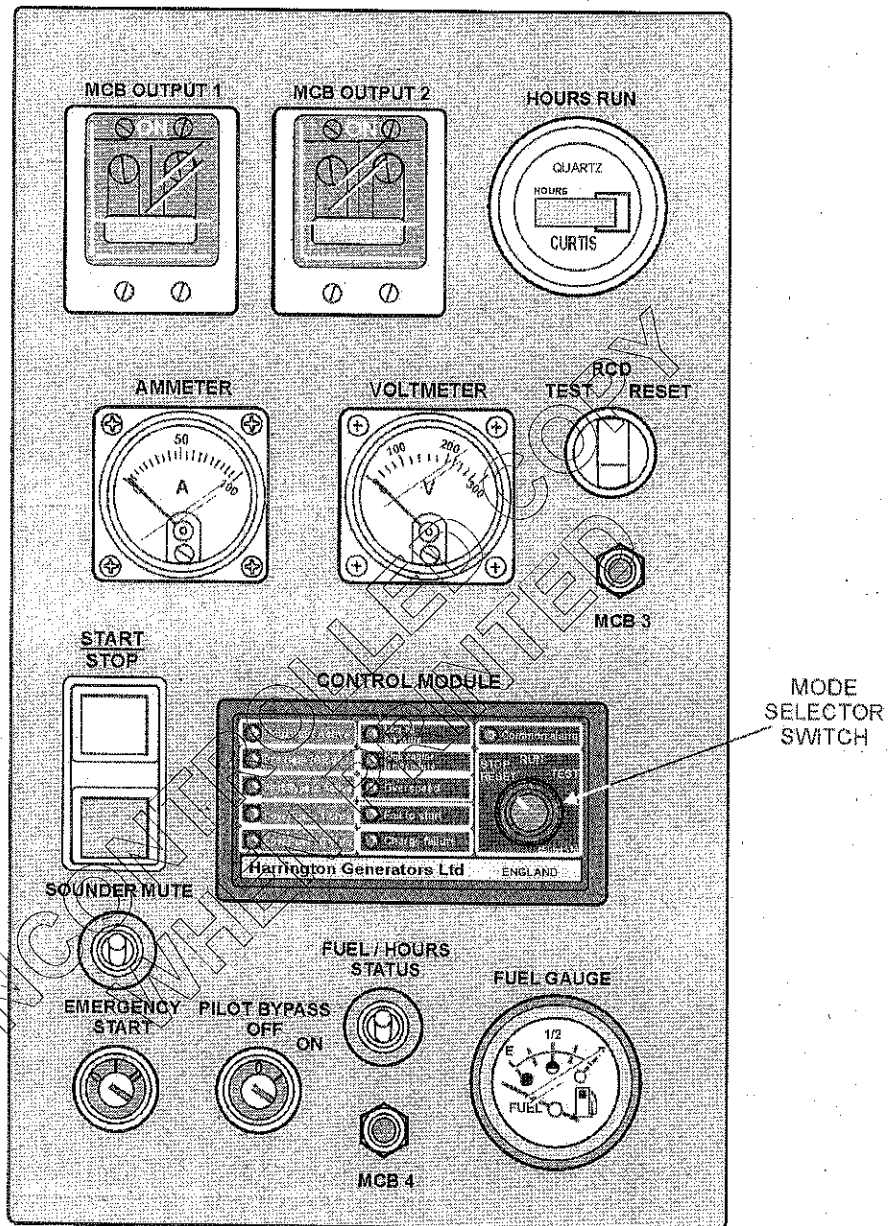


Fig 2. Control panel

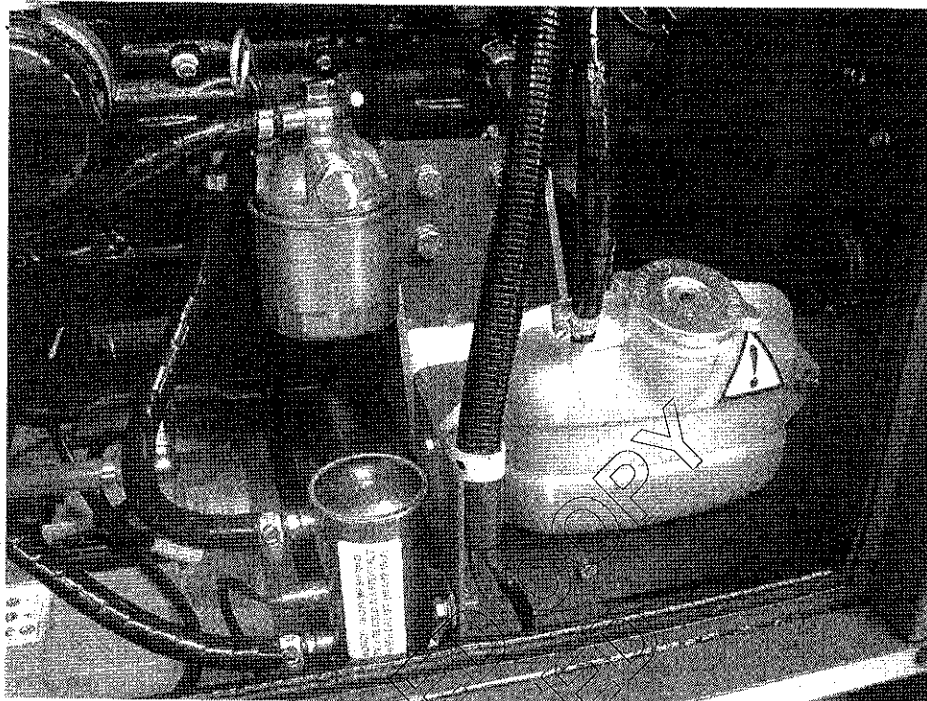


Fig 3 Expansion bottle



Fig 4 Output pod



**CATEGORY 3**

**TECHNICAL DESCRIPTION**

**SUB-CATEGORY 3.0**

**20 KVA GENERATOR EQUIPMENT DESCRIPTION**

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**SUB-CATEGORY 3.0**

**TECHNICAL DESCRIPTION**

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- 18 Generator control module
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- 21 Fuel gauge
- 22 DC control system circuit breaker (Mcb 4)
- 23 AC metering circuit breaker (Mcb 3)
- 24 Hours-run counter
- 25 Voltmeter
- 26 Ammeter
- 27 Output circuit breakers - Output 1 (Mcb 1) and Output 2 (Mcb 2)
- 31 Pilot wire monitor
- 34 Pilot bypass keyswitch
- 35 Emergency start keyswitch (CAUTIONS)
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## SUB-CATEGORY 3.0

### TECHNICAL DESCRIPTION

#### GENERAL

- 1 The Cormorant 20kVA generator set consists of a four-cylinder diesel engine, close-coupled to a 1-phase brushless alternator, housed with the ancillary systems within an acoustic/weatherproof canopy.
- 2 The self-contained unit has the capability to operate autonomously for 12 hours, utilising the on-board fuel, batteries and control and monitoring system.
- 3 The generator has a high power-to-weight ratio, achieved by using a high speed engine/alternator combination and alloy canopy components where possible.
- 4 The canopy houses the exhaust silencer and provides shielding, thus reducing the infra-red, acoustic and electro-magnetic signature from the machine. Exhaust extension pipework and insulation is provided and stowed on-board for use when camouflage nets are deployed.
- 5 The compact, integral control system monitors critical performance parameters of engine, alternator and electrical output, reporting indications, warnings and shutdowns as appropriate.
- 6 The electrical power output interface is via two connectors. The 230V, 1-phase, 50Hz output is protected against overload, short-circuit and earth leakage.
- 7 The pilot wire (Pilot Circuit Line Monitor (PCLM)) protection system is also fitted (Fig 3), although this can be disabled when the generator is required to operate with incompatible equipment.
- 8 A remote control interface socket is fitted, which facilitates monitoring and limited control of the generator at a suitably equipped remote station.
- 9 An inter-vehicle connector is provided to allow remote 24V batteries to be utilised to supplement deficient generator batteries. Alternatively, the connector allows the generator batteries to be used as a slave power source.

#### ENGINE

- 10 The engine is an Isuzu 4LE1, 4-cylinder water-cooled diesel engine, naturally aspirated.
- 11 Engine displacement is 2.9 litres and the combustion system is direct injection for improved cold starting performance.
- 12 Nominal operating speed is 3000 rev/min for 50Hz electrical output.
- 13 The engine has mechanical speed governing with 5% regulation. The electrical system is 24 volt and includes a belt-driven battery charge alternator.

#### ALTERNATOR

- 14 The alternator is a Newage BC1182J 2-pole machine.
- 15 The unit is of rotating field, brushless construction and therefore has no slip rings or brushes to maintain.

16 The engine and alternator are directly coupled via a flexible disc system, the alternator having a single bearing at the non-drive end. The alternator is fitted with an electronic voltage regulator that monitors the terminal voltage and adjusts the exciter field current to maintain a constant voltage independent of load.

## CONTROL AND ELECTRICAL SYSTEMS

17 Reference should be made to the four wiring diagrams (Figs 6, 7, 8 and 9) whilst reading the Control and Electrical Systems section of Sub-cat 3.0.

### Generator control module

18 The generator Control Module (Fig 1), which is located in the centre of the Control Panel (Fig 2), monitors the operational status of the generator and checks engine, alternator and control system parameters against pre-programmed levels. The LED display indicates the following operational sequences, warnings and fault conditions:

Cold start active	Operational indicator
Pre-heat (Glow)	Operational indicator
Pilot Bypass Active	Operational indicator
Low oil fuel 1.5 hours	Warning indicator
Low oil fuel 0.5 hours	Warning indicator
Low oil pressure	Shutdown alarm
High engine temperature	Shutdown alarm
Overspeed	Shutdown alarm
Fail to start	Shutdown alarm
Charge failure	Warning indicator

## CONTROL MODULE

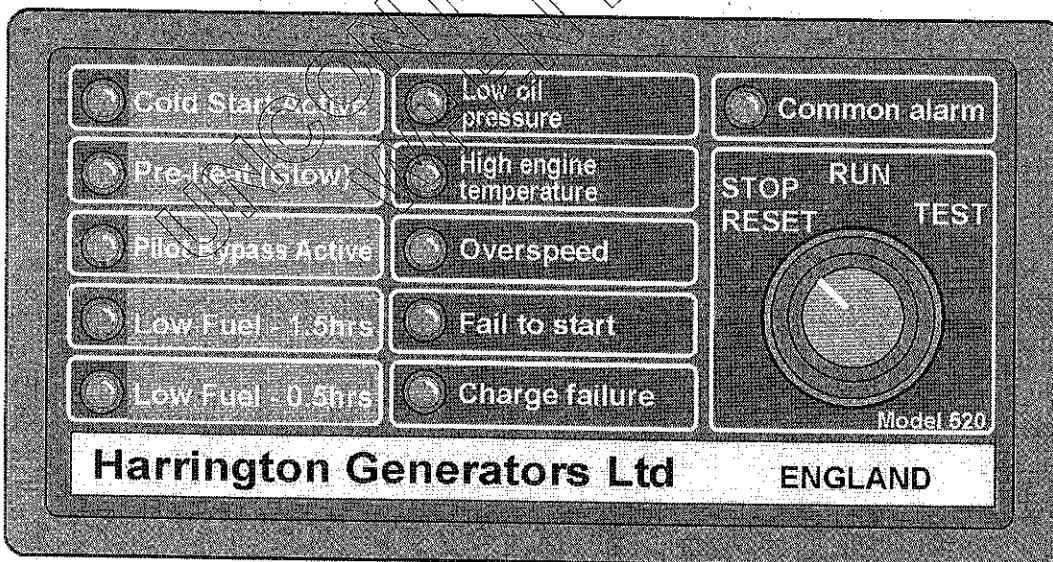


Fig 1 Generator control module

19 Warnings are self-resetting once the fault has been removed. Shutdowns are latching and stop the generator. The mode selector switch must be turned to 'STOP/RESET' and the fault removed to reset the module after a shutdown alarm.

### **Engine Start/Stop pushbuttons**

20 The momentary pushbutton switches (Fig 2) start and stop the generator under normal conditions. The switches are only operational when the control module mode selector is in the 'RUN' position.

### **Fuel gauge**

21 The fuel gauge gives a continuous reading of the fuel level whilst the engine is running. The Fuel/Hours Status switch enables a fuel level reading to be obtained when the unit is not running. Operation of the switch (Fig 2) whilst the engine is running is not detrimental.

### **DC control system circuit breaker (Mcb 4)**

22 The circuit breaker protects the 24V control system circuits against overload and short-circuit. The button protrudes when the breaker has tripped. Press in to latch and reset.

### **AC metering circuit breaker (Mcb 3)**

23 The circuit breaker protects the voltmeter, engine management module and the shunt trip circuits on Mcb 1 and Mcb 2 from overload and short-circuit (refer to Paras 27 to 30). The button protrudes when the breaker has tripped. Press in to latch and reset.

### **Hours-run counter**

24 Records the cumulative total of operational hours of the generator set. The display is activated whilst the engine is running. To check the hours run with the engine stationary, operate the Fuel/Hours Status switch (Fig 2).

### **Voltmeter**

25 Indicates the voltage of the single-phase AC output.

### **Ammeter**

26 Indicates the total load current being supplied by the generator via the two output sockets.

### **Output circuit breakers - Output 1(Mcb 1) and Output 2 (Mcb 2)**

27 Each output socket (Fig 2) is protected by a Miniature circuit breaker (Mcb) that is multi-functional. Primarily, the Mcb(s) protect the generator from overloads and short-circuits. Each Mcb is rated to allow approximately 50% of the generator's full output via each socket.

28 The Mcb(s) can be used as isolator switches for each output socket.

29 Each Mcb is fitted with a shunt trip, which, when energised, will trip the breaker to the 'Off' position.

30 The shunt trip is used in two control circuits as follows:

(1) An earth leakage, detected by a RCD (Residual Current Device) sensing imbalance on the live and neutral of each output, will cause both circuit breakers to trip.

(2) A pilot wire incontinuity on either output circuit will cause that particular circuit breaker to trip. The other output circuit will continue to operate normally.

### Pilot wire monitor

31 The Pilot Wire Monitor (Fig 3) is a safety feature, which checks the continuity of a pilot circuit from the generator through to a terminator at the load.

32 The Pilot Wire Monitor prevents the output of the generator being energised, ie the circuit breakers cannot be switched on unless all connectors in the circuit are in place and the pilot wire is intact. The pilot wire monitor also relies on a 'good' earth return (less than 5Ω) to the generator. This may be via the earth conductor in the power cable or via an earth spike system.

33 There are independent monitors on each of the outputs allowing the two output sockets to be utilised individually if required.

### Pilot bypass keyswitch

34 The Pilot Bypass switch (Fig 2) disables the pilot wire monitor system on both output circuits. This feature is provided to allow connection of loads that do not have pilot wire terminators fitted.

### Emergency start keyswitch

#### CAUTIONS

(1) **EQUIPMENT DAMAGE.** Caution should be exercised when using this feature as damage may be caused whilst it is in use should the generator be allowed to exceed its normal operational parameters.

(2) **EQUIPMENT DAMAGE.** All personnel in the vicinity should be made aware that the emergency stop is inoperable whilst using this feature.

35 The emergency start keyswitch overrides the DSE520 engine management module and all engine safety features to enable the user to start the generator. This switch disables the emergency stop, the low oil pressure and the high engine temperature safety features on the generator. Using this keyswitch does not affect the operation of the pilot wire monitor or the RCD trip.

### RCD test/reset switch

36 In the event of earth fault current detection and the RCD module (Fig 3) causing both output Mcb(s) to trip, the RCD Test/Reset switch will illuminate (Fig 2). The switch is used to reset the RCD circuit, extinguish the warning lamp and allow the output Mcb(s) to be reset to 'ON'. The switch is also used to test the RCD circuit. With both output Mcb(s) in the 'ON' position, switching to 'Test' will cause both Mcb(s) to trip. Reset as above.

### Fuel/hours status switch

37 The switch energises the Fuel Gauge and Hours Run counter when engine is not running.

#### CANOPY

38 The canopy is fabricated from Zintec steel and aluminium alloy and is finished with an Infra-Red Reflective (IRR) powder coating. The function of the canopy is to provide mechanical and weather protection and restrict noise and heat emissions.

39 An acoustic lining of Class O 'fireproof' foam assists with noise attenuation, breakout and vibration reduction.

## FUEL TANK

40 The generator is fitted with a base fuel tank of 100 litres capacity. Filling is via an external hand pump.

41 The tank has a fuel gauge sender and low-level warning switch (Fig 4). The first low-level warning is annunciated on the control module when the fuel level falls to approximately 20 litres although this will be affected if the generator is located on uneven ground. This is sufficient fuel for the generator to operate at full load for at least 1.5 hours. One hour later, a second warning is given and the fuel should be replenished within 30 minutes to avoid 'running out of fuel'.

42 The fuel gauge is located on the control panel and gives a constant indication while the generator is running. To check the fuel level when not running, the Fuel/Hours Status switch is provided. Press and hold to read the gauge.

43 A tank drain point is provided behind a small cover plate on the side of the base (refer to Fig 1 in Sub-cat 1.0).

## BATTERIES

44 The engine starting and generator control systems are powered by two AUK6TNMF batteries (Fig 5) in series to provide a 24 Volt system. The batteries are the sealed, valve-regulated type and are maintenance free. Charging is by a belt-driven alternator and regulator mounted on the engine.

## EXHAUST SILENCER SYSTEM

### WARNING

**PERSONAL INJURY. EXHAUST EXTENSIONS MUST BE DEPLOYED OUTSIDE CAMOUFLAGE NETTING WHILST THE GENERATOR IS RUNNING. WHEN DEPLOYING GENERATORS ENSURE EXHAUSTS AND EXHAUST EXTENSIONS ARE POINTED AWAY FROM THE VEHICLE.**

45 The exhaust silencer is a reactive/absorptive type. Exhaust gases from the engine are fed into the silencer via a stainless steel flexible bellows manifold pipe. This flexible section limits the amount of engine vibration transmitted to the silencer and canopy. The silencer itself is mounted in the hot air duct, so that the relatively cooler air extracted from the canopy is used to cool the body of the silencer. Two exhaust extension sections, each two metres in length, are stowed on top of the canopy. These can be coupled to the generator tail-pipe and up to four sections in series can be used. The primary use of these is to ensure that exhaust gases are directed clear of the generator when camouflage nets are being used. This reduces the risk of hot gases setting fire to the nets.

## FUEL TRANSFER PUMP

### CAUTION

**EQUIPMENT DAMAGE. Caution should be exercised when refueling and using the fuel gauge to monitor the contents of the fuel tank. The fuel gauge is damped so it does not register changes in fuel level instantaneously.**

46 The fuel transfer pump is stowed on the generator trailer and is used to transfer fuel from jerry cans or other containers into the generator tank. A bracket is provided on the generator base to hold the pump whilst in use (refer to Fig 1 in Sub-cat 1.0). The maximum transfer rate is 45 litres per minute.

## WIRING DIAGRAMS

47 The wiring diagrams for the 20kVA Cormorant diesel generator are shown in the following Harrington drawings:

- PD 951-049 Cormorant 20kVA Generator AC control and metering (see Figure 6)
- PD 951-050 Cormorant 20kVA Generator output socket wiring (Figure 7)
- PD 961-069 Cormorant 20kVA Generator DC control wiring (Figure 8)
- PD 951-070 Cormorant 20kVA Generator DC engine wiring (Figure 9)

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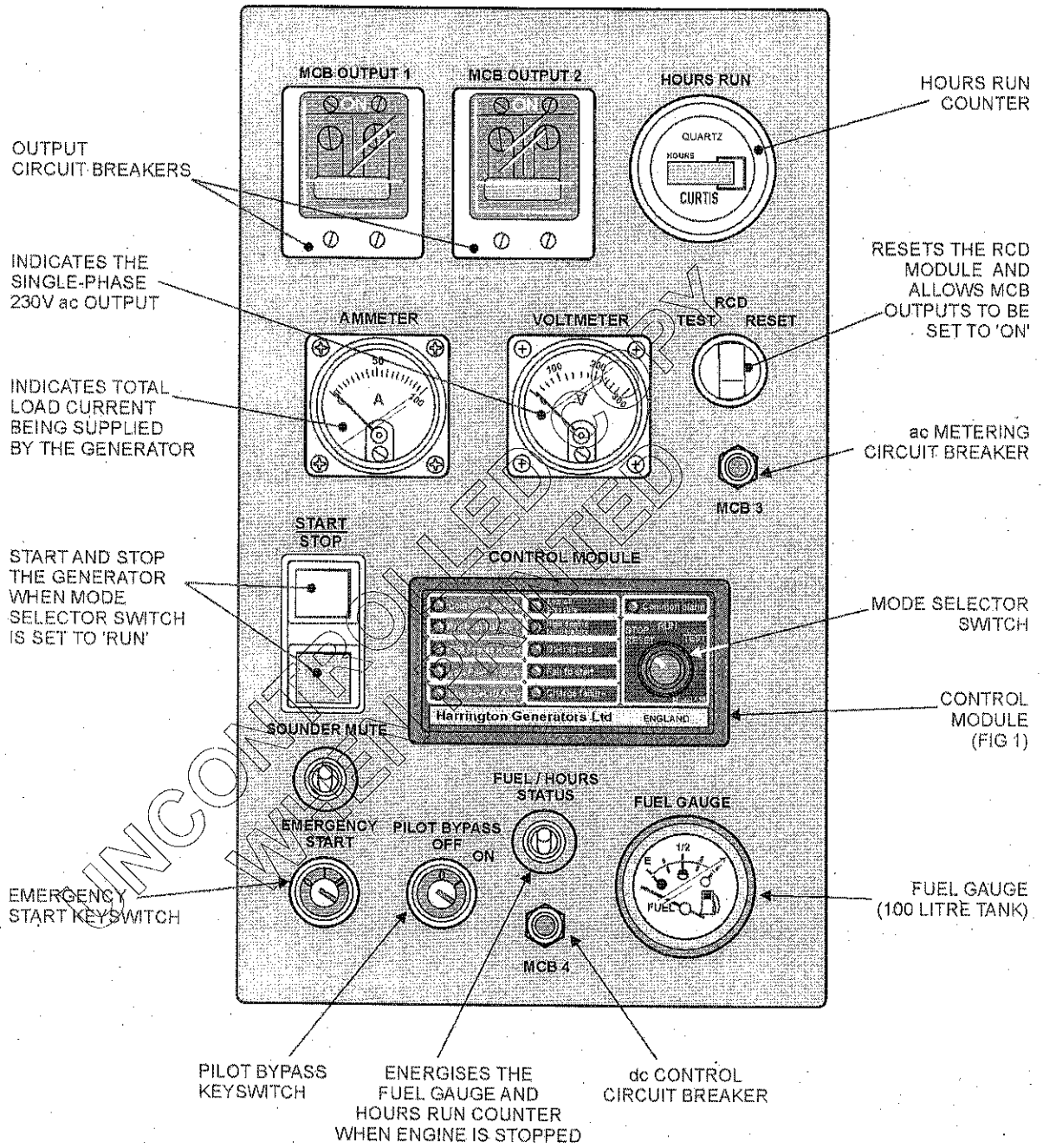


Fig 2 Control panel

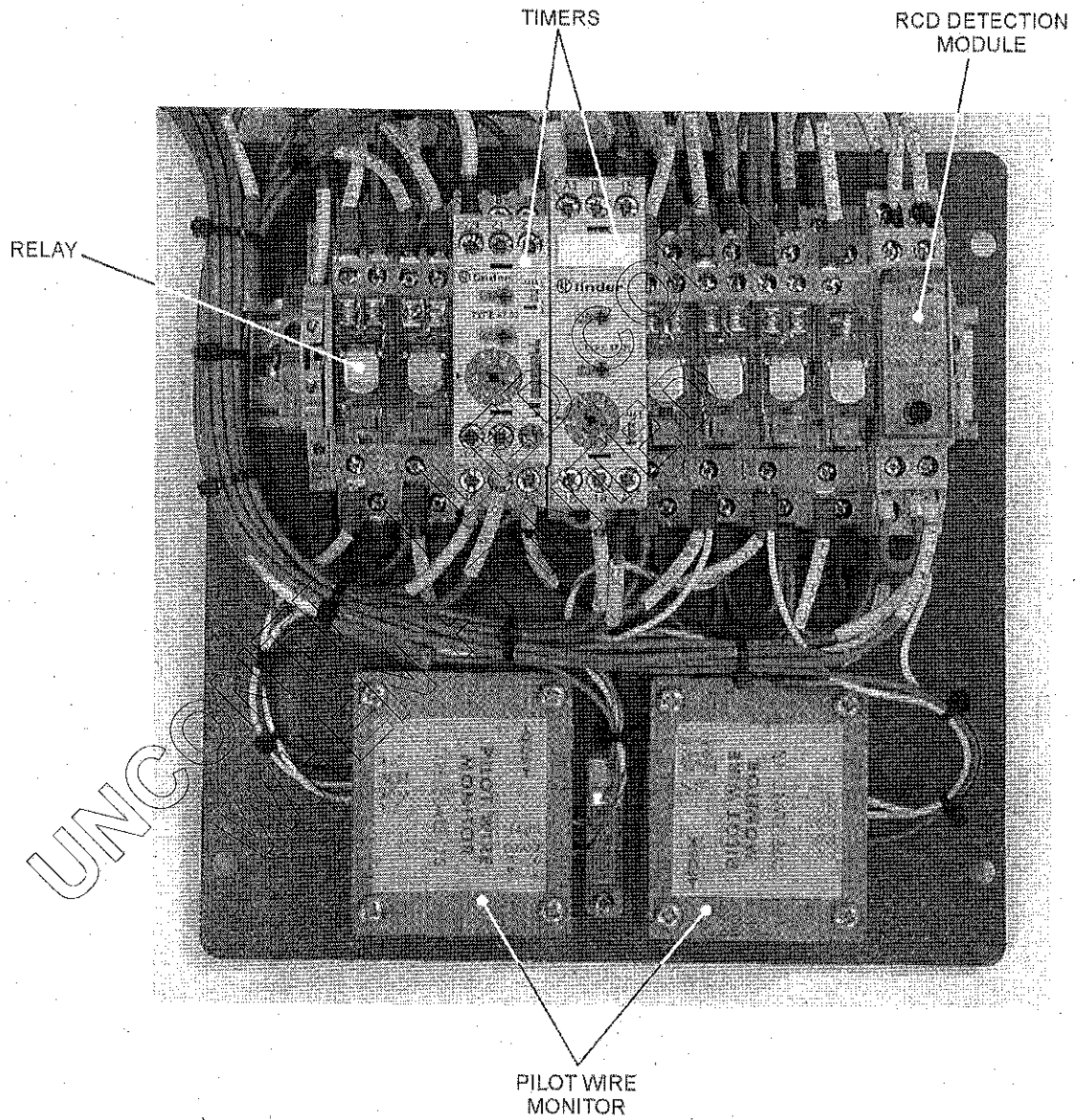


Fig 3 Pilot wire monitor devices and RCD detection module

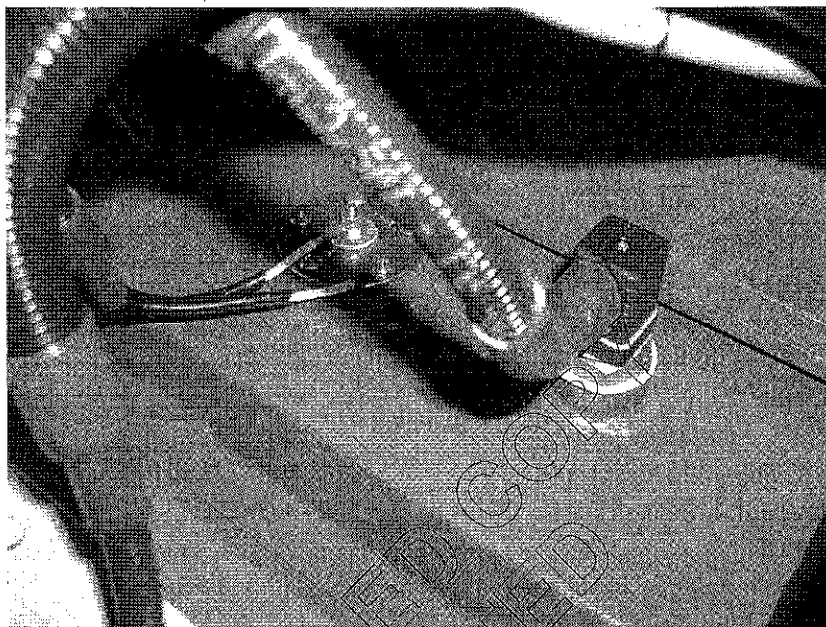


Fig 4 Fuel sender and level switch

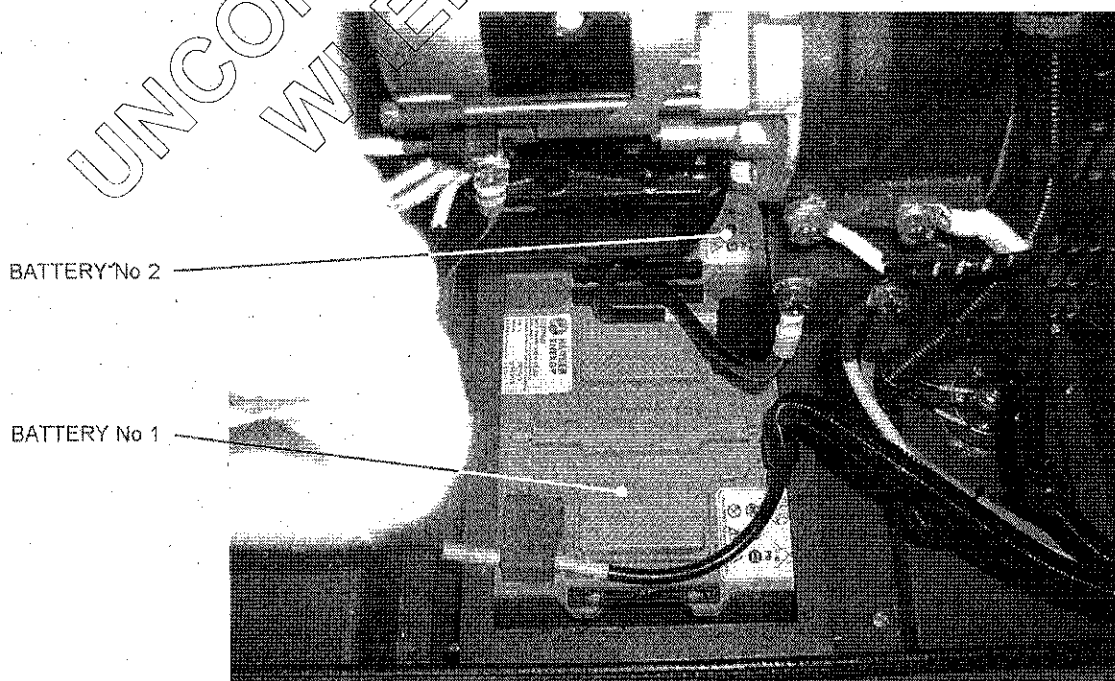
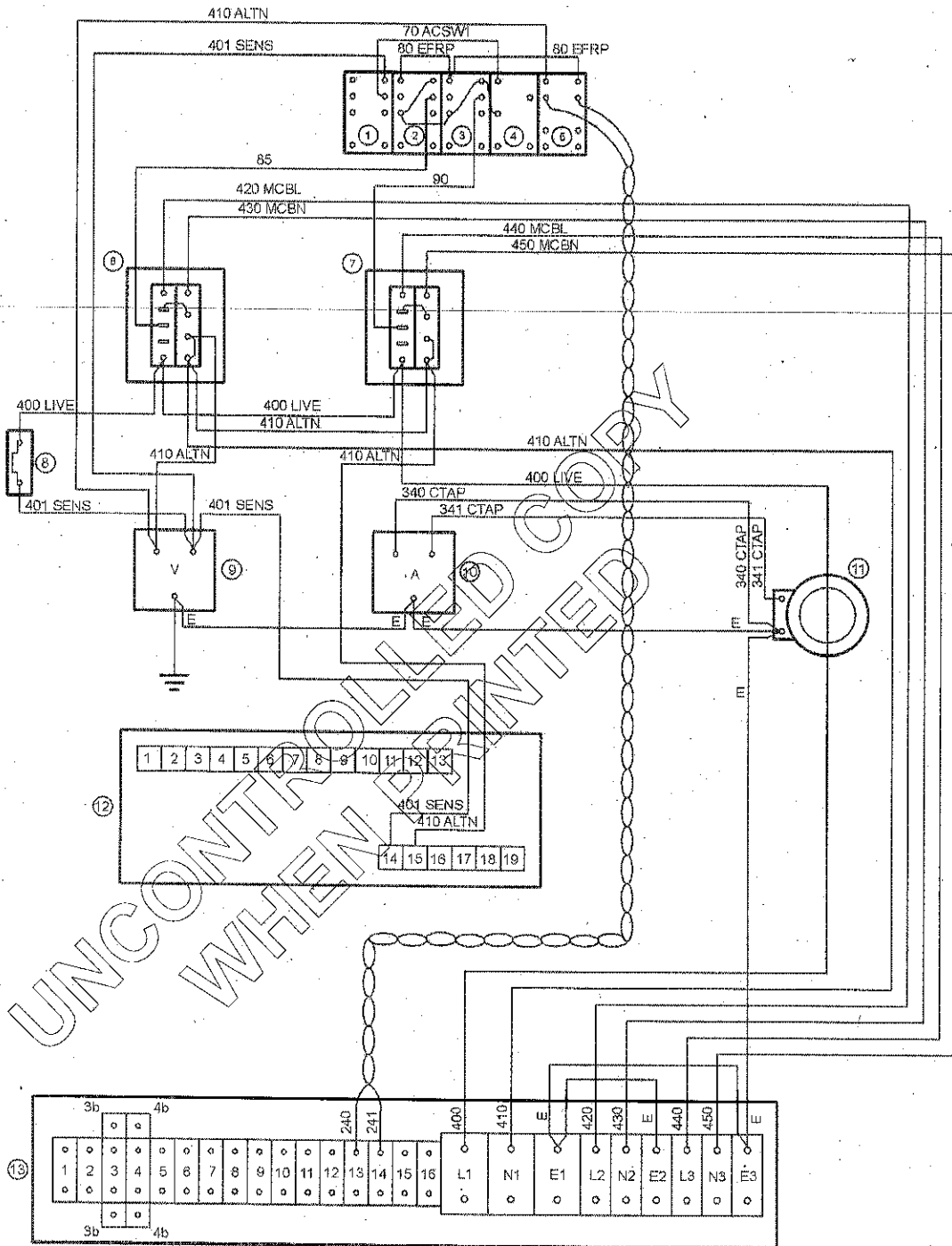
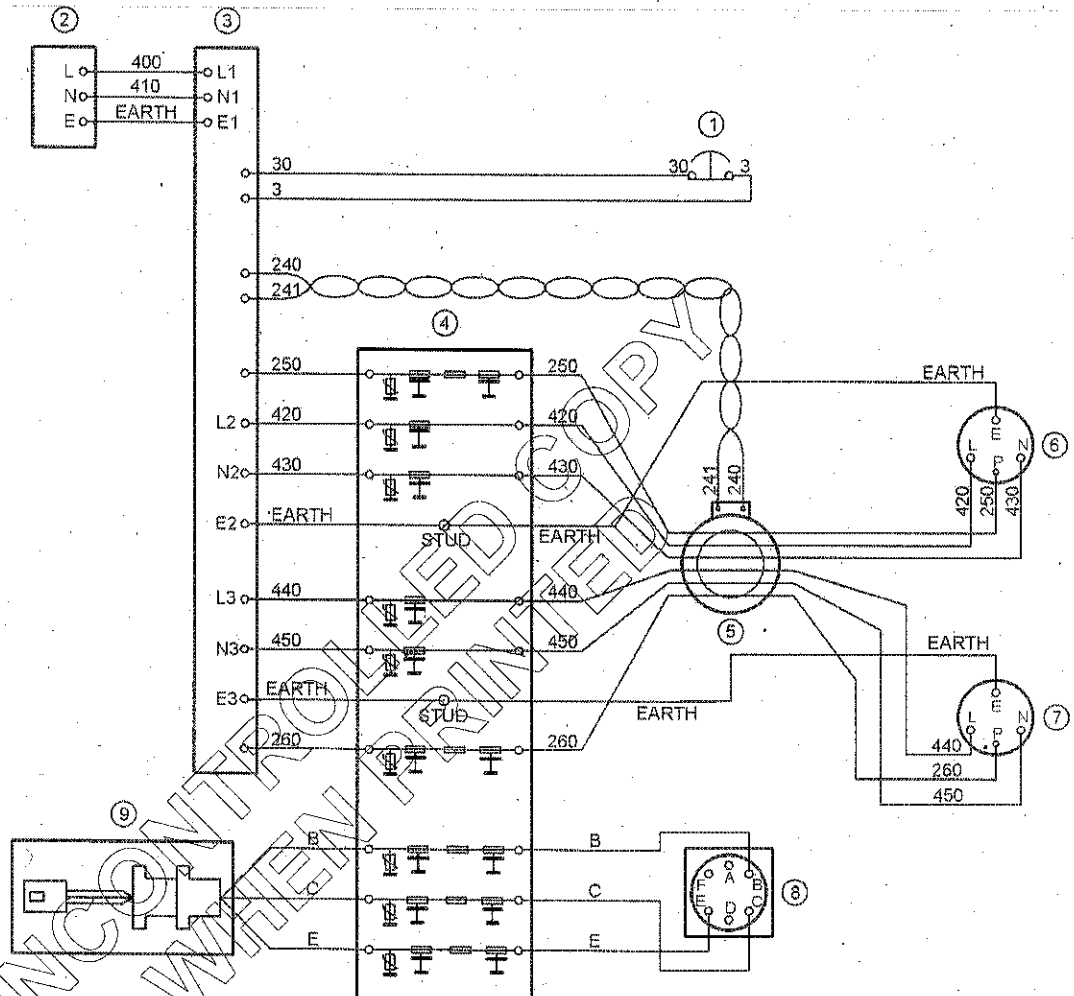


Fig 5 Batteries



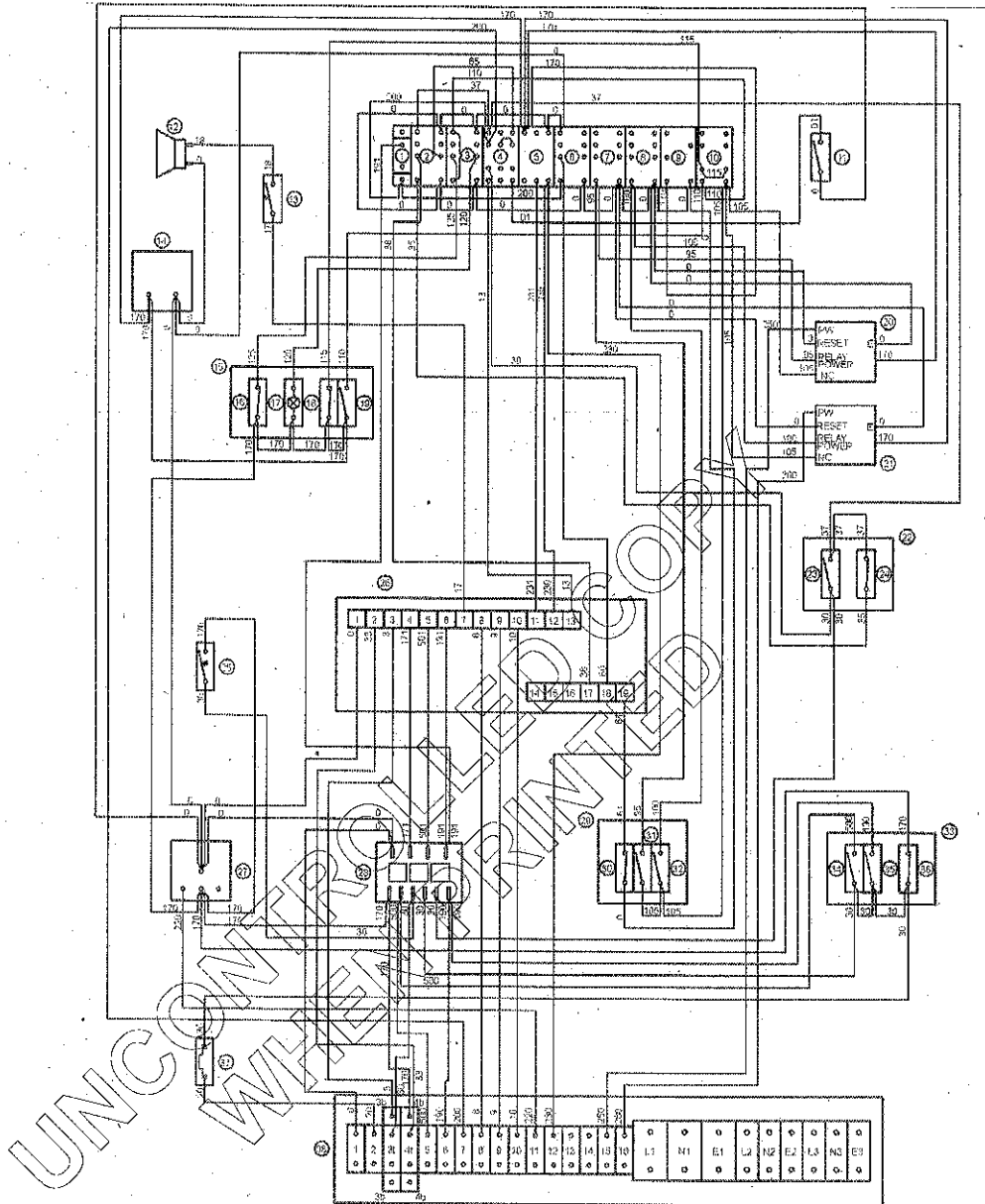
ID	DESCRIPTION	PART No.	ID	DESCRIPTION	PART No.
1	RELAY, RUN-UP RCD INHIBIT	140-031	8	MCB 3, AC METERING	110-067
2	RELAY, OUTPUT 1 RCD LATCH	140-031	9	VOLTMETER, 0-300V	085-057
3	RELAY, OUTPUT 2 RCD LATCH	140-031	10	AMMETER, 0-100A	085-255
4	RELAY, RUN-DOWN RCD INHIBIT	3RS363-837	11	CURRENT TRANSFORMER, AMMETER 100:5	085-257
5	RCD DETECTION MODULE	110-869	12	ENGINE MANAGEMENT MODULE	125-043
6	MCB 1, OUTPUT 1, OVERLOAD/SHUNT TRIP	110-843	13	TERMINAL BLOCK, CONTROL PANEL	N/A
7	MCB 2, OUTPUT 2, OVERLOAD/SHUNT TRIP	110-843			

Fig 6 Cormorant 20kVA generator AC control and metering



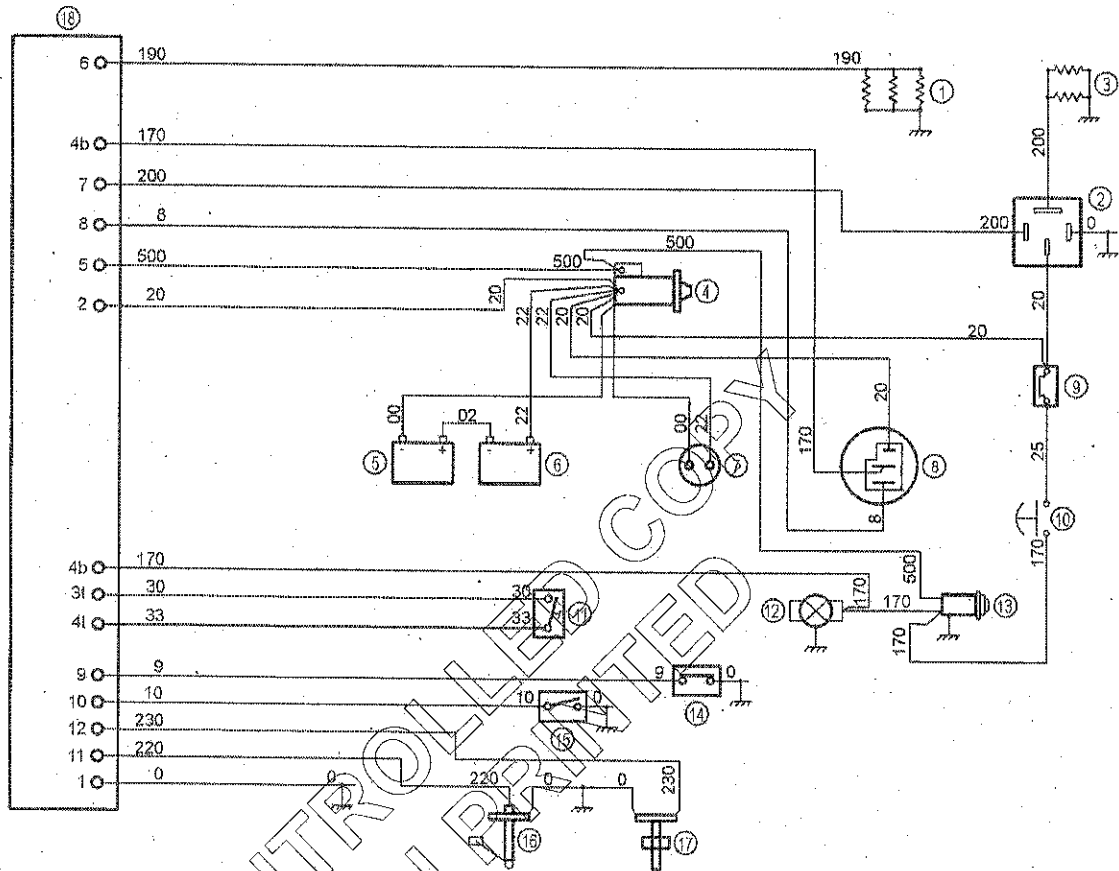
ID	DESCRIPTION	PART No.
1	SWITCH, EMERGENCY STOP	3RS318-979
2	TERMINAL BLOCK, ALTERNATOR	N/A
3	TERMINAL BLOCK, CONTROL PANEL	N/A
4	FILTER, LEMP/NEMP	136-501
5	CURRENT TRANSFORMER, RCD DETECTION	110-864
6	SOCKET, OUTPUT 1, 45A	090-611
7	SOCKET, OUTPUT 2, 45A	090-611
8	SOCKET, REMOTE CONTROL	090-612
9	INTERFACE CONVERTER	501-808

Fig 7 Cormorant 20kVA generator output socket wiring



ID	DESCRIPTION	PART No.	ID	DESCRIPTION	PART No.
1	COLD START BLOCKING DIODE	116-781	21	PILOT WIRE MONITOR, OUTPUT 2	110-601
2	RELAY, START/STOP LATCH	140-031	22	SWITCH, START/STOP PUSH BUTTON	080-001
3	RELAY, RCD LAMP RESET	140-051	23	CONTACT BLOCK, START/STOP N/O	080-002
4	TIMER, COLD START HEATER	140-437	24	CONTACT BLOCK, START/STOP N/C	080-002
5	TIMER, LOW FUEL WARNING	140-430	25	SWITCH, HOURS/FUEL STATUS	080-031
6	RELAY, RUN-UP RCD INHIBIT	140-031	26	ENGINE MANAGEMENT MODULE	125-043
7	RELAY, OUTPUT 1 RCD LATCH	140-031	27	FUEL GAUGE, ANALOGUE	170-620
8	RELAY, OUTPUT 2 RCD LATCH	140-031	28	SLAVE RELAY MODULE, 24V	140-048
9	RELAY, RUN-DOWN RCD INHIBIT	SRS353-837	29	KEYSWITCH, PILOT BYPASS	080-479
10	RCD DETECTION MODULE	110-868	30	CONTACT BLOCK, N/C, MODULE INPUT	080-475
11	THERMOSWITCH, COLD START	110-885	31	CONTACT BLOCK, N/O, LATCH OUTPUT 1	080-474
12	SONDER, WARNING ALARMS	RS178-4187	32	CONTACT BLOCK, N/O, LATCH OUTPUT 2	080-474
13	SWITCH, SONDER MUTE	080-004	33	KEYSWITCH, EMERGENCY START	080-478
14	HOURS RUN COUNTER	086-207	34	CONTACT BLOCK, N/O, CRANK	080-474
16	SWITCH, RCD TEST/RESET	080-472	35	CONTACT BLOCK, N/O, PRE-HEAT	080-474
16	CONTACT BLOCK, RCD LAMP LATCH N/C	080-475	36	CONTACT BLOCK, N/C, FUEL	080-475
17	LAMP, RCD TRIP/TEST	080-473	37	MCB 4, DC CONTROL CIRCUITS	110-088
18	CONTACT BLOCK, RCD RESET N/C	080-475	38	TERMINAL BLOCK, CONTROL PANEL	N/A
19	CONTACT BLOCK, RCD RESET N/O	080-474			
20	PILOT WIRE MONITOR, OUTPUT 1	110-601			

Fig 8 Cormorant 20kVA generator DC control wiring



ID	DESCRIPTION	PART No.
1	PRE-HEAT RAIL, GLOW PLUGS	ENGINE
2	RELAY, COLD START SLAVE	140-035
3	HEATER, COLD START	ENGINE
4	STARTER MOTOR	ENGINE
5	BATTERY NO.1	120-034
6	BATTERY NO.2	120-034
7	SOCKET, 24V INTER-VEHICLE	090-601
8	CHARGE ALTERNATOR	ENGINE
9	MCB 5, FUEL PUMP PRIMING	110-083
10	SWITCH, FUEL PRIME PUSHBUTTON	080-051
11	SWITCH, DC POWER ISOLATOR	080-004
12	FUEL PUMP 24V	ENGINE
13	FUEL SOLENOID, 24V	ENGINE
14	SWITCH, OIL PRESSURE, N/C	ENGINE
15	SWITCH, ENGINE TEMPERATURE, N/O	ENGINE
16	FUEL GAUGE SENDER	170-620
17	SWITCH, LOW FUEL LEVEL	080-021
18	TERMINAL BLOCK, CONTROL PANEL	N/A

Fig 9 Cormorant 20kVA generator DC engine wiring

**CATEGORY 5            MAINTENANCE INFORMATION AND INSTRUCTIONS**  
**SUB-CATEGORY 5.1    FAULT DIAGNOSIS**  
**SUB-CATEGORY 5.2    REPAIR INSTRUCTIONS**  
**SUB-CATEGORY 5.3    ROUTINE MAINTENANCE**

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## SUB-CATEGORY 5.1

### FAULT DIAGNOSIS

#### CONTENTS

Para

- 1 Diagnostics
- 5 Mimic display
- 6 Status display
- 9 Fault finding

Table

- |   |                     |      |   |
|---|---------------------|------|---|
| 1 | Fault finding ..... | Para | 2 |
|---|---------------------|------|---|

Fig

- |   |                                       |      |   |
|---|---------------------------------------|------|---|
| 1 | Remote control socket.....            | Page | 3 |
| 2 | Control panel and control module..... |      | 4 |

#### DIAGNOSTICS

- 1 In addition to traditional fault finding and diagnostics techniques using diagrams and meters etc, the generator has the benefit of diagnostics available via the control module and a PC.
- 2 The appropriate software, interface link and, CMIS workstation or LMT are required.
- 3 Access to the control module (Fig 2) for the interface link is via the 'Remote Control' connector adjacent to the output sockets (Fig 1). The interface link connects into the serial port of the computer.
- 4 Two versions of the diagnostic facility are available, a Mimic display and a Status display.

#### Mimic display

5 The first diagnostic is the Mimic Display, which is provided to allow at-a-glance monitoring of the system. All non-essential information is hidden. Clear graphical displays of the measured values allow easy performance monitoring. Should an alarm occur this is clearly displayed by a flashing red 'Alarm' legend. Details on the system operation are provided to give more information if required.

#### Status display

6 The second diagnostic is the Status Display, which allows the user to see the value of all measured inputs and the status of any of the digital inputs. Output state of the relays and LED operation are also displayed. A text display indicates the present state of operation of modules, shows the time remaining on any system timer that is in operation, and will give details on any shutdown alarm that has occurred.

7 As the diagnostics are real-time the opening and closing of the inputs can be viewed allowing simple checks to be made on panel wiring if this is thought to be at fault. It is therefore possible to simulate a switching signal by earthing the appropriate input connection in the panel. If the input state displayed on the diagnostic page changes this indicates that the wiring is correct. It is possible that the module configuration is incorrect and further investigation is required using the configuration program.

8 Refer also to the DSE P808 for Windows Software Manual, pages 47 to 49.

## FAULT FINDING

9 Fault finding information is detailed in Table 1 below:

**TABLE 1 FAULT FINDING**

Symptom	Possible Cause	Solution
Generator will not crank.	Controller mode switch in 'OFF/RESET' position. Discharged batteries. Poor battery/starter connections. dc protection Mcb tripped.	Switch to 'RUN'. Charge batteries or use inter-vehicle connector to 'jump-start'. Check connections. Tighten and clean as necessary. Push to reset Mcb. If Mcb trips again, investigate wiring on engine systems.
Engine cranks but will not start. ('Fail to Start' alarm.) No white smoke from exhaust whilst cranking.	Insufficient fuel in tank. Fuel filter blocked. Fuel solenoid faulty.	Re-fill with fuel. Replace fuel level and bleed system. Check for 24 Volts at fuel solenoid (fuel pump) during cranking. Repair/replace as necessary.
Engine cranks, but will not start (Fail to start alarm.) White smoke from exhaust whilst cranking.	Cold ambient conditions. Batteries in poor condition - Insufficient crank speed	Reset fail to start alarm at controller. Re-try cranking. Charge batteries or use inter-vehicle connector to jump-start.
Low oil pressure at shutdown.	Low oil level in engine sump.	Top up sump oil to maximum level. Reset alarm at controller. Re-start generator.
High temperature shutdown.	Low coolant in radiator:  Engine fan belt broken. ('Charge Fail' LED also lit)  Cooling air circuit blocked or re-circulating.  Generator overload.	Allow engine to cool before removing radiator cap. Fill radiator with water/additive mixture. Reset alarm at controller.  Replace fan belt.  Check generator canopy inlets and outlets for obstructions. Clear airways. Reset alarm at controller.  Check value of connected load. Reduce to within rated value of generator. (See Sub-cat 1.0.)

(continued)

**TABLE 1 FAULT FINDING (continued)**

Symptom	Possible Cause	Solution
Overspeed shutdown.	Engine overfilled with oil.  Engine governor fault.	Check oil level on dipstick. Drain excess oil until level is at 'maximum'. Reset alarm at controller. Refer to engine handbook or Service Agent.
Underspeed shutdown.	Generator overload.  Air cleaner blocked. Fuel filter blocked.	Check value or connected load. Reduce to within rated value of generator. (See Sub-cat 1.0.) Clean/replace air cleaner element. Replace fuel filter element and bleed system.
Charge Fail warning.	Engine fan belt broken.	Replace fan belt.
Generator runs but main output circuit breaker (Mcb) will not latch.	Pilot wire incontinuity  Poor earth return.  Earth fault on distribution system or load.	Check all connectors in supply line from generator to load are in place and secure.  Check earth bonding and earth continuity between generator and load.  Check system and appliances for earth fault. Optionally systematically disconnect appliances to identify faulty item.

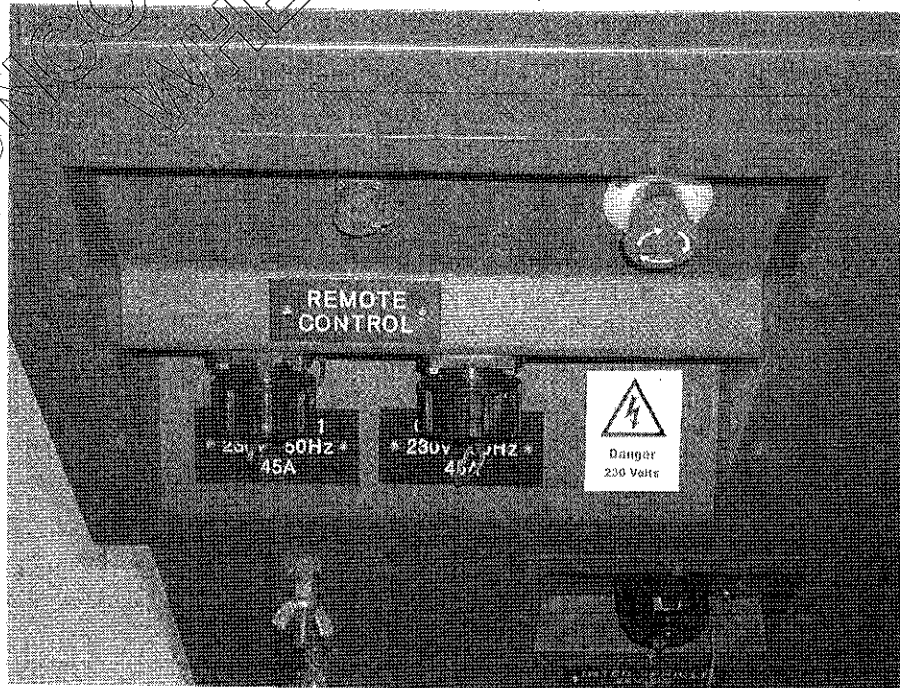
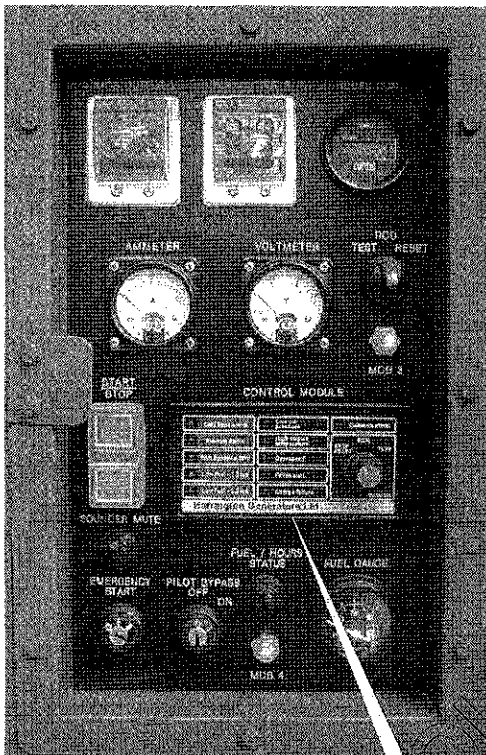


Fig 1 Remote control socket



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**CONTROL MODULE**

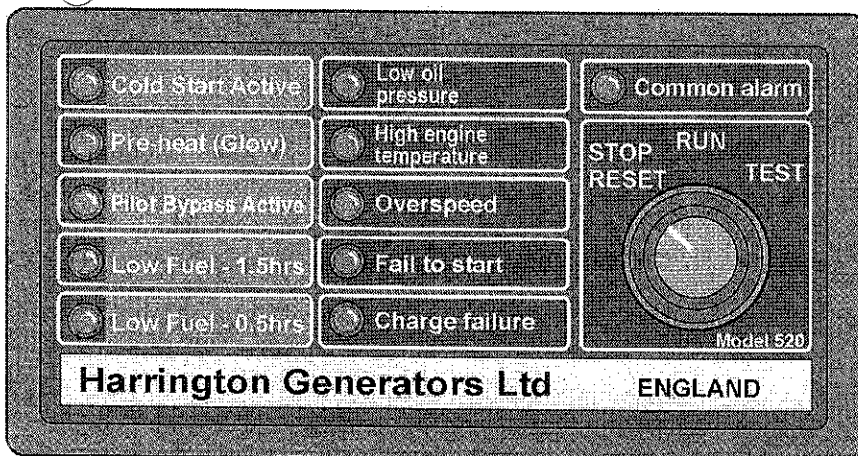


Fig 2. Control panel and control module

**SUB-CATEGORY 5.2**

**REPAIR INSTRUCTIONS**

**CONTENTS**

Para

- 1 Disconnecting the battery negative terminal (WARNING)
- 2 Removing/replacing the batteries (WARNING)
- 3 Removing/replacing the control panel
- 5 Removing/replacing the output pod
- 7 Removing/replacing the 24V inter-vehicle connection pod
- 9 Removing/replacing the canopy roof

Fig

	Page
1 Battery access cover .....	5/6
2 Battery terminals .....	5/6
3 Control panel and door .....	7/8
4 Output pod and inter-vehicle connection pod .....	7/8
5 Canopy roof removal .....	9/10

**DISCONNECTING THE BATTERY NEGATIVE TERMINAL**

**WARNING**

**PERSONAL INJURY. BEFORE COMMENCING ANY SERVICE OR REPAIR WORK, ENSURE THAT THE CONTROL MODULE IS IN THE 'OFF/RESET' POSITION. OPERATE THE EMERGENCY STOP PUSHBUTTON. DISCONNECT THE NEGATIVE TERMINAL ON THE BATTERY. ENSURE THAT THERE IS NO CONNECTION TO THE 24V INTER-VEHICLE SOCKET.**

- 1 Open the hinged canopy access door and fasten back. Working through the door opening, lift the black terminal boot off the negative terminal on the nearest battery. Loosen and remove the negative terminal and bend or tie back the battery lead to prevent it inadvertently re-connecting with the battery.

**REMOVING/REPLACING THE BATTERIES**

**WARNING**

**PERSONAL INJURY. EACH BATTERY WEIGHS 40kg AND THE BATTERIES SHOULD BE LIFTED BY TWO PEOPLE.**

- 2 The generator is fitted with two batteries connected in series. Before removing either or both batteries, disconnect the negative terminal as described in Para 1.

(1) Unlatch and remove the lift-off canopy door. Working through the door opening (Fig 1 and Fig 2), lift the red terminal boot off the positive terminal on the nearest battery.

- (2) Loosen and remove the positive terminal and bend or tie back the battery lead to prevent it inadvertently re-connecting with the battery.
- (3) Remove the four M8 setscrews and remove the battery access cover plate. Remove the two M8 setscrews that hold the battery clamp bracket.
- (4) Lift the hinged battery clamp top frame and tie up.
- (5) Pull/slide the first battery, until it is flush with the canopy battery access opening.
- (6) Lift the red terminal boot off the positive terminal.
- (7) Loosen and disconnect the link cable from the positive terminal.
- (8) The first battery can now be withdrawn and lifted clear of the generator.
- (9) Pull/slide the second battery until it is flush with the canopy battery access opening.
- (10) The second battery, with the link cable attached, can now be withdrawn and lifted clear of the generator.

#### REMOVING/REPLACING THE CONTROL PANEL

- 3 Before commencing work, disconnect the battery negative terminal as described in Para 1.
  - (1) Unlatch and open the control panel weather cover (Fig 3).
  - (2) Remove the nine M6 setscrews that secure the control panel frame to the canopy.
  - (3) Ease the control pod out through the aperture and support it, face down, just forward and below the aperture.
  - (4) Remove the four M5 pozi screws that secure the control panel near cover and remove the cover.
  - (5) Remove the four M5 pozi screws that secure the Current Transformer Plate to the control pod.
  - (6) Ease the Current Transformer Plate forward to gain access to the back.
  - (7) Unscrew and disconnect the 25-way D connector leaving the mating half clamped to the tie.
  - (8) Remove the four M5 setscrews that secure the gland plate to the bottom of the control panel at the rear.
  - (9) Systematically loosen and remove the cables from the terminals until the gland plate with its conduits and cable-ends is separated from the control pod. The control pod can now be lifted clear of the generator.

#### NOTE

The terminals used are the spring-loaded type and the cables are terminated with hook crimps.

- (10) To remove each cable, loosen the screws and with the screwdriver still in the slot, press the screw against the spring and pull the cable and hook crimp.
- 4 Replacement of the control pod is a reversal of the removal procedure.

#### **REMOVING/REPLACING THE OUTPUT POD**

- 5 Before commencing work, disconnect the battery negative terminal as described in Para 1.
  - (1) Remove the control pod as described in Para 3.
  - (2) When the gland plate has been separated from the control panel, remove the conduit gland nut from conduit number 3 and conduit number 5 and withdraw the cables through the gland plate. These are the conduits to the main alternator and the engine respectively.
  - (3) Remove the eight M6 setscrews (Fig 4) that secure the Output Pod to the canopy end panel.
  - (4) Ease the Output Pod forward and lift it clear of the generator, complete with the NEMP/LEMP filter and conduits attached.
  - (5) The Output Pod can be replaced complete with conduits. Alternatively, systematically remove the cover plates and swap the conduit and NEMP/LEMP filter from the outgoing pod to the incoming pod.
- 6 Replacement of the Output Pod is a reversal of the removal procedure.

#### **REMOVING/REPLACING THE 24V INTER-VEHICLE CONNECTION POD**

- 7 Before commencing work, disconnect the battery negative terminal as described in Para 1.
  - (1) Unlatch and remove the lift-off canopy door.
  - (2) Working through the door opening, lift the red terminal boot cover off the positive terminal on the nearest battery (see Fig 2).
  - (3) Leave the positive battery terminal clamp in place and remove the lead marked 22BAT+ from the clamp.
  - (4) Remove the lead marked 00BAT- that is bolted onto the side of the engine flywheel housing.
  - (5) Remove the four M6 setscrews (Fig 4) that secure the Inter-vehicle Socket Pod to the canopy end panel.
  - (6) Ease the pod out through the aperture and withdraw with the conduit attached.
  - (7) The Inter-vehicle Socket Pod can be replaced complete with conduit.
  - (8) Alternatively remove the cover plate and swap the conduit assembly from the outgoing pod to the incoming one.
- 8 Replacement of the Inter-vehicle Socket Pod is a reversal of the removal procedure.

## REMOVING/REPLACING THE CANOPY ROOF

9 For better access during service and repair work, it may be beneficial to remove the canopy roof. Refer to Fig 5.

- (1) Unlatch and remove the lift-off door.
- (2) Unlatch and open the hinged canopy door.
- (3) Remove the fourteen M6 setscrews that secure the roof to the canopy end panels.
- (4) With assistance and using the handles on the roof, lift the roof off and clear of the generator.

10 Replacement of the canopy roof is a reversal of the removal procedure.

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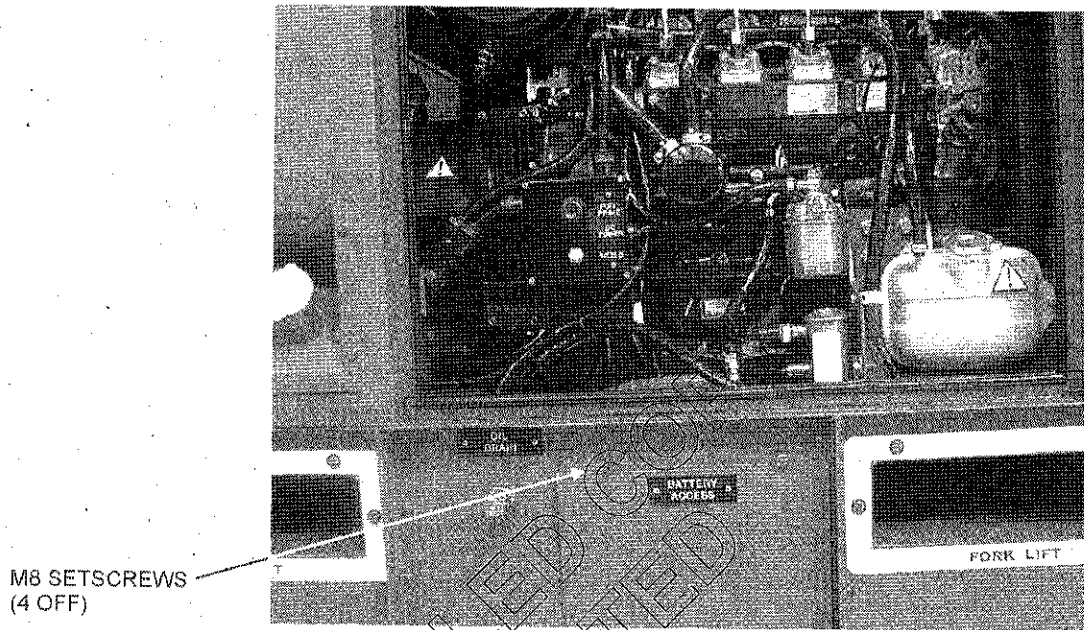


Fig 1 Battery access cover

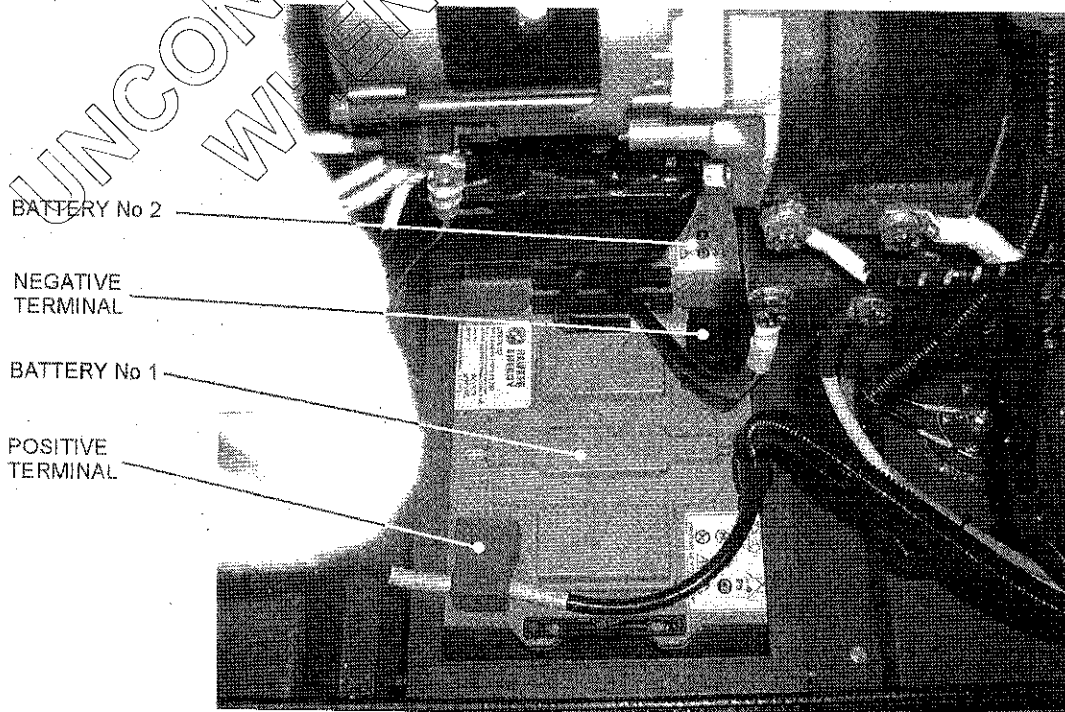


Fig 2 Battery terminals

M6 SETSCREWS  
(9 OFF)



Fig 3 Control panel and door

M6 SETSCREWS  
(8 OFF)

M6 SETSCREWS  
(4 OFF)

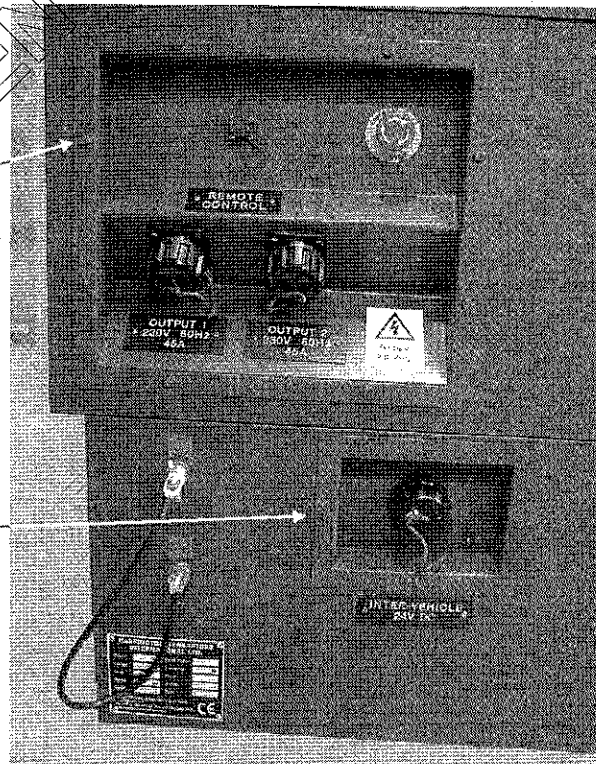


Fig 4 Output pod and inter-vehicle connection pod

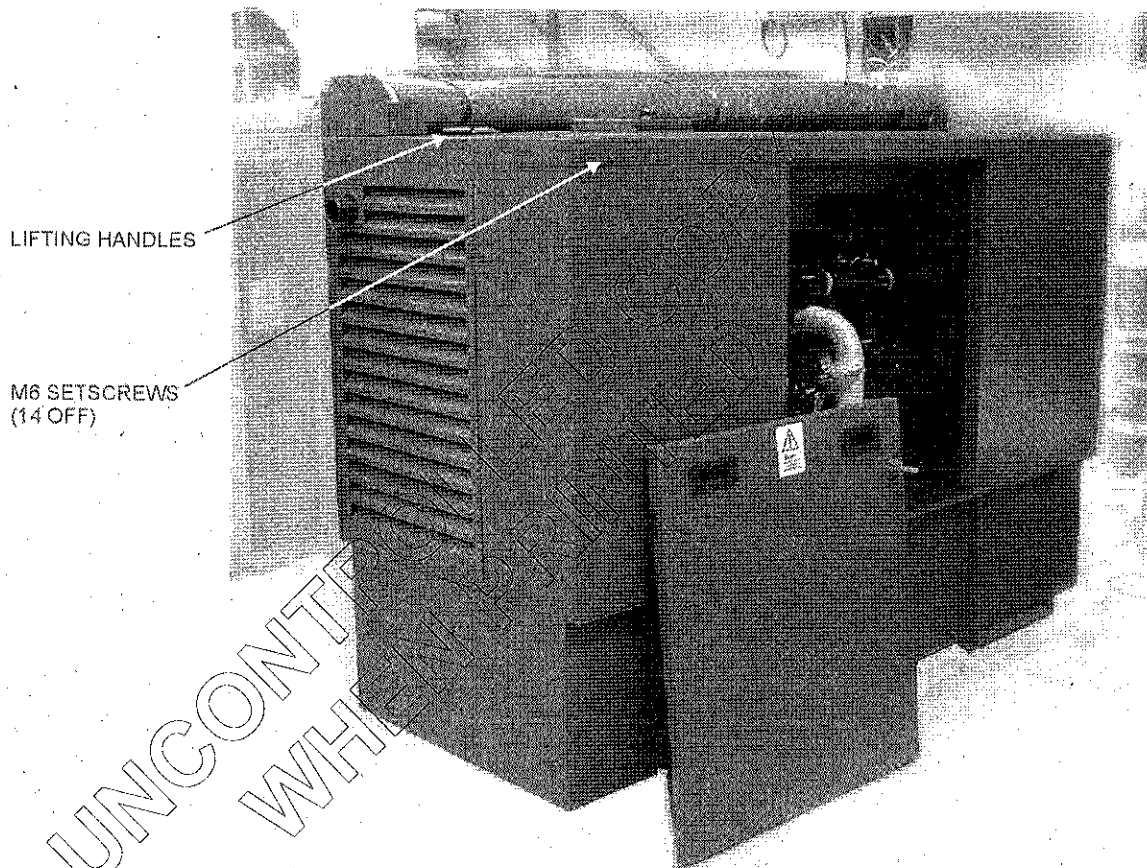


Fig 5 Canopy roof removal

### SUB-CATEGORY 5.3

## ROUTINE MAINTENANCE

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- 3 Oil level fill and drain
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### ENGINE

1 The Lubrication and Maintenance schedule for the engine is detailed in Para 145 of the 4LE1 Engine Instruction Manual (Annex A). A summary of the schedule is also shown in Paras 10 to 16. In addition, the following information details the engine maintenance in relation to the canopy. Daily engine maintenance is via the hinged door on the canopy (Fig 1).

#### Coolant level

2 The coolant level should be checked when the engine is cold (Annex A, Para 94 of the 4LE1 Engine Instruction Manual). To completely refill the radiator and engine with coolant, use the radiator access flap in the canopy roof (Fig 3 and Fig 4).

**Oil level fill and drain****NOTE**

Run the engine, on load if possible, for approximately 15 minutes to warm up the oil before draining. This will significantly reduce the drainage time.

3 Draining of the lubricating oil is achieved using the hose drain point on the side of the canopy base. Remove the cap/end stop and position a suitable receptacle for the collection of the waste oil, or connect a hose leading to a receptacle (thread type ½ inch BSP). Oil draining will begin when the sump tap, positioned just inside the canopy, is turned ON. Refer to the 4LE1 Engine Instruction Manual (Annex A, Para 84) for further information.

**ALTERNATOR**

4 The alternator requires no maintenance other than to ensure that the cooling air vents do not become blocked by dirt, debris, etc. Every 50 operating hours is recommended.

**Automatic voltage regulator**

5 Restricted access to the voltage regulator is via the lift-off canopy door (Fig 2). The voltage regulator is located behind the side plate of the alternator terminal box. No routine maintenance is required.

**CANOPY**

6 Every 250 operating hours check the security of fixings and fasteners on the machine.

7 Lubricate hinges and latches with light machine oil.

8 Ensure that the inlet and outlet louvres are kept clean and unimpeded at all times.

**FUEL TANK**

9 It may be prudent to drain and flush the fuel tank every 500 operating hours, particularly when the generator has operated in high humidity and dusty environments.

**MAINTENANCE SCHEDULE SUMMARY**

10 The following schedule summary details the MINIMUM recommended routine maintenance required for the upkeep of the 20kVA generator set. Refer also to the Maintenance Schedule in the 4LE1 Engine Instruction Manual (Annex A, Para 145) and to the schedule in the Technician Guide (Annex C, Table 1).

11 Operating conditions and experience may lead to the reducing of some of the intervals.

**Initial 50 hour service**

12 Replace the engine oil filter and change the engine oil after the initial 50 hours of engine operation. Thereafter follow the regular maintenance schedule.

**Daily**

13 The following routine maintenance checks should be carried out on a daily basis:

- (1) Check engine oil level.
- (2) Check engine coolant level.
- (3) Check air cleaner dust valve.
- (4) Check air cleaner restriction indicator.
- (5) Check canopy air inlets and outlets.
- (6) General visual inspection.

**Every 50 hours**

14 The following routine maintenance procedures should be carried out after every 50 hours of operation:

- (1) Check fan belt tension.
- (2) Drain water from fuel filter.
- (3) Clean alternator air vents.

**Every 250 hours**

15 The following routine maintenance procedures should be carried out after every 250 hours of operation:

- (1) Change lubricating oil.
- (2) Check fan belt tension.
- (3) Check exhaust flanges and joints for tightness and leaks.
- (4) Check machine fixings and fastenings.

**Every 500 hours**

16 The following routine maintenance procedures should be carried out after every 500 hours of operation:

- (1) Change lubricating oil filter. Change fuel filter element.
- (2) Check air intake hoses, connection and system.
- (3) Clean crankcase vent tube.
- (4) Check cooling system.
- (5) Check coolant concentration.
- (6) Flush and drain the fuel tank.

## Every 1000 hours

17 The following maintenance procedures should be carried out after every 1000 hours:

- (1) Check and adjust engine valve clearances.
- (2) Flush cooling system and re-fill.
- (3) Pressure test cooling system.
- (4) Clean the starter motor commutator.
- (5) Clean the generator slip ring.
- (6) Check brush length and contact pressure.

## CONDITIONING

### Winter operation

18 Operation and storage/transit of the generators at temperatures below  $-5^{\circ}\text{C}$  requires special preparation to ensure reliability.

## WARNING

**PERSONAL INJURY. DO NOT REMOVE THE RADIATOR CAP WHILST THE ENGINE IS RUNNING OR HOT.**

**PERSONAL INJURY. 20KVA GENERATOR COOLANT - ETHYLENE GLYCOL IS HARMFUL IF SWALLOWED. IN CASE OF CONTACT WITH EYES, RINSE IMMEDIATELY WITH PLENTY OF WATER AND SEEK MEDICAL ADVICE. ALWAYS WEAR PROTECTIVE CLOTHING, GLOVES AND EY/FACE PROTECTION. IF YOU FEEL UNWELL, SEEK MEDICAL ADVICE IMMEDIATELY**

### Coolant

19 The coolant must be a 50/50 mixture of water and ethylene glycol antifreeze. Check the concentration using a hydrometer. If no method of checking is available, it is advisable to completely drain the coolant and refill with a new mixture of known concentration. Refer to the 4LE1 Engine Instruction Manual when required (Annex A, Paras 90 to 98).

### Oil change - winter grade

20 Run the engine, on load if possible, for 15 minutes to warm up the oil before draining. This will significantly reduce the drainage time. Refer to the 4LE1 Engine Instruction Manual when required (Annex A, Paras 81 to 89).

21 Stop the engine and drain the oil as described in Para 3.

22 Re-fill the engine with Multi-viscosity diesel oil - grade SAE 5W-30. The Military equivalent is OMD-55 (25 litre, NSN 9150-99-477-3153).

23 Changing the oil filter element is not essential unless the generator is due for service.

### Fuel system

- 24 Refer to the 4LE1 Instruction Manual when required (Annex A, Paras 99 to 105). It is recommended that Dieso (even with winter additives) be not used at temperatures below -5°C.
- 25 Any Dieso in the fuel tank should be completely drained using the drain plug on the side of the canopy base (Fig 5).
- 26 Change the fuel filter element (Fig 6). Refer to Annex A, Para 104.
- 27 Re-fill the fuel tank with AVTUR and bleed the engine fuel system as described in the 4LE1 Engine Instruction Manual (Annex A, Para 102).
- 28 Run the engine for 30 minutes, on load if possible, to ensure that all Dieso within the fuel system has been replaced by AVTUR.

### **Summer operation**

- 29 For operation at high ambient temperatures, Harrington recommends the following preparation:

#### Oil change - summer grade

- 30 Run the engine, on load if possible, for 15 minutes to warm up the oil before draining. This will significantly reduce the drainage time.
- 31 Stop the engine and drain the oil as described in Para 3.
- 32 Re-fill the engine with Multi-viscosity diesel engine oil - grade SAE 15W-40. The Military equivalent is OMD-113 (25 litre, NSN 9150-99-224-2540).
- 33 Changing the oil filter element is not essential unless the generator is due for service.

### Fuel system

- 34 If the generator has been operating with AVTUR as the fuel, it is recommended that Dieso be used at ambient temperatures where there is no risk of waxing, ie above -5°C.
- 35 It is not necessary to drain any AVTUR from the fuel system. Dieso can be mixed/added so that the changeover is gradual.
- 36 Although there are no problems associated with operating on AVTUR at high temperatures, the engine power is slightly reduced (5%) and lubricating properties are not as good.
- 37 Harrington recommends operation on Dieso wherever ambient temperatures allow.



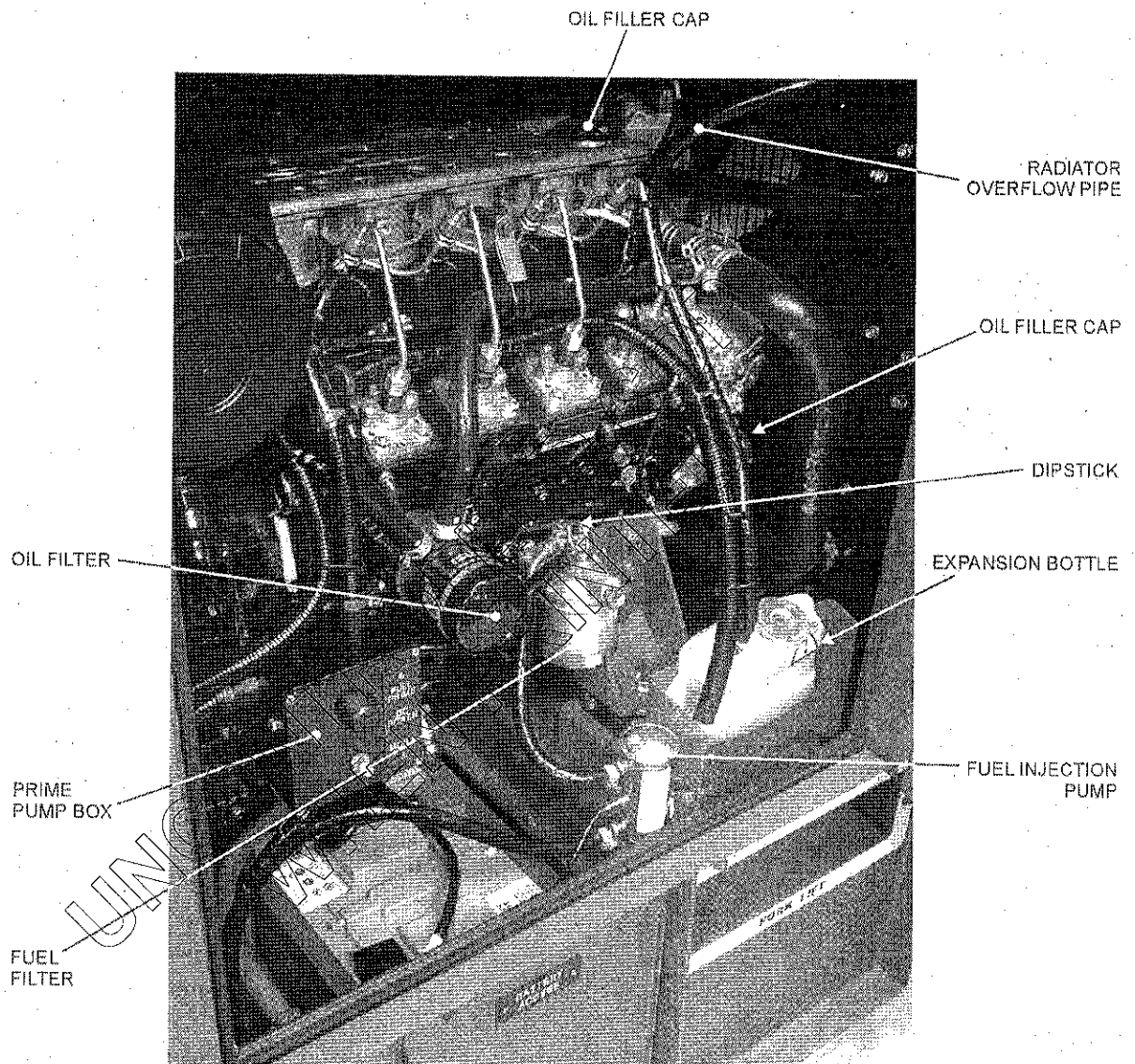


Fig 1 View through hinged canopy door

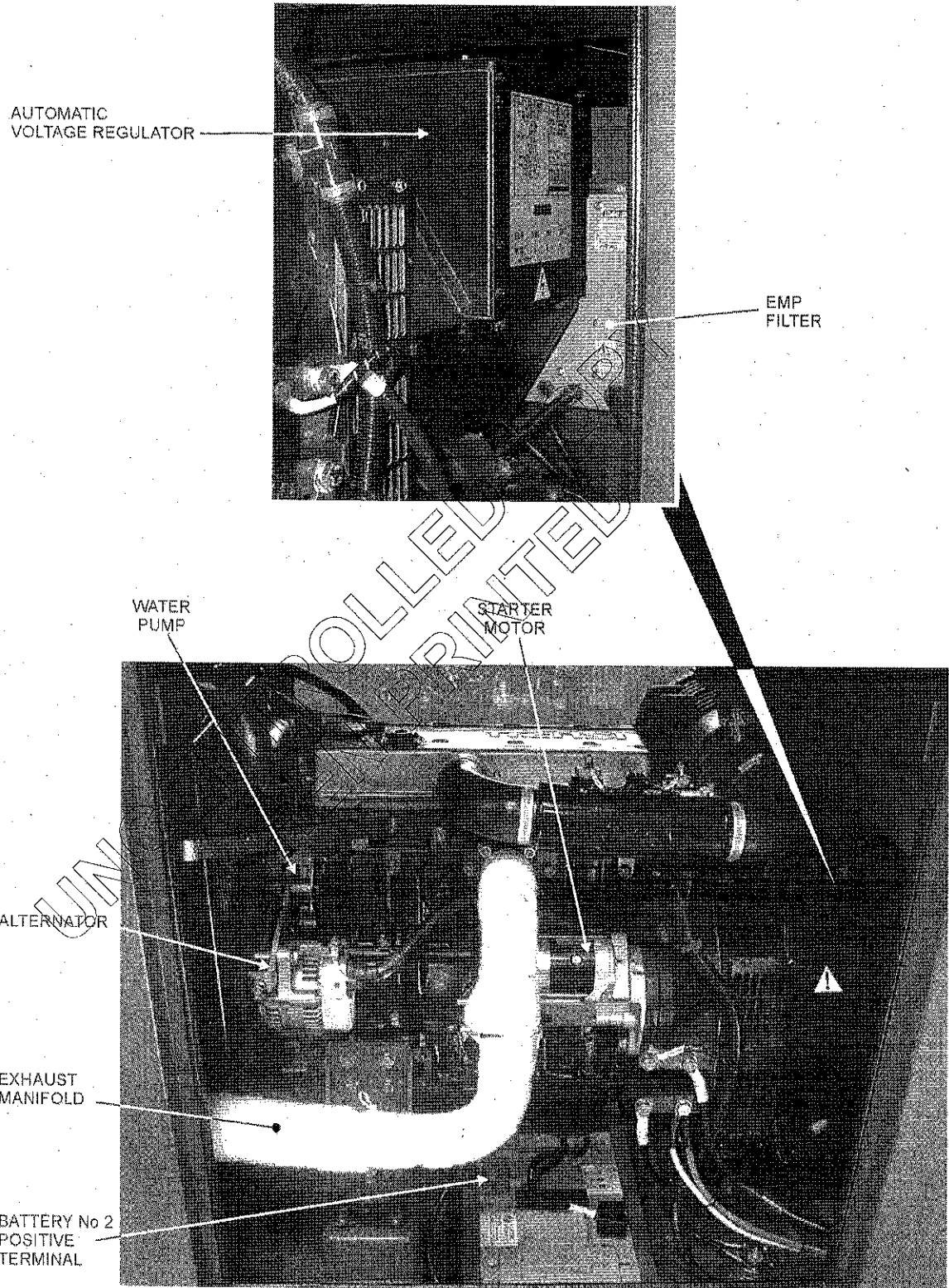


Fig 2 View through lift-off canopy door

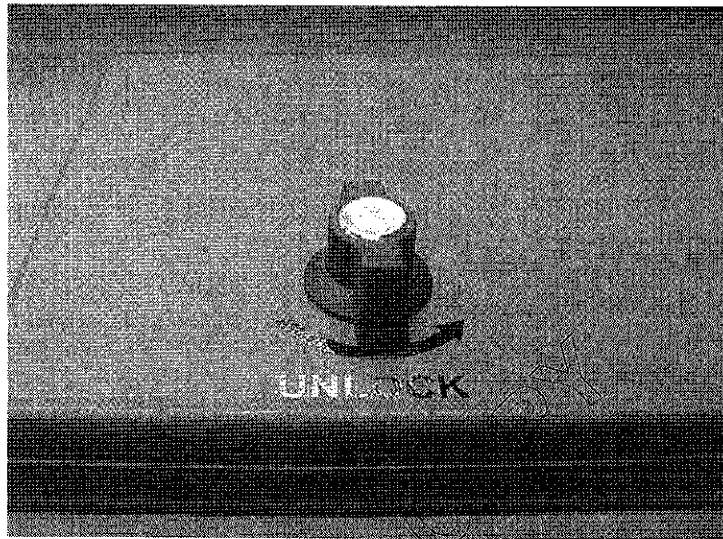


Fig 3 Radiator access flap

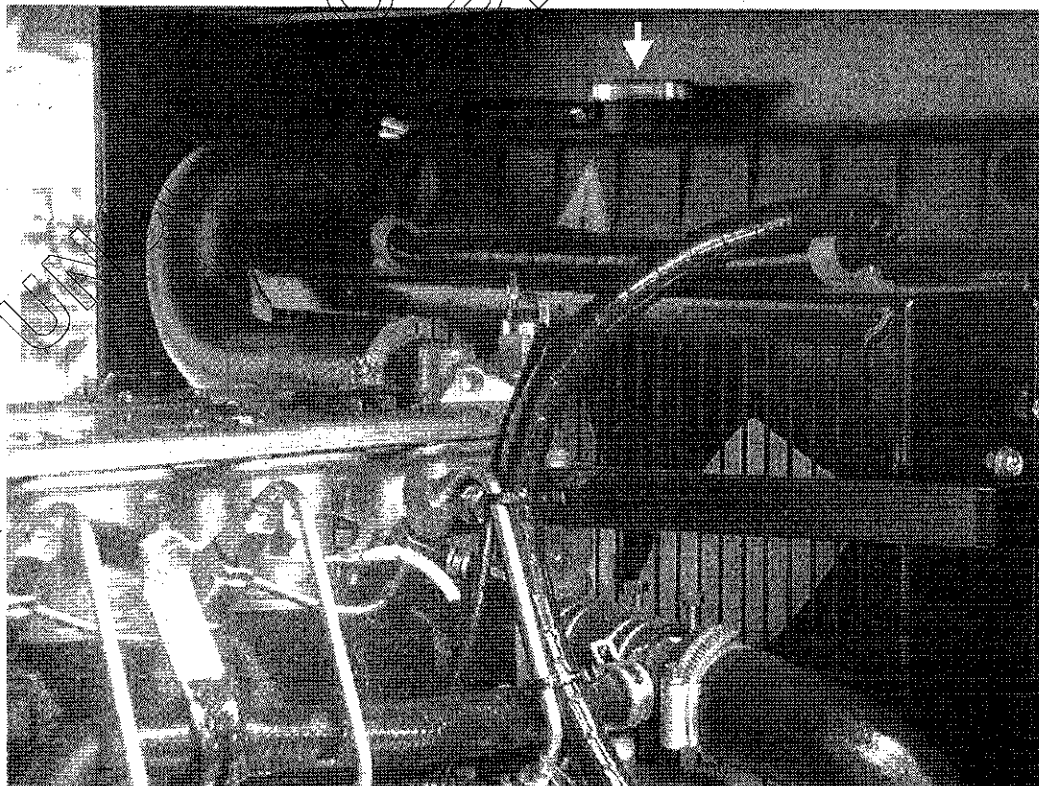


Fig 4 Radiator filler cap

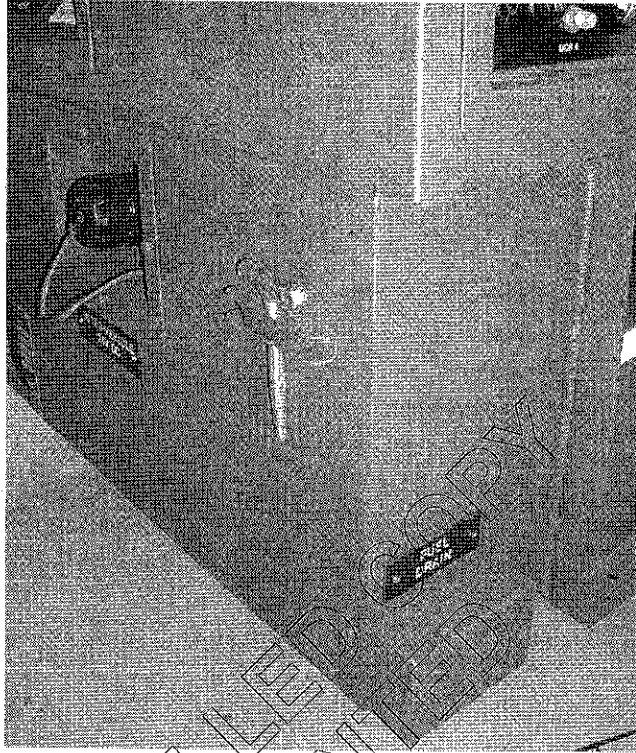


Fig 5 Fuel drain

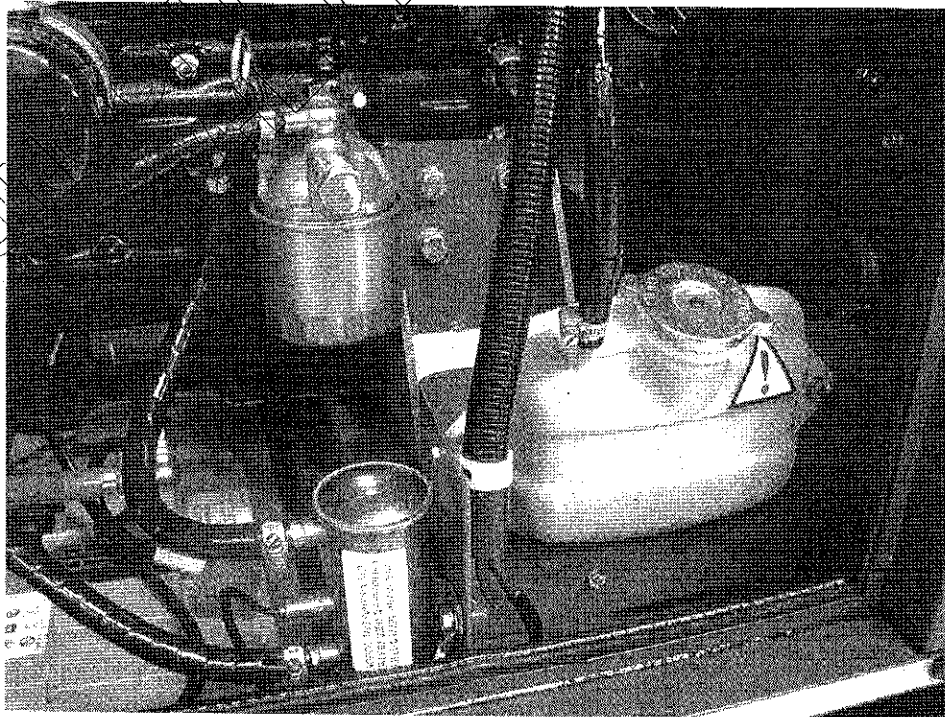


Fig 6 Expansion bottle and fuel filter

**CATEGORY 7**

**PARTS CATALOGUE**

**SUB-CATEGORY 7.2**

**COMMERCIAL PARTS LISTS**

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**SUB-CATEGORY 7.2**

**COMMERCIAL PARTS LISTS**

**CONTENTS**

Para

**20kVA CORMORANT GENERATOR SPARES**

- 1 Engine consumable spares
- 2 Engine spare parts
- 3 Alternator spare parts
- 4 Master parts list
- 6 Service and technical assistance

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2	Engine spare parts .....	2
3	Alternator spare parts .....	3
4	Master parts list .....	3 - 8

**20kVA CORMORANT GENERATOR SPARES**

**ENGINE CONSUMABLE SPARES**

- 1 Consumable spares for the Isuzu diesel engine, Model 4LE1, are detailed in Table 1.

**TABLE 1 ENGINE CONSUMABLE SPARES**

Description	Part No.	Qty
Oil filter element	SZ894456-7412	1
Fuel filter element	SZ894132-9471	1
Air filter element	SZ100020	1
Fan Belt	SZ897230-9390	1

**ENGINE SPARE PARTS**

2 Spare parts for the Isuzu diesel engine, Model 4LE1, are detailed in Table 2.

**TABLE 2 ENGINE SPARE PARTS**

No.	Description	Part No.	Qty
1	Blockage indicator	SZ100011-4LS	1
2	Heater plug chamber	SZ900096-4LE	1
3	Starter motor, 24V	SZ897137-4781	1
4	Alternator, 24V	SZ897112-6760	1
5	Glow plug, 24V	SZ897126-2570	4
6	Fuel control solenoid, 24V	SZ897209-1150	1
7	Manifold heater plug, 24V	SZ900095-ALS	2
8	Fuel feed pump, 24V	SZ600040-ALS	1
9	Oil pressure switch	SZ982720-0690	1
10	Water temperature switch	SZ897125-6000	1
11	Thermostat	SZ897211-2090	1
12	Joint, thermostat cover	SZ894365-6741	1
13	Water pump assembly	SZ897182-8531	1
14	Radiator assembly	SZ400001-ALS	1
15	Radiator mounts, top	SZ400046-ALS	2
16	Radiator mounts, bottom	SZ400012-ALS	2
17	Radiator hose, top	SZ400015-ALS	1
18	Radiator hose, bottom	SZ400035-ALS	1
19	Fan, cooling	SZ513660-3080	1
20	Injector nozzle	SZ894130-5320	4
21	Injector assembly	SZ897079-9760	4
22	Fuel injection pump	SZ897147-5801	4
23	Gasket set	SZ587812-8104	1
24	Jointing compound, red	SZ188440-5400	1
25	Jointing compound, black	SZ188440-1150	1
26	Oil filler cap, top cover	SZ894133-2075	1
27	Oil filler cap, front gearcase cover	SZ894425-6852	1
28	Dipstick	SZ897166-9600	1
29	Lub oil cooler assembly	SZ897102-3200	1
30	Hose, cylinder head to oil cooler	SZ897148-3430	1
31	Hose, oil cooler to tee piece	SZ897148-3450	1
32	Hose, water pump to tee piece	SZ897102-8790	1
33	Exhaust gasket	SZ897042-0280	1

**ALTERNATOR SPARE PARTS**

- 3 Spare parts for the Newage alternator, Model BCI182J, are detailed in Table 3.

**TABLE 3 ALTERNATOR SPARE PARTS**

No.	Description	Part No.	Qty
1	Automatic voltage regulator SX460	NE000-24602/1P	1
2	Rectifier service kit	NRSK-1101	1
3	Bearing, Non drive end	N051-01058	1

**MASTER PARTS LIST**

- 4 The master parts list for the 20kVA Cormorant Generator is provided in Table 4.

**TABLE 4 MASTER PARTS LIST**

No.	Description	Part No.	Qty
1	Isuzu 4LE1 24V 3000rev/min	015-264	1
2	Newage BCI182J	020-231	1
3	Canopy, base assembly	040-743/01	1
4	Canopy, battery spacer bracket	040-743/07	1
5	Canopy, battery clamp	040-743/10	1
6	Canopy, battery access cover	040-743/11	1
7	Canopy, fork pocket, eng end	040-743/12	1
8	Canopy, fork pocket, alt end	040-743/13	1
9	Canopy, fork pocket cover	040-743/17	2
10	Canopy, engine end cover	040-743/18	1
11	Canopy, alternator end cover	040-743/19	1
12	Canopy, roof panel	040-743/20	1
13	Canopy, radiator baffle	040-743/21	1
14	Canopy, lift-off door	040-743/22	1
15	Canopy, hinged door	040-743/24	1
16	Canopy, door catch bracket	040-743/28	2
17	Canopy, fuel tank	040-743/29	1
18	Canopy, e/stop, inter-vehicle pod	040-743/32	1
19	Canopy, fuel filler pod	040-743/33	1
20	Canopy, header bottle bracket	040-743/34	1
21	Canopy, roof foam retaining strip	040-743/35	2
22	Canopy, engine support bracket	040-743/36	2

(continued)



TABLE 4 MASTER PARTS LIST (continued)

No.	Description	Part No.	Qty
23	Canopy, radiator access cover	040-743/37	1
24	Canopy, output socket pod	040-743/38	1
25	Canopy, e/stop, inter-vehicle pod backplate	040-743/40	1
26	Canopy, control panel cover	040-743/41	1
27	Canopy, battery clamp top frame	040-743/44	1
28	Canopy, control panel latch bracket	040-743/45	1
29	Canopy, control panel pod	040-743/46	1
30	Canopy, control pod backplate	040-743/49	1
31	Canopy, control pod glandplate	040-743/50	1
32	Canopy, control pod CT plate	040-743/51	1
33	Canopy, hot air louvre	040-743/53	1
34	Canopy, hot air baffle	040-743/57	1
35	Canopy, cool air louvre	040-743/58	4
36	Canopy, cool air baffle - primary	040-743/62	2
37	Canopy, cool air baffle - secondary	040-743/63	1
38	Canopy, silencer support bracket	040-743/64	2
39	Canopy, battery clamp pivot rod	040-743/65	1
40	Canopy, battery clamp fixing bracket	040-743/66	1
41	Canopy, bracket - fuel transfer pump	040-743/67	1
42	Canopy, alternator end foam support	040-743/68	1
43	Canopy, fuel drain cover	040-743/69	1
44	Canopy, exhaust extension bracket	040-743/70	2
45	Canopy, transfer pump location tongue	040-743/71	1
46	Canopy, transfer pump tongue bracket	040-743/72	1
47	Canopy, transfer pump bracket	040-743/73	1
48	Canopy, exhaust extension strap clamp	040-743/74	3
49	Canopy, fork pod cover plate	040-743/76	4
50	Canopy, tee key storage bracket	040-742/65	1
51	Clamp, module interface converter	030-566	1
52	Anti vibration mount, main	070-486	4
53	Battery (OLDHAM UK6TNMF)	120-034	2
54	Battery lead, positive	120-507	1
55	Battery lead, negative	120-508	1
56	Battery lead, link	120-509	1

(continued)

**TABLE 4 MASTER PARTS LIST (continued)**

No.	Description	Part No.	Qty
57	Battery terminal - Positive	120-211	2
58	Battery terminal - Negative	120-212	2
59	Battery terminal cover - black	120-201	2
60	Battery terminal cover - red	120-202	2
61	Foam tape, battery clamp	160-212	1
62	Fuel pipe, tank to pump	175-001	1
63	Fuel pipe, pump to filter	175-002	1
64	Fuel pipe, filter to pump rail	175-003	1
65	Fuel pipe, leak-off	175-004	1
66	Fuel nipple 1/4in BSP with pick-up tube	170-401	1
67	Fuel nipple 5/16in BSP	170-102	1
68	Fuel nipple 1/8in BSP 5/16in hosetail	170-231	2
69	Fuel filler hose	065-604	1
70	Clamp, filler hose	170-132	2
71	Fuel filler cap	065-501	1
72	Chain, fuel cap retaining	070-930	0
73	Fuel drain elbow, 1/2in BSP	170-142	1
74	Fuel drain plug, 1/2in BSP male	170-143	1
75	Fuel drain reducer, 1in to 1/2in BSP	170-144	1
76	Fuel drain tap, 1/2in BSP	170-145	1
77	Enclosure, fuel pump switch	030-564	1
78	Fuel pump switch, pushbutton	080-051	1
79	Relay, 24V 40A 1-pole, Cold start	140-035	1
80	Relay base, 40A Cold start	140-028	1
81	Oil drain kit	655-001	1
82	Exhaust silencer, 2" ports	180-131	1
83	Exhaust manifold pipe	180-595	1
84	Flexible link pipe	180-596	1
85	Tail pipe	180-597	1
86	Silencer body clamp	180-722	2
87	Exhaust clamp 2-1/4 in	180-713	3
88	Insulation, exhaust manifold	160-301	1
89	Radiator expansion bottle	018-308	1
90	Acoustic foam kit, canopy	160-073	1

(continued)

TABLE 4 MASTER PARTS LIST (continued)

No.	Description	Part No.	Qty
91	Budget lock, universal	070-893	5
92	Key, budget lock	070-860	1
93	Escutcheon cover	070-858	5
94	Latch - wing handle, radiator access cover	070-870	1
95	Cam - wing handle	070-875	1
96	Hinge, side door	070-903	2
97	Hinge, radiator cap access cover	070-905	2
98	Hinge, control panel cover	070-904	2
99	Handle - door, recessed	070-942	3
100	Handle - roof, folding sprung loaded	070-814	2
101	Stop/buffer, door	070-945	1
102	Seal, door - side edge	160-203	2
103	Seal, cover - straight edge	160-202	2
104	Foam tape, panel inserts (10m roll)	160-209	1
105	Strap, exhaust extension stowage	151-211	3
106	Engine management module	125-043	1
107	Interface converter, engine man. module	125-074	1
108	Relay slave module	140-046	1
109	Hours counter, 24V	085-307	1
110	Mcb, 2 pole (45A), output 1 and 2	110-843	2
111	Weather cover, 2-pole mcb	110-836	2
112	Rcd detection module, EFR1	110-859	1
113	Rcd current transformer	110-864	1
114	Pilot Wire Monitor, ELM1E	110-601	2
115	Rcd Reset / Test switch	080-472	1
116	LED module, Rcd reset / test switch	080-473	1
117	Relay 24V, 2-pole	140-031	5
118	Relay 24V, 1-pole	3RS353-837	2
119	Relay base, 2-pole	3RS353-966	2
120	Relay base, 1-pole	3RS353-944	4
121	Timer, 2-pole, cold start heater	140-437	1
122	Timer, 1-pole, low fuel alarm	140-436	1

(continued)

**TABLE 4 MASTER PARTS LIST (continued)**

No.	Description	Part No.	Qty
123	Temperature switch, -12 deg C	110-865	1
124	Mcb, 1-pole (35A), Dc circuit	110-066	1
125	Mcb, 1-pole (10A), Fuel pump	110-063	1
126	Mcb, 1-pole (2A), Ac meters	110-067	1
127	Weather cover, 1-pole mcb	110-091	3
128	Fuel gauge, 24V	170-620	1
129	Sender, fuel gauge	085-709	1
130	Flange, fuel gauge mount	085-703	1
131	Switch, fuel/hours status (10A mom.)	080-031	1
132	Switch, sounder mute	080-004	1
133	Weather cover, toggle switch	080-005	3
134	Fuel level switch, 1 switch position	170-656	1
135	Voltmeter, 0-300V	085-057	1
136	Ammeter, 0-100A	085-255	1
137	Ammeter C.T. 100:5A	085-257	1
138	Start/stop switch - head	080-801	1
139	Start/stop switch - contact ass.	080-802	1
140	Start/stop switch - weather cover	080-803	1
141	Keyswitch, 2 position	080-479	1
142	Fixing adaptor, switch contact blocks	080-480	3
143	Contact block, keyswitch N/O	080-474	5
144	Contact block, keyswitch N/C	080-475	4
145	Keyswitch, 3 position, spring return	080-476	1
146	Key retainer/spring return, 3-pos'n switch	080-478	1
147	Sounder, audible alarm 24V	RS178-4197	1
148	Inter-vehicle connector, 24V NATO	090-601	1
149	Emergency stop switch c/w contacts	3RS318-979	1
150	Legend plate - Em. Stop switch	3RS319-253	1
151	Socket, AC power output, 50A 4 pin	090-611	2
152	Socket, remote monitor, 2A 6 pin	090-612	1
153	Cap, remote monitor socket	090-967	1
154	Gasket, remote monitor socket	090-968	1
155	Filter assembly, NEMP/LEMP	136-501	1
156	Bracket, DIN rail support	135-505	2

(continued)

TABLE 4 MASTER PARTS LIST (continued)

No.	Description	Part No.	Qty
157	Terminal 4mm WDU, DC connections	115-725	15
158	Terminal, diode, WDK2.5D	115-731	1
159	Terminal, double deck WDK2.5	115-732	1
160	End-plate, WDK terminal	115-733	2
161	Terminal 10mm WDU, AC power output	115-727	6
162	End-plate, 2.5 - 10mm terminal	115-742	1
163	End-plate, 16 - 35mm terminal	115-729	1
164	Terminal 35mm, AC power input	115-728	3
165	End stop - DIN terminal	115-730	2
166	Wiring loom, AC alternator to panel	155-001	1
167	Wiring loom, AC output 1	155-002	1
168	Wiring loom, AC output 2	155-003	1
169	Wiring loom, Pilot & remote	155-004	1
170	Wiring loom, E/stop & CT	155-005	1
171	Wiring loom, engine control	155-006	1
172	Wiring loom, Inter-vehicle	155-007	1
173	Generator Information	499-312	1
174	Mod. Strike plate - PPRF	499-511	1
175	Label, control panel fascia	499-568	1
176	Label set, output pod	499-533	1
177	Label kit, canopy	499-588	2
178	Wingnut, M12, brass	150-204	1
179	Earth stud, M12 x 50	150-205	1
180	Washer, earth point - M12, brass	150-206	2
181	Nut, earth point - M12, brass	150-207	1
182	Trailer-generator earth link cable	136-006	1
183	Exhaust extension	180-028	2
184	Pin, exhaust extension retainer	150-917	2
185	Insulation, exhaust extension	160-601	2
186	Pump, fuel transfer	170-674	1
187	Hose, inlet, fuel transfer pump	175-010	1
188	Hose, outlet, fuel transfer pump	175-011	1
189	Nipple, fuel transfer pump	170-308	1
190	Hose clamp, fuel transfer pump	170-131	1

5 For Isuzu Engine parts not listed above, refer to the Isuzu engine parts catalogue. For Newage Alternator parts not listed above, refer to the Newage alternator handbook. For Canopy and Control system parts not listed above, refer to the parts list in Table 4 of this chapter.

#### SERVICE AND TECHNICAL ASSISTANCE

6 Spares, service and technical assistance are available from:

HARRINGTON GENERATORS INTERNATIONAL LTD.  
RAVENS TOR ROAD  
WIRKSWORTH  
DERBY  
DE4 4FY  
ENGLAND

Tel: 44 (0) 1629 824284  
Fax: 44 (0) 1629 824613

#### NOTE

When ordering parts, the generator, alternator and engine serial numbers should be quoted where applicable.

**COTS MANUALS**

- ANNEX A ISUZU DIESEL ENGINE - MODEL 4LE1 INSTRUCTION MANUAL**
- ANNEX B ISUZU DIESEL ENGINE - MODEL 4LE1 WORKSHOP MANUAL**
- ANNEX C ISUZU DIESEL ENGINE - L-SERIES TECHNICIAN GUIDE**
- ANNEX D NEWAGE ALTERNATOR MANUAL**
- ANNEX E DEEP SEA ELECTRONICS plc - ENGINE MANAGEMENT SYSTEM**

UNCONTROLLED COPY  
WHEN PRINTED

**ANNEX A**

**ISUZU DIESEL ENGINE - MODEL 4LE1**

**INSTRUCTION MANUAL**

UNCONTROLLED COPY  
WHEN PRINTED



## ANNEX A

## ISUZU DIESEL ENGINE – MODEL 4LE1 INSTRUCTION MANUAL

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7	Engine external views
	General information
	Standard engine data and specifications
	EPA certified engine data and specifications
8	EC emission control label
12	Engine identification (WARNING)
14	Isuzu engine after service
	Fuel, lubricant and coolant
16	Diesel fuel (CAUTIONS)(WARNING)
25	Lubricant (CAUTIONS)
28	Coolant
	Engine operation (WARNINGS)
29	Checks before operation (WARNINGS)
42	Engine starting (CAUTIONS)(WARNING)
49	Check and operation after engine start-up (WARNINGS)
51	Care in the engine operation (WARNINGS)
74	Engine stopping (CAUTION)
77	Operation and care of new engine
79	Engine care for over-cooling
80	Starting the engine after being left unused for a long period of time
	Periodical inspection and maintenance
81	Lubricating system (WARNINGS)
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## ANNEX A

## ISUZU DIESEL ENGINE - 4LE1 INSTRUCTION MANUAL

## WARNING

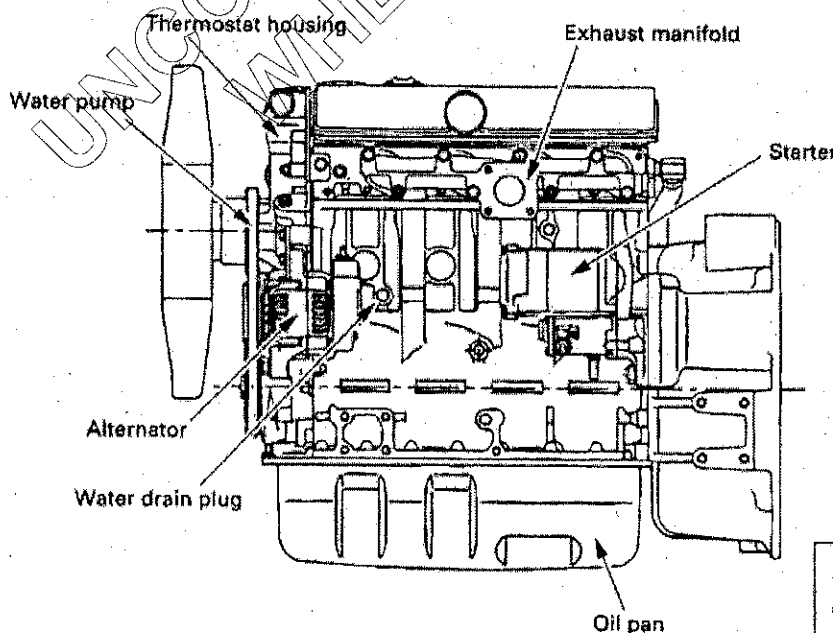
**CALIFORNIA PROPOSITION 65 WARNING. DIESEL ENGINE EXHAUST AND SOME OF ITS CONSTITUENTS ARE KNOWN TO THE STATE OF CALIFORNIA TO CAUSE CANCER, BIRTH DEFECTS, AND OTHER REPRODUCTIVE HARM.**

## FOREWORD

- 1 The ISUZU industrial diesel engines are a product of ISUZU's long years of experience, advanced technology. ISUZU takes great pride in the superior durability and operating economy of these engines.
- 2 In order to get the fullest use and benefit from your industrial engine, it is important that you operate and maintain it correctly. This manual is designed to help you do this.
- 3 Please read this Manual carefully and follow its operating and maintenance recommendations. This will ensure many years of trouble-free and economical engine operation.
- 4 Should your engine require servicing, please contact your nearest ISUZU engine outlet. He knows your engine best and is ready to meet your satisfaction.
- 5 All information, illustrations, and specifications contained in this Manual are based on the latest product information available at the time of publication.
- 6 ISUZU reserves the right to make changes in this Manual at any time without prior notice.

## ENGINE EXTERNAL VIEWS

- 7 Views of the Model 4LE1 are shown in Figs 1 and 2.



*Note:  
Engine details may  
vary depending on the  
specifications.*

Fig 1 External view (LH)

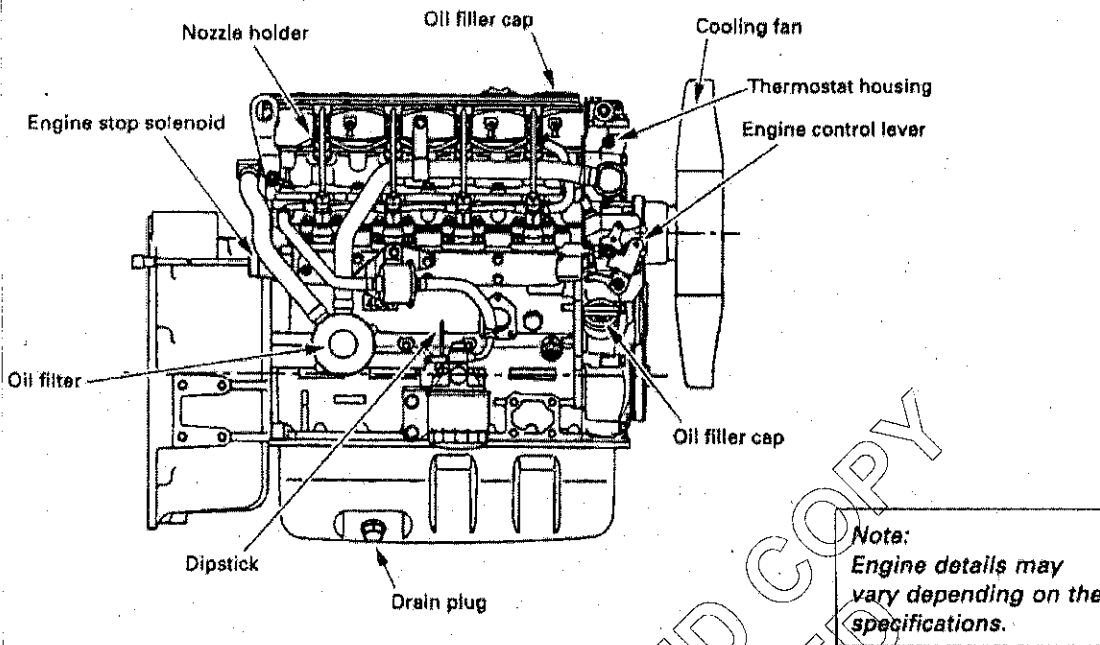


Fig 2 External view (RH)

**GENERAL INFORMATION**

**Standard engine data and specifications**

**TABLE 1 4LE1 STANDARD ENGINE DATA**

Engine Type	Water-Cooled, four cycle, in-line overhead valve type
Combustion type	In-direct Injection
No. of cylinders - bore x stroke mm	4 - 85 x 96
Piston displacement lit (cid)	2.179 (133)
Compression ratio	21.5 to 1
Firing order	1 - 3 - 4 - 2
* Rated output; SEA GROSS kW(hp)/min <sup>-1</sup>	40.5 (54.3) / 3000
* Max. torque; SEA GROSS Nm(lbft)/min <sup>-1</sup>	143 (194) / 1800
Injection pump	Bosch, PFR type
Governor	Mechanical type
Injection nozzles	Throttle type
Specified fuel	Diesel fuel (ASTM D975 No.2-D)

**NOTES**

- (1) These specifications are based on the standard engine.
- (2) Specifications for items marked with an asterisk (\*) will vary according to the type of equipment in which the engine is installed. If you are unable to locate the data applicable to your engine, please contact your equipment supplier.

TABLE 2 4LE1 STANDARD ENGINE SPECIFICATIONS

* Starter	(V-kW)	12 - 1.8	
* Alternator	(V-A)	12 - 35	
Specified engine oil (API grade)		CC or CD	
* Oil volume	lit (qts)	About 8.1 (8.6)	
Coolant volume (Engine only)	lit (qts)	About 2.8 (3.0)	
* Engine dry weight	kg (lb)	180 (397)	
* Engine dimensions	Overall length	mm (in)	687 (27.0)
	Overall width	mm (in)	472 (18.6)
	Overall height	mm (in)	592 (23.3)
Valve clearance (cold)	mm (in)	0.40 (0.015) for exhaust and intake	
Nozzle injection pressure	MPa (psi)	13.2 (1920)	
* Injection timing B.T.D.C.		16°	

## NOTES

- (1) These specifications are based on the standard engine.
- (2) Specifications for items marked with an asterisk (\*) will vary according to the type of equipment in which the engine is installed. If you are unable to locate the data applicable to your engine, please contact your equipment supplier.

## EPA certified engine data and specifications

TABLE 3 EPA CERTIFIED ENGINE DATA

ISUZU engine model name	4LE1		
Engine family	XSZXL02. 2DNB	XSZXL02. 2DNC	XSZXL02. 2DNF
Engine code	22DNB	22DNC	22DNF
Engine type	Water-Cooled, four cycle, in-line overhead valve type		
Combustion type	In-direct Injection		
No. of cylinders - bore x stroke	mm (in) 4 - 85 x 96 (3.35 x 3.78)		
Engine displacement	lit (cid) 2.179 (133.0)		
Compression ratio	21.5 to 1		
Firing order	1 - 3 - 4 - 2		
Rated power: SAE NET	kW(hp)/min <sup>-1</sup> 39.0 (52.3)/3000	33.3 (44.7)/2400	35.0 (46.9)/3000
Fuel flow at max rated power	(mm <sup>3</sup> /stroke) 34.9 36.9 31.1		
Max. torque: SAE NET	Nm(lbft)/min <sup>-1</sup> 139.8 (190)/1750	139.8 (190)/1750	139.8 (190)/1750
Fuel flow at max. torque	(mm <sup>3</sup> /stroke) 35.8 38.8 35.8		
Exhaust emission control system	Engine modification		
Injection pump	Bosch, PFR type		
Governor	Variable speed, Mechanical type		
Injection nozzles	Throttle type		
Specified fuel	Diesel fuel (ASTM D975 No.2-D)		

**TABLE 4 EPA CERTIFIED ENGINE SPECIFICATIONS**

Starter	(V-kW)	12 - 1.2
Alternator	(V-A)	12 - 20
Specified engine oil (API grade)		CC or CD
Lubrication oil volume	L (qts)	6.3 (6.7)
Coolant volume (Engine only)	L (qts)	2.5 (2.6)
Engine dry weight	kg (lb)	132 (291)
Engine dimensions	Overall length	mm (in) 537 (21.1)
	Overall width	mm (in) 475 (18.7)
	Overall height	mm (in) 590 (23.2)
Valve clearance (cold)	mm (in)	0.20 (0.0078) for exhaust and intake
Nozzle injection pressure	MPa (psi)	13.2 (1920)
Injection timing B.T.D.C.		16°

**EC emission control label**

Emission control label: engine label (EPA)

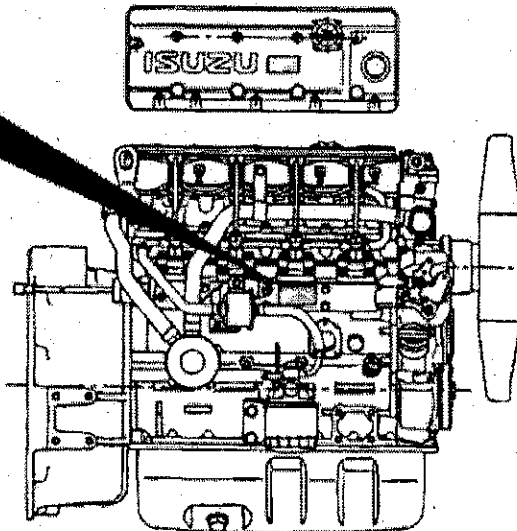
8 Emission control label is attached at the centre of injection pump cover located at the right side of cylinder body, or on the cylinder head cover. The location of emission control label attached on the engine may vary depending on the engine specification.

9 The following is a sample of the label required for engine emission control information, along with location.

**ISUZU** IMPORTANT ENGINE INFORMATION  
 ISUZU MOTORS LTD. MADE IN JAPAN

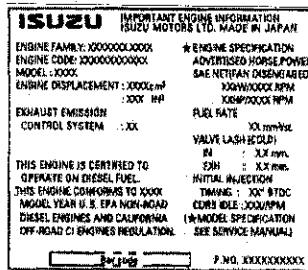
ENGINE FAMILY : XXXXXXXX,XXXX  
 ENGINE CODE : XXXXX  
 MODEL : XXXX  
 ENGINE DISPLACEMENT : XXXXcm<sup>3</sup>  
 DATE OF ENGINE MANUFACTURE : XX / XX  
 ENGINE SPECIFICATION

REFER TO OWNER'S MANUAL FOR MAINTENANCE SPECIFICATION AND ADJUSTMENT.  
 THIS ENGINE CONFORMS TO U.S. EPA REGULATIONS APPLICABLE TO 1999 MODEL YEAR  
 LARGE NONROAD COMPRESSION-IGNITION ENGINES.  
 P. NO. XXXXXX-XXX-X



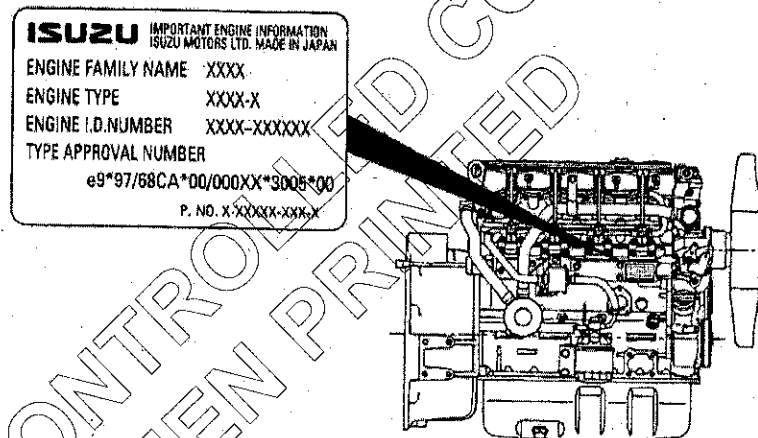
Supplemental: engine label (for EPA)

- 10 Emission control label is attached at a visible point on the equipment.



EC emission control label: engine label

- 11 Emission control label is attached at the front of injection pump cover located at the right side of cylinder body. The following is the detail of a label required for engine emission control information, along with location.



**Engine identification**

Position of display

- 12 The engine serial number is stamped on the front upper right side of the cylinder body, and the engine model is cast on the rear lower right side of the cylinder body just above the oil filter (Fig 3). Further, engine model is described also on an ID label on the top of the cylinder head cover.

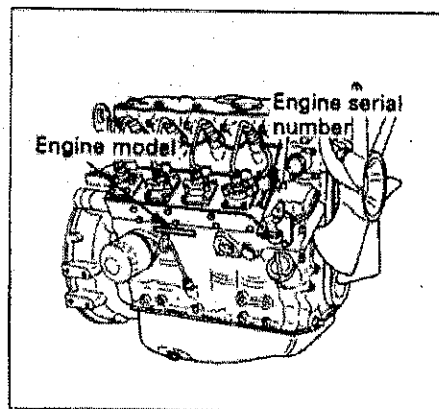


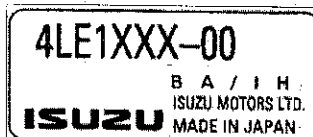
Fig 3 Engine identification

Confirmation of engine serial number

**WARNING**

**PERSONAL INJURY. CONDUCT CONFIRMATION OF ENGINE SERIAL NUMBER WITH THE ENGINE STOPPED. TO AVOID BEING INJURED, DO NOT CHECK IT WHILE THE ENGINE IS STILL HOT.**

13 It is advisable to check the engine serial number, engine model name and type of machine together with the equipment manufacturer's name, as it is required when you contact the distributor for repair, service or parts ordering.

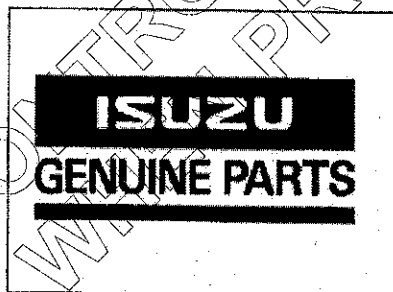


**Isuzu engine after service**

14 Please feel free to contact your ISUZU dealer for periodical inspection and maintenance.

Isuzu genuine parts

15 The ISUZU genuine parts are identical with those used in the engine production, and accordingly, they are warranted by ISUZU MOTORS LIMITED. The ISUZU genuine parts are supplied by the ISUZU distributors or the authorized parts suppliers. Please designate 'ISUZU Genuine Parts' when you need engine parts.



**FUEL, LUBRICANT AND COOLANT**

**Diesel Fuel**

Fuel selection

16 The following specific advantages are required for the diesel fuel.

- (1) Must be free from minute dust particles.
- (2) Must have adequate viscosity.
- (3) Must have high cetane value.
- (4) Must have high fluidity at low temperature.
- (5) Must have low sulphur content.
- (6) Must have little residual carbon.



TABLE 5 DIESEL FUELS

Applicable Standard	Recommendation
JIS (JAPANESE INDUSTRIAL STANDARD)	No.2
DIN (DEUTSCHE INDUSTRIE NORMEN)	DIN 51601
SAE (SOCIETY OF AUTOMOTIVE ENGINEERS) Based on SAE-J-313C	No. 2-D
BS (BRITISH STANDARD) Based on BS/2869-1970	Class A-1

17 If fuel other than the specified one is used, engine function will be lowered.

#### Fuel requirements

#### CAUTIONS

**EQUIPMENT DAMAGE.** The fuel injection pump, injector or other parts of the fuel system and engine can be damaged if you use any fuel or fuel additive other than those specifically recommended by Isuzu. Such damage is not Isuzu's responsibility, and is not covered by the Warranty. To help avoid fuel system or engine damage, please heed the following:

- (1) Some service stations mix used engine oil with diesel fuel. Some manufacturers of large diesel engines allow this, however, for your diesel engine, do not use diesel fuel which has been contaminated with engine oil. Besides causing engine damage, such fuel can also affect emission control. Before using any diesel fuel, check with service station operator to see if the fuel has been mixed with engine oil.
- (2) Do not use any fuel additive (other than as recommended under 'Biocide' in this section). At the time this manual was printed, no other fuel additive was recommended. (See your authorized dealer to find out if this has changed.)

18 Your engine is designed to use either Number 1-D or Number 2-D diesel fuel. However, for better fuel economy, use Number 2-D diesel fuel whenever possible. At temperatures less than -7°C, (20°F), Number 2-D fuel may pose operating problems (see 'Cold Weather Operation' which follows). At colder temperatures, use Number 1-D fuel (if available) or use a 'winterized' Number 2-D (a blend of Number 1-D and Number 2-D). This blended fuel is usually called Number 2-D also, but can be used in colder temperatures than Number 2-D fuel which has not been 'winterized'. Check with the service station operator to be sure you get the properly blended fuel. Note that diesel fuel may foam during a fill-up. This can cause the automatic pump nozzle to shut off even though your tank is not full.

#### CAUTION

**EQUIPMENT DAMAGE.** Do not use home heating oil or gasoline in your diesel engine, either may cause engine damage.

#### Handling of the fuel

19 Fuel containing dust particles or water will cause engine failure. Therefore, the following notice must be observed.

- (1) Take care to prevent the fuel from entry of dust particles or water when filling the fuel tank. When fuelling from an oil drum directly, keep the drum stationary over a long time so that clean fuel can be used after the dust particles or water is completely sedimented.
- (2) Always fully fill the fuel tank. Drain the sedimented particles in the fuel tank frequently by opening the tank draining hole.

Water in fuel

20 During refuelling, it is possible for water (and other contaminants) to be pumped into your fuel tank along with the diesel fuel. This can happen if a service station does not regularly inspect and clean its fuel tanks, or if a service station receives contaminated fuel from its supplier(s).

21 To protect your engine from contaminated fuel, there is a fuel filter system on the engine which allows you to drain excess water.

**WARNING**

**PERSONNEL INJURY. THE WATER/DIESEL FUEL MIXTURE IS FLAMMABLE, AND COULD BE HOT. TO HELP AVOID PERSONAL INJURY AND/OR PROPERTY DAMAGE, DO NOT TOUCH THE FUEL COMING FROM THE DRAIN VALVE, AND DO NOT EXPOSE THE FUEL TO OPEN FLAMES OR SPARKS. BE SURE YOU DO NOT OVERFILL THE CONTAINER. HEAT (SUCH AS FROM THE ENGINE) CAN CAUSE THE FUEL TO EXPAND. IF THE CONTAINER IS TOO FULL, FUEL COULD BE FORCED OUT OF THE CONTAINER. THIS COULD LEAD TO A FIRE AND THE RISK OF PERSONAL INJURY AND/OR VEHICLE OR EQUIPMENT DAMAGE.**

Biocides

22 In warm or humid weather, fungus and/or bacteria may form in diesel fuel if there is water in the fuel.

**CAUTION**

**EQUIPMENT DAMAGE. Fungus or bacteria can cause fuel system damage by plugging the fuel lines, fuel filters or injector. They can also cause fuel system corrosion.**

23 If fungus or bacteria has caused fuel system problems, you should have your authorized dealer correct these problems. Then, use a diesel fuel biocide to sterilize the fuel system (follow the biocide manufacturer's instructions). Biocides are available from your dealer, service stations, parts stores and other automotive places. See your authorized dealer for advice on using biocides in your area and for recommendations on which biocides you should use.

Smoke suppressants

24 Because of extensive testing of treated fuel versus untreated fuel, the use of a smoke suppressant additive is not recommended because of the greater possibility of stuck rings and valve failure, resulting from excessive ash deposits.

**Lubricant**

25 The quality of engine oil may largely affect engine performance startability and engine life. Use of unsuitable engine oil will result in piston ring, piston and cylinder seizure and accelerate the sliding surface wear causing increased oil consumption, lowered output and, finally engine failure. To avoid this, use the specified engine oil.

Engine oil selection

26 API, CC or CD grade.

Oil viscosity

27 Engine oil viscosity largely affects engine startability, performance, oil consumption, speed of wearing and occurrence of seizure, etc. Using lubricants whose viscosity selected according to the atmospheric temperature is important (Fig 4).

**CAUTIONS**

- (1) **EQUIPMENT DAMAGE.** Using a mixture of different brands or quality oils will adversely affect the original oil quality; therefore, never mix up different brand or different type oils.
- (2) **EQUIPMENT DAMAGE.** Do not use API, CA, CB grade and reconstituted engine oil.
- (3) **EQUIPMENT DAMAGE.** Engine damage due to improper maintenance, or using oil of the improper quality and/or viscosity, is not covered by the warranty.

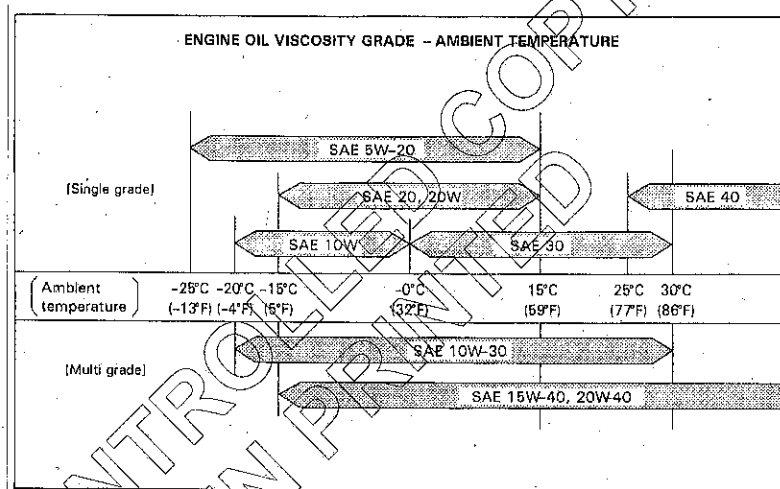


Fig 4 Engine oil viscosity chart

**Coolant**

28 Use drinking water for coolant and replace it periodically.

**ENGINE OPERATION****WARNING**

**PERSONNEL INJURY.** DO NOT BREATHE EXHAUST GAS AS IT CONTAINS CARBON MONOXIDE, WHICH BY ITSELF HAS NO COLOUR OR ODOUR. CARBON MONOXIDE IS A DANGEROUS GAS, IT CAN CAUSE UNCONSCIOUSNESS AND CAN BE LETHAL.

**PERSONNEL INJURY.** IF AT ANY TIME YOU THINK EXHAUST FUMES ARE ENTERING THE CAB, HAVE THE CAUSE DETERMINED AND CORRECTED AS SOON AS POSSIBLE. IF YOU MUST DRIVE UNDER THESE CONDITIONS, DRIVE ONLY WITH ALL WINDOWS FULLY OPEN.

**PERSONNEL INJURY.** PROTECT AGAINST CARBON MONOXIDE ENTRY INTO THE CAB. THE BEST WAY IS TO KEEP THE ENGINE EXHAUST SYSTEM, CAB AND CAB VENTILATION SYSTEM PROPERLY MAINTAINED. WE RECOMMEND THAT THE EXHAUST SYSTEM AND CAB BE INSPECTED BY COMPETENT TECHNICIAN:

- (1) EACH TIME THE VEHICLE HAS AN OIL CHANGE.
- (2) WHENEVER A CHANGE IS NOTICED IN THE SOUND OF THE EXHAUST SYSTEM.

(3) WHENEVER THE EXHAUST SYSTEM, UNDERBODY OR CAB IS DAMAGED OR BECOMES CORRODED. SEE 'MAINTENANCE SCHEDULE' OF THIS MANUAL FOR PARTS REQUIRING INSPECTION.

**PERSONNEL INJURY.** TO ALLOW PROPER OPERATION OF YOUR VEHICLE'S VENTILATION SYSTEM, KEEP THE AIR INLET GRILLE CLEAR OF SNOW, LEAVES OR OTHER OBSTRUCTIONS AT ALL TIMES.

**PERSONNEL INJURY.** DO NOT RUN THE ENGINE IN CONFINED AREAS (SUCH AS GARAGES OR NEXT TO A BUILDING) ANY MORE THAN NEEDED TO MOVE THE VEHICLE OR THE EQUIPMENT.

**PERSONNEL INJURY.** KEEP THE EXHAUST TAILPIPE AREA CLEAR OF SNOW AND OTHER MATERIAL TO HELP REDUCE THE BUILDUP OF EXHAUST GASES UNDER THE VEHICLE OR THE EQUIPMENT. THIS IS PARTICULARLY IMPORTANT WHEN PARKED IN BLIZZARD CONDITIONS.

Checks before operation

**WARNING**

**PERSONNEL INJURY.** FOR SAFETY'S SAKE, CONDUCT THE INSPECTION BEFORE START-UP WITH THE ENGINE STOPPED.

Engine oil level

29 Place the engine on a level surface.

30 Remove the dipstick (Fig 5) from the crankcase, wipe it with clothing. Insert it fully and take it out gently again. Check the oil level by the level marks on the dipstick. The oil level must be between the 'Max' and 'Min' level mark as illustrated (Fig 6).

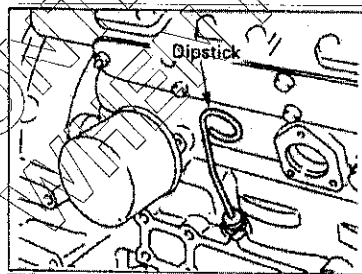


Fig 5 Dipstick

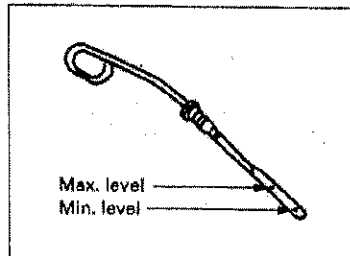


Fig 6 Oil level

31 Take care not to add too much engine oil.

- (1) Drain oil to the max. oil level if oil level is above the max. level mark.
- (2) Add oil to the max. oil level if oil level is below the min. level mark.

- 32 Also check the sample oil on the dipstick for fouling and degree of viscosity.

## NOTE

Oil level check must be made ten or twenty minutes later after the engine has been stopped. When the oil level check is necessary while the engine is running, stop the engine and keep it stationary ten or twenty minutes until the oil thoroughly flows down to the crankcase.

- 33 Oil is poured either through the oil filler at the front of the cylinder head cover or through the oil filler on the right side of the timing gear case (Fig 7). A certain period of time is required before the engine oil completely flows down from the oil filler to the crankcase. Check the oil level ten or twenty minutes after oil replenishment.

## NOTE

If the engine oil is splashed on the fan drive belt, it causes belt slippage or slackness; therefore, take care to avoid it.

## WARNING

**PERSONNEL INJURY. IN ADDING OIL, TAKE CARE NOT TO SPILL IT. IF YOU SPILL OIL ON THE ENGINE OR EQUIPMENT, WIPE IT PROPERLY, OR THIS COULD LEAD TO A FIRE AND THE RISK OF PERSONAL INJURY AND/OR EQUIPMENT DAMAGE.**

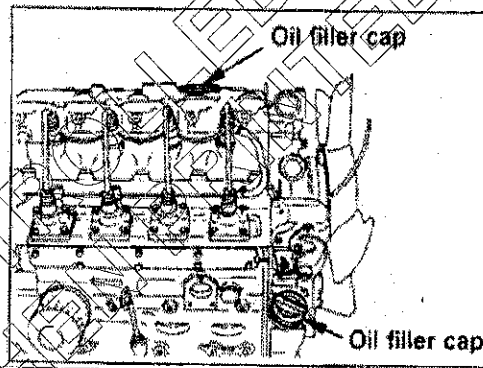


Fig 7 Oil filler caps

Fan belt check

- 34 Check the fan belt for tension and abnormalities (Fig 8). When the belt is depressed **about 10 mm (0.39 in)** with the thumb (about 100 N (22 lb) pressure) at midway between the fan pulley and generator pulley, the belt tension is correct.

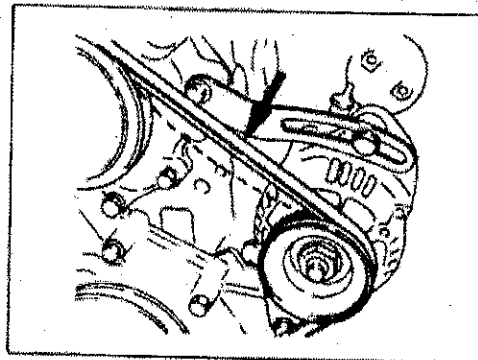


Fig 8 Fan belt tension

35 When the belt tension is too high, it will result in generator failure. Contrarily, a loose belt will cause belt slippage which may result in damaged belt and abnormal noise.

36 Check the belts. Replace them if any damage is found.

### CAUTION

**EQUIPMENT DAMAGE. Replace all belts as a set even when one is not usable. Single belt of similar size must not be used as a substitute for a matched belt set. Otherwise, premature belt wear would result because of uneven belt length.**

#### Coolant level check

37 The coolant level must be between 'FULL' and 'LOW' marks on the reserve tank. Check and see that the level is correct. When the coolant level is lower than the 'LOW' mark, replenish the reserve tank by the filler port, but when the reserve tank is empty, replenish by the radiator filler port.

### WARNING

**PERSONNEL INJURY. WHEN REMOVING THE RADIATOR FILLER CAP WHILE THE ENGINE IS STILL HOT, COVER THE CAP WITH CLOTHING, THEN TURN IT SLOWLY TO GRADUALLY RELEASE THE INTERNAL STEAM PRESSURE. THIS WILL PREVENT YOU FROM GETTING BURNT WITH HOT STEAM SPOUTING FROM THE FILLER PORT.**

38 Use clean drinking water as coolant. When an anti-freeze solution is required, keep to the specified mixing ratio.

#### Radiator cap condition

39 After the replenishment of the coolant, install the radiator cap. Make sure the cap is securely installed.

#### Battery cable condition

40 Check the battery cable connections for looseness or corrosion (Fig 9). The loosened cable connection will result in hard engine starting or insufficient battery charge. The battery cables must be tightened securely. Never reverse '+' and '-' terminals when reconnecting cables after disconnection. Even a short period of reverse connection will damage the electrical parts.

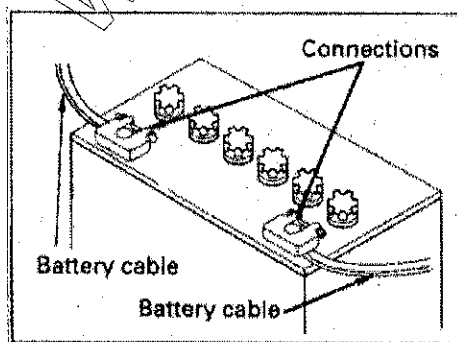


Fig 9 Battery connections

#### Battery electrolyte level

41 The amount of electrolyte in the batteries will be reduced after repeated discharge and recharge. Check the electrolyte for the level in the batteries (Fig 10), replenish with a commercially available electrolyte such as distilled water, if necessary. The battery electrolyte level checking procedure will vary with battery type. Follow the equipment manufacturer's instructions.

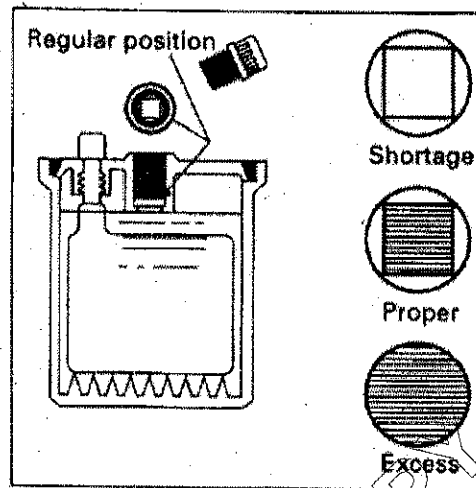


Fig 10 Battery electrolyte level

**CAUTION**

**EQUIPMENT DAMAGE. DO NOT REPLENISH WITH DILUTE SULPHURIC ACID IN THE DAILY SERVICE.**

**WARNINGS**

- (1) **PERSONNEL INJURY. WHEN INSPECTING THE BATTERIES, BE SURE TO STOP THE ENGINE.**
- (2) **PERSONNEL INJURY. AS DILUTED SULPHURIC ACID IS USED AS ELECTROLYTE, BE CAREFUL NOT TO STAIN YOUR EYES, HANDS, CLOTHES AND METALS WITH THE ELECTROLYTE. IF IT GETS IN YOUR EYE, WASH WITH A LARGE AMOUNT OF WATER AT ONCE. THEN GO AND SEE A DOCTOR.**
- (3) **PERSONNEL INJURY. AS A HIGHLY FLAMMABLE HYDROGEN GAS IS RISING FROM THE BATTERIES, DO NOT MAKE A SPARK OR USE FIRE IN ANY OTHER WAY NEAR THE BATTERIES.**
- (4) **PERSONNEL INJURY. WHEN HANDLING SUCH METALLIC ARTICLES AS A TOOL NEAR THE BATTERIES, BE SURE NOT TO CONTACT '+' TERMINAL AS THE VEHICLE BODY IS '-', IT MAY CAUSE A BIG DANGER.**
- (5) **PERSONNEL INJURY. WHEN DISCONNECTING THE TERMINALS, START WITH THE '-' TERMINAL. WHEN CONNECTING THE TERMINALS, CONNECT THE '-' TERMINAL LAST.**

**Engine starting**Pre-starting preparation

42

- (1) Make sure that all hydraulic control levers etc. on the equipment are in the NEUTRAL position.
- (2) Set the engine stop knob in the START position.
- (3) Switch ON the battery switch (if so equipped).
- (4) Insert the starter switch key into the switch key hole. Turn the key clockwise to the DRIVE position and make sure that the meters and warning lamps are actuated.

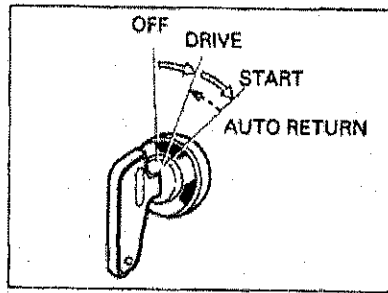


Fig 11 Starter switch (QOS system)

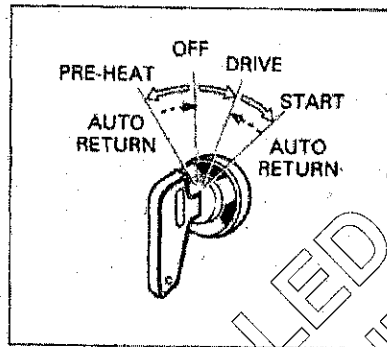


Fig 12 Starter switch (control resistance)

Pre-heating procedure

- 43 As an engine starting aid, pre-heating is required in cold engine starting.
- 44 The type with QOS system. This pre-heating uses 'QOS', a quick pre-heating system which automatically controls pre-heating time utilizing coolant temperature to conduct the irreducible minimum of pre-heating (Fig 11).
  - (1) Turn the key to the DRIVE position, and the glow plug built in the engine will grow red-hot to pre-heat the engine. At this time the pre-heating indicator lamp on the meterboard is actuated.
  - (2) When the pre-heating indicator lamp goes out, try starting the engine at once.

**TABLE 6 RELATIONSHIP BETWEEN WATER TEMPERATURE AND PRE-HEATING TIME**

Water Temperature	Pre-heating Time
50°C (122°F)	About 1 sec.
20°C (68°F)	About 2 sec.
0°C (32°F)	About 3.5 sec.
-15°C (5°F)	About 5 sec.

- 45 The type with a control resistance (Fig 12)
  - (1) Turn the starter switch key counter-clockwise to PRE-HEAT position in order to heat the glow plugs on the engine.
  - (2) Turn the starter switch key clockwise to START position as soon as the control resistance coil indicates red heat.



**WARNING**

**PERSONNEL INJURY. DO NOT TOUCH THE RED (HOT) CONTROL RESISTANCE COIL OR ALLOW COMBUSTIBLE MATERIALS SUCH AS PAPER, CLOTH OR LEAVES ON IT. THIS COULD LEAD TO A FIRE AND THE RISK OF PERSONAL INJURY AND/OR EQUIPMENT DAMAGE.**

Engine starting

46 Depress the engine throttle lever or throttle pedal and turn the starter switch key clockwise to START position. The cranking period must not exceed ten seconds. Continuous starter operation of more than ten seconds will lead to over-discharge of the batteries as well as starter seizure. If the engine cannot be started in one time attempt, keep the batteries and the starter stationary at least 30 seconds for their functional recovery, then repeat the pre-heating and the starting operations.

**CAUTION**

**EQUIPMENT DAMAGE.** Continuous re-engagement of the starter to the flywheel ring gear without giving them a break will result in the damage to the starter pinion gear and flywheel ring gear.

47 If, despite repeated operations, the engine does not start, wait for a minute or more until the functions of the batteries and starter are recovered and then repeat pre-heating and starting operations.

48 When repeating starting operation, return the key to the OFF position and then pre-heat and start the engine once again. If the engine still remains unstarted, something may be wrong with the engine. Check the repeated parts to located the cause.

**CAUTION**

**EQUIPMENT DAMAGE.** Do not use starting 'aids' in the air intake system. Such aids can cause immediate engine damage.

**Check and operation after engine start-up**Warming-up operation

49 Do the warming-up operation at 1000 min<sup>-1</sup> about ten minutes after the engine has started. As the lubrication for the entire engine systems will be done in this warming-up, do not speed up and load it abruptly. Particularly, observe this in cold season operation.

Check after the engine start-up

50 Check the following items in the engine warming-up operation.

(1) Engine oil pressure. Although the engine oil pressure gauge readings vary depending on ambient temperature or a type of oil, the gauge registers around 390 to 690 kPa (57 to 100 psi) in the warming-up. In the oil pressure warning lamp type, make sure that the lamp is off.

(2) Charge condition. The charge condition is normal when once the ammeter registers greatly on the plus side in the engine starting, then gradually the meter registering will be minimized. In the warning lamp type, make sure that the lamp is completely off during the warming-up.

(3) Engine noise and exhaust smoke colour. Pay attention to engine noise and, if any abnormal noise is heard, check the engine to detect the cause. Check the fuel combustion condition by the exhaust smoke colour. The exhaust smoke colour after engine warming-up and at no-load operation:

Colourless or light blue  
Black colour  
White colour

Normal (Perfect combustion)  
Abnormal (Imperfect combustion)  
Abnormal (Imperfect combustion)

NOTE

Engine noise after start-up might be noisier than that of warmed-up engine and, the exhaust smoke colour also being more blackish than the normal condition. However, it will be normalized after warming-up engine.

(4) Leakage in the system. Check the following items:

- |                                 |   |
|---------------------------------|---|
| a. Lube oil leakage             | Check both sides and bottom of the engine assembly for lube oil leaks, paying particular attention to the lube oil pressure gauge pipe joint, lube oil filter and lube oil pipe joints. |
| b. Fuel leakage                 | Check the fuel injection pump, fuel lines and fuel filter for leakage.  |
| c. Coolant leakage              | Check the radiator and water pump hose connections also the water drain cocks on the radiator and cylinder body for leakage.  |
| d. Exhaust smoke or gas leakage |   |

(5) Checking coolant level. The coolant level could drop depending on the equipment because the mixed air is expelled in about 5 minutes after the engine started. Stop the engine, remove radiator cap, and add coolant.

**WARNING**

**PERSONNEL INJURY. IF THE RADIATOR CAP IS REMOVED WHEN THE ENGINE IS HOT, HOT STEAM WILL RUSH OUT AND YOU COULD GET BURNT. COVER THE RADIATOR CAP WITH A THICK CLOTH AND LOOSEN THE CAP SLOWLY TO REDUCE THE PRESSURE, THEN REMOVE THE CAP.**

**Care in the engine operation**

51 During engine operation, always pay attention to the following items if the engine indicates any sign of abnormalities.

Engine oil pressure

52 Engine oil pressure is normal when the oil pressure gauge shows 290 to 590 kPa (43 to 85 psi) in the engine warmed-up condition, although the engine oil pressure may vary depending on a type of oil or engine specification. In continuous engine operation, engine oil pressure is slightly lower than the pressure at start-up time. If, in continuous engine operation, the engine oil pressure warning lamp is off, engine oil pressure is normal.

53 When the engine oil pressure gauge shows the following abnormal conditions, stop the engine immediately and check the engine oil amount in the oil sump and oil leakage:

- (1) The oil pressure gauge shows below 200 kPa (28 psi) though the engine speed is raised.
- (2) The oil pressure gauge indicator oscillates greatly in the engine low speed range.
- (3) When the engine oil pressure warning lamp goes on and off repeatedly.

54 When no lack of engine oil or no oil leakage is found, contact your equipment supplier to determine the cause of the abnormal reading.

Coolant temperature

55 The engine performance will be adversely affected if engine coolant temperature is too hot or too cold. The normal coolant temperature is 75 to 85°C (167 to 185°F).

**WARNING**

**PERSONNEL INJURY. IF THE ENGINE COOLANT TEMPERATURE GAUGE SHOWS AN OVERHEAT CONDITION OR YOU HAVE OTHER REASON TO SUSPECT THE ENGINE MAY BE OVERHEATING, CONTINUED OPERATION OF THE ENGINE (OTHER THAN AS SPELLED OUT HERE) EVEN FOR A SHORT PERIOD OF TIME, MAY RESULT IN A FIRE AND THE RISK OF PERSONAL INJURY AND SEVERE VEHICLE OR EQUIPMENT DAMAGE. TAKE IMMEDIATE ACTION AS OUTLINED IN THE FOLLOWING.**

56 Overheating. If you see or hear escaping steam or have other reason to suspect there is a serious overheat condition, stop and park the vehicle or equipment as soon as it is safe to do so and then turn off the engine immediately and get out of the vehicle or equipment.

57 The engine cooling system may overheat if the engine coolant level is too low, if there is a sudden loss of engine coolant (such as hose splitting), or if other problems occur. It may also temporarily overheat during severe operating conditions such as:

- (1) Climbing a long hill on a hot day.
- (2) Stopping after high rpm.

58 If the Engine Coolant Temperature gauge shows an overheat condition, or you have reason to suspect the engine may be overheating, take the following steps:

- (1) If your air conditioner (if equipped) is on, turn it off. And turn on the heater.
- (2) Do not turn off your engine.
- (3) With the transmission in Neutral, increase the engine speed to about one-half full operating speed or 1200 RPM, maximum. Bring the idle speed back to normal after two or three minutes.

59 If the engine coolant temperature does not start to drop within a minute or two, let the engine run at normal idle speed for two or three minutes.

60 If the engine coolant temperature does not start to drop, turn off the engine and get out of the vehicle or equipment then proceed as follows:

**WARNING**

**PERSONNEL INJURY. TO HELP AVOID BEING BURNED:**

**(1) DO NOT OPEN THE ENGINE ACCESS COVER IF YOU SEE OR HEAR STEAM OR ENGINE COOLANT ESCAPING FROM THE ENGINE COMPARTMENT. WAIT UNTIL NO STEAM OR ENGINE COOLANT CAN BE SEEN OR HEARD BEFORE OPENING THE ENGINE COVER.**

**(2) DO NOT REMOVE THE RADIATOR CAP OR ENGINE COOLANT RESERVE TANK CAP IF THE ENGINE COOLANT IN THE TANK IS BOILING. ALSO DO NOT REMOVE THE RADIATOR CAP WHILE THE ENGINE AND RADIATOR ARE STILL HOT. SCALDING FLUID AND STEAM CAN BE BLOWN OUT UNDER PRESSURE IF EITHER CAP IS TAKEN OFF TOO SOON.**

61 If no steam or engine coolant can be seen or heard, tilt the cab or open the engine access cover. If the engine coolant is boiling, wait until it stops before proceeding. Look at the see-through reserve tank. The engine coolant level should be between the 'MAX' and 'MIN' marks on the reserve tank. If necessary, pour engine coolant into the reserve tank only, never directly into the radiator. Also, do not check engine coolant level at the radiator.

62 Make sure the fan belts are not broken, or are off the pulleys, and that the fan turns when the engine is started.

63 If the engine coolant level in the reserve tank is low, look for leaks at the radiator hoses and connections, heater hoses and connections, radiator, and water pump. If you find major leaks, or spot other problems that may have caused the engine to overheat, do not run the engine until these problems have been corrected. If you do not find a leak or other problem, carefully add engine coolant to the reserve tank. (Engine coolant is a mixture of ethylene glycol antifreeze and water. See 'Engine Care in cold season' (Para 137) for the proper antifreeze and mixture).

#### WARNING

**PERSONNEL INJURY. TO HELP AVOID BEING BURNED, DO NOT SPILL ANTIFREEZE OR ENGINE COOLANT ON THE EXHAUST SYSTEM OR HOT ENGINE PARTS. UNDER SOME CONDITIONS THE ETHYLENE GLYCOL IN ENGINE COOLANT IS COMBUSTIBLE.**

64 If the engine coolant level in the reserve tank is at the correct level but there is still an indication on the instrument panel of an overheat condition, YOU MUST LET THE ENGINE COOL FIRST. You may then add engine coolant directly to the radiator.

65 Once the Engine Coolant Temperature Gauge no longer signals an overheat condition, you can resume operating at a reduced speed. Return to normal operating after about ten minutes if the gauge pointer does not again show an overheat condition.

66 If no cause for the overheat condition was found, see a qualified service technician.

67 Overcooling. The engine operation at low coolant temperature will not only increase the oil and fuel consumption but also will lead to premature parts wear which may result in engine failure.

#### Engine hour meter (engine operation hour indicating) (if so equipped)

68 This meter indicates the engine operation hours. Make sure that the meter is always working during engine operation.

69 Periodical engine maintenance is scheduled on the operation hours indicated on the hour meter.

#### Liquid and exhaust smoke leakage

70 Be careful with lubricant, fuel, coolant and exhaust smoke leakage.

#### Abnormal engine noise

71 Pay attention to the noise from the engine or other related parts, checking if the noise is normal.

#### State of the exhaust smoke

72 Be careful with exhaust smoke colour, check if it is whitish or blackish.

#### Electrical system

73 Do not turn the key to OFF position during engine running. This may cause electrical parts damage.

**Engine stopping**

- 74 Make sure that all of the control levers on the equipment are in NEUTRAL position.
- 75 Before stopping the engine, cool down the engine by operating it at low idle speed for about three minutes. During this operation, check the engine noise and the engine oil pressure for abnormalities.
- 76 To stop the engine, turn the starter switch key to OFF position. Switch off the battery (if so equipped).

**CAUTION**

**BATTERY DISCHARGE.** Leaving the starter switch key in the DRIVE position for a long while after the engine has been stopped, will discharge the batteries wastefully.

**Operation and care of new engine**

- 77 Your ISUZU engine is carefully tested and adjusted in the factory, however, further, thorough run-in, ie break-in operation, is necessary.
- 78 If the new engine is harshly operated, lubricating oil film will be reduced leading to abnormal wear or seizure. Particularly, avoid harsh engine operation within the initial 100 operation hours observing the following notice.
- (1) Perform the warming-up operation continuously until the engine is warmed-up. In this operation, do not race the engine.
  - (2) Also do not operate the engine with rapid acceleration, rapid machine starting and continuous high speed operation.

**Engine care for over-cooling**

- 79 Engine over-cooling causes premature wear and increased fuel consumption. When the coolant temperature is not raised to 75 to 85°C (167 to 185°F) indefinitely, take action to raise the temperature using a radiator curtain or such like.

**Starting the engine after being left unused for a long period of time**

- 80 When the vehicle or equipment is left unused for 'more than three months' without running the engine (warming up), conduct a thorough inspection of the vehicle before starting the engine. After starting the engine, be sure to warm it up for more than ten minutes at 1000 min<sup>-1</sup>.

**PERIODICAL INSPECTION AND MAINTENANCE****Lubricating system**

- 81 Servicing of the engine oil or the oil filter element affects the engine performance as well as the engine life.
- 82 Change the engine oil and the oil filter element periodically with the specified ones. (Refer to LUBRICANT at Paras 25 to 27).

Engine oil and oil filter element change

83 Engine oil change and oil filter element change must be made according to the following change schedule.

Change Interval	
Engine Oil	Initial 50 and thereafter every 250 operating hours
Oil Filter Element	Initial 50 and thereafter every 500 operating hours

84 Engine oil draining

**WARNING**

**PERSONNEL INJURY. TO AVOID BEING BURNED, DO NOT DRAIN OIL WHILE THE ENGINE IS STILL HOT.**

- (1) Wipe clean around the oil filler cap (Fig 13) taking care that no foreign particles enter. Remove the filler cap.
- (2) Remove the oil pan drain plug and drain the engine oil completely (Fig 14).

85 It is advisable that draining be done while the engine is warm, to minimize the draining time.

**NOTE**

Use a receptacle to receive the drained oil so that the engine and equipment may not be stained with the drained oil.

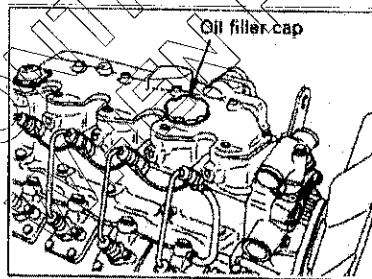


Fig 13 Oil filler cap

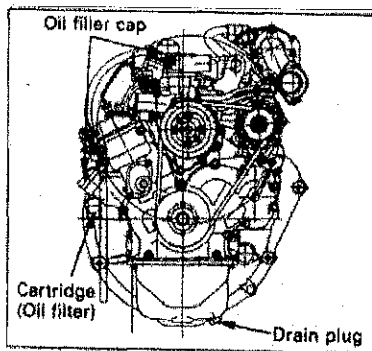


Fig 14 Oil filter and drain plug

- 86 Oil filter element removal. Use a filter wrench to remove the cartridge type oil filter element (Fig 15).

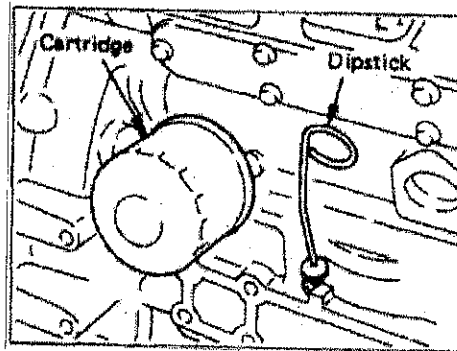


Fig 15 Oil filter removal

- 87 Oil filter element installation

- (1) Apply light engine oil to the O-ring.
- (2) Screw in new cartridge until its sealed face comes in contact with the O-ring.
- (3) Use a filter wrench to further turn in the cartridge by  $3/4$  turn.

Used oil disposal

- 88 Do not dispose of used engine oil (or any other oil) in a careless manner such as pouring it on the ground, into sewers, or into streams or bodies of water. Instead, recycle it by taking it to a used oil collection facility which may be found in your community. If you have a problem disposing of your used oil, it is suggested that you contact your dealer or service station. (This also applies to diesel fuel which is contaminated with water. See 'Diesel Fuel' in Para 16.)

Used engine oil

**WARNING**

**PERSONNEL INJURY. USED ENGINE OIL CONTAINS HARMFUL CONTAMINANTS THAT HAVE CAUSED SKIN CANCER IN LABORATORY ANIMALS. AVOID PROLONGED SKIN CONTACT. CLEAN SKIN AND NAILS THOROUGHLY USING SOAP AND WATER – NOT MINERAL OIL, FUELS, OR SOLVENTS. LAUNDER OR DISCARD CLOTHING, SHOES, OR RAGS CONTAINING USED ENGINE OIL.**

- 89 Discard used engine oil and other oils properly.

**Cooling System**

Fan belt tension adjustment

- 90 Adjust fan belt tension when belt slackness is greater than the specified amount and when the belts are being replaced (Fig 16).

**WARNING**

**PERSONNEL INJURY. TO HELP AVOID BEING INJURED, CHECK AND ADJUST FAN BELT TENSION WITH THE ENGINE STOPPED.**

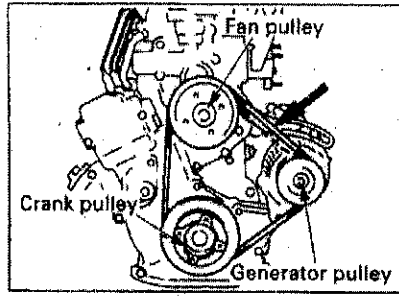


Fig 16. Fan belt

91 Belt tension. Belt tension is normal when it is depressed 10 mm (0.39 in) with the thumb at the midway between the fan pulley and generator pulley. (About 100 N (22 lb) depressing force).

Fan belt slackness : **About 10 mm (0.39 in)**

92 Adjusting procedure. Belt tension adjustment (Fig 17) is made by pivoting the generator at the generator mounting bolt.

- (1) Loosen the generator adjusting plate bolt and the generator mounting bolt.
- (2) Pivot the generator at the mounting bolt toward the engine left or right-hand side as required.
- (3) Tighten the mounting bolt and the adjusting bolt.

**NOTE**

Belt tension may vary slightly after the generator is fixed. Therefore, recheck the belt tension after tightening the bolts.

- (4) After the adjustment, operate the engine about five minutes at a low idle speed and recheck the belt tension. Particularly, pay attention to this matter when installing new belts. Belt tension may vary due to the initial belt conforming.

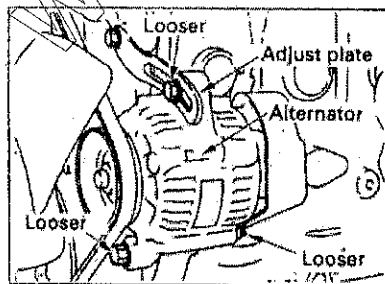


Fig 17 Fan belt tension adjustment

Fan belt change

93 Use of a fan belt of poor quality will result in premature belt wear or belt elongation leading to engine damage such as overheat. Therefore use of the ISUZU genuine fan belts is highly recommended.

Coolant change

94 The coolant must be changed at intervals of **six months**. If the coolant is being fouled greatly, it will lead to engine overheat or coolant blow-off from the radiator.



Coolant draining

95 Drain the coolant as follows:

- (1) Remove the radiator cap. Open the drain cock at the radiator lower part to drain the coolant from the radiator.

**WARNING**

**PERSONNEL INJURY. WHEN REMOVING THE RADIATOR FILLER CAP WHILE THE ENGINE IS STILL HOT, COVER THE CAP WITH A RAG, THEN TURN IT SLOWLY TO RELEASE THE INTERNAL STEAM PRESSURE. THIS WILL PREVENT A PERSON BEING SCALDING WITH HOT STEAM SPOUTING OUT FROM THE FILLER PORT.**

- (2) Drain away the coolant from the engine by loosening the water drain plug (Fig 18) at the rear of alternator on the left side of cylinder body.

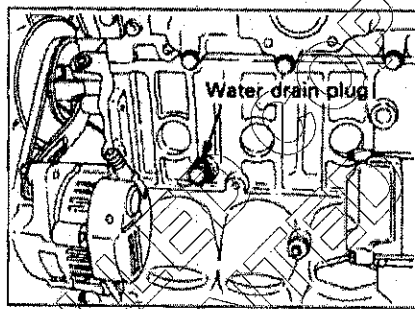


Fig 18 Water drain plug

Filling with coolant

96 Fill the system with coolant as follows:

- (1) Close or tighten the coolant drain plug.
- (2) Use clean drinking water as a coolant. Fill up the radiator with the coolant until the level comes up to the filler port neck. Fill gradually to prevent air entry.

Coolant volume (Engine only): Refer to 'Main Data Specifications'.

- (3) With the system filled, operate the engine about five minutes at a low idle speed, then the air contained in the coolant circuit is bled. The coolant level will drop. Stop the engine to replenish the coolant.

Cleaning outside of radiator

97 Mud or dried grass caught between radiator fins will block the air flow, resulting in lower cooling efficiency. Clean the radiator fins with steam or compressed water. For the cleaning interval, refer to the instruction manual prepared by the equipment manufacturer. If the fins are stuffed, however, clean them at any time. Further, if the fins are deformed, repair or replace them.

Cooling system circuit cleaning

98 When the cooling system circuit is fouled with water scales or sludge particles, cooling efficiency will be lowered. Periodically clean the circuit interior with a cleaner.

Cooling system cleaning interval: **Every 1000** operation hours.

**Fuel system**

99 The fuel injection pump and fuel injection nozzles are precisely manufactured, and therefore, using the fuel which contains water or dust particles will result in either injection pump plunger seizure or injection nozzle seizure. A fuel filter element fouled with sludge or dust particles will lead to decreased engine output. In addition, a clogged filter element can cause low output or automatic air bleeding failure.

100 Perform inspection and maintenance periodically as follows:

Removal of water from the fuel

101 If water reaches the fuel filter element bottom, follow the procedure below to drain the water.

- (1) Turn the fuel filter lever just above (close) until it stops, to cut off the fuel. (See Fig 19).
- (2) Loosen the ring nut, remove the cup together with the element, and drain the fuel.
- (3) Clean the cup, install the element and tighten to the filter body with the ring nut.
- (4) Turn the fuel filter lever just below (open) until it stops, to conduct air bleeding for the fuel.

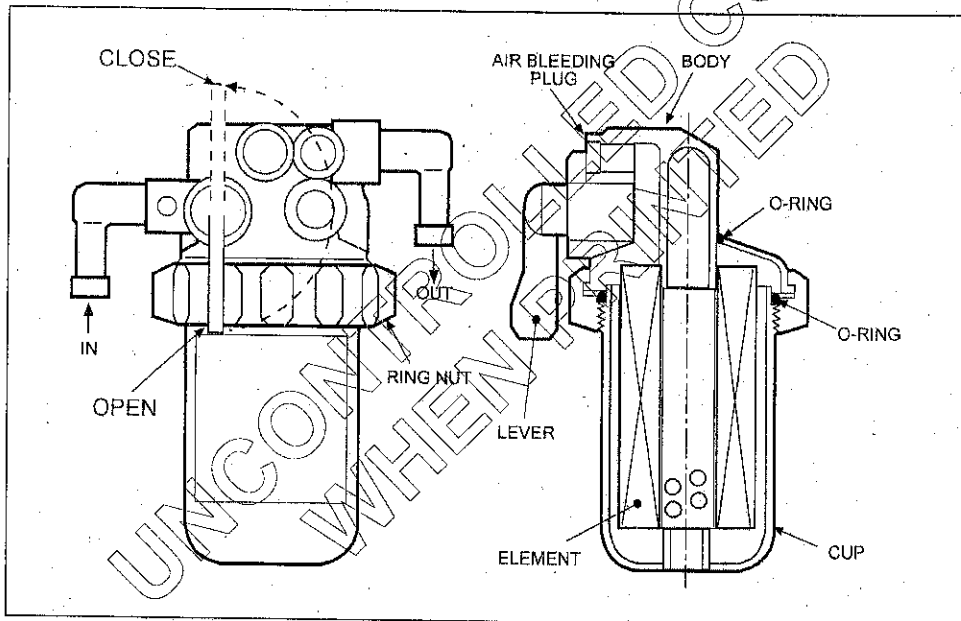


Fig 19 Draining water from the fuel

**NOTES**

- (1) If the cup is removed without turning the fuel filter lever just above, the fuel may flow out.
- (2) The cartridge and cup contain fuel. Take care not to spill it during disassembly.
- (3) Perform the 'fuel system air bleeding' after the water in the fuel is drained.

Fuel system air bleeding

102 The entry of air into the fuel system will cause hard engine starting or engine malfunction. When servicing such as emptying the fuel tank, draining for the water sedimentor, and the fuel filter element change is done, be sure to conduct air bleeding. Because of the 'automatic air-bleeding system' being employed, turn the starter switch to the DRIVE position and activate the 'electromagnetic pump' to bleed the air.

103 Air bleeding procedure

- (1) When the 'starter switch' is set to the DRIVE (ON) position to activate the electromagnetic pump, fuel is forcibly sent to the fuel valve of each injection pump (Fig 20) and further to the leak-off pipe of each nozzle holder, where air in the fuel leaks off automatically to the fuel tank.
- (2) Start the engine and check the fuel system for fuel leak.

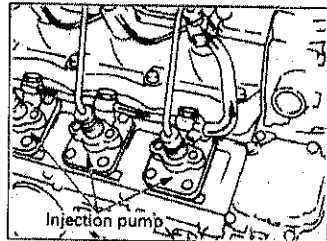


Fig 20 Injection pump

Fuel filter element change procedure

Change Interval	
Fuel Filter Element change interval	Every 500 operating hours

## 104 Change the fuel filter element as follows:

- (1) Turn the fuel filter lever (Fig 21) to the closed position.

## NOTE

If the cup is removed without turning the lever as instructed, the fuel may flow out.

- (2) Loosen the ring nut, remove the cup, and take out the element.
- (3) Clean the cup, install a new element, and install new packing on the ring nut.
- (4) Tighten the cup to the body securely with the ring nut.
- (5) After installation, turn the fuel filter lever to the open position.

## NOTES

- (1) With the lever positioned just above the fuel remains off, and therefore, the engine cannot be started.
- (2) During removal, be careful not to stain the parts around with the fuel in the cup.
- (3) After changing the fuel filter element, conduct fuel air bleeding.

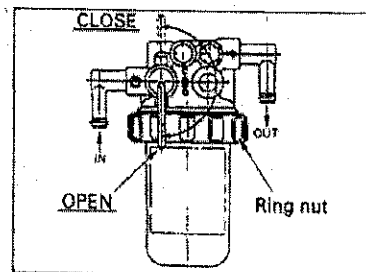


Fig 21 Fuel filter element

Change procedure with spin-on type filter

105 Change the spin-on type fuel filter element (Fig 22) as follows:

- (1) Loosen the fuel filter turning it counter-clockwise with a filter wrench.
- (2) With a rag wipe clean the fitting face on the upper cover, so that new fuel filter can be seated properly.
- (3) Lightly oil the O-ring. To reinstall, turn the filter assembly clockwise carefully to prevent the fuel from spilling until the O-ring is fitted against the sealing face of the filter cover. Turn 2/3 turn further with the filter wrench.

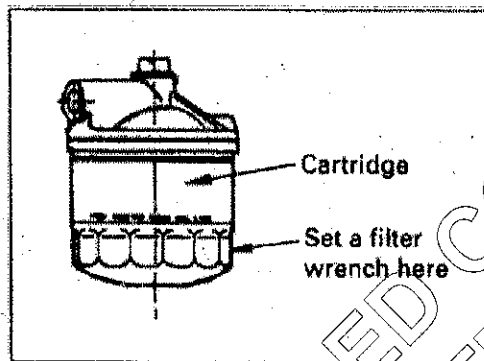


Fig 22 Spin-on type fuel filter element

Governor Control Seals

106 As the governor (timing gear case) is precisely adjusted, most of the controls are sealed, please do not break them. When the adjustment is necessary, contact your machine supply source.

**NOTE**

The manufacturer does not warrant the claim on the engine with the governor seals broken.

**Air intake system**

Air cleaner

107 Engine performance and life vary with the air intake conditions. A dirty air cleaner element reduces the amount of intake air, causing reduced engine output or disordered engine. Also, a damaged element leads to abrasion of cylinders and valves, resulting in increased oil consumption, reduced output and shortened engine life. Handling of air cleaner varies with the equipment model. Perform periodic inspection and maintenance following the equipment manufacturer's instructions.

**NOTES**

- (1) Shorten the cleaning or change interval when the equipment is used in dusty areas.
- (2) Change the element, if element damage is found during air cleaner cleaning.
- (3) Take care not to cause air leakage (sucking) when reassembling the air cleaner.

Air cleaner with dust indicator

108 This indicator (Fig 23) is attached to the air cleaner. When the air cleaner element is clogged, air intake resistance becomes greater and the dust indicator signal turns into red indicating element change time. When the signal turns into red, clean the air cleaner or replace the element. Then press the dust indicator button to reset the indication.

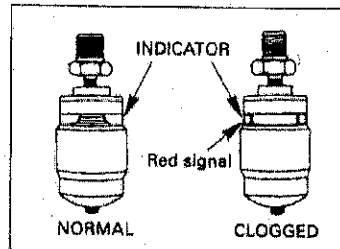


Fig 23 Dust indicator

**Engine electrical**

109 The ISUZU engine uses a 12 volt system and a negative grounding type for the electrical system.

Battery servicing

110 Battery maintenance schedules will vary with equipment and battery types. Follow the equipment manufacturer's instructions.

Gravity of the batteries

111 The battery charge condition is judged by the electrolyte gravity measurement. Periodically measure the electrolyte gravity of the batteries (Fig 24). For the internal check follow the equipment manufacturer's standard. The relationship between the electrolyte specific gravity and the battery conditions are as follows:

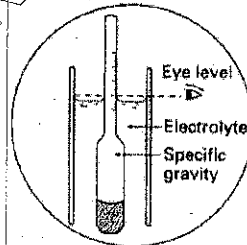


Fig 24 Electrolyte specific gravity

**TABLE 7 ELECTROLYTE SPECIFIC GRAVITY**

Electrolyte Specific Gravity	Battery Conditions
Over 1.300	Over 100% (Over charged)
1.290 – 1.270	100%
1.260 – 1.240	75%
Below 1.230	Below 50% (Insufficiently charged)

**WARNING**

**PERSONNEL INJURY. THE BATTERY ELECTROLYTE IS DILUTE SULPHURIC ACID. SO, BE CAREFUL NOT TO STAIN YOUR BODY AND CLOTHES WITH IT. IF STAINED, RINSE PORTION IN CLEAN WATER.**

Gravity conversion

112 The specified electrolyte temperature for the gravity measurement is 20°C (68°F). Measure the electrolyte temperature and carry out the conversion in accordance with the following formula when the temperature does not fall to the specified temperature.

$$S_{20} = S_t + 0.0007(t - 20)$$

Where  $S_{20}$  = gravity at 20°C  
 $S_t$  = gravity measured  
 $t$  = electrolyte temperature when measured

Battery terminal connections

113 Periodically, check the battery terminals for loose connection and corrosion.

114 For the check interval, follow the machine manufacturer's standard. Loose connections will cause hard engine starting or deficient battery charging.

115 If the terminals are excessively corroded, disconnect the battery cables and polish them with a wire brush or sandpaper.

116 Never reverse the '+' and '-' terminals when reconnecting the cables. Even a short period of reverse connection could damage the electrical parts.

Cleaning of battery

117 When the battery is fouled, clean it with clean water or tepid water and wipe them with a dry cloth to remove the water. Apply a light coat of Vaseline or grease to the battery post.

Generator Servicing

118 The polarity of the generator is negative grounding type. When an inverted circuit connection takes place, the circuit will be in short circuit instantaneously resulting in generator failure.

119 Do not put water directly on the generator. Entry of water into the generator leads to an electrolyte corrosion causing generator failure. Pay attention particularly when cleaning the engine.

120 When the battery is charged with a external electric source, be sure to disconnect the battery cables.

Wiring connections

121 Check all of the electric wiring connections for looseness and damage.

**Engine assembly and others**

122 To continue trouble free engine operation over a long period of time, the servicing items need a skilled maintenance technician, therefore, consult your machine supply source on the following items when necessary.

Fuel injection nozzle

123 Use an injection nozzle tester to check the static injection starting pressure and the fuel spray conditions (Fig 25).

Injection nozzle pressure test interval: **Every 1500** operation hours

124 When the injection starting pressure is too high or too low or the fuel spray pattern is improper, an abnormal fuel combustion take place in the engine leading a lowered output and blackish exhaust smoke. Further, it causes a piston seizure or piston damage etc. In such cases, the injection nozzle test or the nozzle replacement is required.

Injection starting pressure: 12.7 – 13.7 MPa (1850 – 1990 psi)

**WARNING**

**PERSONNEL INJURY. WHILE USING A NOZZLE TESTER, HIGH PRESSURE MAY BLOW OFF THE FUEL OIL AND INJURE THE WORKER. KEEP OFF THE NOZZLE END.**

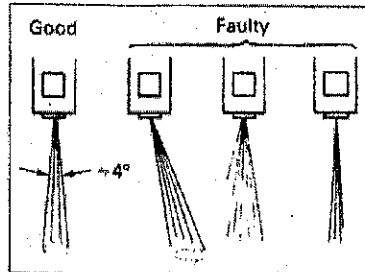


Fig 25 Fuel injection test

Valve clearance adjustment

125 The valve clearance must be adjusted **every 1000** operating hours, or whenever the valve rocker is abnormally noisy, or in an engine malfunction though the fuel system is properly working.

Valve clearance : 0.20 mm (0.0078 in) (When the engine is cold)

126 Adjustment procedure

(1) Turn the crankshaft clockwise so that the mark groove on the crank pulley is aligned with the TDC mark (cast out) on the timing gear case cover (Fig 26).

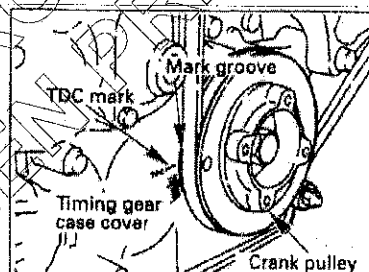


Fig 26 Valve clearance adjustment

(2) Remove the cylinder head cover and check to see if cylinder No. 1 is at TDC in the compression stroke or at TDC in the exhaust stroke. When the intake and exhaust valves are closed, the cylinder is at TDC in the compression stroke, and when only the exhaust valve is open, it is at TDC in the exhaust stroke (Fig 27).

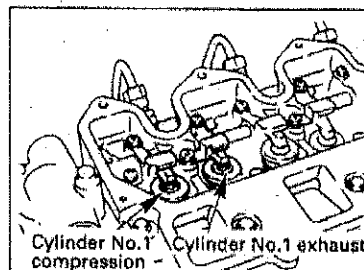


Fig 27 Exhaust and compression strokes

- (3) In accordance with the conditions of cylinder No. 1, measure and adjust if required, the clearance of the valves marked with either ○ or ⊙ in the table below.

TABLE 8 VALVE CLEARANCES

Cylinder No.	1		2		3		4	
	I	E	I	E	I	E	I	E
When No. 1 cylinder is at TDC in the compression stroke	○	○	○			○		
When No. 4 cylinder is at TDC in the compression stroke				⊙	⊙		⊙	⊙

I : Inlet      E : Exhaust

- (4) On completion of the valve clearance adjustment in Sub-para (3) above, make mark alignment as in Sub-para (1) above by giving a turn to the crankshaft in normal direction. Then measure and adjust the clearance of the other valves.

## NOTE

The rocker arm is made of die-cast aluminium. Therefore, be careful not to tighten the adjusting screw to excess.

Adjustment of injection timing

- 127 The injection timing may not be readjusted. Take care not to forget to insert a shim on the mounting surface when reassembling the injection pump after it was removed.

Cylinder compression pressure measurement

- 128 The cylinder compression pressure measurement must be done **every 1000** operation hours, or whenever the engine output is reduced.

Compression pressure: 3.04 MPa (441 psi)  
 Test condition: Cranking speed 250 min<sup>-1</sup>  
 Coolant temperature 75°C (167°F)

- 129 Repair the engine and/or replace some parts of engine if compression pressure is lower than 2.55 MPa (370 psi).

Starter and generator servicing

- 130 Do the starter and the generator servicing **every 1000** operating hours on the following items.

- (1) Starter commutator cleaning.
- (2) Generator slip ring cleaning.
- (3) Carbon brushes and the brush contact check.

Radiator pressurization valve check

- 131 A pressurization valve is incorporated in the radiator cap assembly. Check the valve actuating pressure with a radiator compression tester. For the pressurization valve actuating pressure and the check interval, follow the equipment manufacturer's standards.



**ENGINE CARE IN COLD SEASON****Fuel**Fuel selection

132 In the cold zone, the fuel might be frozen resulting in hard engine starting; therefore, select a suitable fuel for such engine operation.

133 Use ASTM 975 No. 2-D fuel if you expect temperature above  $-7^{\circ}\text{C}$  ( $20^{\circ}\text{F}$ ). Use Number 1-D if you expect temperatures below  $-7^{\circ}\text{C}$  ( $20^{\circ}\text{F}$ ).

134 If Number 1-D is not available, a 'winterized' blend of 1-D and 2-D is available in some areas during the winter months. Check with the service station operator to be sure you get the properly blended fuel.

**CAUTION**

- (1) **EQUIPMENT DAMAGE.** Methyl alcohol base antifreeze is not recommended because of its effect on the non-metallic components of the cooling system and because of its low boiling point.
- (2) **EQUIPMENT DAMAGE.** High silicate antifreeze is not recommended because of causing serious silica gelation problems.
- (3) **EQUIPMENT DAMAGE.** Usage and mixing ratio etc. should be followed to the antifreeze manufacturer's recommendations.

**Engine oil**

135 Engine oil viscosity largely affects engine startability, so the use of lubricant with selected viscosity according to the atmospheric temperature is important. (Refer to Fig 4.)

136 At low atmospheric temperature, engine oil viscosity will increase to cause hard engine starting.

**Coolant**

137 Where the atmospheric temperature falls below freezing point, the cooling system should be drained after engine operation, but to eliminate the need for repeated draining and refilling, the use of anti-freeze solution is highly recommended.

138 A 50/50 Ethylene glycol base antifreeze/water mix (which provides protection to  $-37^{\circ}\text{C}$  ( $-34^{\circ}\text{F}$ )) is recommended for use in these ISUZU diesel engines).

139 Concentrations over 65% adversely affect freeze protection, heat transfer rates, and silicate stability which may cause water pump leakage.

140 Never exceed a 60/40 antifreeze/water mix (which provides protection to about  $-50^{\circ}\text{C}$  ( $-58^{\circ}\text{F}$ )).

**WARNING**

**PERSONNEL INJURY. UNDER SOME CONDITIONS THE ETHYLENE GLYCOL IN THE ENGINE COOLANT IS COMBUSTIBLE. TO HELP AVOID BEING BURNED WHEN ADDING ENGINE COOLANT, DO NOT SPILL IT ON THE EXHAUST SYSTEM OR ENGINE PARTS THAT MAY BE HOT. IF THERE IS ANY DIFFICULTY, HAVE THIS ROUTINE PERFORMED BY A QUALIFIED TECHNICIAN.**

### Battery

141 Always pay attention to charging the batteries completely in the cold season. As the discharge current from the battery is large in cold engine starting, it takes a comparatively long while to recharge the batteries than when recharging after normal engine starting. Particularly, as the gravity of the insufficiently charged battery's electrolyte is low, it will easily be frozen. Pay attention to keep the batteries warm in the cold season.

142 To replenish the battery with distilled water, do it immediately before the engine operation. If the work is done after the engine has already been in operation, the distilled water replenished will not be mixed with the original electrolyte, allowing the danger of freezing, the not mixed distilled water staying in the battery cell upper part.

### Engine starting

143 In cold engine starting at atmospheric temperature of below 0°C (32°F), pay attention to the following items:

- (1) Do the preheating operation before cranking the engine with the starter.
- (2) Set the engine throttle lever or pedal to the 1/3 position of the full lever or pedal stroke.
- (3) If the engine does not start with the initial cranking, keep the batteries stationary a while to recover their power and, reattempt the preheating and the cranking operation.
- (4) In order to protect the starter, one time cranking must be limited to within 10 seconds.
- (5) In cranking operation, when a phenomenon that the starter pinion and the flywheel ring gear engagement is not taking place, this is a sign of weakened battery power, charge the batteries with an external electrical source.
- (6) In extreme cold temperature engine starting, do the engine cranking while setting the throttle lever at no fuel position, to allow the engine rotating or travelling parts to come to an unrestricted condition from the adhesive cold lubricant. After, carry out preheating and cranking to start the engine.

### CAUTION

**EQUIPMENT DAMAGE.** Do not use starting "aids" in the air intake system. Such aids can cause immediate engine damage.

**ENGINE ELECTRICAL WIRING DIAGRAM**

144 As the electrical wiring differs depending on the respective equipment, merely standard wiring is shown in the diagram (Fig 28).

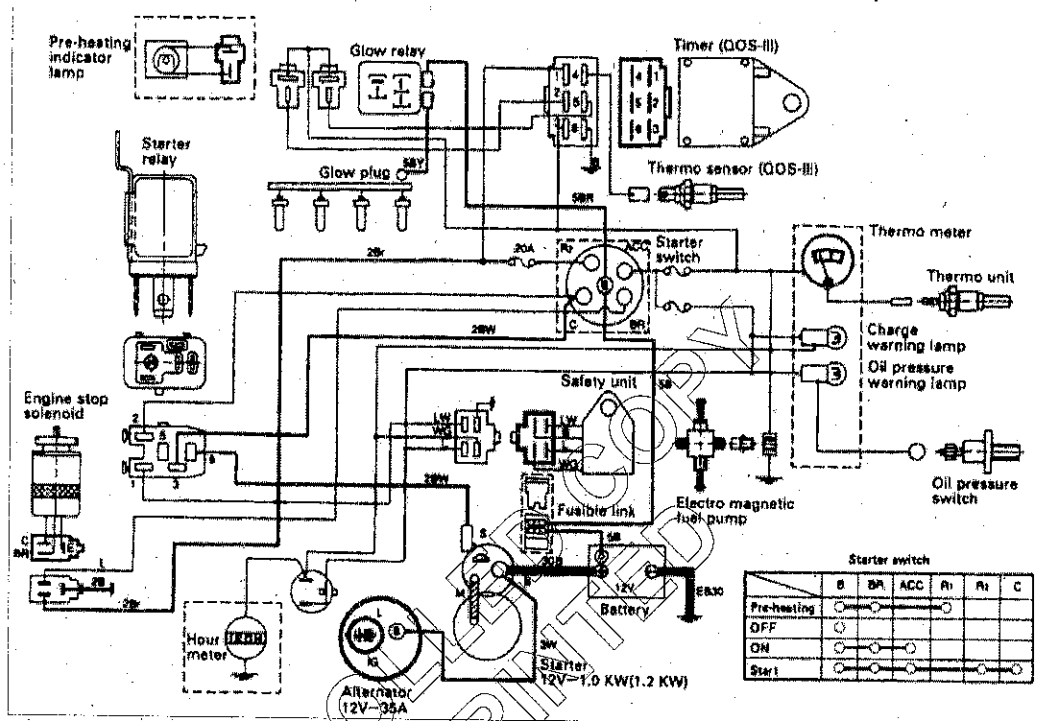


Fig 28 Engine electrical wiring diagram

**ENGINE MAINTENANCE SCHEDULE**

145 When performing the following items (Table 9), the daily inspection items should also be carried out.

**TABLE 9 ENGINE MAINTENANCE SCHEDULE**

No.	Description of check and maintenance	Daily	(Operation hours)							Remark
			50	250	500	750	1000	1250	1500	
1	Oil level and oil fouling	○								See 'Explanation of maintenance schedule' at Para 146.
2	Oil leakage check	○								
3	Oil pressure gauge registration	○								
4	Oil pressure warning lamp	○								
5	Engine oil replacement		(○)	○	○	○	○	○	○	
6	Oil filter element replacement		(○)		○		○		○	
7	Fuel leakage check	○								
8	Draining water in fuel filter	○								
9	Fuel filter element replacement				○		○		○	
10	Injection nozzle check (*)				○*		○*		○*	

\* This is a recommended maintenance. The failure to perform this maintenance item will not nullify the emission warranty or limit recall liability prior to the completion of the engine's useful life. Isuzu, however, urges that recommended maintenance service is performed at the indicated intervals.

TABLE 9 ENGINE MAINTENANCE SCHEDULE (continued)

No.	Description of check and maintenance	Daily	(Operation hours)						Remark	
			50	250	500	750	1000	1250		1500
11	Coolant level and fouling check	○								See 'Explanation of maintenance schedule' at Para 146.
12	Coolant leakage check	○								
13	Radiator filler cap fitting condition	○								
14	Fan belt tension check (Replace if necessary)	○								
15	Coolant temperature registration	○								
16	Coolant replacement									
17	Radiator external face cleaning									
18	Cooling system circuit cleaning									
19	Radiator filler cap function check (*)									

No.	Description of check and maintenance	Daily	(Operation hours)						Remark	
			50	250	500	750	1000	1250		1500
20	Electrolyte level check	○								See 'Explanation of maintenance schedule' at Para 146.
21	Battery cleaning	○								
22	Battery charge condition	Ammeter registration								
		Charge warning lamp								
23	Electrolyte gravity check									
24	Starter and generator check and cleaning (*)					○				
25	Wiring and connection check									
26	Preheating condition check									
27	Air cleaner element replacement									

No.	Description of check and maintenance	Daily	(Operation hours)						Remark	
			50	250	500	750	1000	1250		1500
28	Engine starting conditions and noise conditions	○								See 'Explanation of maintenance schedule' at Para 146.
29	Exhaust smoke condition	○								
30	Cylinder compression pressure (*)					○				
31	Valve clearance check (*)					○				
32	Positive crankcase ventilation valve							○*		

## NOTES

(1) The service intervals after 1500 operation hours should also be made every 250 operation hours in accordance with this check and maintenance schedule.

(2) When the servicing on the asterisked (\*) items is necessary, consult the equipment supplier.

**Explanation of maintenance schedule**

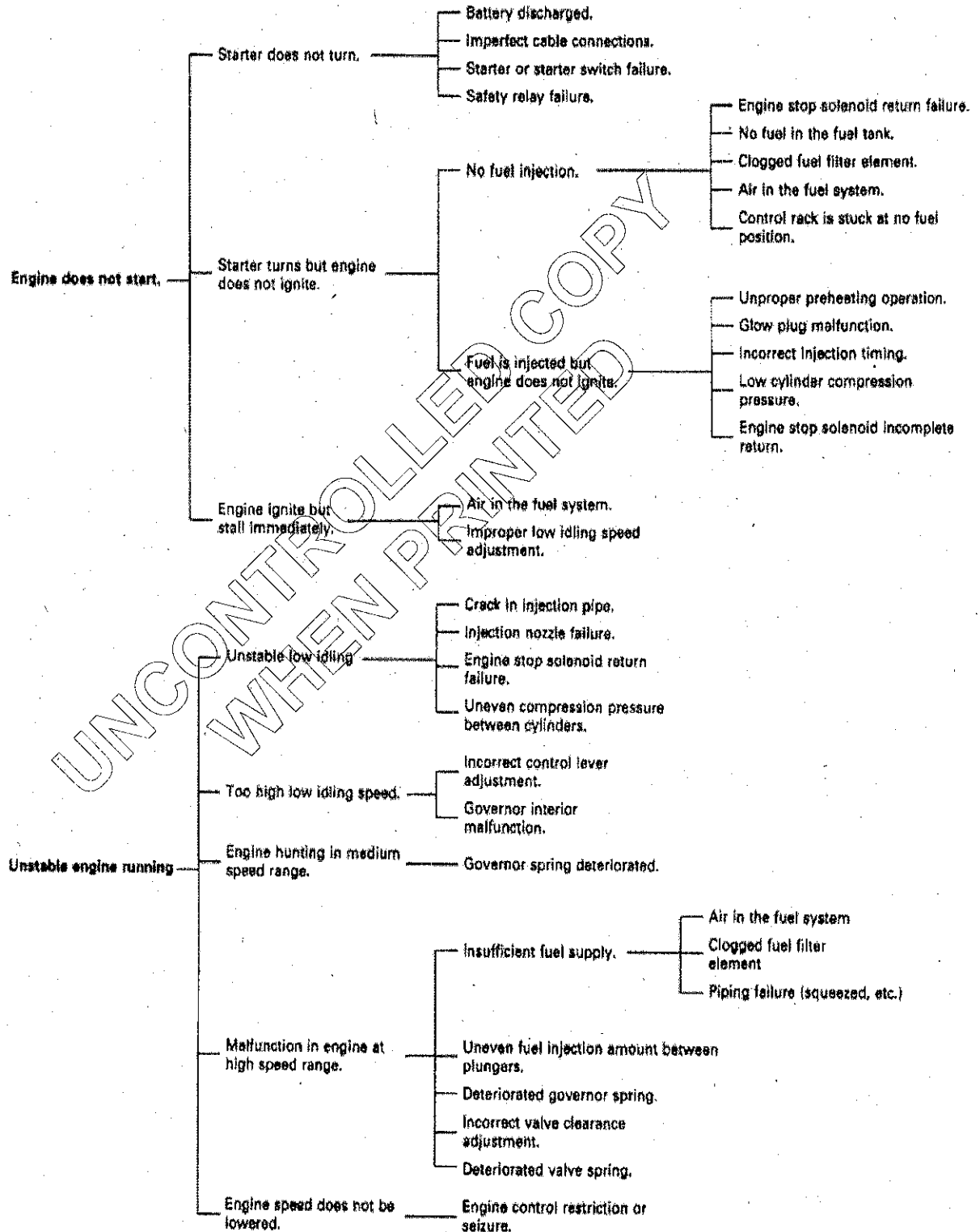
146 The following is a brief explanation of the servicing listed in the preceding Engine Maintenance Schedule.

- |    |  |  |
|----|--|--|
| 1  | <b>Oil level and oil fouling</b>             | Check that the oil level is between the max. level mark and the min. level mark. Drain oil to the max. level mark if oil level is above the max. level mark. Add oil to the max. level mark if oil is below the min. level mark. |
| 2  | <b>Oil leakage check</b>                     | Replace any damaged or malfunctioning parts which could cause leakage.   |
| 3  | <b>Oil pressure gauge registration</b>       | Engine oil pressure is normal at about 290 to 590 kPa in warmed-up condition. Check and repair the lubrication oil system, if it is abnormal.  |
| 4  | <b>Oil pressure warning lamp</b>             | Warning lamp is off while engine running. If it stays on, check and repair the lubrication system.   |
| 5  | <b>Engine oil replacement</b>                | Change oil every 250 hours.  |
| 6  | <b>Oil filter element replacement</b>        | Change element every 500 hours.  |
| 7  | <b>Fuel leakage check</b>                    | Inspect the fuel lines for damage which could cause leakage. Replace any damaged or malfunctioning parts.  |
| 8  | <b>Draining water in fuel filter</b>         | Drain water in fuel filter if water has collected in the fuel element.   |
| 9  | <b>Fuel filter element replacement</b>       | Change element every 500 hours.  |
| 10 | <b>Injection nozzle check</b>                | Clean the injection nozzle tips every 1500 hours. (This is a required maintenance). Check injection opening pressure and spray condition.  |
| 11 | <b>Coolant level and fouling check</b>       | Check coolant level and add coolant if necessary.  |
| 12 | <b>Coolant leakage check</b>                 | Repair part for coolant leakage.   |
| 13 | <b>Radiator filler cap fitting condition</b> | The radiator cap must be installed tightly.  |
| 14 | <b>Fan belt tension check</b>                | Check and adjust fan belt deflection. Look for cracks, fraying and wear.   |
| 15 | <b>Coolant temperature registration</b>      | Coolant temperature is normal at about 75 to 85°C (167 to 185°F). Check and repair the cooling system if coolant temperature is abnormal.  |
| 16 | <b>Coolant replacement</b>                   | Change coolant at intervals of 6 months or 12 months respectively if coolant is plain water, or long life coolant (LLC).   |
| 17 | <b>Radiator external face cleaning</b>       | According to the equipment manufacturer's specification.   |

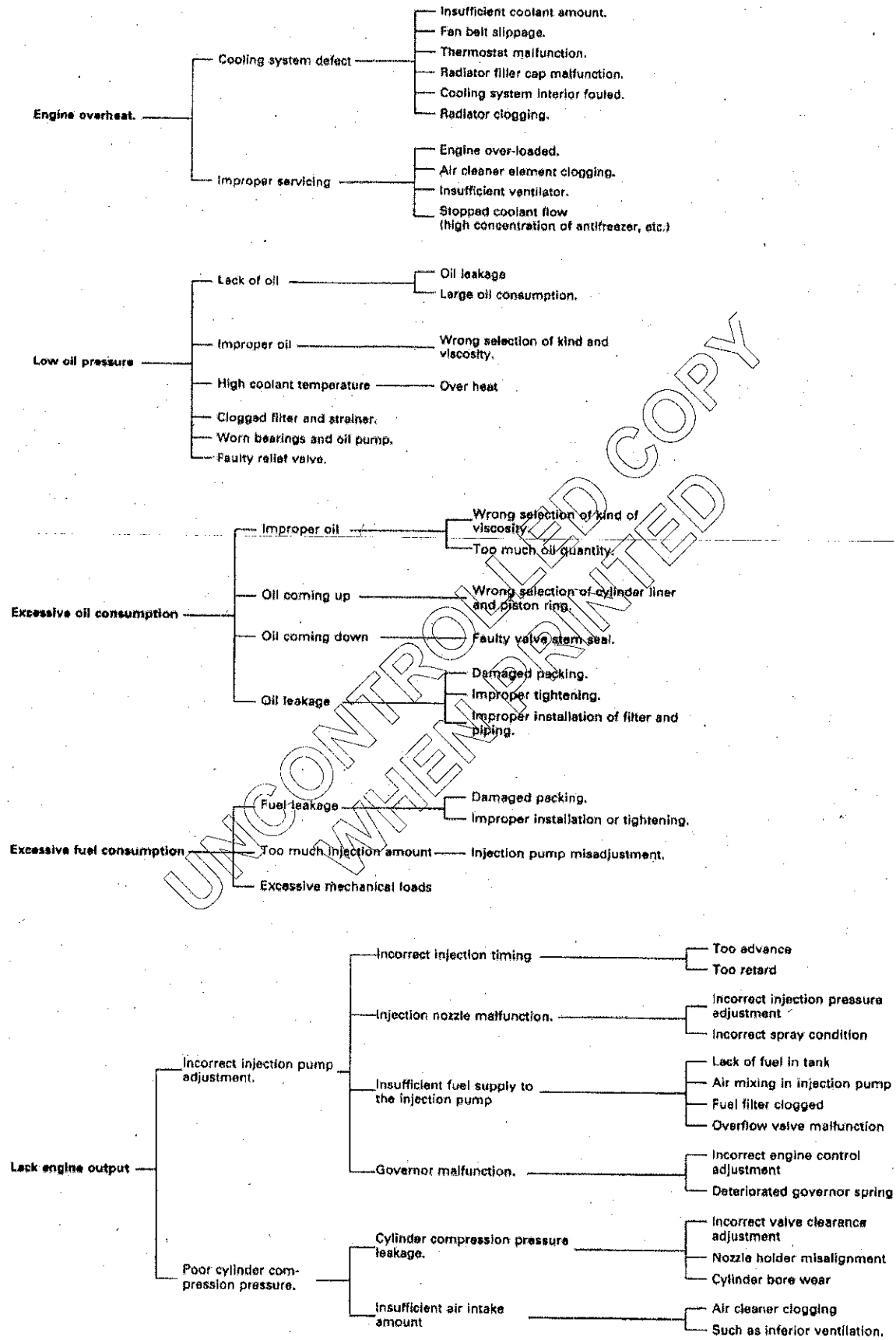
- |    |  |  |
|----|--|--|
| 18 | <b>Cooling system circuit cleaning</b>               | Clean the cooling system circuit every 1000 hours.   |
| 19 | <b>Radiator filling cap function check</b>           | Check radiator pressure cap periodically for proper operation according to the equipment manufacturer's specifications.  |
| 20 | <b>Electrolyte level check</b>                       | Replenish with distilled water if necessary.   |
| 21 | <b>Battery cleaning</b>                              | Clean the terminals.   |
| 22 | <b>Battery charge condition</b>                      | Ammeter registration goes to plus (+) side while engine running. In the lamp type, the lamp is off while the engine is running. Check charging circuit if the lamp is not off. |
| 23 | <b>Electrolyte gravity check</b>                     | Check according to the equipment manufacturer's specifications.  |
| 24 | <b>Starter and generator check and cleaning</b>      | Check wear condition of brush and commutator.  |
| 25 | <b>Wiring and connection check</b>                   | Check according to the equipment specifications.   |
| 26 | <b>Preheating condition check</b>                    | Check preheating condition of the system.  |
| 27 | <b>Air cleaner element replacement</b>               | Change element according to the manufacturer's specifications.   |
| 28 | <b>Engine starting condition and noise condition</b> | Check engine stability and noise.  |
| 29 | <b>Exhaust smoke condition</b>                       | Check exhaust smoke colour.  |
| 30 | <b>Cylinder compression pressure</b>                 | Check every 1000 hours.  |
| 31 | <b>Valve clearance check</b>                         | Incorrect valve clearance will result in increased engine noise and lower engine output. Thereby adversely affecting engine performance. Check and adjust every 1000 hours.    |
| 32 | <b>Positive crankcase ventilation valve cleaning</b> | Perform the adjustment, cleaning, repair or replacement every 1500 hours.  |

**SIMPLE ENGINE TROUBLESHOOTING**

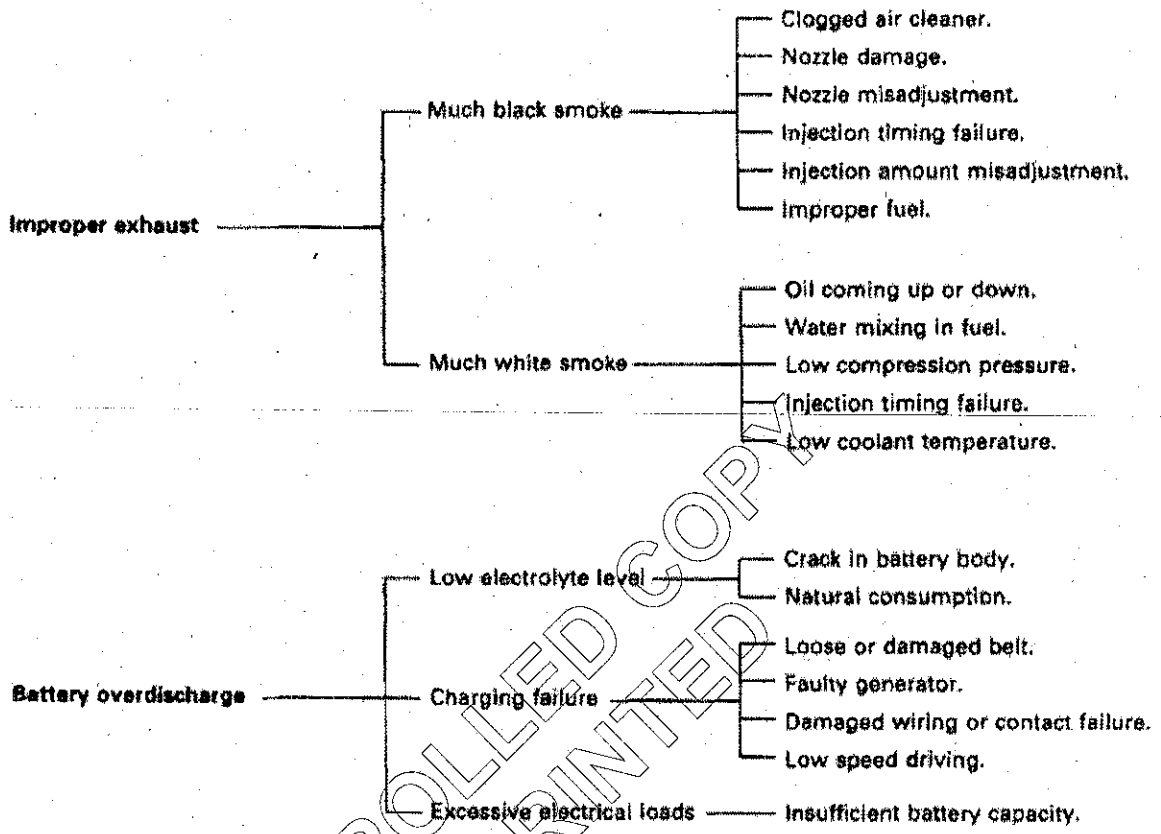
147 This section contains a simple guide to troubleshooting. When a failure takes place on your ISUZU engine, diagnose the cause referring to this troubleshooting guide. If the cause of failure cannot be detected or you are unable to manage the failure, consult your machine supply source or nearest ISUZU engine service outlet.



ISUZU INSTRUCTION MANUAL







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**INSTRUCTION MANUAL (INDUSTRIAL)**

**4LB1, 4LC1, 4LE1**

**IDE-6001**

**Issued by**

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