

GENSET USER MANUAL
For G Series (35 -250 kVA)

Reliable. Economical. Total Solution.



Diesel Generator Set
CPCB-II Compliant

SMS GENSET TO 56767
(For sales enquiries)

Toll Free No.: 1800 266 0670
(For service and support)

Greaves Cotton Limited
Auxiliary Power Business



Dear Customer,

Welcome to Greaves family.

The DG set you have purchased incorporates the latest in Diesel GENSET technology with all the elements viz. Engine, Generator, Controls and Canopy integrated in an optimal way. The outcome is a product engineered to deliver round the clock service of prime, stand-by, and continuous supply of electric powerhouse whenever you need it.

Needless to say, that the performance of the equipment is dependent on adherence to good practices of Installation, operation & maintenance. In order to facilitate this, we have included installation guidelines and O & M instructions in this user manual. We strongly recommend that the users need to thoroughly go through the contents of this manual & ensure that the guidelines & instructions are followed, so that you can enjoy many years of trouble-free performance from your DG set.

Please feel free to speak with any of our Regional offices or HO for additional information.

Once again we thank you for buying a Greaves Power DG set and will look forward to hearing your valuable feedback in near future.

With Best Wishes,

For Greaves Cotton limited

Auxiliary Power Business



Auxiliary Power Business

While asking for assistance to our Authorized Service Dealer, please provide the following information.

- Engine Serial Number
- GENSET Site Location
- Name of the Company
- Your Name, Detailed Address, and Phone / Mobile Number
- General Description of Assistance required

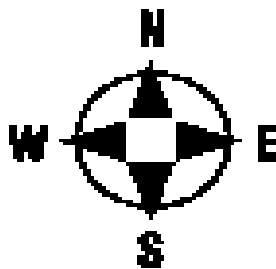
Greaves Toll Free No. 1800-266-0670

For Emergency Contact

AGM-Service, HO Greaves Cotton Limited,
Engine Business, Chinchwad, Pune-411 019
Phone: +91-20-67308260 Mobile: +91-9923201928

Regional Service Manager
Express Building Annexe, 9-10,
Bahadur Shah Zafar Marg,
New Delhi- 110 002
Mobile: +91-9810770502

Regional Manager
Engine Business,
Chinchwad, Pune-411 019
Phone: +91-9923201868



Regional Service Manager
Akash Tower, 5th Floor, 781,
Anandpur, Kolkata-700 107
Phone: +91-9836886517

Regional Service Manager
Lakshmi Chambers, No. 30,
Anna Salai Little Mount,
Saidapet, Chennai-600 015
Phone: +91-9176832884



GENSET Model and Sr. No:

.....

Engine Model and Sr. No:

.....

Alternator Sr. No. Make & Type:

.....

Control Panel Sr. No. Make & Type:

.....

First Service Check Details:

.....

Second Service Check Details:

.....

Service Dealer Stamp & Signature:

.....



Important Notice

1. This warranty is applicable for Greaves Power GENSET manufactured by Auxiliary Power Business division of Greaves Cotton Limited. Before commissioning of the said GENSET, please go through the contents of this section carefully.
2. For details of Greaves authorised service dealer for your GENSET, please contact either your supplier of GENSET or nearest Greaves area office.
3. For availing the warranty services, please ensure following:
 - a. Produce this warranty / user manual booklet to Greaves authorized service dealer, when requested.
 - b. Carry out first service check through Greaves authorized service dealer within 7 days of installation, followed by second service check within 500 Hrs. or 6 months from the date of first service check, whichever is earlier.
 - c. Use recommended grade or lube oil and ensure periodic change of lube oil, as recommended by the Greaves authorised service dealer.
 - d. Use genuine air filter elements, lube oil filter elements, fuel filter elements, coolant and additives, sourced from Greaves authorised service dealer.
 - e. Please maintain the log-book for the GENSET at your end. The suggested format for log-book is provided below along with all the service coupons.
 - f. Carry out repairs of GENSET only through Greaves authorised service dealer only.

The performance of GENSET depends on the quality and grade of lube oil and periodic or preventive maintenance. To ensure the originality of oil, Greaves has launched the lube oil branded as Greaves Maxtherm. Please use this lube oil and genuine filters sourced through Greaves authorised parts and service dealer and avail extended warranty.

Auxiliary Power Business



Please provide following details to our Authorised service dealer. It will help them for quick restoration of your GENSET.

GENSET Model and Serial No:
Engine Serial No.
Detailed Site Address
Contact Person Name & Telephone/ Mobile No.
No. of Hrs. ran till date
Nature of Failure



Revisions in User Manual #P21190060197

Revision No.	Modification Summary	Date
00	New Release	10-10-2014



Warranty Policy
Greaves Cotton Diesel GENSET

1. Warranty Policy (Diesel GENSET):

Greaves Cotton Ltd. warranty for the GENSET is limited to its defective materials/ components and/or workman-ship and is valid until a period of 30 months from the date of invoice OR a period of 24 months from the date of commissioning at site or completion of 5000 hours of operation, whichever event shall occur first provided the user of the GENSET uses recommended genuine spare parts including “Greaves Maxtherm“ Lube Oil & Coolant wherever applicable and use of genuine Air Filter element and Lube Oil Filter element purchased only from authorized dealers of Greaves Cotton Ltd.

The foregoing warranty is not applicable in the event of, if:

- a. The GENSET has been stored improperly and not protected from adverse weather conditions of any nature.
- b. The GENSET has not been installed strictly as per the recommendations of Greaves Cotton Ltd. and not operated in accordance with the instructions contained in this user manual.
- c. The defective/improper fuel, lubricants, coolants and any of their associated systems are utilized.
- d. Unauthorized person carries out repairs and alterations.
- e. The maintenance of the GENSET is not strictly done as per the procedure detailed in Greaves Cotton Ltd. operator’s handbook/instruction manual.
- f. Improper tools and equipment’s are utilized at any stage during erection, commissioning and maintenance.
- g. During operation, the GENSET is subjected to misuse, negligence, accident, or by-passing safety systems.
- h. Failure in any way results from use of components / parts not manufactured or not authorized by us for use on our GENSET.

2. Terms & Conditions for Warranty

- a. The components having shelf life like rubber components, belts, hoses and replacement filters / consumables which are normally maintenance spares are not covered within the scope of this warranty.
- b. In cases of complaints which are proprietary bought out items, our warranty is limited to the extent of warranty of the manufacturer to us.



- c. If the GENSET is improperly stored beyond period of six months without recommended long storage treatment and used without recommended de-preservation.
- d. All goods are supplied on the condition that under no circumstances we undertake liability for the indirect or consequential loss or damage of any nature.
- e. The warranty shall not apply to normal wear and tear of the individual components or damages due to the negligence or improper handling by the purchaser or his employees or agents or due to damage by any cause beyond our control.
- f. The warranty does not apply to defect arising due to default in periodic/ preventive maintenance and lapse in the use of recommended genuine spare parts including “Greaves Maxtherm” Lube Oil and Coolant wherever applicable and use of genuine Air Filter element and Lube Oil Filter element and also subject to adequate quantity of lubricating oil / coolant in respective circuits.
- g. Claim under warranty shall be summarily rejected if the defects are not notified within warranty period specified above and lodged within 3 days of the expiry of the warranty period.
- h. The new or repaired part(s) will be delivered free of Ex-works cost of Chinchwad/Chakan Pune. Any additional delivery cost to be borne by the purchaser / customer.
- i. In respect of any warranty claim accepted by us, we shall arrange to replace or repair relevant and respective parts free of cost to the customer. If parts are replaced, the defective part shall be property of Greaves Cotton Ltd. In any case, wherever the parts are supplied with free charges, Greaves Cotton Ltd. shall not be liable for any fitment and / or other charges.
- j. Greaves Cotton Ltd. shall not be responsible for replacement of the complete unit under any circumstances. In case of any warranty claim, the responsibility of Greaves Cotton Ltd. shall be limited to the extent of replacement or supply of defective parts.

3. Warranty Policy (Producer Gas, Bio Gas, and Compressed Natural Gas)

Greaves Cotton Ltd. warranty for the GENSET is limited to its faulty design, defective materials/ components and/or workman-ship and is valid until a period of 15 months from the date of dispatch of GENSET from its Works/Warehouse or 12 months from the



date of commissioning or completion of 3500 hours of operation, whichever event shall occur first provided the user of the GENSET uses recommended genuine spare parts including “Greaves Maxtherm “ Lube Oil & Coolant wherever applicable and use of genuine Air Filter element and Lube Oil Filter element purchased only from Authorized Dealers of Greaves Cotton Ltd. Our above warranty policy for engines / DG Sets operated on Producer Gas, Bio Gas, and CNG like gaseous fuel should have minimum of following characteristics.

Characteristics	Producer Gas	Bio Gas	CNG
Methane	≤ 1.5 %	≤ 65.0 %	> 85.0 %
H ₂ S Content	-	≤ 0.15 %	-
Moisture Content	1.0 %	≤ 1.0 %	-
Dust Content	≤ 0.5 %	≤ 0.5 %	-
Calorific Value	> 1200 kCal/m ³	> 5600 kCal/m ³	> 9600 kCal/m ³

- a. Our above warranty clause will not be applicable for the components coming under direct contact of gaseous fuel. Wear & tear of parts like Piston(s), Piston rings, Liners, Bearings & Bearing bushes since these components are prone to the reaction with undesirable gaseous contents.
- b. To establish the performance / load capacity of the engine/GENSET it will be the responsibility of the customers to produce the certificate of gas composition and calorific value from Government approved laboratory.
- c. In case of Dual-fuel application diesel replacement is guaranteed up to maximum of 70%.
- d. Maintenance intervals may be reviewed by Greaves Cotton Ltd. as per the actual composition of the gas at site which is to be followed by the customer.

For Auxiliary Power Business
Greaves Cotton Limited,
Chinchwad, Pune



LOG SHEET [Sample for Use]

The user is requested to maintain a separate log book registering the following mentioned parameters in the table. Following tables are meant for providing a reference to you.

Engine Model		HP Rating			RPM	
Date						
Daily use in Hours						
Hour Meter Reading						
Cooling Water Temperature (° C)						
Lube Oil	Pressure (Kg/cm3)					
	Temp (° C)					
Fuel added (Litres)						
Lube Oil added (Cubic Cms.)						
Engine (RPM)	No Load					
	Full Load					
Current (Amp) 3-phase						
Voltage (Volts)						
Frequency (Hz)						
PF & kW if provided						
kWH meter reading if provided						
Remarks - Record events of maintenance/repairs						



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	Temp (°C)					
Fuel added (Litres)						
Lube Oil added (Cubic Cms.)						
Engine (RPM)	No Load					
	Full Load					
Current (Amp) 3-phase						
Voltage (Volts)						
Frequency (Hz)						
PF & kW if provided						
kWH meter reading if provided						
Remarks - Record events of maintenance/repairs						



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Engine (RPM)	No Load					
	Full Load					
Current (Amp) 3-phase						
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PF & kW if provided						
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Lube Oil	Pressure (Kg/cm3)					
	Temp (° C)					
Fuel added (Litres)						
Lube Oil added (Cubic Cms.)						
Engine (RPM)	No Load					
	Full Load					
Current (Amp) 3-phase						
Voltage (Volts)						
Frequency (Hz)						
PF & kW if provided						
kWH meter reading if provided						
Remarks - Record events of maintenance/repairs						



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SECTION A

GENERAL



SECTION A - GENERAL			
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Chapter 1 Introduction

This manual after reading it thoroughly ensures the user that, user would be able use the GENSET efficiently and safely. The manual is an integral part of the GENSET and must be kept in the immediate vicinity of the same and accessible at any point of time for the user/personnel. The personnel must have carefully read and understood this manual before starting any associated work. The basic prerequisite for the safe working is compliance with all the safety and handling instructions stated in this manual. Furthermore, the local accident prevention regulations and general safety conditions for the application of the GENSET are also applicable. Illustrations in this manual are merely provided for basic understanding and can be different from the actual.

1.1 Explanation of the Symbols

This topic describes the various types of symbols that are used in this manual.

1.1.1 Safety Information

Safety information in this manual is identified using symbols. The safety information is introduced using signal words (shown in Table A1.1) which expresses the scale of the hazard. Always comply with the safety instructions and act cautiously in order to avoid accidents, injuries to persons and damage to property.




	<p>DANGER! Points out a <u>directly dangerous situation</u> which results in death or severe injuries if it is not avoided.</p>
	<p>WARNING! Points out a <u>potentially dangerous situation</u> which can result in death or severe injuries if it is not avoided.</p>
	<p>CAUTION! Points out a <u>potentially dangerous situation</u> which can result in minor/slight injuries or damage to property if it is not avoided.</p>

Table A1.1



1.1.2 Tips & Recommendations



Note! Highlights the useful tips, recommendations and information for efficient and trouble free operation.

1.2 Limitation on Liability

All information and instructions for use in this manual have been compiled meticulously taking into account the applicable standards & regulations, latest state of the art technology and our many years of expertise, knowledge and experience. However, the manufacturer accepts no liability for damage resulting due to:

- Non-Observance of the Instructions
- Improper usage of the product
- Use of Untrained Personnel
- Unauthorized Modifications
- Technical Changes
- Use of Non-Original Spare Parts

The actual scope of delivery/supply can be different from the explanations and illustrations stated herein, due to the latest technical changes. The agreed obligations in the supply contract, the general terms & conditions and the delivery conditions of the manufacturer and the applicable legal regulations in force at the time of the conclusion of the contract are applicable. We reserve the right to make technical modifications in order to improve usability.

1.3 Copyright

This manual is protected by copyright law and exclusively to be used for intended purpose. Passing this manual on to third parties, duplication of any kind even in the form of excerpts as well as the use and/or disclosure of the contents without the written consent of the manufacturer is not permitted, except for internal purposes. Violations oblige to compensation. The right for further claims remains reserved.

1.4 Warranty Terms

The warranty terms are provided in the manufacturer's terms and conditions.



1.5 Customer Service

Please refer to our website www.greavescotton.com or contact us on +91-20-67308260 or +91-9923201928 for a list of our sales and service partners. Also, we request you in sharing the new information and experience arising out of usage of the product, which can be valuable for the development of the same.



Chapter 2 Safety

This chapter provides an overview of all important safety aspects for optimal protection of personnel as well as safe and trouble-free operation of the GENSET. Disregarding this manual and safety regulations specified herein may result in considerable danger.

2.1 Customer's Responsibility

The GENSET system is used commercially. The owner of the GENSET is thus subjected to the legal obligations for health and safety at work. As well as the operational safety instructions laid out in this user manual, the applicable safety, accident prevention and environmental regulations for the application must also be complied with. The following particularly apply:

- a) The owner must educate himself/herself about the applicable health and safety conditions and also determine hazards arising out, from the special operating conditions at the site of location of the GENSET for risk analysis. He / She must implement this in the form of operating instructions for the operation of the GENSET.
- b) During the complete usage / running time of the GENSET, the owner must check whether the operating instructions created by him correspond with the current status of the regulations and must adapt those if necessary.
- c) The owner must clearly regulate and specify the responsibilities for installation, operation, maintenance and cleaning.
- d) The owner must ensure that all employees involved with the GENSET have read and understood the operating instructions. He /She must also train the personnel and inform them about the dangers at regular intervals.
- e) The owner must provide the necessary protective equipment / apparels for the personnel.
- f) The owner is also responsible for maintaining the GENSET in proper working condition. Therefore, he / she should strictly observe the following:
 - i. The owner must ensure that the maintenance intervals specified in this manual are complied with.
 - ii. The owner must arrange for all safety equipment to be checked regularly for functionality and completeness.
 - iii. The owner must ensure that antifreeze is filled for engines with radiators.
 - iv. Explosive and easily flammable substances must always be kept away from the engine as the engine can become very hot during operation.



- v. No one touch rotating parts while the GENSET is running.
- vi. Only fill with fuel when the GENSET is switched off. Do not fill in the vicinity of naked flames or ignitable sparks, do not smoke and do not spill any fuel.
- vii. This operator's manual must be kept in the immediate vicinity of the system and must be accessible at any time to all persons working on and with the system.
- viii. The system must only be operated if it is in proper working condition.
- ix. In the case of doubt, always contact the nearest Greaves Diesel service dealer before starting the GENSET.
- x. Only regular maintenance in accordance with the information in this operator's manual maintains the operational readiness of the GENSET.
- xi. Perform maintenance and cleaning work only when the GENSET is switched off.
- xii. Strictly observe all the information in the operator's manual.
- xiii. Observe all warning and information signs on the system and keep these in legible condition. If a warning or information sign should be lost or difficult to read, always request a replacement from the nearest Greaves authorised service dealer.

2.2 Personnel Requirements

The due consideration should be given to following statements while employing the operator.

- a) **Trained person** should be instructed by the owner about the tasks assigned to him/her and possible dangers in the case of improper behaviour.
- b) **Technical personnel** are persons who on the basis of their professional training given by Greaves, experience and knowledge of the relevant conditions can perform the work assigned to them using the operating and repair instructions and can recognize and avoid possible dangers themselves.
- c) Only persons who are expected to perform their tasks reliably are permitted as personnel.
- d) Persons whose reaction capability is impaired, for example, through drugs, alcohol or medication are not permitted.
- e) When selecting the personnel, the stipulations regarding age, qualification and employment history must be observed scrupulously.



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WARNING! Danger of injury for unqualified personnel! Improper handling can result in severe personal injury and/or material damage. Therefore ensure that all jobs concerned with GENSET are carried out by qualified personnel only.

2.3 Appropriate Use

The system is designed and constructed exclusively for the intended purpose described in this manual. Any other use is considered to be improper. Greaves Cotton Ltd. accepts no liability for any danger and damage resulting out of misuse. The risk would be solely borne by the user / owner of the GENSET. The installation must be made so that all applicable safety regulations for the operation of GENSET are complied with. Proper use also means compliance with all the information contained in this operator's manual. Any use beyond the intended use and/or other types of use is considered misuse and can result in dangerous situations.



WARNING! Danger due to misuse! Misuse can result in dangerous situations. Any types of claims for damage arising out of improper use are excluded. Refrain particularly from the following uses of the system:

- Operation of the GENSET while it is not in the installed condition.
- Operation of the GENSET without sufficient safety devices.
- Operation of the GENSET with non-approved fuels.

2.4 Personnel Protective Equipment

Wearing of personnel protective equipment is required when working to minimize the health hazards. Always wear the protective equipment that is necessary for the respective task when working. Follow the instructions on personal protective equipment that is posted in the work area. Also refer the Table A2.1 (a) & (b), which enlists the some of accessories / protective equipment's.



For General Operation / Use	
	Protective Clothing: It's a closely stitched apron with low resistance to tearing, narrow sleeves, and no protruding parts. It mainly provides the protection against being entangled by moving machine parts. Don't wear jewellery item.
	Safety Boots: To protect against heavy parts falling down on feet or probability of slipping on slippery ground.

Table A2.1 (a)








For Special Operation / Use	
	Ear Defenders: To protect the against hearing damage / impairment.
	Hard Hat: To protect head against parts and materials falling down and flying around.
	Gloves: To protect the hand against friction, graze punctures or deep cuts as well as contact with hot surfaces.
	Safety Goggles: To protect the eyes against parts flying around or squirts of fluids.


Table A2.1 (b)


2.5 Specific Dangers

The following lists the residual risks that have been determined by the risk assessment team. Notice the safety instructions listed here and the warnings in subsequent chapters of this manual, to reduce the possibility of health hazards and to avoid dangerous situations.

	<p>Warning! Rotating Parts: Risk of injury due to rotating parts.</p> <p>Rotating parts can cause severe damage / injury to your body. Therefore:</p> <ul style="list-style-type: none"> • Do not reach into or work on rotating parts during operation. • Do not open or remove covers / shields during operation. • Pay attention to the run-on time after switching off the GENSET. • Ensure that there are no parts still moving or the GENSET is not running before opening the covers. • Wear close-fitting clothing / apron while operating or servicing.
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	<p>Warning! Substances Harmful to Health: Danger of poisoning, skin rashes and allergies. Fuels, antifreeze and lubricants contain substances harmful to health and can result in severe poisoning and skin rashes or allergies. Therefore:</p> <ul style="list-style-type: none"> • Observe the safety data sheet of the manufacturer of fuels, antifreeze and lubricants. • Avoid spilling fuels and fog formation. • In the case of inhalation, bring affected person into the open air immediately and contact a doctor. • Contact doctor immediately in the case of swallowing but rinse mouth thoroughly with water as first aid treatment. • Avoid direct skin and eye contact. But, in the case of contact with the skin or eyes, rinse immediately with adequate amount of water. Then, contact a doctor to get the medication / advice. • Apply suitable skin protection cream before working on tanks, piping or supply equipment. • Wear protective gloves made of plastic or rubber during the work. • Follow proper disposal of contamination in accordance with environmental regulations. Fuels, antifreeze and lubricants must not get into the sewer system. • Do not eat, drink or smoke when working in the vicinity of GENSET.
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	<p>Warning! Highly Flammable Substances: Fire hazard due to presence of highly flammable substances. Highly flammable substances include liquids or gases which may catch fire causing serious and even fatal injuries. Therefore:</p> <ul style="list-style-type: none"> • Do not smoke within the danger zone and the immediate vicinity. Avoid using open flames or ignition sources. • Keep a fire extinguisher ready all the time. • Report suspicious materials, liquids or gases immediately to the person in charge. • Suspend any work activities in case of fire. • Leave the danger zone until the all clear signal is given by authorized means.
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Warning! Hot Operating Parts: Risk of burn involved due to hot operating parts. Operating parts can reach high temperatures during operations and can cause burns in case of contacts. Therefore:

- Check whether operating parts are hot before handling them.
- If necessary let them cool down to ambient temperature.



Caution! Hot Surfaces of GENSET Components/Parts: Contact with hot surfaces can cause burns. Therefore:

- Always wear protective clothing and protective gloves for all work in the vicinity of hot parts.
- Ensure that all parts have cooled down to the ambient temperature before operating GENSET.



Warning! Antifreeze: Danger of poisoning, skin rashes, and allergies. Antifreeze contains substances harmful to health and can result in severe poisoning and skin rashes or allergies. Therefore:

- Observe the safety data sheet of the antifreeze manufacturer.
- Wear rubber gloves when handling antifreeze.
- Never mix different types of antifreeze.
- Contact a doctor immediately in the case of swallowing. Rinse mouth thoroughly with water.
- Avoid direct contact of antifreeze with bare skin and eye.
- Wear protective gloves made of plastic or rubber during the work.
- Collect drained coolant from the engine in a suitable container and dispose of in accordance with the environmental regulations.



Warning! Risk of injury due to non-functional safety devices: Safety is only ensured if the safety devices are intact. Therefore:

- Check whether the safety devices are functional and correctly installed before starting work.
- Never deactivate safety devices.



2.6 Behaviour in Case of Emergency & Accidents


2.6.1 Preventive Measures

- a) Always be prepared with necessary equipment's for facing the unforeseen circumstances like fire hazard and/or accidents.
- b) Keep first aid equipment {first aid kit, blankets etc.) and fire extinguishers ready at designated places.
- c) Familiarize personnel with accident reporting, first aid and rescue equipment by conducting the drill periodically.
- d) Keep access routes clear for rescue vehicles.

2.6.2 Actions in the Case of Accident

- a) Operate the EMERGENCY STOP button on the GENSET immediately.
- b) Initiate first aid actions.
- c) Rescue people from the danger zone.
- d) Inform the responsible person at the usage location.
- e) Notify the rescue services.
- f) Keep access routes clear for rescue vehicles.

2.7 Environmental Protection

	<p>Caution! Danger to the environment due to mishandling: Significant environmental damage can occur, particularly for incorrect disposal, if environmentally hazardous operating materials are mishandled. Therefore:</p> <ul style="list-style-type: none">• Always follow the recommended instructions.• Take immediate action if environmentally hazardous materials reach the environment.• Inform the responsible local government authorities about the damage caused to the environment in the case of doubt / ambiguity.
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The following environmentally hazardous substances are used in GENSET: Lubricant, Coolant, Antifreeze, and Diesel contain toxic substances. They must not reach the environment. The disposal of the same must be performed by a specialist disposal company.

SECTION B

GENSET





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Chapter 1 General Description of GENSET

Your new Greaves Power GENSET is a high performance and low maintenance product. It is ruggedly designed so as to minimize breakdowns and interruption in the supply of power to your applications. The GENSET consists of an Engine closely coupled with an Alternator along with a Control Panel, all housed within a Canopy. The Canopy is an acoustic enclosure that attenuates the GENSET sound within ARAI norms.

The engine is Greaves Make G series, water-cooled, four-stroke, and multi-cylinder incorporated with direct injection compression ignition. In addition to these features, the engine designers have paid special attention to ease of maintenance, ease of assembly and dis-assembly, reliability and standardization.

The alternator is of Crompton Greaves / Stamford make, with state-of-the-art self-excited, self-regulated and brushless design. Automatic Voltage Regulator (AVR) gives excellent voltage regulation along with under speed and over excitation protections.

The Control Panel could be of Deep Sea make, PROCOM make, or DATAKOM make which is fitted with an Electronic Controller for display and protections.

1.1 Name Plate Details

Sl. No.	Part Name	Part No.	Part Description	Part No.	Part Description	Part No.	Part Description	Part No.	Part Description	Part No.	Part Description
1	Engine	1000000000	1000000000	1000000000	1000000000	1000000000	1000000000	1000000000	1000000000	1000000000	1000000000
2	Alternator	1000000000	1000000000	1000000000	1000000000	1000000000	1000000000	1000000000	1000000000	1000000000	1000000000
3	Control Panel	1000000000	1000000000	1000000000	1000000000	1000000000	1000000000	1000000000	1000000000	1000000000	1000000000
4	Canopy	1000000000	1000000000	1000000000	1000000000	1000000000	1000000000	1000000000	1000000000	1000000000	1000000000
5	AVR	1000000000	1000000000	1000000000	1000000000	1000000000	1000000000	1000000000	1000000000	1000000000	1000000000
6	AVR	1000000000	1000000000	1000000000	1000000000	1000000000	1000000000	1000000000	1000000000	1000000000	1000000000
7	AVR	1000000000	1000000000	1000000000	1000000000	1000000000	1000000000	1000000000	1000000000	1000000000	1000000000
8	AVR	1000000000	1000000000	1000000000	1000000000	1000000000	1000000000	1000000000	1000000000	1000000000	1000000000
9	AVR	1000000000	1000000000	1000000000	1000000000	1000000000	1000000000	1000000000	1000000000	1000000000	1000000000
10	AVR	1000000000	1000000000	1000000000	1000000000	1000000000	1000000000	1000000000	1000000000	1000000000	1000000000

Fig. B1.1 IVR Component Detail



Fig. B1.2 Name Plate Photograph Image

1	Set Type	5	Panel Type
	A: RTU		A: SRCP
	B: Base Engine		B: AMF
	C: Canopied		C: SUNC
2	kVA Rating		D: KERALA
	045: 45 kVA		E: INS Panel
	040: 40 kVA	6	Phase
	250: 250 kVA		1: Single Phase
3	Alternator Make		3: Three Phase
	C: Crompton Greaves Limited	7	Controller
	S: Stamford		D: Deep Sea
	L: LEROY SOMER		K: DATAKOM
	M: MECCALTE		E: EMS
4	Engine Make		P: PROCOM
	1: Greaves	8	Year of Manufacturing
	2: Escorts		14: 2014
		9	Month of Manufacturing
			A: January
			B: February
			C: March
		10	Serial No.
			0001

Table B1.1 GENSET Nomenclatures



1.2 GENSET Rating Matrix

No.	GENSET Model	GENSET Rating	Engine Model	GENSET Dim. L x W x H	Open Set Dim.
1	GPWII-35	35 kVA	3G11TAG23	2400 x 1150 x 1550	-
2	GPWII-40	40kVA	3G11TAG23	2400 x 1150 x 1550	-
3	GPWII-45	45kVA	3G11TAG23	2400 x 1150 x 1550	-
5	GPWII-50	50kVA	4G11TAG22	2400 x 1150 x 1550	-
4	GPWII-62.5	62.5kVA	4G11TAG22	2400 x 1150 x 1550	-
5	GPWII-75	75kVA	4G11TAG22	2400 x 1150 x 1550	-
6	GPWII-80	80kVA	4G11TAG22	2400 x 1150 x 1550	-
7	GPWII-82.5	82.5kVA	4G11TAG23	2400 x 1150 x 1550	-
8	GPWII-100	100kVA	4G11TAG23	2400 x 1150 x 1550	-
9	GPWII-125	125kVA	4G11TAG24	2400 x 1150 x 1550	-
10	GPWII-160	160kVA	6G11TAG24	2400 x 1150 x 1550	-
11	GPWII-180	180kVA	6G11TAG24	2400 x 1150 x 1550	-
12	GPWII-200	200kVA	6G11TAG24	2400 x 1150 x 1550	-
13	GPWII-250	250kVA	6G11TAG25	2400 x 1150 x 1550	-

Table B1.2 GENSET Rating Matrix

1.3 Brief Description of the GENSET Package

The GENSET package includes an engine, alternator, exhaust system, cooling system and a control system. The GENSET consists of an Engine closely coupled with an Alternator along with a Control Panel, all housed inside a canopy. The engine is Greaves make G11 series, water-cooled, four-stroke, multi-cylinder and direct injection compression ignition. In addition to the performance parameters, the engine designers have paid special attention to ease of maintenance, ease of assembly and dis-assembly, reliability and standardization. The alternator is either Crompton Greaves make or Stamford make, with state-of-the-art self-excited, self-regulated and brushless design. The Control Panel is fitted with an Electronic Controller for display and protections.

1.3.1 Engine

The engine incorporated in the GENSET is of proven reliability and specifically designed to operate in conjunction with an alternator. The engine is of heavy-duty, industrial type 4-stroke compression ignition and fitted with all necessary accessories.

1.3.1.1 Engine Governor

The primary function of the governor system is to maintain the engine speed in relation to varied load requirements. The governor senses the engine speed and controls the engine fuel rate in order to maintain practically constant speed. As the alternator load increases, the engine speed tends to reduce. The governor maintains engine speed within limits regardless of the load on the alternator. To maintain this constant speed the governor increases fuel flow to the engine. This adjusts the horse power to a point sufficient to maintain the engine speed and compensate for the load change. Same principal is applied when the load decreases. As the load is reduced the speed would increase, the governor will then reduce fuel delivery thus decreasing the horse power to maintain the constant speed.

1.3.1.2 Engine Silencer & Exhaust System

The Exhaust Silencer is provided to reduce noise emission from the engine and designed to direct exhaust gases to areas where they will not be objectionable. The silencer is of residential type fitted in the canopy with flange fitting at the outlet to enable discharge of exhaust gases at desired location, through extension piping, as required.



Fig. B1.3 Exhaust Piping Arrangement



1.3.1.3 Engine Cooling System

The engine cooling system is offered in two ways, v.i.z. Radiator Cooled and Heat Exchanger. The details of the same are as mentioned below.

(a) Radiator Cooled

The engine cooling system comprises of a radiator, a high capacity pusher/sucker fan and thermostat. The engine-alternator is close coupled and the assembly is arranged such that the alternator is the first component to come into contact with the cool air as it passes over the GENSET. As the air flow passes over the engine, the fan pushes it through the radiator. This method of cooling allows the alternator fan to pull a portion of the cooling air through the alternator. Both the engine and alternator are therefore kept at their proper operating temperature. Fig. B1.4 below shows the radiator cooling system arrangement.



Fig. B1.4 Radiator Cooling System

(b) Heat Exchanger

The engine cooling system comprises of heat exchanger, and a thermostat. Fig. B1.5 below shows the heat exchanger cooling system arrangement.



Fig. B1.5 Heat Exchanger Cooling System

1.3.2 Alternator

The alternator used is of self-excited, self-regulated, brushless design. The alternator is provided with an Automatic Voltage Regulator (AVR) that gives excellent voltage regulation and also protects the alternator from under speed and over excitation. On most alternators, current is supplied through twelve leads connections, enabling the operator to reconnect the GENSET to obtain a three phase voltages up to 480 V. On reconnection, you can also get a single phase voltages from 120 V to 240 V.

1.3.3 Fuel Tank & Base Frame

The design of the base frame incorporates a removable fuel tank with a capacity of approximately 8 hours operation. The base frame is manufactured from heavy gauge sheet steel and welded to form a rigid assembly.

1.3.4 Vibration Isolator

The GENSET is fitted with vibration isolators in the form of anti-vibration mountings that are designed to reduce the vibration being transmitted from the rotating mass of the GENSET to the foundation on which the GENSET is mounted. The anti-vibration mountings selected to suit the particular duty and are fitted between with the engine, alternator feet and the base frame.



1.3.5 Control Panel

The Control Panel is mounted inside the canopy. The canopy is provided with toughened glass cover opening for viewing the controls on the Control Panel. The Control Panel is fitted with an Electronic Controller and suitable switchgear and controls to operate and control the GENSET.



Chapter 2 Installation of G Series GENSET

This chapter lays down the procedure of installing your G Series GENSET. You are requested to follow these guidelines for safe operations and reliable performance.

2.1 Location

Selecting a location for the GENSET is very important part of installation procedure. Always locate the GENSET in an area that will provide adequate ventilation and physical protection for the unit. For the purpose of simplifying maintenance and inspection requirements it will also be important to place the GENSET in such a position so as to allow easy movement around it without overcrowding. Generally, 1.5 to 2.0 meters space all around the GENSET should be ensured. The location should be clean, dry and have good drainage capabilities. Should the location be outdoors, protect the GENSET with a weatherproof enclosure i.e. Canopy (available as an optional retrofit item).

Another point to keep in mind is the space required to undertake major overhaul or service operations. In some cases doors must be sized to allow for access in and out for the complete GENSET and major accessories. Air inlet and outlet vents can often be made removable to provide an access. For acoustic enclosures ensure that the openings provided for fresh air inlet and outlet are not blocked.

2.2 Foundation

The foundation should be made of cement concrete block. Following are the recommended details of the concrete block:

- If the soil is loose, then soling should be done before making the concrete block.
- The depth of the concrete block should be 600 mm with 100 mm above the floor level.
- The concrete block should be extended by at least one meter on all sides. For GENSET dimensions, refer GENSET Ratings Matrix.
- Surface of concrete block should be in one water level

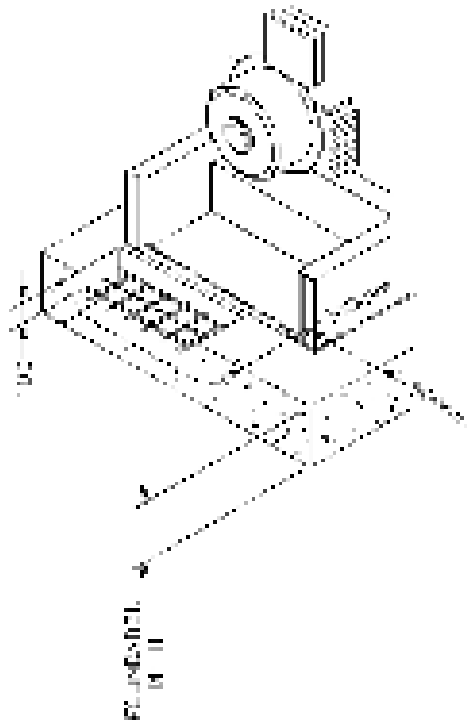


Fig. B2.1 Typical Foundation Detail of GENSET

2.2.1 Isolation

It is advisable that the principal foundation of each GENSET rests on bedrock or solid earth completely independent of other foundations, cement work, walls or operating platforms.

2.2.2 Vibration

The design of the GENSET is such that only minimal vibration is transmitted to the foundation. Anti-vibration mounts are fitted between engine, alternator and base frame or in larger capacity GENSET vibration isolators are mounted below the base frame. If generator rooms are situated on upper floors special attention to vibration isolation is necessary. Often spring type vibration isolators will be needed. It is necessary to ensure that building structures are capable of supporting the GENSET, fuel storage and accessories.

2.2.3 Grounding (Indian Electricity Rules)

Grounding should be done in accordance with applicable National, Local Code or Regulation.

2.2.4 Air Inlet

Engine inlet air must be clean and as cool as possible. These conditions will drastically affect both engine life and performance. Normally the inlet can be taken from the area surrounding the installation site. However, in some cases the condition of the air surrounding the GENSET may permit ducting the air from outside or another room. When it does become necessary to duct air in, the air filter should remain mounted to the engine as opposed to a remote mounting (such as on a roof or in another room). This will eliminate the possibility of dirt leaking through the duct work upstream of the air filter.

2.3 Cooling & Ventilation

It is recommended that the GENSET should be installed in open air. However, if it is installed inside a room, special attention should be paid towards its ventilation. Following figure B2.2 shows the air flow over of the GENSET.

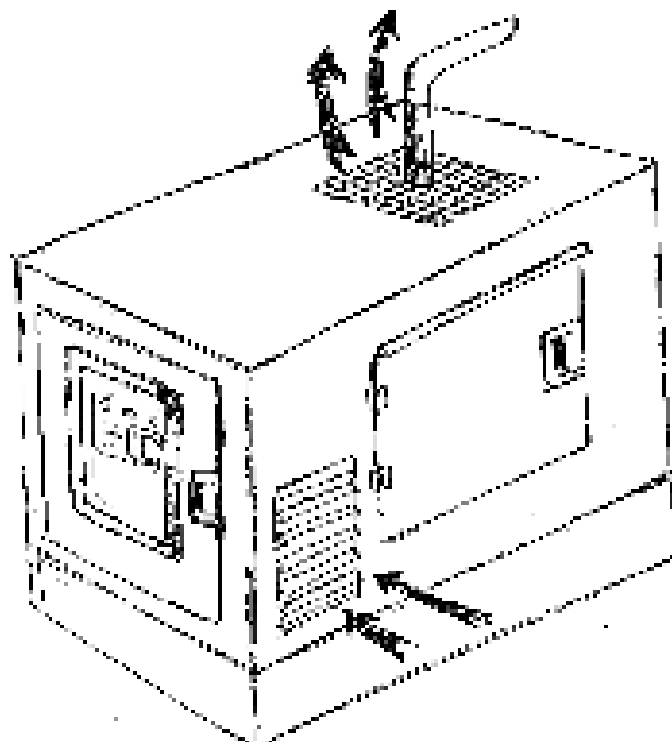


Fig. B2.2 Typical Air Flow over the GENSET

Windows must be provided in line on either side walls one for hot air to go out of the room and the other for letting in the atmospheric air without any restriction between window & canopy. Recommended window size = 1.5 X Frontal area of air passage of the canopy. Fig. B2.3 shows typical exhaust fan arrangement.

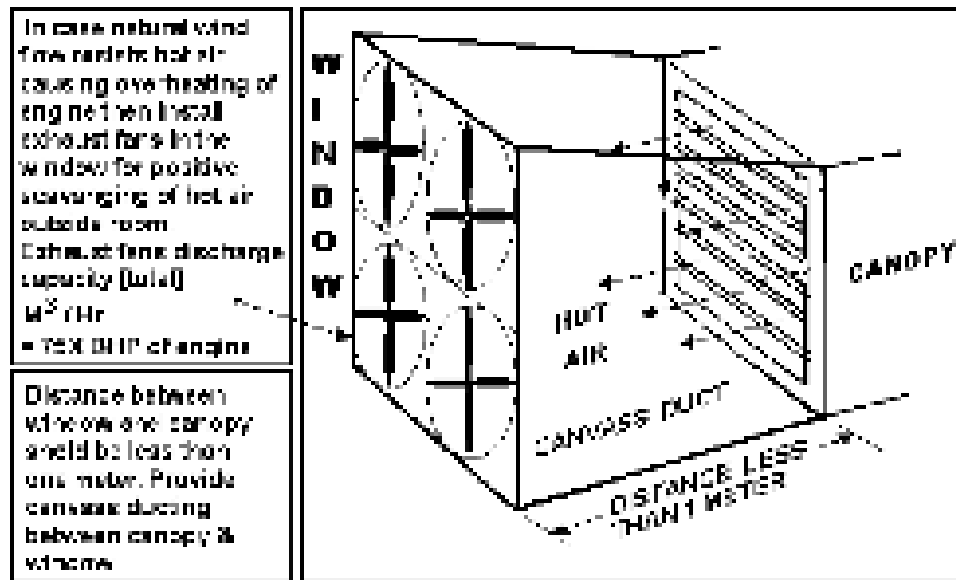


Fig. B2.3 Typical Exhaust Fan Arrangement

2.4 Exhaust Piping Arrangement

The exhaust system is used to direct exhaust gases to non-confined areas and reduce the noise to tolerable levels. When designing a system the main objective is to minimize back pressure. Excessive back pressure in an exhaust system will create horsepower loss and increase the engine operating temperature, and emissions. The installation of exhaust piping is usually required when the GENSET is placed inside a room. This is to direct the exhaust gases out of the room. Thereby, ensure that all the pipes are well supported and that springs or other dampers are used at points of high vibration. Due to the heat radiation of the exhaust pipes, it is recommended that all the pipes be located at least 250 mm from any combustible material. Wrapping the exhaust pipes with high temperature insulator or installing fitted insulated sections will aid in preventing excessive heat radiation within the room. Following are the recommendations for exhaust piping installation:

- i. Piping should have minimum bends and the bends should be smooth.
- ii. Silencer and exhaust piping should be insulated by asbestos rope to reduce radiated heat.
- iii. Inner diameter of the exhaust pipe should be the same as that of engine exhaust outlet for the first 5 meters length of pipe with one smooth bend. Smooth bend means bend which has radius equal to 2.5 times diameter of the pipe.
- iv. When length of pipe is more, calculate the exhaust pipe ID by following method.
 - a. Before actually doing installation of exhaust piping, decide how it should be routed and number of bends required?

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- b. Always use smooth bends and keep number of bends to minimum.
- c. Below table shows equivalent length of pipe for each type of bend. For example, one sharp bend gives a back pressure equal to back pressure caused by 10 meter straight pipe.
- d. After noting number of bends and type of bends involved calculate total equivalent length. As the equivalent length increases, increase Inner Diameter of exhaust pipe as mentioned below:

For first 5 Meters	Keep same diameter available on engine exhaust outlet [Nominal size]
From 5 to 15 meters	Increase Inner Diameter by 20%. [ID. (minimum) = 1.2 X Nominal size]
From 15 to 25 meters	Increase Inner Diameter by 40% [ID. (minimum) = 1.4 X Nominal size]

Table B2.1



CAUTION! Total exhaust system assessment should be done by competent personnel. If planned exhaust piping length is crossing 50 meters, then we recommend the use of soot arrestor blower.

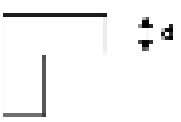
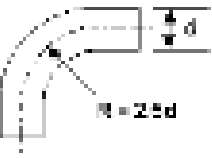

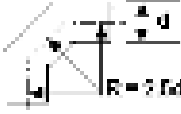

Sr No	Type of bend	Equivalent length
1	Sharp bend 	10 Meters
2	Smooth bend 	1 Meter
3	Semi smooth bend 	6 Meters
4	Semi smooth fabricated bend 	4 Meters
5	Straight pipe 	Actual length

Fig. B2.4

2.4.1 Location of Silencer

Always install the silencer near the engine, recommended within the first 5 meters, inside or outside the canopy. By doing so, you will be able to minimize the noise in the exhaust piping.

2.4.2 Support to Exhaust Piping

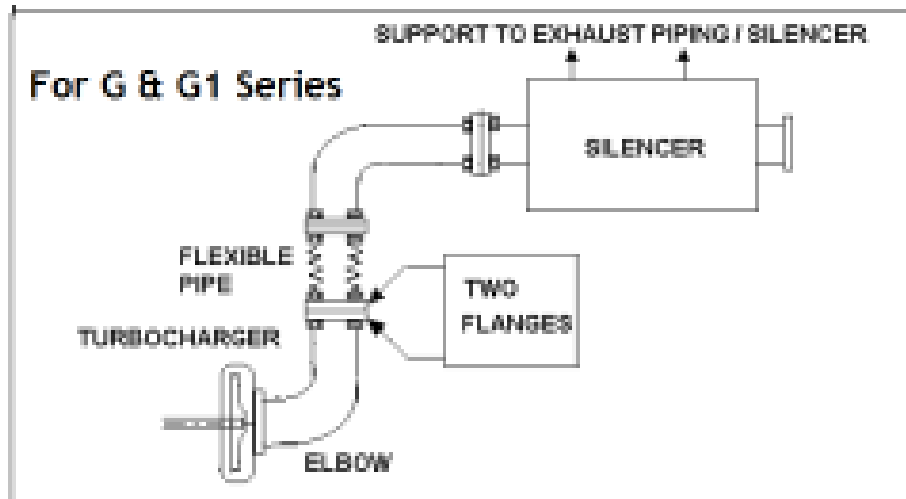


Fig. B2.5

As shown in the above figure B2.5, put bolts in the holes of two flanges above, with gasket in between. Engage two threads of nuts, but do not tighten them. See that alignment of piping is proper. Give support to exhaust piping / silencer such that there is about 5 mm gap between the two flanges. Tighten the nuts. Flexible pipe will get elongated and make a perfect joint. This ensures that the load of exhaust piping does not come on the turbocharger.

2.4.3 Protection of Tail End of Exhaust Pipe

When tail end is horizontal, a 45° downward cut should be given at the end of the pipe. When the tail end is vertical, a rain cap should be provided. Coarse wire mesh at the end of the pipe should be provided otherwise birds can build nest. Refer Fig. B2.6

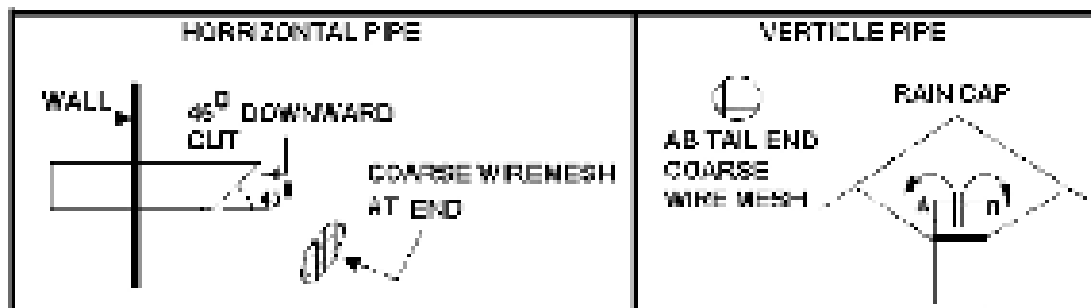


Fig. B2.6

2.4.4 Flexible Connections

The exhaust piping should be connected via a flexible joint located on the engine exhaust outlet. This connection serves the following three purposes.

- i. It relieves some of the weight of the exhaust piping from the engine.
- ii. It isolates the exhaust system from vibration.
- iii. It allows for some movement of either the GENSET or exhaust system components.

Long piping runs should be divided into sections separated by additional flexible connections. This will also compensate for the expansion and contraction of the piping itself due to temperature change. Any insulation material used for a flexible connection should allow for the expansion and contraction of the connections, due to temperature changes. Generating sets with acoustic enclosure are provided with exhaust outlets having connecting flanges. Exhaust gases from the outlet can be routed away to desired location. For up to 3 meter distance exhaust pipe size same as provided on the outlet can be used. For longer lengths total exhaust system assessment should be done by competent personnel. In no case, exhaust back pressure should exceed 50 mm of Hg, when measured at exhaust manifold of engine, at rated load.

2.5 Fuel System

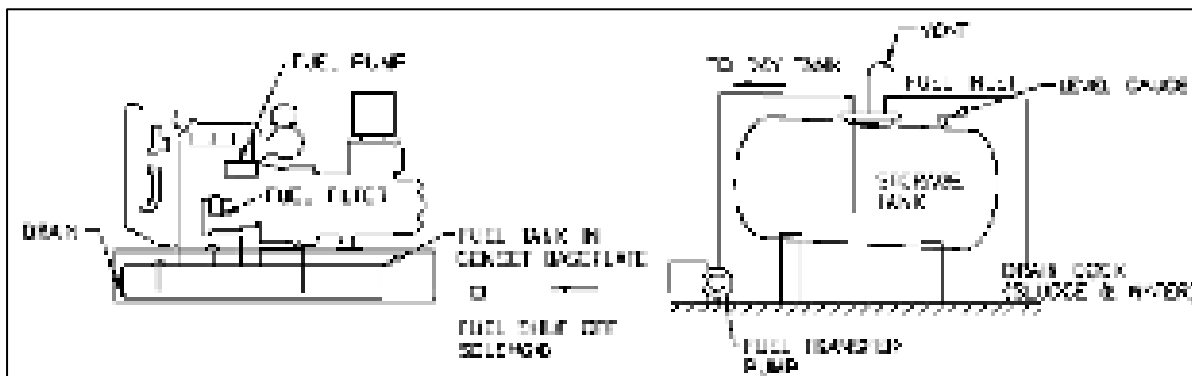


Fig. B2.6 Typical Fuel Installation

The fuel system must be capable of delivering to the engine a clean and continuous supply of fuel. When designing a fuel system, always incorporate the requirements of Local, State, or National Codes, which may pertain to either the fuel system or the electrical apparatus utilized by the system.

2.5.1 Diesel Fuel Bulk Storage

Bulk fuel storage is the most preferable method of providing fuel supply. This method allows bulk fuel purchases which will minimize dirt and contamination possibilities, especially when



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the fuel is seldom used. The bulk storage tank may be located either above or below the ground. A vent must be installed on the main tank to relieve the air pressure created by filling the tank as well as preventing a vacuum within tank as fuel is consumed. The tank bottom should be rounded and placed on a 2 degree tilt to assure a concentrated settling of both water and sediments. At the low point of the tank a drain valve should be installed to remove water that may accumulate due to condensation. Underground tanks must be pumped periodically to remove this water. This is best done by placing a tube through the filter pipe to the low end of the tank. For these reasons it is imperative that the tank be placed in or on stable ground to assure that eventual settling does not change the location of the low point of the tank. Burying the tank below the frost line will help in avoiding seasonal settling. Another consideration to be made when locating the main tank is the height difference between it and the auxiliary tank (day tank). The maximum vertical lift capability of a standard electric motor driven fuel transfer pump is 5m. Do not place either tank at a level that would exceed the pump lift capabilities. Also keep in mind the possibilities of pressure drop created by excessive horizontal distances and pipe work bends.

The fuel delivery line carrying fuel to the engine and the fuel return line for carrying excessive fuel back to the tank should be no smaller than the fitting sizes on the engine. For longer runs or extremely low ambient temperatures increase the size of these lines to ensure adequate flow. The fuel lines can be made of any fuel compatible material such as steel pipe or fuel line tube that will tolerate ambient conditions. Overflow piping should be of the same material and one size larger. The fuel return line should enter the tank at the top and contain no shut-off valve. This line should be designed with a minimum amount of bends or dips to prevent an air lock in the system. The fuel delivery line should pick up the fuel from the point no lower than 20mm from the bottom of the tank. If at all possible locate this line at the end of the tank opposite to that of the return line and at the high end of the tank. Flexible fuel lines should be used at a point between the tank and engine (preferably adjacent to the GENSET) to avoid the potential damage that could be created by vibration.

2.5.2 Day Tanks

Auxiliary tanks or day tanks as they are commonly referred to are recommended. Refer figure B2.6 for typical fuel tank installation. All standard GENSETS with acoustic enclosure are provided with tank fitted in the base frame. This day tank will produce a ready fuel supply.



2.5.2 Filter & Traps

Clean fuel will aid in attaining maximum engine life and dependability. Primary filters are recommended for use between the engine filters and the transfer pump. Water and sediment traps should also be included upstream of the transfer pump. However, on border line pump installations do not increase fuel line restrictions to a point exceeding the capabilities of the pump.

2.6 Fire Precautions

When performing a GENSET installation the following points should be noted:

- i. The room should be designed so that there is an easy escape route for operating personnel in the event of fire within the room.
- ii. A recommended type of fire extinguisher or fire extinguishing system should be provided.
- iii. Gravity operated fire valves operated by fusible links, mounted above the engine, can be installed in the fuel lines.
- iv. The room should be kept clean and free from accumulated rubbish things which can be a fire hazard.

2.7 Starter Batteries

Resistance in the starting circuit has a significant effect on the starting ability of the engine. Therefore, the batteries should be located as close as possible to the GENSET (batteries should be accessible for servicing). Maintenance procedures should be carried out rigorously since the batteries have to be in perfect condition to start the diesel engine.



Warning! Batteries emit highly inflammable gases. Do not smoke or create sparks or naked flames adjacent to batteries.

2.8 Electrical Connections

Only fully qualified and experienced electrical technicians should be allowed to carry out electrical installation work. The electrical connection to the GENSET should be made with flexible cable to prevent the transmission of vibration and possible damage to the alternator or circuit breaker terminals. If it is not convenient to use flexible cable throughout then a link box can be installed close to the set with a flexible connection between it and the set.



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The cable may be laid in a duct or on cable tray. When bending cable, reference must be made to the recommended minimum bending radius. No rigid connection should be made between the set and the cable support system, e.g. cable tray. When single core cables are used the gland plates must be of non-ferrous material, e.g. aluminium, brass or a non-metallic material such as Teflon. The cable must be suitable for the voltage being used and adequately sized to carry the rated current with allowances made for ambient temperature, method of installation, proximity of other cables, etc. All electrical work should be carried out in accordance with any applicable National, Local Standards, Codes or Regulations. All connections should be carefully checked for integrity. Phase rotation must be checked for compatibility with the installation. This is vitally important when connection is made to an auto transfer switch, or if the machine is to be paralleled.

2.8.1 Protection

The cables connecting the GENSET with the distribution system should be protected by means of a circuit breaker, fuses or other means to disconnect the GENSET in case of overload or short circuit.

2.8.2 Loading

When planning your distribution system it is important to ensure that, a balanced load is presented to your GENSET. If loading on one phase is excessive in comparison to the other two phases it will cause overheating in the alternator windings, imbalance in the phase to phase voltage output and possible damage to sensitive 3 phase equipment connected to the system. Ensure that no phase current exceeds that of the current rating of the GENSET. It may be necessary to reorganize the electrical distribution system if a GENSET is to be connected to an existing installation.

2.8.2.1 Linear Loads

Linear Loads can be identified from the following characteristics:

- i. Load impedance is always constant regardless of the applied voltage.
- ii. The load current increases proportionately as the voltage increases and decreases as the voltage decreases.

Examples of linear loads are motor, incandescent lighting and heating loads.



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2.8.3 Power Factor

The power factor (COS Φ) of the connected load should be determined. Power factor below 0.8 will overload the generator. The GENSET will provide its kilowatt rating and will operate satisfactorily from 0.8 to unity power factor. Particular attention must be given to installation with automatic or manual power factor correction equipment to ensure that a leading power factor is not present under any conditions. This will lead to voltage instability on the generator output and may result in damaging over voltages.

2.8.4 Grounding Requirements

Regulations vary and advice should be sought from the local power supply body. The factory connects the frame of the alternator to the frame of the GENSET therefore the complete mass of the GENSET is at the same potential. The connection if required of the generator winding star point / neutral to earth is the responsibility of the installation technicians.



Warning! Never attempt to work on live wiring. Always stop the GENSET and open the circuit breaker on the load cables before working on the alternator or its connectors.

2.8.5 Start-up

Before attempting to start the GENSET refer Topic 2.4 of this Section.

2.9 Noise Control

Your GENSET can be supplied with accessories and components to reduce noise emissions. Typically available noise controllers are residential and super critical silencers, acoustic louvers and splitter vents, fan silencers and acoustically treated enclosures. The requirements for each site vary enormously and for any critical installation we recommend you consult your dealer at an early stage. The information needed to select acoustic equipment is:

- i. The model and capacity of the GENSET
- ii. The location and overall site plan
- iii. The designed noise level at a fixed distance, normally 1m or 7m
- iv. Environmental conditions, ambient temperature, etc.



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Noise emissions from diesel GENSET (without acoustic treatment) are at sound pressure levels of between 100 dB (A) and 110 dB (A) at 1m. Greaves GENSET with acoustic enclosures have a typical noise pressure level of 75 dB (A) or less (average) at a distance of 1 meter from the enclosure. Intermediate levels of treatment will prove more economic and are often satisfactory depending only on the nature and type of installation. Hospital Care Areas will require more attention than the normal commercial / industrial installation.



Chapter 3 Maintenance

3.1 General

The periodical maintenance is the key to long GENSET life. Below is a schedule that should keep your GENSET in top running condition. Also included in this schedule are routine maintenance operations required for the engine and alternator (see Engine Maintenance and Alternator Maintenance Sections).

It is good practice to have all of the maintenance and service operations performed by trained personnel familiar with the GENSET maintenance. This, along with a good service records system, should aid in developing an efficient maintenance program. The service records of each GENSET should include information such as complete nameplate data with model and serial numbers, all drawing and wiring diagrams, spare parts stock lists, as well as a service schedule and a copy of this manual. These records will allow quick reference and may help to diagnose a problem in the future.

3.1.1 Daily Maintenance or At Each Start-up

Standby applications may lengthen these requirements to weekly.

- i. Make a visual check of the entire GENSET. Watch for signs of potential leaks from the engine fuel system, cooling system or lubrication seals.
- ii. Check the alternator for obstructions in the cooling air ventilation screens.
- iii. Check the alternator and control box for heavy accumulation of dust and dirt. Clean any heavy accumulations as electrical hazards or cooling problems could arise.
- iv. Check the air filter. Clean or replace the same if necessary.
- v. Check the fuel level.
- vi. Check the engine coolant level.
- vii. Be sure that the radiator air flow is not obstructed.
- viii. Check the condition of the fan and alternator belts and their tension.
- ix. Check all the hose connections and hose conditions.
- x. Check the engine oil level.
- xi. Check the battery terminals for corrosion.
- xii. Check the battery electrolyte level and fill it with distilled water if necessary.



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- xiii. Refer to the engine maintenance section for specific engine maintenance requirements.
- xiv. Start the GENSET after all the checks have been made.
- xv. Drain condensate traps in the exhaust system, if so equipped, and check for exhaust leaks.
- xvi. Check for any abnormal noise or vibration.
- xvii. Check for fluid leakage or high temperature.
- xviii. Dispose of any unnecessary items in the vicinity of the GENSET that may inhibit operation or represent cause of potential injury.
- xix. Check the control panel for indications of abnormal operation.

3.1.2 Maintenance Every 6 Months or 500 Hrs. of Operation

Apart from repeating the daily requirements, do the following.

- i. Check all safety devices by electrically simulating a fault to ensure that all systems will function properly in the event of a fault.
- ii. Check all rubber components, such as hoses, AVM's for wear, cracks and replace them if necessary.
- iii. Clean all battery cap vents.
- iv. Start the GENSET and observe the instrument panel to ensure that all the gauges and meters are operating properly.
- v. Tighten all exhaust connections.
- vi. Tighten all electrical connections.
- vii. Refer to the engine maintenance section, for further details.

3.2 Alternator Unit Cleaning

The alternator unit should be cleaned inside-out on a regular basis. The frequency of such cleanings depends on the environmental conditions of the operating site. The following procedure should be applied when cleaning is necessary:-

Disconnect all power. Wipe dust, oil, water or any other liquids from the external surfaces of the alternator unit. All of these materials can work their way into the windings and may cause overheating or insulation breakdown. Remove these same materials from the ventilation screens around the circumferences of the unit.



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Do not permit such material to accumulate on these screens as this will obstruct air flow. Such debris is best removed with a vacuum cleaner as a vacuum cleaner will not redeposit these materials on other parts of the equipment. **DO NOT USE COMPRESSED AIR, STEAM OR HIGH PRESSURE WATER CLEANER.** A vacuum cleaner should also be used to clean the windings of the alternator unit. This will remove dust from the coils that cannot be reached with a wiping cloth.

3.3 Radiator Maintenance

The radiator supplied with your generator set is designed and constructed to give many years of trouble free operation in industrial environments. There are, however, several points of maintenance that will ensure trouble free operation.

3.3.1 General Operating Notes

Corrosion in the radiator can be a prime cause of failure. This is stimulated by air in the water. Always ensure pipe connections are free of leaks and bleed air from top of the radiator regularly to keep the system “air free”.

Radiators should not be left standing in a partially filled condition. Radiators left partly filled with water will suffer much more rapidly from the effects of corrosion. For an inoperative generator set, either drain the radiator completely or ensure that it is maintained full. Whenever possible, radiators should be filled with distilled or naturally soft water, and dosed with suitable corrosion inhibitors.



Warning! Radiator coolant is normally very hot and under pressure. Do not work on the radiator or disconnect pipework until it has been cooled down. Do not work on the radiator or remove any guarding while the fan is in motion.

3.3.2 Cleaning

The external and internal cleaning techniques are as mentioned below.

3.3.2.1 External Cleaning of Radiator

In dusty or dirty conditions the radiator fins can get blocked with loose debris, insects, etc. and this fouling will have an effect on the performance of the radiator.



For regular removal-of light deposits, use a low pressure stream jet. More difficult deposits may need a detergent with a low pressure hot water hose. Stubborn deposits, which cannot be removed by the above methods, may require removal of the radiator and immersion in a heated alkali degreasing solution for about 20 minutes and then washing off with a hot water hose.

3.3.2.2 Internal Cleaning of Radiator (By Expert Personnel)

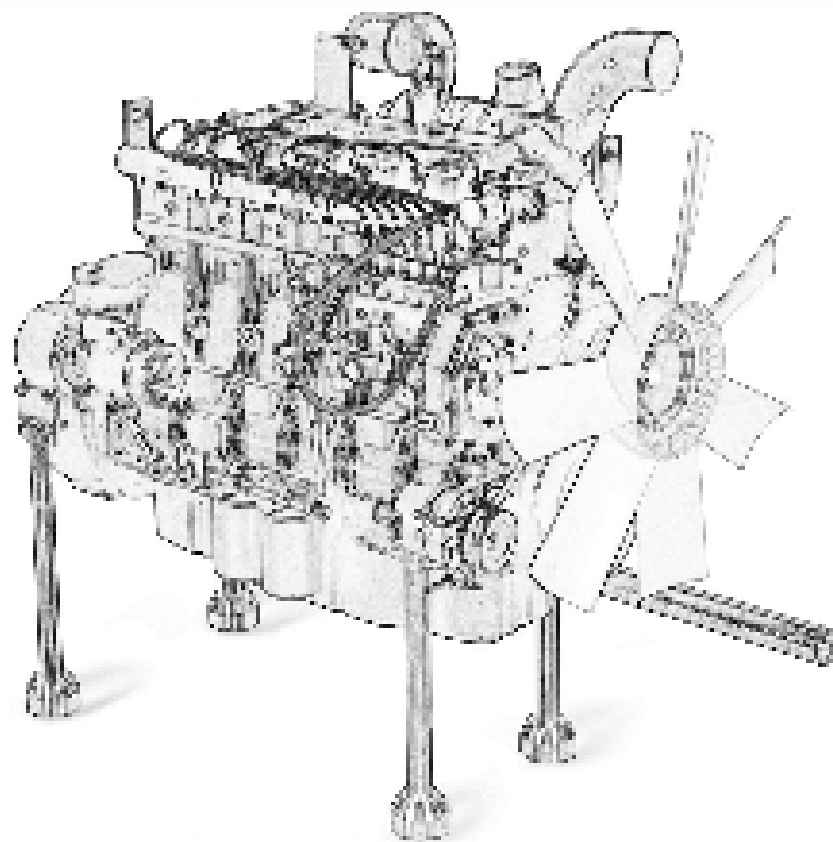
If, due to leaky joints for instance, or indiscriminate topping up with hard water has been carried out for some time, or if the generator set has been run without inhibitors the system may become fouled by scale. To descale the radiator call GREAVES authorised service dealer.

The procedure for the same is as follows:

- i. Drain the water system and disconnect and bank off the pipe connections to the engine.
- ii. Prepare a 4% solution of inhibited acid solvent and fresh water. Add the acid to the water, never vice versa.
- iii. Allow several minutes for mixing, then heat the solution to 49°C (120°F) maximum.
- iv. Run the solution slowly into the radiator via the filler cap or a branch in the manifold.
- v. Foaminess will occur; when it ceases, fill the radiator completely with the heated solvent.
- vi. Allow to stand for several minutes; then drain the solvent back into the original container through the bottom manifold or drain plug.
- vii. Examine the interior of the headers. If scale remains, repeat the process outlined above with the solvent strength increased to 8%.
- viii. After descaling the acid solution has to be neutralized as follows:-
 - a. Fill the mixing container with fresh water, heat to boiling point then add common washing soda crystals at the following strength; 0.5 kg of soda to 20 litres water (1 lb. soda to 4 gallons water). Fill the radiator with this solution, and then drain it back into the container.
 - b. Flush the radiator in this manner several times, finally leaving the radiator full for at least an hour. Drain until empty and wash out the radiator with hot fresh water.
 - c. Before putting the radiator into service again, fill with water and apply a test pressure equal to twice that of the working pressure. Examine carefully for any leaks which may have been revealed by descaling.
 - d. Prior to re-commissioning, the coolant must be dosed with any necessary corrosion inhibitors and/or the correct proportion of antifreeze.

SECTION C

DIESEL ENGINE





SECTION C - DIESEL ENGINE			
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Chapter 1 General

1.1 Safety

Safety of your personnel, property and equipment should be the first priority during installation, operation, maintenance of your engine and equipment. The engine can cause harm in the following ways against which your personnel have to guard. Refer Table C1.1 for more details.

Sl. No.	Hazard	Example
1	Rotating Parts	Flywheel, Pulleys, Radiator Fan
2	High Temperature	Exhaust related Parts, Exhaust Gases, Water, Oil
3	Hot or Hazardous Sprays	Fuel, Lube Oil, Water, Exhaust Leaks or Hose/Pipe Bursts
4	Electrical Shocks/Sparks	Alternators, Starters, Control Panels, Battery Wirings
5	Loose Objects	Loose parts flying out (likelihood after maintenance)
6	Poison	Additives, diesel, lube oil, exhaust gases can cause damage if consumed or inhaled

Table C1.1

- i. Never get near the engine while it is running wearing loose items like tie, long chains, scarf, long loose clothes, tags with mobile phones etc.
- ii. Display safety instruction clearly in the operating area.
- iii. Make the operating persons aware of the safety related issues.
- iv. Provide necessary safety equipment to the operating persons.
- v. Follow all applicable safety related regulations and laws.

1.2 Operation Guidelines

- i. It is assumed that the reader and the user of these operating instruction is familiar with the basic mode of operation of four stroke combustion engine and is able to follow technical issues reasonably well. The text has been kept therefore as short as possible for clarity and is backed by photographs and sketches.
- ii. Read the instructions carefully before installation of the engine or equipment.
- iii. In case of any doubt or difficulty, seek help from authorized Greaves service dealers.
- iv. Your engine needs clean air, clean fuel, clean lube oil and clean coolant.



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- v. Giving attention to these factors improves the life of your equipment, reduces the running costs, and also increases the mean time between failures.

1.3 Maintenance Guidelines

- i. Please read the maintenance instructions. Seek services of authorized Greaves service dealers if needed.
- ii. Follow maintenance schedules.
- iii. Plan your maintenance.
- iv. Always use genuine spare parts, listed lube oil, listed additives and unadulterated fuel from reputed agency.
- v. Always use correct tools.
- vi. Always carry out maintenance in a clean area.
- vii. Follow good engineering practices during maintenance.

Chapter 2 Engine Description

2.1 Engine Orientation

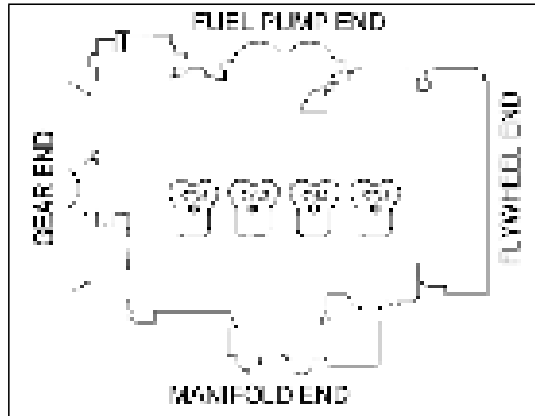


Fig. C2.1 Engine Orientation

2.2 Engine Nameplate



Fig. C2.2 Engine Nameplate

2.3 Location of the Nameplate



Fig. C2.3 Location of Nameplate

2.4 Cylinder Nomenclature

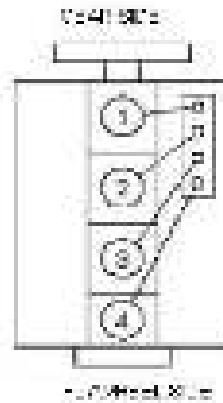


Fig. C2.4 Typical Cylinder Nomenclature

2.5 Engine Nomenclature System

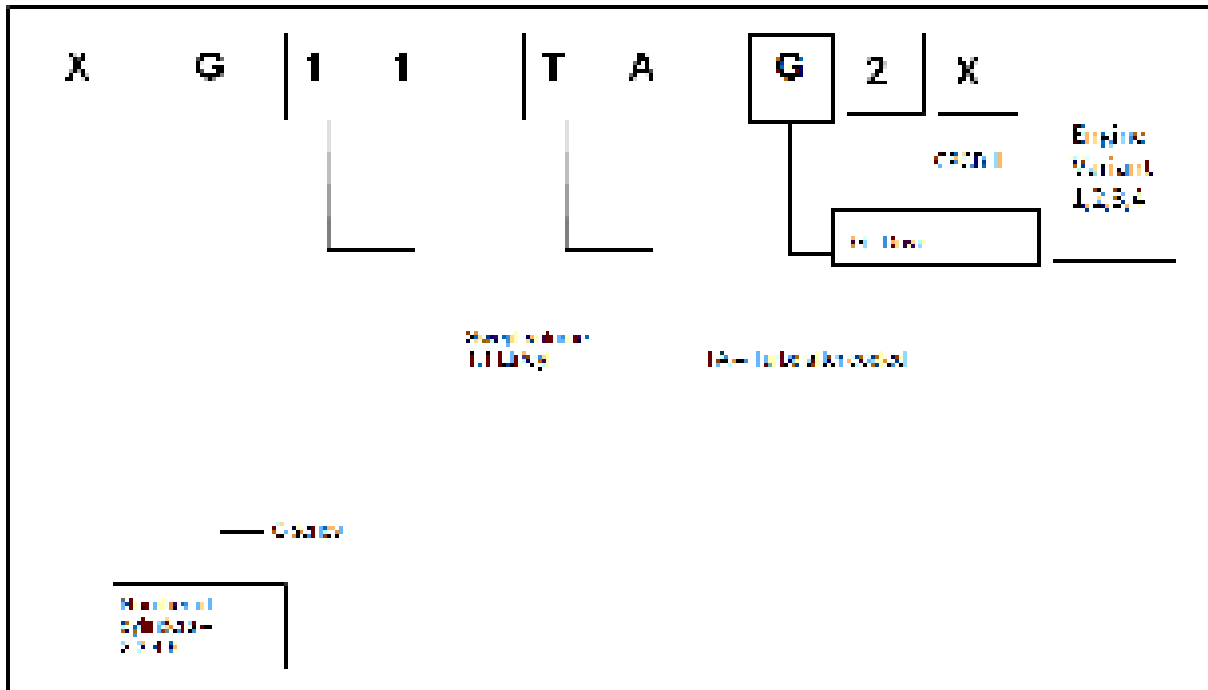


Fig. C2.5 Engine Nomenclature System



2.6 Technical Data of G Series Engine for Diesel GENSET Application [CPCB-II Norms Followed]

Family	3G11TAG			4G11TAG				6G11TAG			
Model	3G11TAG23	3G11TAG23	3G11TAG23	4G11TAG22	4G11TAG22	4G11TAG23	4G11TAG24	6G11TAG24	6G11TAG24	6G11TAG24	6G11TAG25
Rating	35 KVA	40 KVA	45 KVA	50/62.5	75/80 KVA	82.5/100	125 KVA	160 KVA	180 KVA	200 KVA	250 KVA
(A) GENERAL DATA											
Type	4 stroke, direct injection, compression ignition										
Bore	105			105				105		108	
Stroke	130			130				133		133	
Cylinder	3			4				6			
Firing Order	1 - 3 - 2			1 - 3 - 4 - 2				1 - 5 - 3 - 6 - 2 - 4			
Rotation	Anticlockwise looking at Flywheel										
Vol. / Cyl.	1125 cc.										
Total Volume	3.375 Litres			4.5 Litres				6.9 Litres		7.3 Litres	
Aspiration	Turbocharged After Cooled										
Cooling	Water Cooled										
CR	1:17			1:17				1 : 16.8			
Starting	Electric start (12 VDC)										
BMEP in bar @ Rt.	7.84	9.03	10.02	14.48	13.24	16.36	19.82	17.1	19.30	21.19	24.84

Auxiliary Power Business



Model	3G11TAG23	3G11TAG23	3G11TAG23	4G11TAG22	4G11TAG22	4G11TAG23	4G11TAG24	6G11TAG24	6G11TAG24	6G11TAG24	6G11TAG25
Rating	35 KVA	40 KVA	45 KVA	50/62.5	75/80 KVA	82.5/100	125 KVA	160 KVA	180 KVA	200 KVA	250 KVA
(B) POWER & EFFICIENCY											
Net Rated Power kW	33.1	38.1	42.3	59	74.5	93.0	114	144.5	163	178.8	227.0
Brake Horse Power HP	45	52	59	83	105	127	155	196.5	221.7	243.2	304.4
kW Electrical	28	32	36	50	66	80	100	128	144	160	200
Alternator Efficiency	87.6	87.8	88.5	90.1	90.4	90.0	91.0	92.5	92.5	93.5	93.0
Fan Power & Other Losses kW	1.7	1.9	2.1	2.9	3.7	4.7	5.7	7.2	8.6	8.9	11.4
Overload	10 % Overload (1 hour in 12 hours) as per (ISO 3046)										
RPM	1500										
Governing Standard	Class A1- IS 10000, less than 4.5% Droop										

Auxiliary Power Business



Model	3G11TAG23	3G11TAG23	3G11TAG23	4G11TAG22	4G11TAG22	4G11TAG23	4G11TAG24	6G11TAG24	6G11TAG24	6G11TAG24	6G11TAG25
Rating	35 KVA	40 KVA	45 KVA	50/62.5	75/80 KVA	82.5/100	125 KVA	160 KVA	180 KVA	200 KVA	250 KVA

(C) DRIVES

Water Pump	Centrifugal, Gear driven, 2833 RPM										
Lube Oil Pump	G-rotor, Gear driven, 1962 RPM										
Radiator Fan	Belt Driven, Separate Fan drive, Pusher fan										
Charging Alternator	Belt Drive										

(D) COOLING SYSTEM

Cooling	Pressurized (7 PSI) water cooled with radiator, with thermostat (74-82°C), pusher fan OR Pressurized (7 PSI) water cooled with Heat Exchanger, with thermostat (74-82°C)										
Water Flow (LPM)	100	100	100	140	140	140	140	206	206	206	206
Pressure Drop of Water across Engine	0.3 to 0.4 Bar										

Auxiliary Power Business



Model	3G11TAG23	3G11TAG23	3G11TAG23	4G11TAG22	4G11TAG22	4G11TAG23	4G11TAG24	6G11TAG24	6G11TAG24	6G11TAG24	6G11TAG25
Rating	35 KVA	40 KVA	45 KVA	50/62.5	75/80 KVA	82.5/100	125 KVA	160 KVA	180 KVA	200 KVA	250 KVA
(D) COOLING SYSTEM [continued]											
Max. Pressure Drop of Water across Radiator	0.3 Bar										
Max. Pressure Drop of Water across CAC	50 mm of Hg										
Radiator Cap Pressure	7 PSI										
Heat Lost by Water in Radiator (kCal/hr.)	27622	27622	27622	46472	46472	58950	58950	111016	111016	111016	111016

Auxiliary Power Business



Model	3G11TAG23	3G11TAG23	3G11TAG23	4G11TAG22	4G11TAG22	4G11TAG23	4G11TAG24	6G11TAG24	6G11TAG24	6G11TAG24	6G11TAG25
Rating	35 KVA	40 KVA	45 KVA	50/62.5	75/80 KVA	82.5/100	125 KVA	160 KVA	180 KVA	200 KVA	250 KVA

(D) COOLING SYSTEM [continued]

Temp. Drop across Radiator	7 to 10 °C
----------------------------	------------

(E) LUBRICATION SYSTEM

Lube Oil Grade	CF4 15W40
Lube System	Pressurized (3.5-4.5 bar) with Sump capacity 10 litres Max. - 9 Litres Min. Oil temperature 80 to 120 °C Max
Lube Oil Cooled by	Plate Type Oil Cooler
Lube Oil Cold Kick	5 to 7 bar
Lube Oil Filter	Spin on type single element with filtration capacity 10 to 20 micron
Lube Oil Change	After 500 Hrs. of Operation / Running



Auxiliary Power Business

Model	3G11TAG23	3G11TAG23	3G11TAG23	4G11TAG22	4G11TAG22	4G11TAG23	4G11TAG24	6G11TAG24	6G11TAG24	6G11TAG24	6G11TAG25
Rating	35 KVA	40 KVA	45 KVA	50/62.5	75/80 KVA	82.5/100	125 KVA	160 KVA	180 KVA	200 KVA	250 KVA

(E) LUBRICATION SYSTEM [continued]

Lube Oil Pressure Trip	1.5 bar										
Piston Cooling	Nozzle Type										
Lube Oil Consumption	3 % of Specific Fuel Consumption										

(F) FUEL SYSTEM

Fuel Used	High Speed Diesel (BIS 1460)										
Fuel Injection	Inline Fuel pump BOSCH, Injector BOSCH										
Fuel Filter	Twin bowl, screwed type										
Typical Fuel Temp. °C	30-38	30-38	30-38	36-38	36-38	38-42	38-42	38-42	38-42	38-42	38-42

Auxiliary Power Business



Model	3G11TAG23	3G11TAG23	3G11TAG23	4G11TAG22	4G11TAG22	4G11TAG23	4G11TAG24	6G11TAG24	6G11TAG24	6G11TAG24	6G11TAG25
Rating	35 KVA	40 KVA	45 KVA	50/62.5	75/80 KVA	82.5/100	125 KVA	160 KVA	180 KVA	200 KVA	250 KVA

(F) FUEL SYSTEM [continued]

Fuel Filter Size	10 to 15 micron										
Fuel Feed Pump	MICO A Type, mounted on Fuel Injection Pump (FIP)										
Suction Head of Feed Pump	1 Meter										
Injector	MICO P Type										
Governing	Mechanical / Electronic										
SFC in LPH	12.0	12.0	12.0	20.01	20.01	25.4	30.71	47.53	47.53	47.53	60.35

(G) AIR INTAKE SYSTEM

Air Filter	Dry Type, with filtration capacity 10 micron										
Air Suction Depression (Max-New) mm WC	150	150	150	150	150	150	150	150	150	150	150

Auxiliary Power Business



Model	3G11TAG23	3G11TAG23	3G11TAG23	4G11TAG22	4G11TAG22	4G11TAG23	4G11TAG24	6G11TAG24	6G11TAG24	6G11TAG24	6G11TAG25
Rating	35 KVA	40 KVA	45 KVA	50/62.5	75/80 KVA	82.5/100	125 KVA	160 KVA	180 KVA	200 KVA	250 KVA

(G) AIR INTAKE SYSTEM [continued]

Air Suction Depression (Max-Clog) mm WC	400	400	400	400	400	400	400	400	400	400	400
---	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

(H) EXHAUST SYSTEM

Exhaust Outlet Temp. °C (Max.) after Turbine	550	550	550	485	485	500	500	560	560	560	550
--	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

Exhaust Back Pressure (Max)	50 mm of Hg										
-----------------------------	-------------	--	--	--	--	--	--	--	--	--	--

Auxiliary Power Business



Model	3G11TAG23	3G11TAG23	3G11TAG23	4G11TAG22	4G11TAG22	4G11TAG23	4G11TAG24	6G11TAG24	6G11TAG24	6G11TAG24	6G11TAG25
Rating	35 KVA	40 KVA	45 KVA	50/62.5	75/80 KVA	82.5/100	125 KVA	160 KVA	180 KVA	200 KVA	250 KVA

(H) EXHAUST SYSTEM [continued]

Exhaust Mass kg/hr.	250	250	250	480	480	610	714	1005	1005	1005	1350
---------------------	-----	-----	-----	-----	-----	-----	-----	------	------	------	------

(I) SERVICE DATA

Inlet Valve Tappet Clearance Cold	0.4 mm										
Exhaust Valve Tappet Clearance Cold	0.4 mm										
Bumping Clearance	0.8 - 1.2 mm										
Crankshaft End Play	0.1 - 0.35 mm										
CON Rod End Play	0.4 mm										

Auxiliary Power Business



Model	3G11TAG23	3G11TAG23	3G11TAG23	4G11TAG22	4G11TAG22	4G11TAG23	4G11TAG24	6G11TAG24	6G11TAG24	6G11TAG24	6G11TAG25
Rating	35 KVA	40 KVA	45 KVA	50/62.5	75/80 KVA	82.5/100	125 KVA	160 KVA	180 KVA	200 KVA	250 KVA

(I) SERVICE DATA [continued]

Flywheel Housing Face Run-Out w.r.t. Crank Shaft Axis	0.25 mm Max.
---	--------------

Flywheel Housing Bore Run-Out w.r.t. Crank Shaft Axis	0.25 mm Max.
---	--------------

(J) VALVE / FUEL INJECTION TIMING

Inlet Valve Opens	3° BTDC
Inlet Valve Closes	23° ABDC

Auxiliary Power Business



Model	3G11TAG23	3G11TAG23	3G11TAG23	4G11TAG22	4G11TAG22	4G11TAG23	4G11TAG24	6G11TAG24	6G11TAG24	6G11TAG24	6G11TAG25
Rating	35 KVA	40 KVA	45 KVA	50/62.5	75/80 KVA	82.5/100	125 KVA	160 KVA	180 KVA	200 KVA	250 KVA

(J) VALVE / FUEL INJECTION TIMING [continued]

Exhaust Valve Opens	33° BBDC										
Exhaust Valve Closes	1° ATDC										
Fuel Injection Timing	7 +/-1° BTDC			6 +/-1° BTDC				9 +/-1° BTDC			

(K) BOLT TORQUE TIGHTNING DATA

M B Cap bolts	7-14-20 kgf (Torque in step)										
Cylinder head bolts	5-9-15 kgf (Torque in Step)										
Inlet, exhaust manifold	6 kgf										

Auxiliary Power Business



Model	3G11TAG23	3G11TAG23	3G11TAG23	4G11TAG22	4G11TAG22	4G11TAG23	4G11TAG24	6G11TAG24	6G11TAG24	6G11TAG24	6G11TAG25
Rating	35 KVA	40 KVA	45 KVA	50/62.5	75/80 KVA	82.5/100	125 KVA	160 KVA	180 KVA	200 KVA	250 KVA

(K) BOLT TORQUE TIGHTNING DATA [continued]

Turbo Charger bolt	8 kgf
CON rod	5-9-13 kgf (Torque in Step)
Flywheel bolts	17 kgf
Flywheel housing bolts	9.5 kgf
Injector nut	5 kgf
Oil Sump	2.5 Kgf
Idler Gear	6 kgf on line
Pulley	17 kgf
M 12	8.5 kgf
M 10	5 kgf
M 8	2.5 kgf

Table C2.1 Technical Data of G Series

2.7 Engine Illustrations

2.7.1 Turbocharger Side

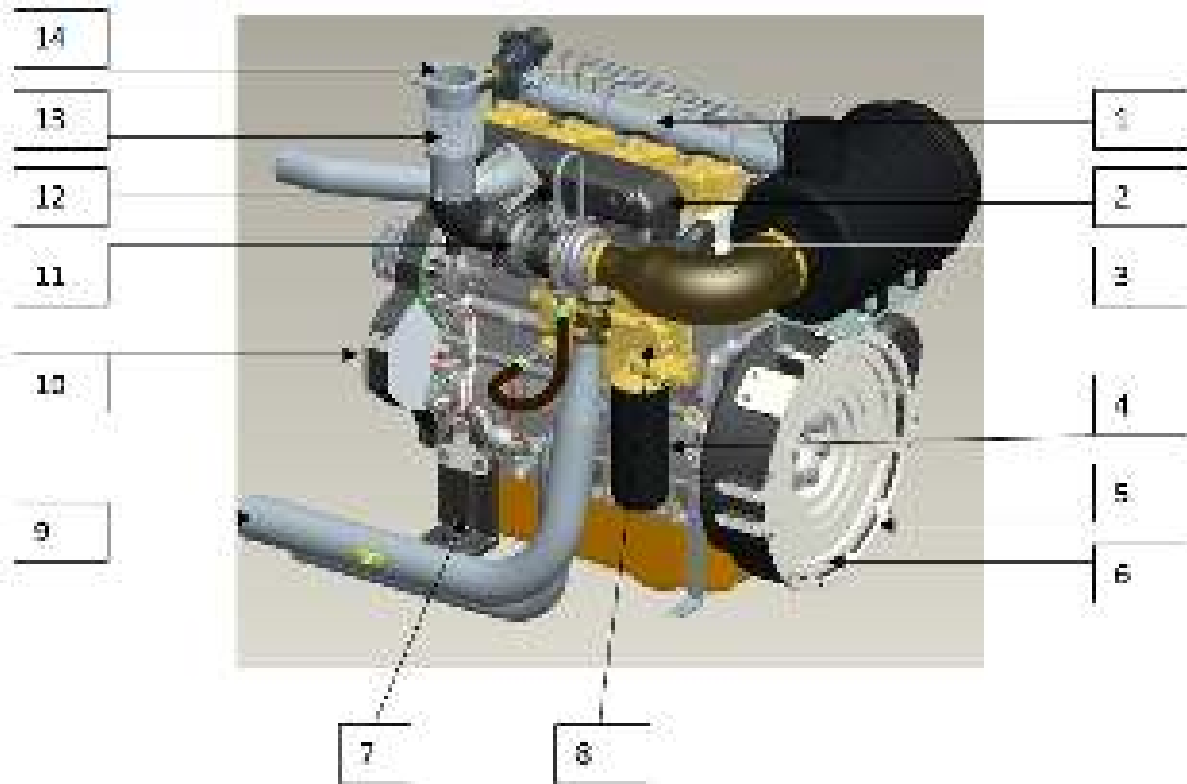


Fig. C2.6 Turbocharger Side Engine Illustration

1	Water manifold	8	Oil Header
2	Air Manifold	9	Turbocharger to CAC in connection pipe
3	Exhaust manifold	10	Gear casing
4	Lube. Oil filter	11	Turbocharger
5	Flywheel Housing	12	Oil supply to turbocharger
6	Flywheel	13	Exhaust Bellow
7	Engine Foot	14	Exhaust Outlet

2.7.2 Fuel Pump Side

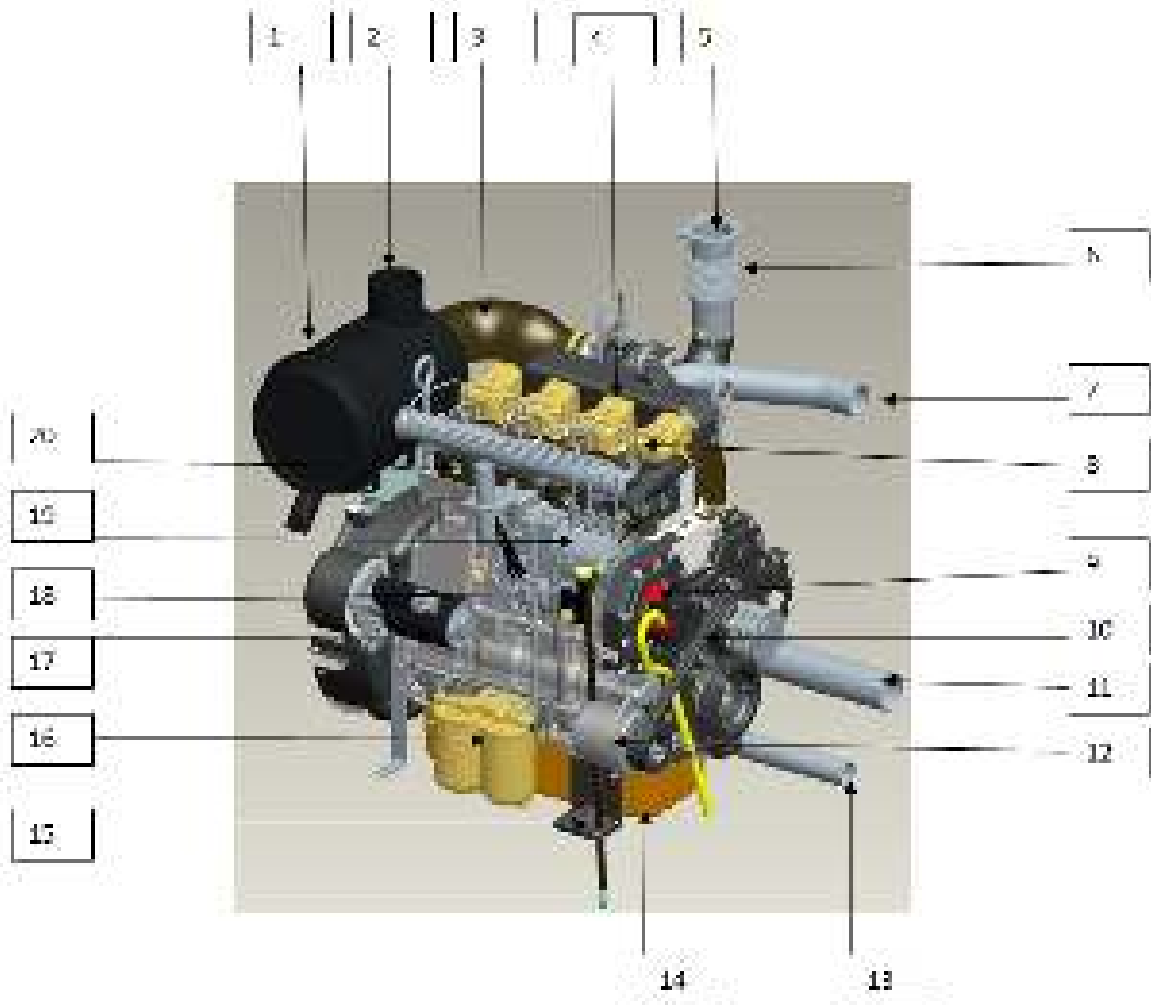


Fig. C2.7 Fuel Pump Side Engine Illustration

1	Air Cleaner	12	Alternator
2	Air inlet	13	Water In
3	Air filter to turbo connection pipe	14	Oil Sump
4	Rocker Cover	15	Engine Foot
5	Exhaust Outlet	16	Fuel Filter
6	Exhaust Bellow	17	Starter
7	CAC to inlet manifold connection	18	Fuel Feed Pump
8	High pressure pipe	19	Fuel Pump
9	Oil filler Cap	20	Cylinder Head
10	Belts		
11	CAC air in pipe		

2.7.3 Engine Dimensions & Weight

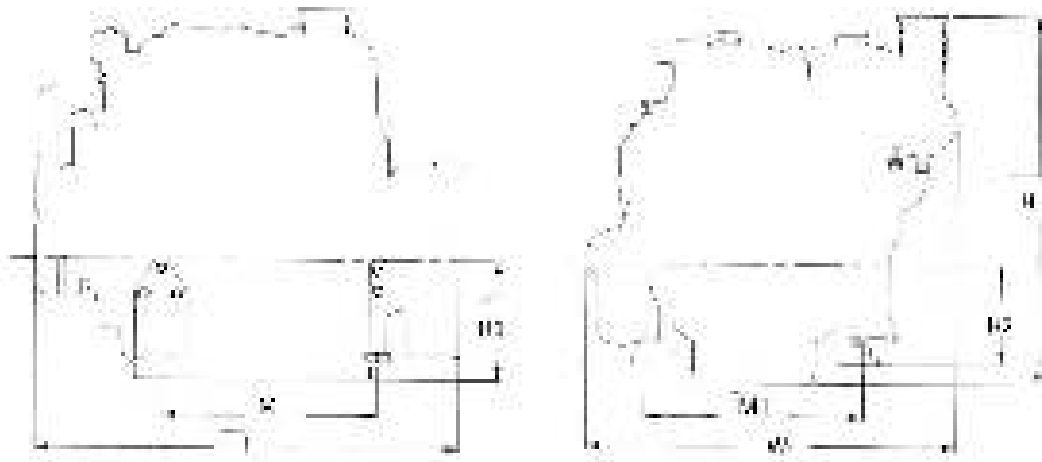


Fig. C2.8 Overall Engine Dimensions

Engine Series	L	M	M1	W	H	H1	H2	Engine Weight in Kg.	Flywheel Flange SAE No.
3G	795	323	454	812	1115	343.2	228.029	400	SAE3/11.5"
4G	900	451	454	804	1025	276	233	480	SAE3/11.5"
6G	1635	665	454	832	1091	233	285	600	SAE1/14"

Table C2.2 Engine Dimensions & Weight

2.7.4 Engine Lifting Instructions

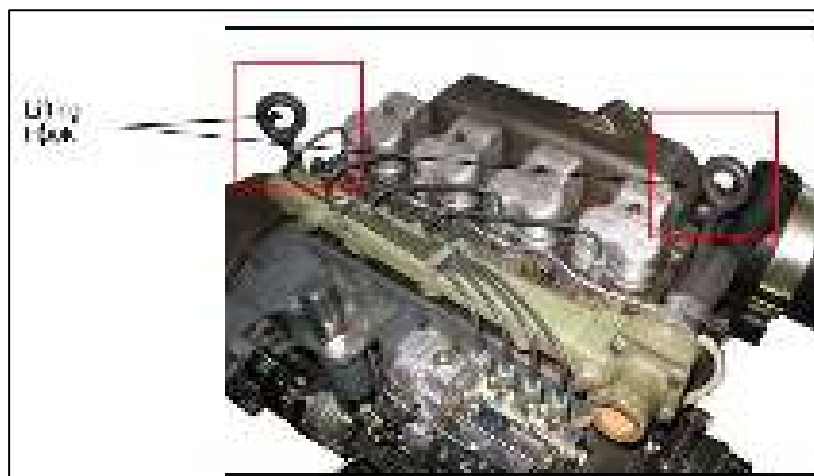


Fig. C2.9 Lifting Hook Illustration



Auxiliary Power Business

Take all safety precautions while lifting and moving the engine. Only trained personnel should handle the engine. You can consult Greaves service dealers, if necessary.

Firstly, remove water and oil from the engine before lifting. If your engine has cast iron sump then the engine can be rested on the sump. For any other type sump, use blocks under engine feet. Avoid jerks or abrupt resting of engine. The engine should never be rested, stored or lifted in any other direction than upright. The engine should never be rolled on the ground.

The engine is provided with four transportation feet even if only two feet (gear end) are required for application. Store the spare feet, (flywheel end) carefully. Fit those two extra feet before lifting the engine. The engine should not be rested on bell housing for long durations.

Use only the eyebolts provided on the engine crankcase for lifting purpose. The eyebolts are to be used for lifting engine only. Do not lift engine coupled with alternator or entire DG set using these bolts. Ensure that, the I-bolts are completely engaged before engine is lifted.

While lifting the engine, use correct size of tackles, ropes, chains, cranes, hoists or any other lifting or transportation device. While lifting or transportation, the ropes or tackles should be positioned in such a way that they do not damage engine components like rocker cover, fuel pumps, high pressure pipes, etc. The engine should be balanced while lifting and moving. Do not keep the engine hanging on lifting tackles.



Chapter 3 Systems

3.1 Lubrication System

3.1.1 Engine Lubrication System

G series engines use positive pressurized lubrication system. The main functions of the lubrication system are as follows:

- i. Lubrication of friction related parts
- ii. To carry away the heat generated by friction
- iii. To avoid corrosion
- iv. To wash away debris created by friction wear

The lube oil system is adequately designed to provide sufficient lubrication, oil change period, filter element life and minimize lube oil consumption and running cost. The operational detail of the lubrication system is as mentioned below.

- a. The G series engine uses a positive displacement, G-rotor pump, which is gear driven.
- b. The system has a pressure-regulating valve, lube oil filter and lube oil cooler, which are housed in a lube oil header.
- c. Providing oil through push rod lubricates the rocker assembly. The fuel pump and turbochargers are positively lubricated.

Fig. C3.1 illustrates circuit diagram of engine lubrication system. Refer table C3.1 for recommended lube oil to be used for long life.

Recommended Oil for G11 series engines	
Company	Oil brand name
Greaves Cotton Ltd	Greaves Maxtherm (API CF-4 15W-40)

Table C3.1 Engine Dimensions & Weight

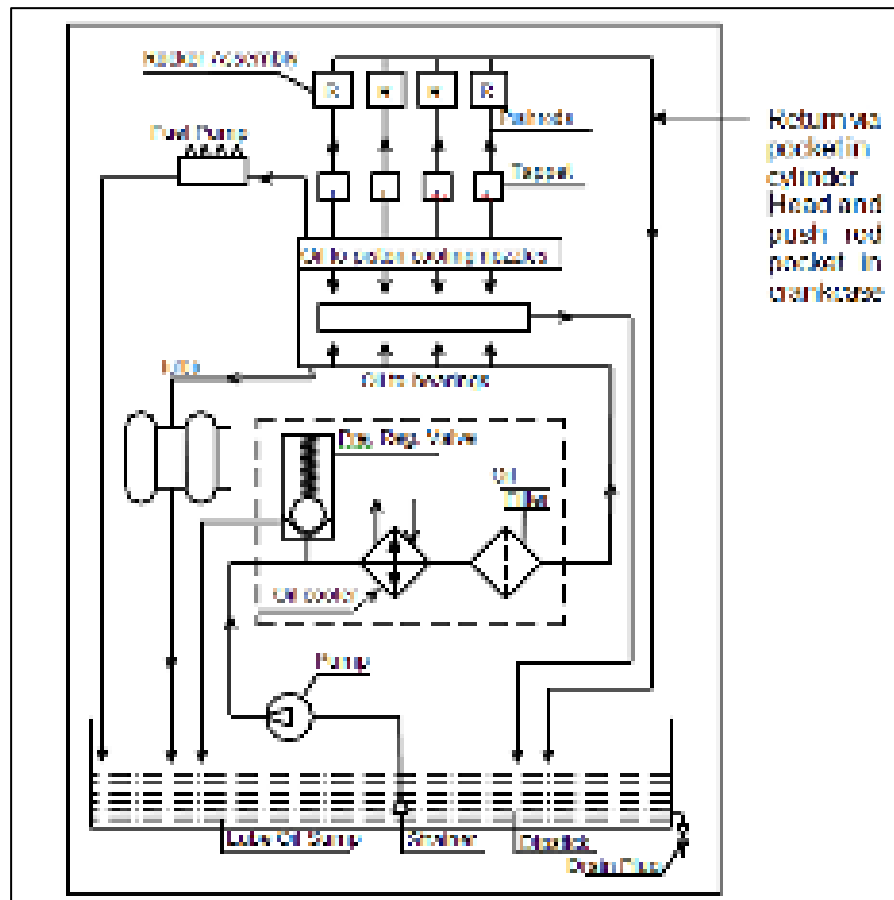


Fig. C3.1 Illustration of Circuit Diagram for Engine Lubrication System

3.1.2 G-Series Lubrication System

Lube oil pump is G rotor type pump. Refer Table C3.2 for Lube Oil Pressure at various working conditions.

Speed	Pressure bar
Low idle speed	1.5 to 2 bar
High idle speed	5 to 6 bar
Under full load operating conditions	4 to 5 bar

Table C3.2

If at any operating condition the lube oil pressure drops below 2.5 bar, then change lube oil filter element. If the problem persists then contact Greaves authorized service agent or dealer.

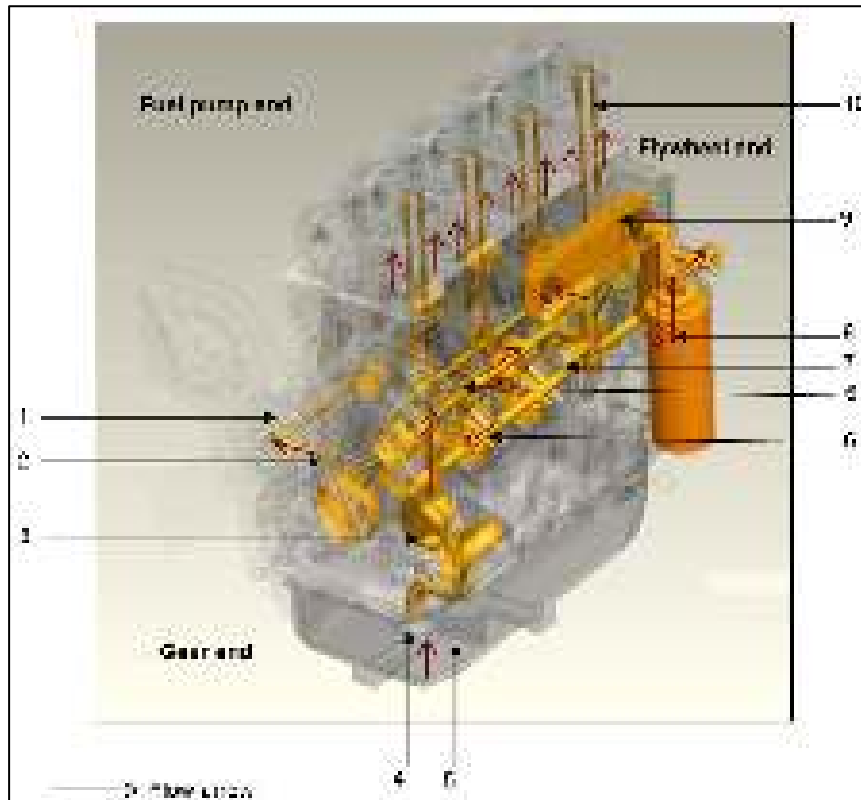


Fig. C3.2 G Series Lubrication System (Lube Oil Filter Side)

1	Intermediate gear support	6	Main oil gallery
2	Nozzle gear lubrication	7	Pressure regulating valve
3	Lube oil pump	8	Lube oil filter
4	Lube oil suction strainer	9	Lube oil cooler
5	Lube oil sump	10	Push rods

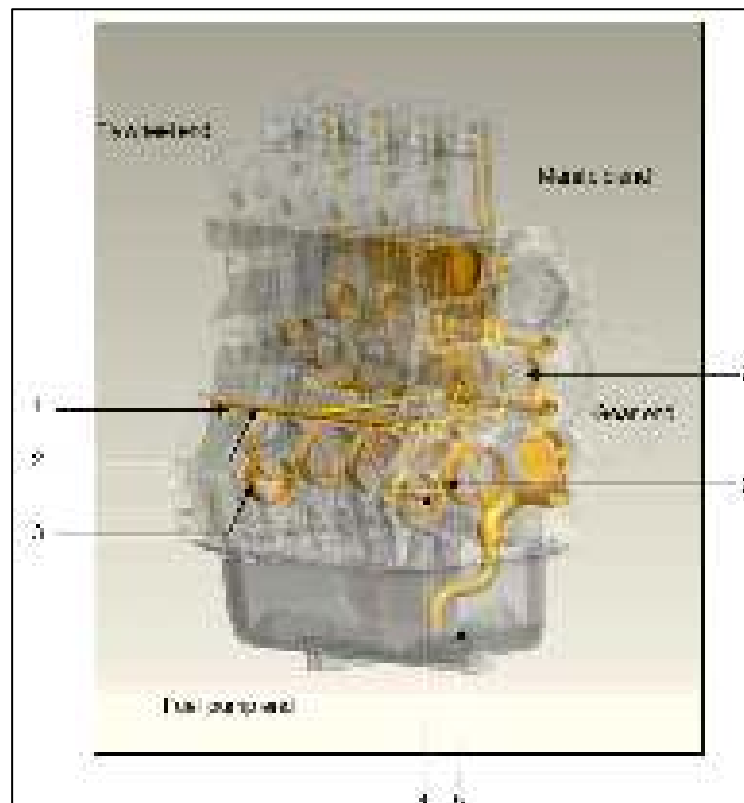


Fig. C3.3 G Series Lubrication System (FIP Side)

1	Piston cooling nozzle	5	Lube oil sump
2	Piston cooling nozzle gallery	6	Main bearings
3	Crank pins	7	Cam bores
4	Oil holes on crank shaft		

3.1.3 Permissible Engine Inclination

Permissible Engine Inclination is 1 deg. However for continuous or intermittent operation at an inclination contact our technical team for approval.

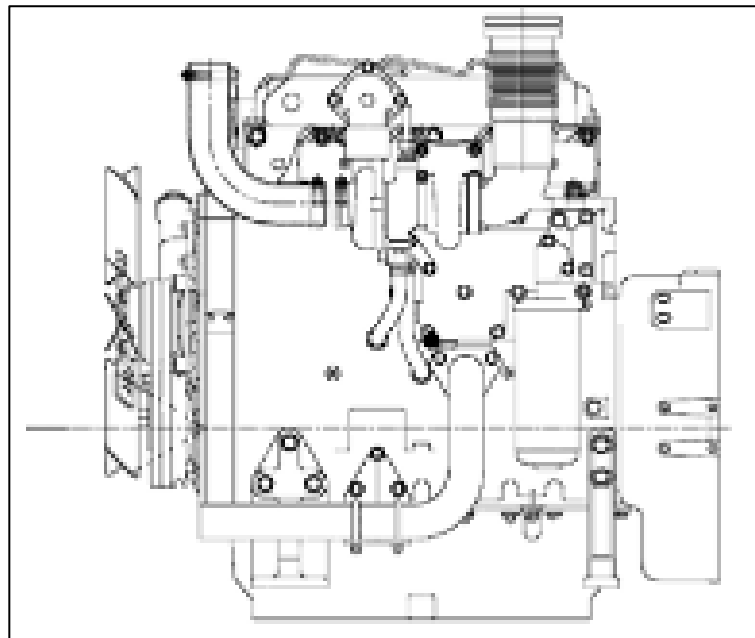


Fig. C3.4 Engine Inclination

3.2 Engine Cooling System

3.2.1 Description of Engine Cooling System

G11 series engines are water-cooled engines. The water pump is gear driven. The water is cooled by a radiator fan system. The fan is driven by a fan drive system and is not mounted on the water pump. The water also cools lube oil in the lube oil cooler.

A thermostat (74°C start to 82°C full open) controls the water temperature. The radiator has a pressure cap, which maintains the static pressure at 0.5 bar (7 psi). A drain plug is provided to drain the system. The water system provides adequate cooling in a simple and efficient manner to satisfy the cooling needs of canopy enclosed GENSET application.

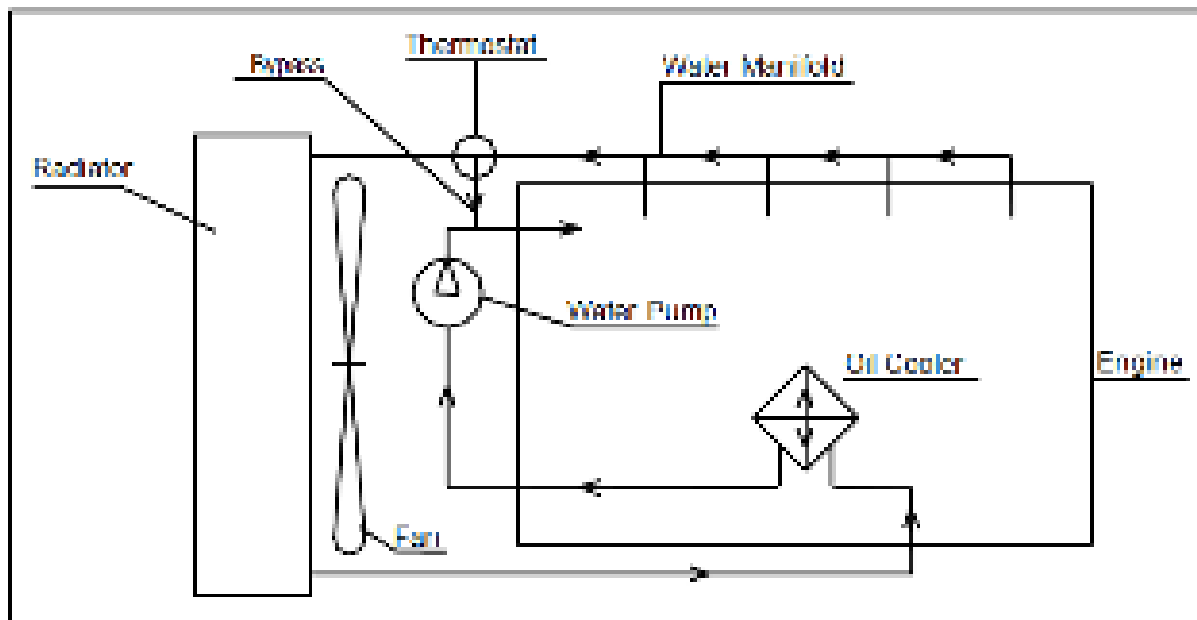


Fig. C3.5 Engine Cooling System

3.2.2 Engine Cooling System Component Data

Pump	Centrifugal
Drive	Engine driven gear drive
Static water pressure (radiator cap)	7 psi
Typical steady state water temp	72 - 90 ° C
Max allowable water temp	95 - 96 ° C

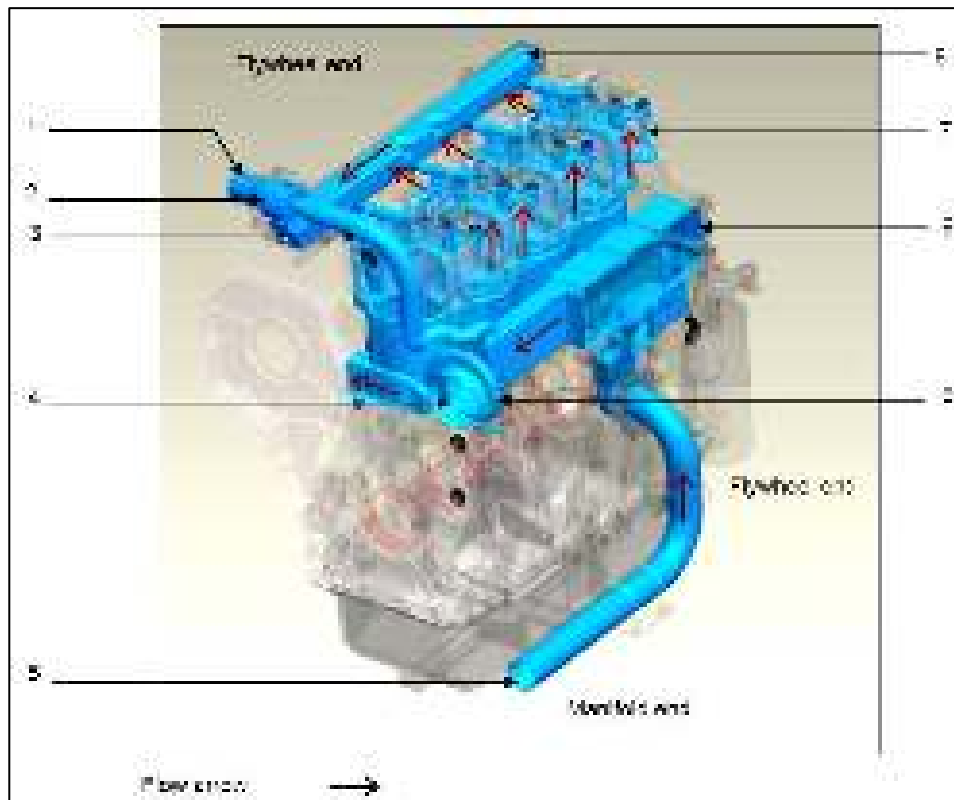


Fig. C3.6 Illustration of G-Series Cooling System Lube Oil Side

1	Water out to radiator	6	Oil cooler cavity
2	Thermostat	7	Cylinder head
3	Bypass	8	Water manifold
4	Water pump	9	Weeping hole
5	Water in from radiator		

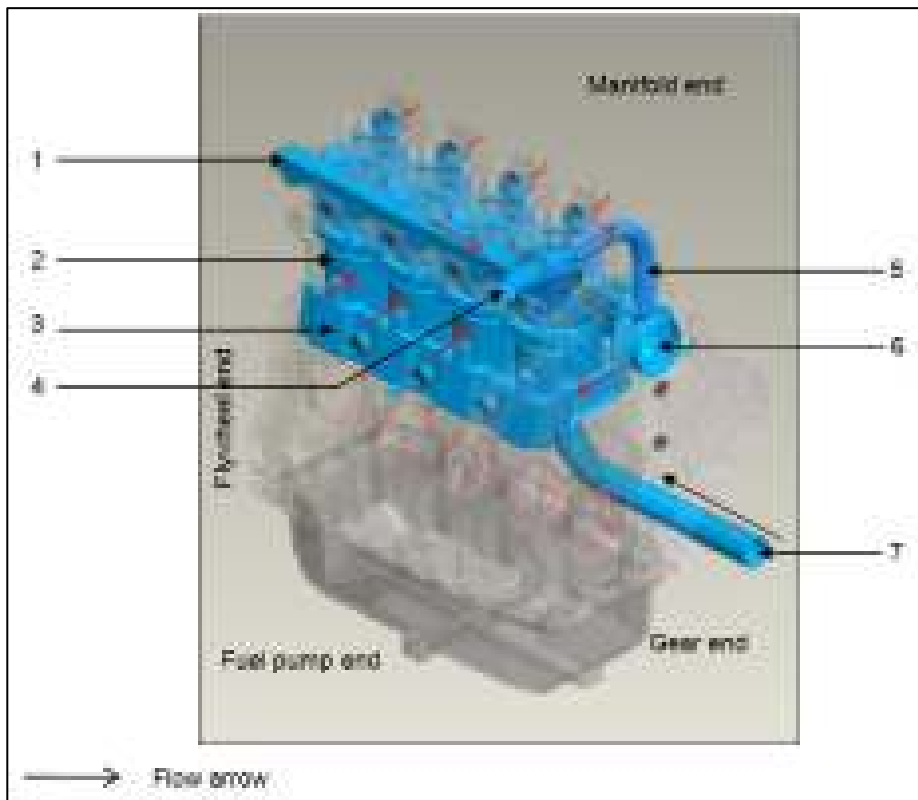


Fig. C3.7 Illustration of G-Series Cooling System FIP Side

1	Water outlet manifold	5	Bypass
2	Cylinder water cavity	6	Water pump
3	Water core	7	Water in
4	Water out		

3.2.3 Water Specifications

pH value	7 - 9
Calcium/magnesium hardness	180-ppm max
Chlorides	Less than 40 ppm
Sulfates	Less than 100 ppm
TDS (Total Dissolved Solids)	Less than 400 ppm

3.2.4 Coolant Additive Specification

Fill requisite quantity of cooling water duly mixed with Greaves MAXTHERM specialty summer coolant / anti-freeze compounds about 20% by volume or cooling conditioner with anti-freeze, if required.

3.2.5 Filling-up Coolant on New Installation

The engine is supplied with the coolant, which has to be filled up after installation. For this refer the procedure mentioned below:

- i. Open the de-aeration plug.
- ii. Open the radiator cap.
- iii. Ensure all hoses are in place.
- iv. Prepare coolant in the specified proportion.
- v. Pour coolant through the spout.
- vi. Water takes some time to fill up the system through the radiator tubes.
- vii. Wait for 20 seconds before restarting the pouring.
- viii. Coolant will first start coming out of the de-aeration opening.
- ix. Wait for the air to escape and close the plug.
- x. Keep on pouring till the water is filled up in the radiator top tank. Close the cap firmly.



Fig. C3.8 Radiator Cap Removal



Fig. C3.9 De-aeration Plug

3.2.6 Topping-up Coolant in an already Installed Engine



Fig. C3.10 Topping-up Coolant

While topping-up the coolant, please follow the guidelines laid below:

- i. Never open the radiator cap of an engine that has just stopped.
- ii. Wait for at least 15 minutes after stopping the engine.
- iii. For normal top ups, it is not necessary to de-aerate the system.
- iv. Fill up coolant wait till the coolant level settles.
- v. Confirm that the level is correct. Put the radiator cap back.

3.2.7 Draining the Coolant System



Warning! Coolant mixture is poisonous. Store it safely.

- i. The engine is provided with 3 drain plugs.
- ii. The drain plug on oil cooler header is for draining the system till cylinder head level.
- iii. The drain plug on crankcase is for draining the entire engine.
- iv. The drain plug on the radiator is for draining the entire system.
- v. Drain the coolant in a tray.
- vi. Dispose-off the coolant safely in an environmentally friendly way.

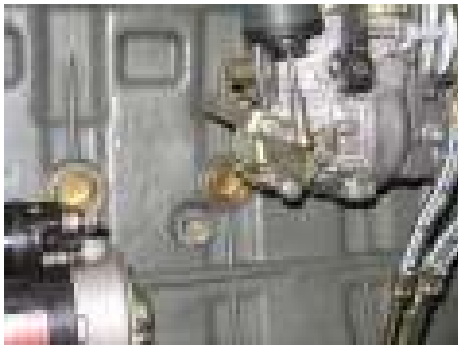


Fig. C3.11 Drain Plug on Crank Case



Fig. C3.12 Drain Plug on Oil Cooler-Header

3.2.8 Thermostat Element Replacement

Thermostat is provided in the cooling circuit to attain the stable coolant temperature as quickly as possible. Normally the thermostat does not require any regular maintenance. However, if sudden coolant temperature variation is observed, inspect the thermostat element. If the element is not resting properly on its seat or if there is any other defect in the thermostat element, it is advisable to replace it. Refer Fig. C3.13

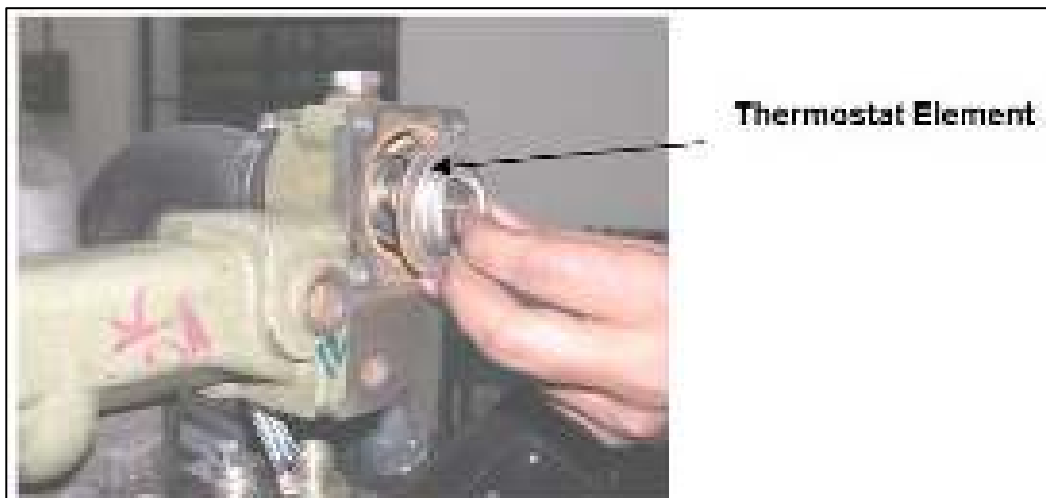


Fig. C3.13 Thermostat Element

3.2.8 Water Pump

G series engine have gear driven water pump. A weeping hole is provided on the crankcase for the water to leak out. In an unlikely event of water coming out of weeping hole, immediately stop the engine and inform service dealer for changing of pump seal or sealing ring. Refer Fig. C3.14



Fig. C3.14 Water Pump

3.2.10 Cleaning the Radiator / CAC

Radiator / CAC have to be cleaned every 500 hours. This frequency can vary depending on the dust condition in the area of installation, application and environment. Blowing compressed air in the direction opposite to the normal fan airflow direction cleans radiator. Do not use water or chemicals. These can harden the deposits into very hard cake-like formations, which are very difficult to dislodge.

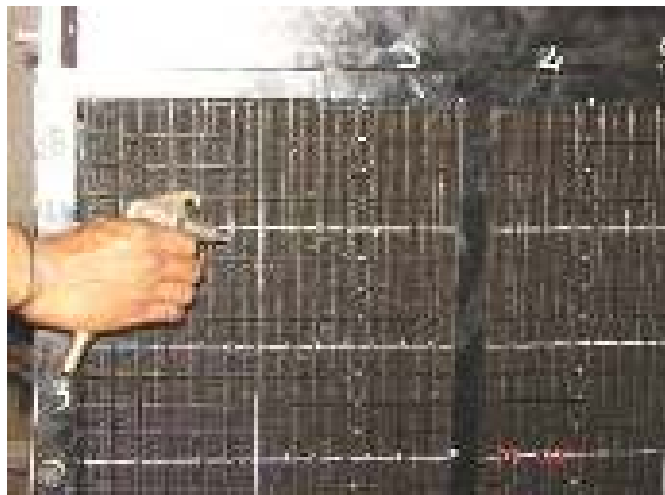


Fig. C3.15 Cleaning the Radiator

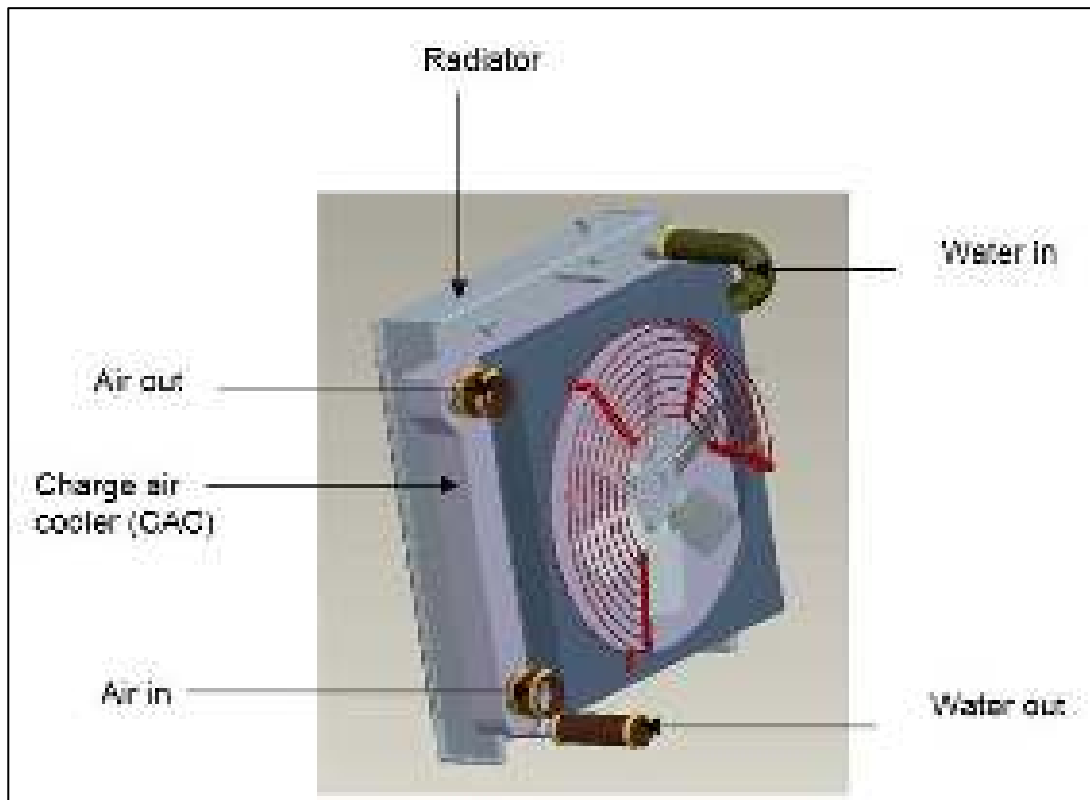


Fig. C3.16 Computer Model of Radiator Charging Air Cooler Arrangement

3.3 Fuel System

3.3.1 G Series Engine Fuel System

Engine must be operated with good quality diesel. Preferred quality specifications are (IS: 1460 2005) - Cetane 51, Sulfur 0.015% Max, Density 0.825gm/cc. G11 series engine uses inline mono-block high pressure fuel injection pump, with multi-hole mechanical injectors. It is provided with a feed pump and double element fuel filter. The system is calibrated to deliver performance and meet emission norms. Since the high pressure injection system is used on this engine, gravity flow of fuel from fuel tank to fuel injection pump (FIP) is recommended. The fuel tank height can be up to three meters (to be recommended by installation / service engineer), it can also be below FIP provided suction head is up to one meter. FIP and injectors are supplied by BOSCH and warranty is covered. Servicing the fuel system must be carried out by highly skilled personnel. This has to be done by authorized service agency or shop.

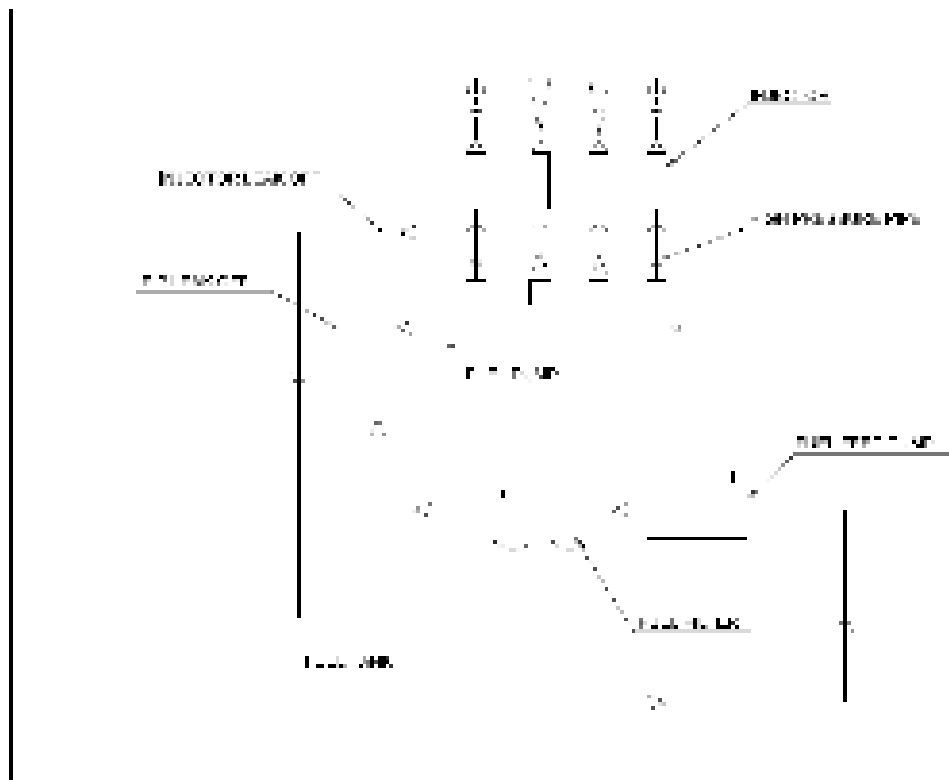


Fig. C3.17 Circuit Diagram of Fuel System

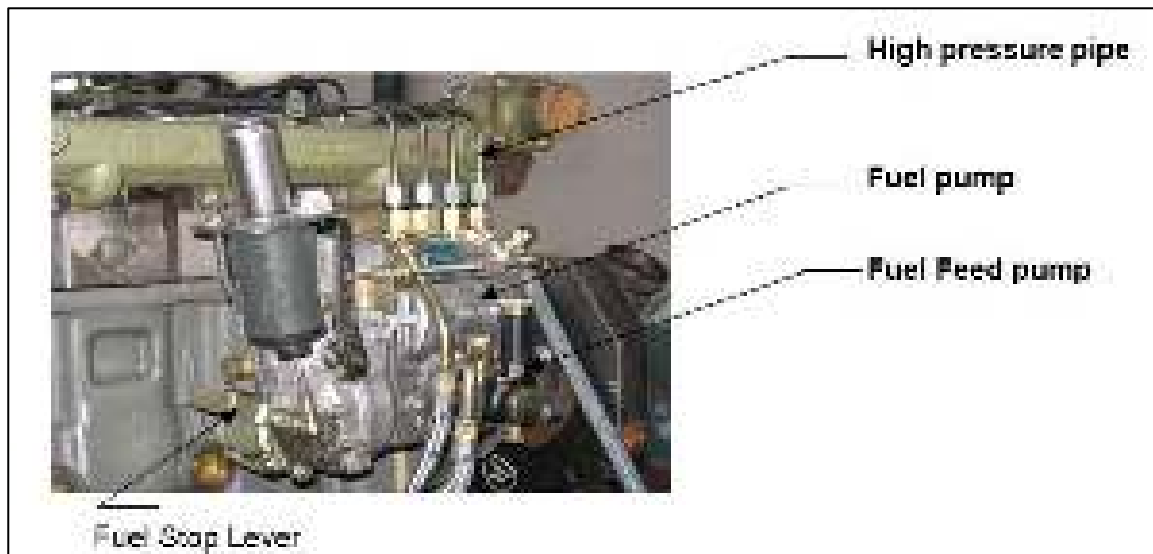


Fig. C3.18 Illustration of Fuel System

3.3.2 Trapped Air Removal from Fuel System

Bleeding of delivery pump needs to be performed under following conditions;

- i. Before engine operates for the first time.
- ii. After long period of preservation.
- iii. If FIP or HPP loosened and there is air in the line.

Bleeding process is mentioned as below; (Refer Fig. C3.19)

- i. Unscrew feed pump knob.
- ii. Loosen fuel inlet banjo.
- iii. Pump manually, till fuel comes through the screw free of air, later on Knob may be relocked.



Fig. C3.19 Illustration of Air Removal from Fuel System

3.4 Electrical System

3.4.1 Starter / Alternator

Electrical system is provided with the engine including a 12/24 Volts starter and an alternator. Refer illustrations below.



Fig. C3.20 Starter Motor



Fig. C3.21 Alternator

3.4.2 Electrical Control Panel

For details, please refer Section E of this manual.

3.4.2 Battery

Even though battery is an optional item during purchase, but recommended specification of the same is 12 Volt / 24 Volt (optional), 88 Amp-Hrs.



Fig. C3.22 Typical Battery



Chapter 4 Engine Operation

4.1 Standard and Typical Operating Condition

Standard Operating Conditions				
Sl. No.	Parameters	Unit	Value	Remark
1	Ambient temperature (ISO 3046)	°C	25	-
2	Relative humidity (ISO 3046)	%	50	-
3	Altitude (ISO 3046)	Above mean sea level	100	-
4	Ambient temperature at which de-aeration will be applicable	°C	35	For turbocharged after cooled engines
5	Relative humidity at which deration will be applicable	%	85	For turbocharged after cooled engines
6	Altitude at which deration will be applicable	Above mean sea level	1000	For turbocharged after cooled engines
7	Minimum temp at which engine can be started without starting aid	°C	2	-
8	Air cleanliness for standard dry air cleaner	mg/m3	25	At 1.5 m above ground in normal industrial area or agricultural land on a wind less conditions
9	Inclination in both directions	Degree	< 1	For GENSET Application

Table C4.1



Typical Steady State Operating Parameters				
Sl. No.	Parameters	Unit	Value	Remark
1	Lube oil pressure	bar	3.5-4.5	-
2	Lube oil temperature	°C	85-100	-
3	Water temperature	°C	78-85	-
4	Suction depression (new air cleaner element) Max.	mm WC	150	-
5	Suction depression (clogged air cleaner element) Max.	mm WC	250	250 mm for new filter, max 550 mm choke limit
6	Exhaust back pressure	mm Hg	25	-
7	Steady state rpm variation	RPM	5	-
8	Max fuel suction lift	Meter	1	-
9	Typical fuel temperature	°C	35 - 39	-

Table C4.2

4.2 Starting the Engine

4.2.1 Safety Instructions

- i. The legal regulation for safety must generally be observed.
- ii. The engine may only be operated or maintained by trained staff.
- iii. Ensure sufficient ventilation in engine room.
- iv. Cleaning maintenance and repair should be done when engine is stopped and secured.



Fig. C4.1



4.2.2 First Time Start after Engine Installation

- i. Check all electrical, fuel, exhaust and other connections.
- ii. Check that all critical fasteners are tightened. (Flywheel coupling, foot mounting, AVM bolts, crank pullet bolts, etc.) Check engine alignment and mounting on foundation.
- iii. Engine is filled with Lube oil through the filler neck. Oil to be filled at desired level to be checked with dipstick. Confirm that engine has adequate coolant and oil. (Refer Fig. C4.1)
- iv. Confirm that air bubbles have been removed from fuel and coolant circuit. (Refer Fig. C4.2 (a) & (b))
- v. Check belt tension and make adjustments, if required. (Refer Fig. C4.3)
- vi. Confirm the battery condition.
- vii. Confirm that all necessary safety guards are in place.
- viii. Confirm if all safety precautions have been taken.
- ix. Confirm that the electrical breaker is in OFF position.

Note: Sudden loading of the engine from 0 to 100% of rated load is to be avoided for turbocharged and turbo after cooled engine. In turbo after cooled engines sudden loading is limited to 45 to 50 % of the rated power as per ISO 8528. Never try to start the engine on load.

- i. Start the engine and run on no load for 5 to 10 minutes.
- ii. Observe abnormalities like noise, vibration, rattling brackets, leakages, etc.
- iii. Check oil pressure. Confirm that all the meters are working.
- iv. Confirm that everything is OK and then slowly load the engine.
- v. The engine is provided with a battery-charging alternator.
- vi. During the normal running of the engine, the charging lamp should be OFF.
- vii. If the battery-charging lamp turns ON during engine running, it is an indication that the battery is not getting charged. Check the circuit and take corrective actions.



Fig. C4.2 (a)



Fig. C4.2 (b)



Fig. C4.3 Inspection & Checking of V Belt Tension

4.2.3 In Case of Key Start



Fig. C4.4 Engine Control Panel



Auxiliary Power Business

For starting the engine turn the key from “OFF” to “ON”. This will light up the battery voltage gauge and the pilot lamp will light up. Turn the key further to start ignite the engine, when the engine picks up speed, release the key.

Note:

- a. Wait for 20 to 30 seconds between 2 startup attempts.
- b. Do not turn the key when the engine is running.

4.2.4 In Case of Push Button Start

Press the push button. Release immediately when the engine picks up speed.

Note:

- a. Do not push the button when the engine is running.
- b. Wait for 20 to 30 seconds between 2 startup attempts.

4.2.5 Auto Mains Failure (AMF) Startup

- i. In case of Auto Mains Failure (AMF) mode operation of power generation application, the engine starts automatically when the grid power fails.
- ii. It is extremely important to inform everybody that GENSET is in AMF mode.
- iii. Access to area nearby GENSET should be avoided as the engine can start automatically without notice.
- iv. In case of maintenance, it is necessary to put the engine in non-AMF mode and remove battery cables before starting maintenance.

4.3 Stopping the Engine

- i. Remove the load from the engine.
- ii. Run for 2 minutes to stabilize the temperatures. Recommended for turbocharged and turbo after cooled engines.
- iii. Push the stop button to stop the engine.
- iv. The engine can also be stopped manually by turning the stop lever on the fuel pump (Refer Fig. C4.5).
- v. Turn the key to “Off” mode so that battery does not get depleted / discharged.



Fig. C4.5

4.4 Safety Stop

The engine will automatically stop in case of certain safety conditions like;

- a. High water temperature
- b. Low lube oil pressure

Check the reason for this event before trying to restart. Do not restart; till the event is completely explained and corrective action is taken. Never bypass safety or try to change their operating limits.

4.5 Running-In

A good running-in will ensure long life for the engine. During the first 50 hours of running, do not load the engine suddenly and restrict the load to 80 %. After 50 hours, the engine can be loaded suddenly (Typically a sudden load of 45 % of the rated load is allowed as per ISO 8528) and full load can be applied. After 100 hours carry out the following actions:

- i. Change oil,
- ii. Change lube oil filter cartridge,
- iii. Change fuel filter elements,
- iv. Change fuel filter on feed pump (Button filter or sediment bowl),
- v. Check belt tension and correct it, if required,
- vi. Check tappet clearance and correct it, if required,
- vii. Check engine for leakages and tighten the fasteners, if required.

Take corrective action if abnormal noise, vibrations are observed. Now the engine is ready for its long life.



Chapter 5 Service & Maintenance

5.1 Maintenance of Lube Oil System

5.1.1 General

Oil change periods depend on the engine usage, application, installation and quality of fuel and lube oil. It is necessary that oil should be changed at least once in six months, if the engine use is less than specified, oil change period varies. For GENSET applications, it is necessary that the engine be installed on level horizontal plane area (Angle 1 deg. max). For trolley mounted GENSET transitional angle of 12 deg. is acceptable. However, GENSET should never be run in an inclined position on continuous basis.

	3G11	4G11	6G11
Sump capacities	8 Liters	10 Liters	17.5 Liters

Table C5.1

Oil change period	First oil change after 60hr.,Next oil change refer topic 5.10
Oil filter change period	Refer topic 5.10
Steady state lube oil pressure	3.5 - 4.5 bar
Steady state lube oil temp	85-105° C
Lube oil consumption	0.3 % of fuel consumption

Table C5.2

For lube oil viscosity recommendation, refer table C5.3

Ambient Temperature (Deg. C)	Grade of oil
-20 to + 20	SAE 10 W 30
-10 to +55	SAE 15 W 40
-5 to +45	SAE 20 W 40

Table C5.3

5.1.2 Changing Lube Oil



Fig. C5.1 Illustration of Drain Plug Removal

After the scheduled oil change period, oil should be changed irrespective of the oil condition. In this period, the chemical properties of the oil are depleted. This is not visible to naked eye or cannot be judged by experience or feel. Start the engine and run it till it gets warmed up. When the oil temperature reaches 70 to 80 °C, stop the engine. Place a tray under the sump and open the drain plug. (as illustrated in Fig. C5.1)

Please note here that the oil is hot. Drain the oil completely. (Wait for approximately 20 minutes). Refit the drain plug. Remove the oil filter and drain it. Fill up the oil filter with fresh specified oil from sealed pack and refit the oil filter. (Refer figure C5.4) Open the oil-filling cap. Take required quantity of specified oil from a sealed package. Pour in the lube oil through a funnel, after a specified quantity is filled up; confirm the oil level by dipstick. (Refer figure C5.3) and fit back the oil filler cap. (Refer Fig. C5.2) Dispose-off the used oil in an eco-friendly way.



Fig. C5.2 Illustration of Lube Oil Cap Refitting



Fig. C5.3 Illustration of Checking Oil Level with Dip-Stick



Fig. C5.4 Illustration of Replacing Lube Oil Filter



5.1.3 Checking the Oil Level

This is preferably done before starting the engine. If the engine is running, then stop it and wait for 30 minutes (for an accurate measure of oil level). Routine checking can be done in a few minutes after stopping the engine. Lube oil sump capacity is seven liters at mean dipstick marking. Fill the oil till upper level mark without exceeding it. Do not operate engine with oil level below lower mark. Remove dipstick and wipe it. Re-insert the dipstick till it rests on the collar. Remove the dipstick and observe the oil level. If the level is between low mark and high mark, oil level is ok. If level is below low oil level mark, fill up oil at least to between low and high oil marks. If the oil level is above high-level mark, then drain the oil and bring the level back to high level. More oil in the sump than required is not only a waste; in extreme cases it is injurious for the engine.

5.1.4 Changing Oil Filter

- i. This operation is done preferably a few hours after the oil is changed.
- ii. G series engines use spin-on type oil filters.
- iii. Clean up the lube oil filter area on the engine.
- iv. Remove the oil filter cartridge.
- v. A commercially available strap type tool can be used to remove and re-fit the oil filter cartridge. The cartridge has oil in it and has to be stored carefully to avoid spillage.
- vi. Take a new genuine oil filter cartridge. Fill up fresh specified oil from sealed package into the oil filter cartridge. Fit it as per instructions given on filter.

Note: Never try to clean up a cartridge and re-use. This causes severe injury to the engine.



5.2 Maintenance of Fuel System

Use only clean fuel, without water or particulate suspension, impurities etc. Maintain the fuel tank full reducing possibility of air and condensation entering the system. Bleeding of delivery pump must be done if,

- i. Engine operates for the first time.
- ii. If engine is idle for long time.
- iii. If High Pressure Pipe lines are loosened.
- iv. If air is trapped in the system between fuel tank and feed pump connecting flexible pipe.

5.2.1 Fuel Filter

To protect the FIP and Injectors, fuel filter is provided before FIP. If the filter element is contaminated then it needs to be replaced. (Refer Fig. C5.5) Changing fuel filter cartridge follows the procedure as mentioned below:

- i. Close the fuel cock.
- ii. Loosen the filter cartridge with strap wrench.
- iii. Coat the seal of the new filter cartridge with fuel.
- iv. Screw the filter cartridge in filter head down to the seal, then tighten by $\frac{1}{2}$ turn.
- v. Bleed the fuel filter.



Fig. C5.5 Fuel Filter Illustration

5.2.2 Fuel Strainer

Fuel feed pump is mounted on FIP. It has a fuel strainer, which needs cleaning periodically. Remove banjo bolt below feed pump at the inlet. Unplug screw to take out the strainer. Clean the strainer with diesel and refit the assembly.

5.2.3 Fuel Injection Pump

It is recommended that Fuel Injection pump servicing is done by BOSCH authorized service agent / personnel at authorized service center preferably through Greaves service personnel.

5.2.4 Injector NOP (Nozzle Opening Pressure) Adjustment

Injector servicing needs to be done by authorized service personnel. Hence this needs to be brought to the authorized service station for servicing and setting. (Refer Fig. C5.6)



Fig. C5.6 Typical Nozzle Testing

5.2.5 Dry Type Air Cleaner

The element in the air cleaner needs to be replaced or serviced, when maximum allowable restriction has been reached. Remove the filter element gently. It is recommended to replace the filter element once used. But only in exceptional cases the filter element is to be blown out in longitudinal direction and then inside. Re-assemble the element after careful inspection and confirmation for reuse. (Refer Fig. C5.7 & C5.8)



Fig. C5.7 Air Filter



Fig. C5.8 Air Filter Element

5.3 Inspection & Checking of V-Belt Tension

Ensure that the belt tension is correct by pressing it with finger or thumb as shown in Fig. C4.3. Deflection needs to be 5 to 8 mm. It can be adjusted at the alternator adjustor. Operate the engine with new belt for five to ten minutes and then adjust the belt tension.

5.4 Checking & Adjustment of Valve Clearance

Adjust the valve clearance when engine is in cold condition. Adjust the clearance with piston at top dead center and ensure that both valves are closed. Clearance is 0.4 mm for both inlet and exhaust valves. (Refer Fig. C5.9)



Fig. C5.9 Checking & Adjustment of Valve Clearance

5.5 Flywheel Run-Out (Refer Fig. C5.10)

Inspection of flywheel run-out may be carried out as follows.

- i. Flywheel run-out on face: 0.2 mm.
- ii. Flywheel coupling mounting bore run out w.r.t. Crank shaft axis 0.10 mm max.



Fig. C5.10 Inspection of Flywheel Run-Out

5.6 Timing Gear



Fig. C5.11 Timing Gear

Except water pump and oil pump gear, all other gears in the gear train has timing markings, which need to be aligned to get correct fuel injection and valve timing. FIP gear has kidney slots and it is mounted on coupling flange on FIP shaft with four bolts. The finer adjustment of injection timing can be made by loosening these bolts and turning FIP shaft as required in any desired direction. Match idler gear mark '0' with crank gear mark '0'. Locate cam gear in dowel & ensure matching of mark '1' on cam gear with mark '1- 1' on idler gear.



5.7 Maintenance of Cooling System

The engine cooling system contains gear driven water pump, cooling passages on the engine and cylinder head, water manifold, thermostat, radiator, fan and lube oil cooler (which is cooled by engine water). The water used should be clean, free from dirt or dust, floating matter, colorless, without smell. Add Greaves supplied coolant in correct proportion for efficient cooling of the system. Bad water can cause severe corrosion. These corrosion products can block cooling system and severely damage the engine. Hard water can completely chock up the cooling system with scale formation, salts, sulfates and other compounds. This can cause engine seizure. Never use concentrated acidic compounds or soda lime to clean up the cooling system.

5.8 Battery Checking Instructions

The battery is of lead acid type. After 150 hours of running it should receive the attention as mentioned follows:

- i. Brush the dirt from the battery.
- ii. Remove the vent plugs.
- iii. Check the level of Acid.
 - a. The acid in each cell should be kept in level with the top of the separators. Top up, if necessary, with distilled water. Do not allow distilled water to come in contact with metal, use only the glass or earthenware container and funnel.
 - b. Do not bring a naked light bulb near when plugs are removed or when the battery is on charge, as the gas given off by the acid is highly inflammable.
 - c. The charge of the battery can be checked with hydrometer which shows specific gravity of the electrolyte. This varies with the state of the charge. Check the specific gravity of the acid with a hydrometer. When charged the specific gravity should be as follows:

A	B	C
At climates below 80°F (27°C) specific gravity corrected to (60°F) (16°C)	At climates between 80°F & 100°F (27°C - 38°C) specific gravity corrected to (60°F) (16°C)	At climates over 100°F (38°C) specific gravity corrected to (60°F) (16°C)
1.28-1.30	1.25-1.27	1.22-1.24

Table C5.4

Auxiliary Power Business

When the hydrometer is as low as 1.25 for “A”; “1.20” for B; and “1.18” for “C” the battery must be charged as soon as possible, either by the engine or from an independent source.

- i. Clean the vent plugs and free their air passages.
- ii. Ensure that the terminals are free from corrosion. If corrosion has taken place, the terminal should be disconnected from the battery and the corrosion scraped off. Wipe with a rag moistened with weak ammonia or bicarbonate of soda solution. The terminal should be bolted tightly on the terminal posts and coated with petroleum jelly (no grease).

Please note that while engine is supplied it would be charged on low amperage or slow charge from authorized battery maintenance / repair shop. Time required for initial battery charging is approximately 48 Hrs. Always use battery full charged while commissioning of engine.

5.9 Some Assorted Maintenance Jobs

- i. Starter and alternator brushes to be replaced, if worn out to unacceptable level.
- ii. To clean exhaust, silencer and piping for dirt.
- iii. Fuel tank to be drained to remove sediments or cleaned at regular intervals.
- iv. Check and tighten fasteners, if required at regular intervals.

5.10 Electronic Governor and Actuator Fitment (Optional)



Fig. C5.12

Engine speed is sensed by magnetic pickup sensor. This sensor is used by electronic control unit to give signal to rotary actuator to control speed regulating lever of fuel injection unit to control the speed of engine at 1500 rpm for 50Hz GENSET.



5.11 Maintenance Schedule

Sl. No.	Maintenance Description	Maintenance Schedule								
		Daily	60 Hrs.	500 Hrs.	1000 Hrs.	1500 Hrs.	3000 Hrs.	3500 Hrs.	10000 Hrs.	Others
1	Check oil level in Sump	**								
2	Check Belt tension	**								
3	Check Fuel level in tank	**								
4	Check water level in radiator	**								
5	Check Battery condition	**								
6	Clean coarse fuel filter		**	**	**	**	**	**	**	Every 500 Hrs.
7	Change air filter element			**	**	**	**	**	**	Every 500 Hrs.
8	Change filter on the feed pump			**	**	**	**	**		
9	Change oil filter cartridge		**	**	**	**	**	**		
10	Change fuel filter cartridge		**	**	**	**	**	**		

Auxiliary Power Business



Sl. No.	Maintenance Description	Maintenance Schedule								
		Daily	60 Hrs.	500 Hrs.	1000 Hrs.	1500 Hrs.	3000 Hrs.	3500 Hrs.	10000 Hrs.	Others
11	Changing oil		**	**	**	**	**	**		
12	Cleaning up radiator fins			**	**	**				
13	Checking up valve clearance and set if necessary		**	**	**	**	**	**		First re-set valve clearance after 60 hours of running.
14	Tightening up external fasteners				**		**			Check regularly
15	Clean injector, nozzles and spray Change if necessary				**		**			
16	Cleaning up fuel tank				**		**			Or at least once in a year
17	Cleaning up exhaust silencer							**		Or at least once in a year
18	Checking exhaust bellows and change if necessary							**		After 3500 Hrs.
19	Checking valve and insert condition, change if necessary							**		

Auxiliary Power Business



Sl. No.	Maintenance Description	Maintenance Schedule								
		Daily	60 Hrs.	500 Hrs.	1000 Hrs.	1500 Hrs.	3000 Hrs.	3500 Hrs.	10000 Hrs.	Others
20	Calibrating fuel pump								**	To be done by Bosch Authorized Dealer
21	Changing valve stem seals if leakage observed								**	If leakage is observed
22	Changing gear end and flywheel end oil seals								**	Whenever the oil leakage is observed
23	Changing thermostat element								**	
24	Changing cylinder head gaskets								**	
25	Changing air / exhaust / water manifold / thermostat housing gaskets								**	
26	Checking sensors and change if necessary								**	
27	Overhauling starter and alternator								**	
28	Checking and changing AV mounts if required								**	

Auxiliary Power Business



Sl. No.	Maintenance Description	Maintenance Schedule								
		Daily	60 Hrs.	500 Hrs.	1000 Hrs.	1500 Hrs.	3000 Hrs.	3500 Hrs.	10000 Hrs.	Others
29	Replace radiator cap with rubber ring							**		
30	All hoses and hose clips								**	
31	Changing main bearings if required								**	
32	Changing CON ROD big end and small end bearings if required								**	
33	Changing set of gaskets and O rings								**	
34	Changing water pump if required								**	
35	Changing valves, valve guides and valve seat inserts if required								**	
36	Changing high pressure pipes								**	
37	Changing injectors if required								**	
38	Changing liners if required								**	
39	Changing piston assembly if required								**	

Auxiliary Power Business



Sl. No.	Maintenance Description	Maintenance Schedule								
		Daily	60 Hrs.	500 Hrs.	1000 Hrs.	1500 Hrs.	3000 Hrs.	3500 Hrs.	10000 Hrs.	Others
40	Checking and changing con rod small end bush if required								**	
41	Changing fuel pump elements if required								**	To be procured from Bosch authorized dealer
42	Checking all critical fasteners and replace if necessary								**	
43	Checking fan drive assembly							**		
44	Add coolant additive			**	**	**	**	**	**	Every 500 hrs.
45	Replace cooling water and additive						**			
46	Change belt							**		
47	Check engine protection system				**		**		**	



Auxiliary Power Business

Note:

- i. This schedule is applicable only when Greaves Maxtherm oil and coolant are used.
- ii. Typical or usual change periods are maximum periods. Depending on the local conditions, these may have to be shortened. Set up your own maintenance frequency with experience, based on the site conditions.
- iii. Never re-use following items
 - a. Cylinder head gasket,
 - b. Copper washers,
 - c. O-rings,
 - d. Valve stem seals,
 - e. Oil seals,
- iv. Top and major overhaul depends on the type of loading, quality of installation, quality and regularity of maintenance, etc., the above mentioned intervals are typical periods. Users should keep a close watch on their engine installation to see the signs of service requirement. It is also advisable to get the engine overhauled in lean operation period or ahead of a heavy season of running.
- v. Major overhaul should be carried out at 10000 hours or 7 years whichever is earlier. Carry out all activities of top overhaul also. Except rubber parts and gaskets if metal parts can be reusable then need not be replaced based on condition of the parts.



CAUTION! Kindly check the centrifuge type lube oil filter at every service interval. If you find any cake formation then clean it thoroughly and refit it once again.



Chapter 6 Engine Preservation

6.1 Engine Preservation during Prolonged Period of Non-usage

If the period between engine dispatch from Greaves and the installation is more than six months or if engine is to be non-operational for more than twelve months, the engine has to be preserved to avoid damage due to corrosion, dust, and other factors. Preferably a preserved engine should be covered in plastic sheet and stored in cool dry, shaded place.

Following instructions are to be followed for engine preservation:

- i. Run the engine with clean fuel at rated speed at no load for about 10 minutes. This warms up the engine and the lube oil is circulated all over inside the engine.
- ii. Stop the engine and immediately drain the oil. Fill up the engine with one of the preservative oils to the low level mark on dipstick. Choose preservative oil from the list given below.
- iii. Run the engine at rated speed with no load for 5 minutes.
- iv. Make a clean solution of preservative oil and diesel (1: 5 ratio) and connect the mixture to the fuel pump inlet by gravity feed.
- v. Drain the coolant from cooling system. Rinse the system thoroughly with clean water. Fill the cooling system with mixture of water and any of the coolant additives listed in the requisite ratio.
- vi. Crank the engine and run it at rated speed with no load for half a minute. Stop the engine.
- vii. Remove air cleaner, fuel filter and lube oil filter, pack them separately.
- viii. Drain preservative oil from sump and refit the drain plug. Drain Water-preservative mixture from cooling circuit. Treat all unpainted open surfaces with rust preventive coats.
- ix. Seal all openings with caps, plastic sheets or waterproof paper. Seal the dipstick with the tape.
- x. After this point do not rotate the engine.
- xi. Remove belts and store separately.
- xii. The battery should be disconnected. Ensure electrolyte level. Charge the battery at regular intervals.
- xiii. Put a mark on the engine indicating date of preservation.



Auxiliary Power Business

- xiv. Periodically inspect the engine for corrosion, effects of humidity and dirt.
- xv. The above procedure has to be repeated after every 12 months.

Manufacturer	Rust Preventive	Cooling System	Lube Oil and Fuel Circuit
Bharat Petroleum	Bharat Rustol 152	Bharat Sherol B emulsion with water (1: 20 ratio)	Bharat Preserve oil 30
Indian Oil Corporation	Servo RP 125	Servo Cut S 20% Emulsion with water	Servo preserves 30. Servo Run-N oil 30
Hindustan Petroleum	Rustop 274	Koolkit 40.5% emulsion with water	Auto run T 120
Veedol	Veedol Rustop IT	Veedol Amulkut 4 Emulsion with water 1:15	Veedol 30/40

Table C6.1 Recommended Preservatives

6.2 Putting a preserved engine back into operation

- a. Remove all seals. Clean up the engine. Remove rust preventive coat.
- b. Fit air cleaner, fuel filter, Lube oil filter, and belts.
- c. Use new filter elements. Apply correct tension to the belts.
- d. If rubber components (Hoses, belts, etc.) are cracked or have become brittle, then replace them.
- e. Fill up correct grade lube oil up to the high level mark on dipstick.
- f. Fill up coolant. Remove trapped air.
- g. Connect supply of clean fuel. Remove trapped air.
- h. Fit a charged battery. Check the electrical connections.
- i. Run the engine at rated speed at no load for 5 minutes. Observe and look for any irregular noise, vibration, etc. If some irregular behavior is observed take corrective actions or call authorized service dealer.
- j. If everything found operative and functional then start the engine and put it into service.



Chapter 7 Installation Do's & Don'ts

Installation do's

- i. Install the engine on horizontal, hard area. This area should be properly ventilated. It should have access to maintenance areas.
- ii. All the mounting structure should properly rest on the ground.
- iii. Check with civil engineers and architects before mounting the engine on slabs, beams, raised structures, above ground floor, etc.
- iv. Check fire hazard possibility near fuel, oil storage.
- v. Plan release direction of the exhaust.
- vi. Judge engine size properly. Seek help from Greaves service dealers or area offices for this purpose.
- vii. Provide adequate safety measures around installation area.

Installation don'ts

- i. Never install the engine on inclined surface.
- ii. Remember that a good installation reduces running cost, maintenance cost, provides reliable and safe service.



SECTION D

ALTERNATOR



SECTION D - ALTERNATOR

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Chapter 1 Crompton Greaves Alternator

1.1 General Information

The Crompton Greaves Alternator's incorporate advanced European technology and are designed for optimum performance using the most accurate methods of design, manufacturing and testing. If the alternators are used as per recommendations in this manual, you are ensured with a continuous working and a prolonged trouble-free life of the alternator.

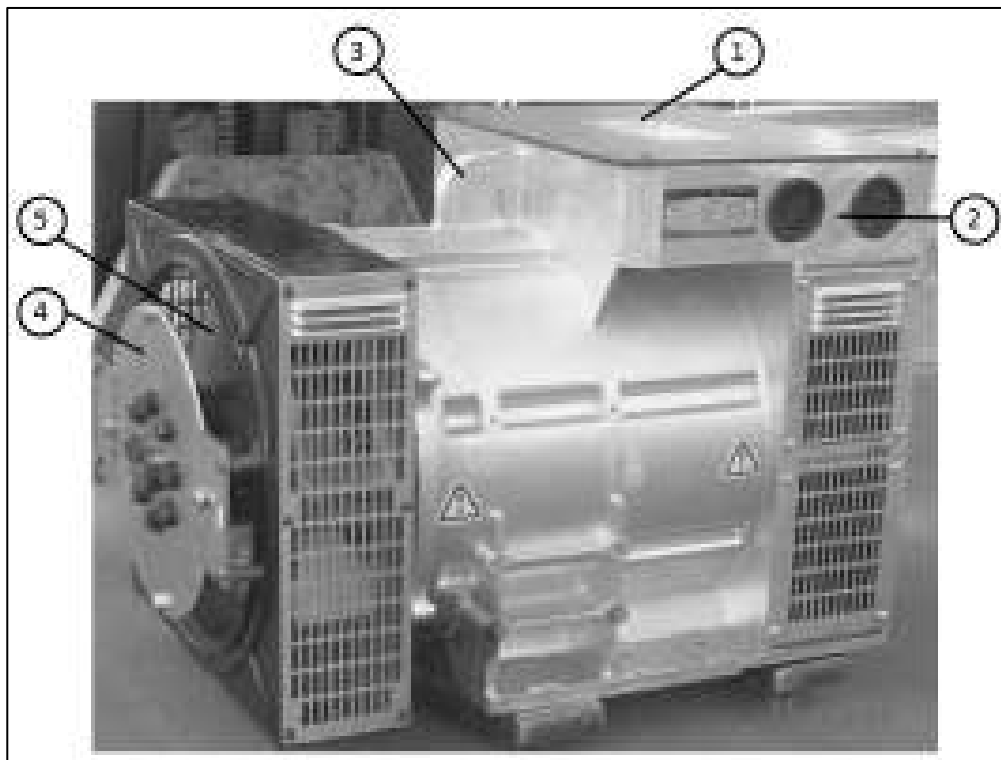


Fig. D1.1 Illustration of Crompton Greaves Alternator

1	Terminal Box Cover	4	Coupling Disk
2	Terminal Board	5	Fan
3	Eye Bolt		



1.2 Specifications

Specifications	Standard	Optional
Rated Voltage	415 V in 3 phase 240 V in 1 phase	Up to 600 V in 3 phase Up to 300 V in 1 phase
Terminals	6 leads	Reconnectable 12 leads
Voltage Regulation	±1%	-
Speed	1500 rpm	1800, 3000, 3600 rpm
Insulation Class	Class 'H'	Class 'F'
Type of Mounting	B3, B2	SAE No.: 0, 1, 2, 3, 4, 5 Disc: 18", 14", 11.5", 10", 8", 7.5"
Degree of Protection	IP 21	IP 23
Duty Rating	Continuous (S1)	-
10% Overload	1 Hr. in 12 Hrs.	-
Parallel Operation provision	> 200 KVA	< 200 KVA
Harmonic Distortion Factor NL L-L	< 2.5%	-
Max. Unbalanced Load	25%	-
TVD at Full Load 0.8 p.f.	15-20%	-
TVR at Full Load 0.8 p.f.	20-25%	-

Table D1.1 Alternator Specification (CG Make)

1.3 Operating Conditions

The alternator is rated for maximum ambient temperature of 40°C and altitude of 1000 meters above sea level. If the ambient temperature exceeds 40°C, a deration factor of 4% should be applied for every 5°C rise in temperature. If the altitude is higher than 1000 meters, a deration factor of 4% should be applied for every 500 meters increase in altitude.



1.4 Ratings Chart

Single Phase Series			
Brushless AC Generators - Voltage Regulation $\pm 1\%$			
kVA	Frame (G2R/G1R)	% Efficiency	
		FL	3/4 FL
1 Phase, 230V, 50 Hz, 4 Pole, 1500 RPM, 0.8 pf			
35	200SC	87.2	87.8
40	200SD	88.0	88.4
Three Phase Series			
Brushless AC Generators - Voltage Regulation $\pm 1\%$			
kVA	Frame (G2R/G1R)	% Efficiency	
		FL	3/4 FL
3 Phase, 415V, 50 Hz, 4 Pole, 1500 RPM, 0.8 pf			
35.0	200SE	87.9	88.4
40.0	200SE	88.1	88.8
45.0	200SA	89.0	89.7
50.0	200SB	88.5	89.2
55.0	200SB	89.5	90.2
62.5	200SC	90.6	90.9
75.0	200MB	90.9	92.0
82.5	200MD	90.5	91.2
90.0	200MDX	91.5	92.0
100	250SB	90.8	91.2
110	250SD	92.5	93.0
125	250SD	92.3	92.8
140	250MA	92.3	92.8
150	250MB	92.3	92.9
160	250MB	92.5	93.0
180	250LB	92.9	93.6
200	250LD	93.1	93.7
225	315SE	93.3	93.8
250	315SE	93.2	93.9

1.5 Features

1.5.1 Mechanical Features

- i. Aluminium frame die-cast stator up to 200 KVA and steel stator for higher frames.
- ii. Sturdy cast iron end shields fixed on to the stator frame by 8.8 class high tensile screws.
- iii. High quality steel shafts are amply designed to take care of overload and short circuit condition.
- iv. Sturdy, dynamically balanced rotors are designed for withstanding the runaway engine speed and are with continuous damper cage for high performance under strenuous conditions of parallel operations and non-linear (thyristor) and unbalanced loads.
- v. Aluminium fans for effective cooling extend the winding life.
- vi. Screens or louvered covers on all openings for safety.
- vii. Easy mount SAE Adaptors are offered with single bearing AC Generators to simplify coupling with all popular engines.

1.5.2 Termination

- i. Integral terminal box is provided for higher reliability.
- ii. Top terminal box with side cable entry ensures wiring flexibility.
- iii. Spacious terminal box accommodates all types, including aluminium cables.
- iv. Anti-loosening fasteners ensure stable cable terminations.
- v. Standard 6 leads for rated voltage and optional reconnectable 12 leads for different voltages in three phase AC Generators.

1.5.3 Automatic Voltage Regulator (AVR)



Fig. D1.1 Automatic Voltage Regulator (AVR)



Auxiliary Power Business

- i. Under speed protection with LED indicator.
- ii. Over excitation protection with LED indicator.
- iii. Designed for thyristor load without additional filter circuits.
- iv. Moulded construction for protection against shocks, vibrations and adverse atmospheric conditions.
- v. Under speed protection in AVR, protects both the Alternator and the v/f sensitive loads. The AVR has provision for setting the frequency below which voltage dropping occurs linear to speed. This feature also enables the engine to recover the speed faster during motor starting.

1.5.4 Winding and Insulation System

The armature coils of the stator main winding are made from dual coated, class H copper wires. Single layer concentric winding with $2/3^{\text{rd}}$ pitch offers simplicity, reduced overhangs, neat look while reducing voltage distortion and superior capability to cope with non-linear loads. The auxiliary winding in stator provides power to the AVR, improving the motor starting capability of the AC Generator.

The insulation system is class H. All wound components are impregnated in an unsaturated polyester resin of 200 class temperature. The impregnation provides much needed rigidity and protection against the harsh environment, typical for the AC Generators applications. With high mechanical strength provided to the rotating components, the AC Generators withstand over speed of 2250 rpm for 2 minutes.

1.5.5 Radio Interference

The alternator has negligible Radio Frequency interference and meets in general the limits permitted by VDE 0875 (N).

1.5.6 Waveform

The alternator is designed to give an excellent output waveform. The total harmonic content of line-to-line voltage waveform on no load is less than 5%, as per the limits specified by IEC/IS standards.

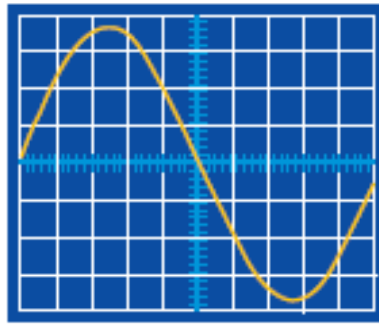


Fig. D1.2 Alternator Waveform

1.5.7 Overload

The alternator is capable of delivering an overload of 10% for one hour after every six hours of running.

1.5.8 Motor Starting Duty

Each kVA of AC Generator is capable of starting 1 HP of Induction Motor on direct on line starting.

1.5.9 Transient Voltage Dip

Sudden application of full load at 0.8 p.f. (lag) results in 15-20% dip in terminal voltage.

1.6 Safety Requirements

- i. Before any cleaning, lubrication or maintenance operation, ensure that the GENSET is stationary and disconnected from power supply.
- ii. While stopping the GENSET, ensure the compliance with the procedure for stopping the engine (prime mover).
- iii. Before installing the alternator, arrangements must be made to earth the engine in compliance with relevant electrical regulations.
- iv. For handling unpacked alternators, always use ropes having suitable carrying capacity and do not lift the alternator too much from the floor (max. 30 cm.)
- v. The alternator should be securely connected and perfectly aligned with the engine; otherwise unsafe vibrations may occur resulting in alternator bearing failure.



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- vi. The alternator is designed to ensure the rated output when it is installed in an environment having maximum ambient temperature of 40°C and at an altitude of 1000 meters. In case of deviation in any of these conditions, appropriate deration should be applied.
- vii. The operators in charge of the installations must be skilled technicians who know the characteristics of GENSETS.
- viii. The operator must always wear work gloves and safety shoes. In case the alternator or whole GENSET is to be lifted from the floor, the operators must wear safety helmet.
- ix. Make sure the GENSET foundation is suitable to bear the combined weight of the alternator and engine.
- x. No person should wear fluttering clothes (such as stoles etc.) near the engine and any such garment must be fastened with elastic bands at its ends.
- xi. Alternator must never and for no reason is run with following guards removed:
 - a. Terminal box cover
 - b. Rear cover
 - c. Fan ventilation guard
- xii. Alternators produce heat proportional to the output. Therefore, do not touch it if you do not wear anti scorch gloves, after switching it off, do not touch until it is cooled down.
- xiii. Even if all engine components are protected, keep away from the GENSET. Do not lean or sit on the alternator for whatever reason.
- xiv. The alternator should be cleaned only when it is not live and is at room temperature. It can be cleaned from the outside using compressed air.
- xv. Never use liquids or water for inside cleaning.

1.7 Electrical Checks

Before starting kindly make sure,

- i. The terminal nuts are properly tightened.
- ii. The control panel protection equipment is correctly set.
- iii. There is no short circuit due to wrong connections either/or in between the terminals of the alternator and the power switch or breaker (this part of the circuit is not protected by the breaker).



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1.7.1 Checking the Insulation Resistance

If the alternator has been stored under damp conditions or has taken a lengthy time in shipment, the insulation resistance must be checked. To check the insulation resistance follow the below mentioned procedure:

- i. Remove all external connections including neutral to earth link, if any from the alternator.
- ii. Connect a Megger of 500 V DC between any one AC output terminals and the magnet frame.
- iii. In case the test reveals an insulation resistance less than 2.0 M Ω (IR value at room temperature); identify the weak winding or component by step by step isolation.



Warning! If the Insulation Resistance (IR) is less than 2 M Ω then the alternator should not be operated.

1.8 Do's and Don'ts

1.8.1 Do's

- i. Tighten the foot mounting bolts.
- ii. Ensure that the alternator is properly grounded.
- iii. Ensure the tightness of terminal bolts.
- iv. Check that the body and neutral earthing is perfect.
- v. Check that the rating of alternator is matching the load requirement.
- vi. Check the voltage and phase sequence during commissioning.
- vii. All covers and guards should be fitted before starting the generator.
- viii. After servicing the alternator, make sure the connections are as per connection diagram.
- ix. Maintain and operate the GENSET correctly.
- x. Run the GENSET daily for at least 5-10 minutes on no load.

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1.8.2 Don'ts

- i. Do not load the alternator more than its capacity mentioned on the nameplate.
- ii. Do not operate the alternator at a power factor less than 0.8.
- iii. Do not start the GENSET on load.
- iv. Do not operate the GENSET without covers.
- v. Do not block the air inlet and outlet of the GENSET.
- vi. Do not keep excessive wiring lengths at the load end.
- vii. Do not expose the alternator to moist conditions.
- viii. Do not use under rated and low grade cables.
- ix. Do not operate the alternator if its Insulation Resistance is less than 2 Mega Ohms.
- x. Do not apply capacitive load.
- xi. Do not operate the GENSET with the field pole fasteners loose.

1.9 Maintenance

1.9.1 General

The frequency of maintenance depends largely on the site conditions. Frequent maintenance of approximately once a week should be practiced initially and the period extended as experience is gained.



Important Note! The alternator should be completely isolated from all electrically live wires before any electrical or rotating part is touched.

1.9.2 Cleaning

The alternator including the excitation unit should be cleaned internally by blowing out with a blow of dry air and by wiping away any deposits of grease and carbon dust with a clean dry cloth. All fasteners, especially the connectors should be inspected for tightness at regular intervals.



1.9.3 Bearings

The bearings used in the alternator are of sealed type and from reputed manufacturers. Thus they don't require greasing. The bearings are designed for approximately 40,000 hours of operation and should be replaced after that. However, in case high bearing noise is observed or leakage of grease is noticed, it is strongly recommended that the bearing to be checked and replaced immediately to prevent failure during running, as this could cause irreversible damage to the GENSET.

1.10 Troubleshooting

1.10.1 Electrical Failure Troubleshooting

When an electrical failure occurs, following should be checked:

- i. In order to find out if the failure has occurred in the alternator itself or in the regulation system, you should test the alternator on no load (at nominal speed), exciting the exciter stator directly using an external DC source.
- ii. When applying DC voltage to the exciter stator, you should comply with following polarities: apply negative (-) polarity of the auxiliary source to the negative terminal and positive polarity of auxiliary source to the positive terminal of exciter field.
- iii. Verify that when feeding the winding according to the excitation data at no load, the voltage supplied by the alternator is almost the rated one.

1.10.2 Troubleshooting Chart

Fault	Cause	Repair
No Voltage build-up	Insufficient residual voltage	Excite the rotor using a battery
	Improper connection	Correct the connection
	Low speed	Reset the speed to nominal
	Faulty winding	Check the winding resistance and rewind if required
	Rotating Rectifier failure	Replace the rotating rectifier
	Faulty AVR	Replace the AVR
Low Voltage on No Load	Low speed	Reset the speed to nominal
	Faulty rotating rectifier	Replace the rotating rectifier
	Faulty winding	Check the winding resistance and rewind if required



Fault	Cause	Repair
Low Voltage on Load	Low speed at full load	Set the rated speed of the engine
	Faulty AVR	Replace the AVR
	Faulty rotor winding	Check the winding resistance and rewind if required
	Overload on alternator	Operate on specified load
High Voltage on Load	Capacitors on the load side	Disconnect Power Factor improvement capacitors
	Faulty AVR setting or AVR faulty	Correct the setting/Replace the AVR
Too High Voltage on No Load	Excessive speed	Adjust the revolving speed
	Faulty AVR setting	Correct the setting/replace the AVR
Voltage Oscillations	Incorrect AVR setting	Set the AVR stability pot
	Thyristor load more than specified limits	Reduce the Thyristor load
Unbalanced Voltage	Unbalanced load	Correct the load
	Loose connections	Tighten the connections
	Stator winding faulty	Check the winding resistance and rewind if required
Excessive overheating of one or both bearings (temperature of bearings over 80°C) (with or without noise)	Set misalignment	Align the set properly
	Bearing loose in end shield housing	Replace the faulty end shield



Fault	Cause	Repair
Excessive overheating of alternator frame	Air flow (inlet/outlet) partially clogged or hot air is being circulated either from alternator or engine	Clean the inlet/outlet of the alternator
	Alternator operating at high voltage on load	Set the voltage at rated value
	Alternator overloaded	Operate at specified load
	Load power factor less than 0.8 lag	Correct the load power factor
Excessive vibrations	Defective mounting or play in the coupling	Replace the coupling and check the alignment. Reset the speed to nominal.
Excessive vibrations and humming noise coming from the alternator	Three phase alternator is loaded on one phase in excess of acceptable limits	Check and correct the load
	Start up with no load: if humming persists, faulty stator winding	Rewind the stator
Smoke, sparks or flames coming from the alternator	Short circuit in the external circuit (including wiring between alternator and control panel)	Stop the set immediately and rectify the short circuit
	Object fallen into the alternator causing short circuit or flash in the stator winding	Stop the set immediately and remove the object and check the alternator for further problems caused by the object

Table D1.2 Alternator (CG Make) Troubleshooting

Chapter 2 Stamford Alternator

2.1 General Information

This topic explains Stamford BC16/18 range alternators that are of brushless rotating field design, self-excited and self-regulated AVR controlled. However, optionally, as per requirement you can also order for alternators with any of the following variations:

- a. Double bearing
- b. Brush type
- c. Transformer controlled
- d. Class 'F' winding
- e. With PMG



Fig. D2.1 Stamford Alternator



2.2 Specifications

Specifications	Standard	Optional
Rated Voltage	415 V in 3 phase 230 V in 1 phase	Up to 690 V in 3 phase
Terminals	6 leads	Reconnectable 12 leads
Voltage Regulation	±1.5%	-
Speed	1500 rpm	1800, 3000, 3600 rpm
Insulation Class	Class 'H'	Class 'F'
Degree of Protection	IP 23	-
Duty Rating	Continuous	-
10% Overload	1 Hr. in 12 Hrs.	-
Harmonic Distortion Factor NL L-L	< 3%	-
Max. Unbalanced Load	15%	-
TVD at Full Load 0.8 p.f.	15% max at linear load	-
TVR at Full Load 0.8 p.f.	15% max at linear load	-



2.3 Ratings Chart

The alternator is rated for maximum ambient temperature of 40°C and altitude of 1000 meters above sea level.

Single Phase Series		
Brushless AC Generators - Voltage Regulation \pm 1%		
kVA	Frame	% Efficiency @FL
1 Phase, 230V, 50 Hz, 4 Pole, 1500 RPM, 0.8 pf		
35	UCI224E	79.0
40	UCI224E	79.0
Three Phase Series		
Brushless AC Generators - Voltage Regulation \pm 1%		
kVA	Frame	% Efficiency
3 Phase, 415V, 50 Hz, 4 Pole, 1500 RPM, 0.8 pf		
35.0	PI144H	87.6
40.0	PI144J	87.8
45.0	UCI224D	88.5
50.0	UCI224D	88.5
55.0	UCI224E	89.1
62.5	UCI224F	90.1
75.0	UCI224G	90.4
82.5	UCI224G	90.4
100	UCI274C	90.0
110	UCI274D	90.5
125	UCI274V	91.0
140	UCI274E	92.0
160	UCI274F	92.5
180	UCI274G	92.5
200	UCI274H	93.5
225	HCI 434C/444C	93.0
250	HCI 434C/444C	93.0



2.4 Construction

2.4.1 Stator Frame

The Stator frame is made of sheet metal which reduces the overall weight of the machine and is aesthetically better. The sheet metal enclosures are fixed on the steel bars welded on the stator core.

2.4.2 Stator Core

The stator core is made of high quality low content silicon steel stampings with C-4 coating for better welding of core packs. These are oriented 90 deg. After every one fourth length for better magnetic properties. The slots are skewed to reduce the tooth ripples in the voltage wave form.

2.4.3 Stator Winding

The armature coils are made from dual coated, class 200 copper wire & wound with a 2/3 pitch. The 2/3rd pitch winding eliminates the effect of triple n harmonics. This reduces the voltage distortion and increases the capability of the alternator to cope with non-linear loads.

2.4.4 Stator / Insulation System

The insulation system is class H. All wound components are impregnated in an unsaturated polyester resin with processes designed specifically to provide protection against the harsh environment encountered in the generator applications. Resins are selected and developed to provide the high build required for static windings and the high mechanical strength required for the rotating components. The rotating components can withstand on over speed of 2250 rpm for three minutes.

2.4.5 Rotor Core

The Rotor core is made of high quality low content silicon steel stampings. The poles carry continuous damper windings to facilitate parallel operation.

2.4.6 End Shields

End shields are of cast iron construction and are fixed by easily accessible high tensile bolts.



2.4.7 Bearings

The bearings used are of sealed bearing type. The bearing life is 30,000 hours of operation and is subject to working conditions and environment. High axial vibration from the engine or misalignment of the set will also stress the bearing reducing its life.

2.4.8 Shaft

The shaft is made of high quality grade steel. The shaft is liberally designed for overload and short-circuit conditions.

2.4.9 The Rotating Rectifier Assembly

The rotating rectifier consists of the rectifier hub made of dough moulding compound, the rectifier fins and the rectifier diodes which is specially designed to withstand the centrifugal forces during rotation. The surge suppresser fitted across the field ensures the protection of the diodes in case of surges.

2.4.10 Terminals and Terminal Box Assembly

Standard generator is 3 phase reconnectable with 12 ends brought to the terminals. AVR is fitted on the NDE panel of the terminal box as a standard supply. The terminal box has removable panels for easy access.

2.4.11 Enclosure

IP23 is standard for all industrial generators. The machine is protected against spraying water i.e. water falling as a spray at an angle up to 60° from the vertical shall have no harmful effect. Air filters are available as an option for all generators at reduced rating (5% de-rate).

2.4.12 Balancing

All generator rotors are dynamically balanced to better than Grade 2.5 (BS 6861: Part 1) for minimum vibration in operation.

2.4.13 Radio Interference

The absence of brush gear and the high quality of AVR design ensure low levels of interference with radio transmission. Additional RFI suppression kit can be supplied if required.

2.4.14 Step Load Capability

Additional function controls of DIP and DWELL are provided to enable the load acceptance capacity of the generator set to be optimised. The Dip feature is available in SX421, MX341 & MX321 AVR's & the DWELL feature in MX321 AVR. The Dip feature helps to reduce the block load coming on the engine & the DWELL introduces a time delay in the recovery of voltage to allow the engine to have an improved speed recovery.

2.5 Operating Principle

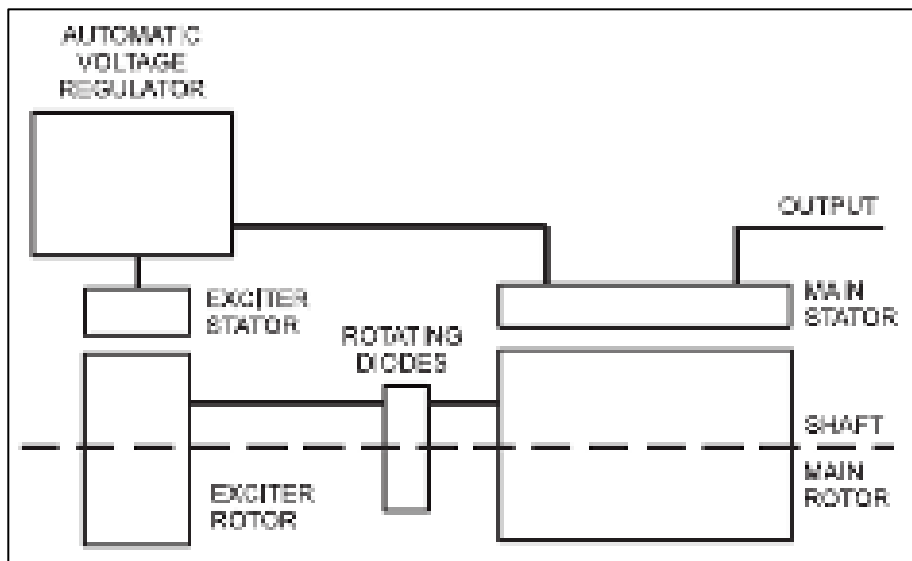


Fig. D2.2 Operating Principle

The main stator provides power for excitation of the exciter field via the SX460 (SA465) AVR which is the controlling device governing the level of excitation provided to the exciter field. The AVR responds to a voltage sensing signal derived from the main stator winding. By controlling the low power of the exciter field, control of the high power requirement of the main field is achieved through the rectified output of the exciter armature.

The AVR senses average voltage on two phases ensuring close regulation. In addition to this it detects engine speed and provides voltage fall off with speed, below a pre-selected speed (Hz) setting, preventing over-excitation at low engine speeds and softening the effect of load switching to relieve the burden on the engine.



2.6 Automatic Voltage Regulator (AVR) - SX460

AVR is a controlling device, which governs the level of excitation provided to the exciter field. The AVR responds to a voltage sensing signal derived from the main stator winding. AVR senses average voltage on two phases ensuring close regulation. In addition to this, it detects engine speed and provides voltage fall off with speed, below pre-selected speed setting, preventing over- excitation at low engine speeds and softening the effect of load switching to relieve the burden on the engine. The AVR is fully encapsulated to withstand humid and corrosive atmospheric conditions.

2.6.1 Technical Specifications of AVR

Input Parameters	Description / Value
Voltage	Jumper Selectable 95 - 132 V AC or 190 - 264 V AC
Frequency	50 - 60 Hz nominal
Phase	1
Output Parameters	Description / Value
Voltage	Max. 90 V DC or 207 V AC
Current	Continuous 4 A DC Intermittent 6 A for 10 sec
Resistance	15 ohms minimum
Regulation	+/-1.0 %
External voltage adjustment	+/-10 % with 1 K Ω 1 watt trimmer
Under frequency protection	Yes
Set Point	97% of 50 Hz
Build up voltage	4 V @ AVR Terminals
Environmental Parameters	Description / Value
Operating Temperature	-40° to +70° C
Storage Temperature	-55° to +80° C
Relative Humidity 0 - 70° C	95%

2.6.2 AVR Connections

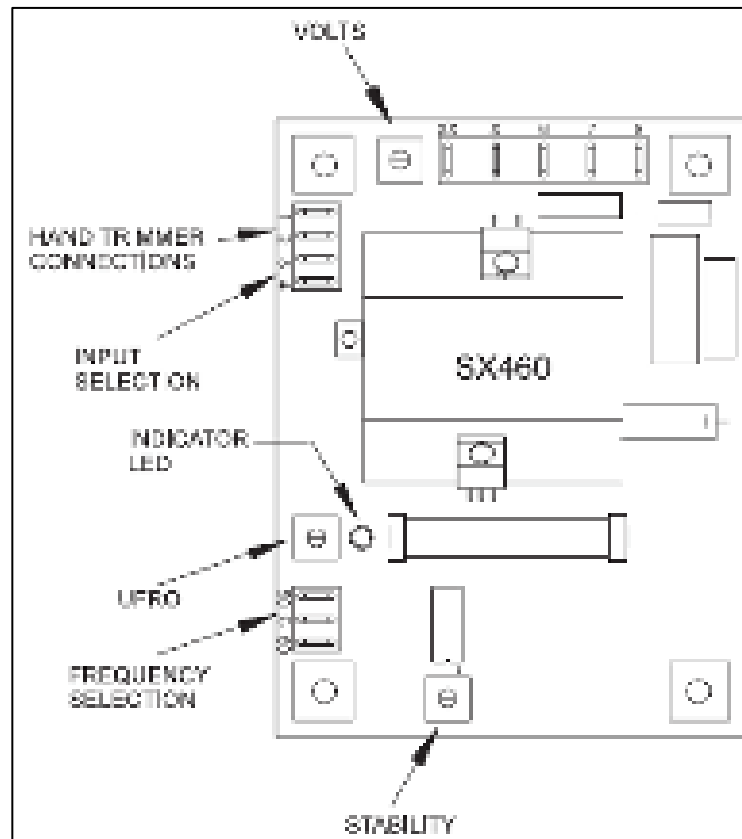


Fig. D2.3 SX460 AVR Connection Diagram

The following ‘jumper’ connections on the AVR should be checked to ensure that they are correctly set for the generating set application.

- i. **Frequency Selection**
 - a. 50 Hz operation - LINK C-50
 - b. 60 Hz operation - LINK C-60
- ii. **External Hand Trimmer Selection**
 - a. No external hand trimmer - LINK 1-2
 - b. External hand trimmer - REMOVE LINK 1-2 & connect trimmer across terminals 1 & 2
- iii. **AVR Input Selection**
 - a. High Voltage (220/240 V) - INPUT No Link
 - b. Low Voltage (110/120 V) - INPUT Link 3-4

2.6.3 AVR Settings

Most of the AVR adjustments are factory set in positions which will give satisfactory performance during initial running test. Subsequent adjustments may be required to achieve optimum performance of the set under operating conditions. Following potentiometer settings are provided on the AVR:

i. Volt

This potentiometer is used to adjust the output voltage of the alternator. Start the generator and run it on no load at nominal frequency. Slowly turn VOLTS potentiometer clockwise until rated voltage is reached.

ii. Stability

The STABILITY control potentiometer is preset and should normally not require adjustments, but should this be required, usually identified by oscillations of the voltmeter, proceed as follows:

- a. Run the generator on no load and check that the speed is correct and stable.
- b. Turn the STABILITY control potentiometer clockwise; then turn slowly anti-clockwise until the generator voltage starts becoming unstable. The correct setting is slightly clockwise from this position. (i.e. the machine volts are stable but close to the unstable region)

iii. Under Frequency Roll Off (UFRO)

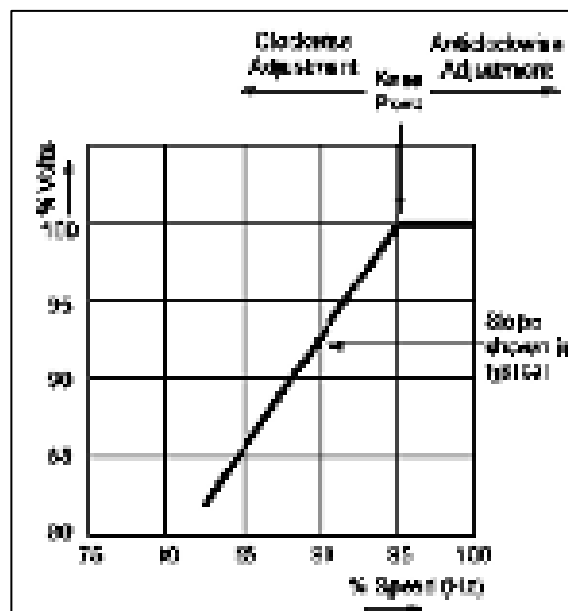


Fig. D2.4 Graph Illustrating Under Frequency Roll Off



The UFRO control potentiometer sets the “Knee point”. Symptoms of incorrect settings are:

- a. The LED indicator just above the UFRO control potentiometer, being permanently lit when the generator is on load.
- b. Poor voltage regulation on load, i.e. operation on the sloping part of the characteristics.

Clockwise adjustment lowers the frequency (speed) setting of the “Knee point” and extinguishes the LED. For optimum setting the LED should illuminate as the frequency falls just below the nominal frequency, i.e. 47 Hz on a 50 Hz generator.

2.7 Typical Single Bearing Alternator Exploded View

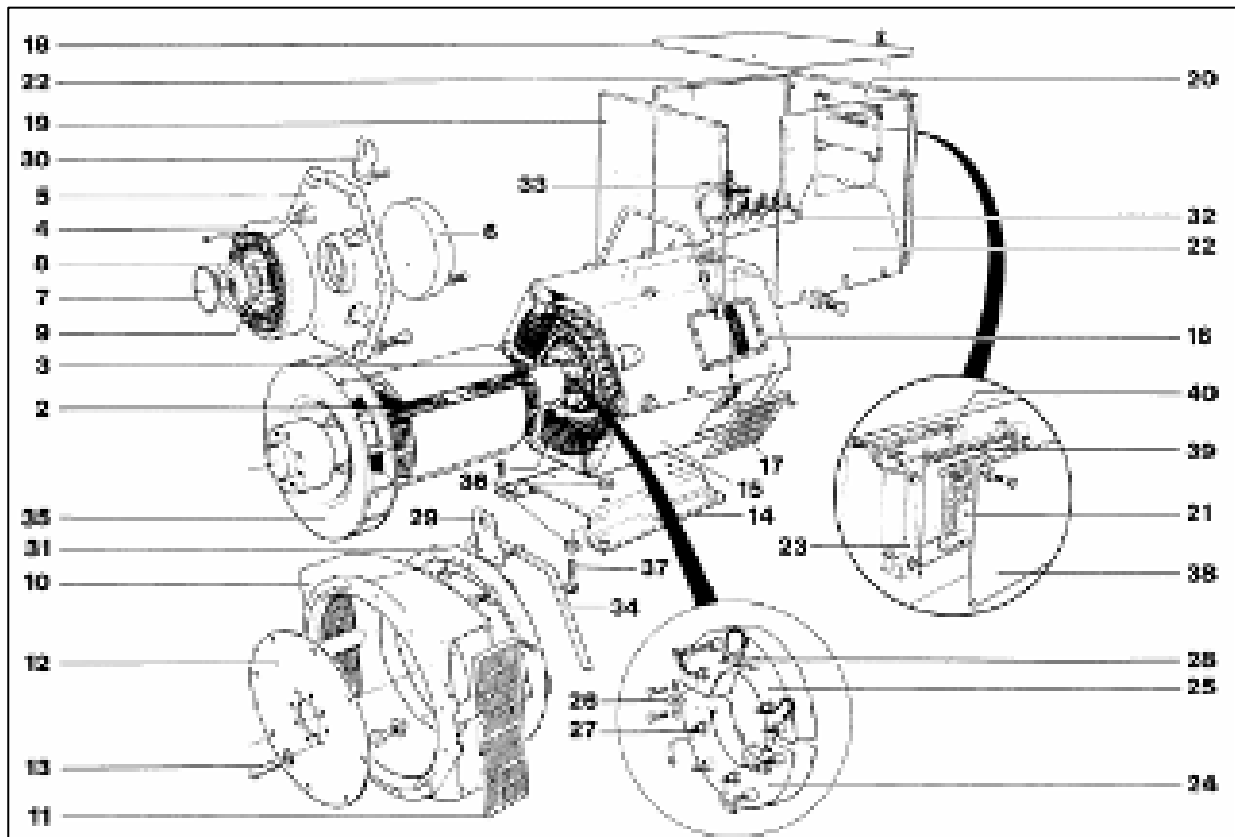


Fig. D2.5 Typical Single Bearing Generator / Alternator Exploded View

Note: Below mentioned is the description of acronym used in the part list of single bearing alternator.

1. N.D.E. - Non Driven End
2. D.E. - Driven End
3. AVR - Automatic Voltage Regulator



Ref. No.	Description	Ref. No.	Description
1	Stator	21	AVR
2	Rotor	22	Side Panel
3	Exciter Rotor	23	AVR Mounting Bracket
4	Exciter Stator	24	Main Rectifier Assembly-Forward
5	N.D.E. Bracket	25	Main Rectifier Assembly-Reverse
6	Cover N.D.E	26	Varistor
7	Bearing 'O' Ring N.D.E.	27	Diode-Forward Polarity
8	Bearing N.D.E	28	Diode-Reverse Polarity
9	Bearing Circlip N.D.E.	29	Lifting Lug-D.E.
10	D.E. Bracket/Engine Adapter	30	Lifting Lug-N.D.E.
11	D.E. Screen	31	Frame to End Bracket Adaptor Ring
12	Coupling Disc	32	Main Terminal Panel
13	Coupling Bolt	33	Terminal Link
14	Foot	34	Edging Strip
15	Frame Cover Bottom	35	Fan
16	Frame Cover Top	36	Foot Mounting Spacer
17	Air Inlet Cover	37	Cap Screw
18	Terminal Box Lid	38	AVR Access Cover
19	End Panel D.E.	39	AVR Anti Vibration Mounting Assembly
20	End Panel N.D.E.	40	Auxiliary Terminal Assembly

Table D2.1 Part List of Typical Single Bearing Generator



2.8 Maintenance

2.8.1 General

The machine should be stopped and isolated from all supplies before any electrical or rotating part of it is touched. The frequency with which maintenance is required depends to a large extent upon the site conditions. Frequent maintenance (say once a week) should be practiced at first and the period extended as experience is gained.

2.8.2 Cleaning

The alternator and excitation unit should be periodically cleaned internally by blowing out with a jet of dry air and by wiping away any deposits of grease and carbon dust with a clean dry cloth. At less frequent intervals, all nuts and screws should be checked to ensure that they are tight, especially the connections.

2.8.3 Pre-Running Checks

1. Insulation Checks:

Before starting the GENSET, both after completing assembly and after installation of the set, test the insulation resistance of the windings. To check the insulation resistance follow the procedure as below:

- a. Disconnect all electronic components, AVR, electronic protection equipment etc.
- b. Short the diodes on the rotating rectifier assembly.
- c. Disconnect any earthing conductor connected between neutral and earth.
- d. Connect one terminal of the Megger earth.
- e. Connect other terminal to the winding terminal.
- f. The measured value of insulation resistance for all windings to earth and phase to phase should be minimum 1 MΩ.

2. Voltage and Frequency:

Check that the voltage and frequency levels required for the GENSET application are as indicated on the alternator nameplate.

2.8.4 Residual Voltage Check (Field Flashing)

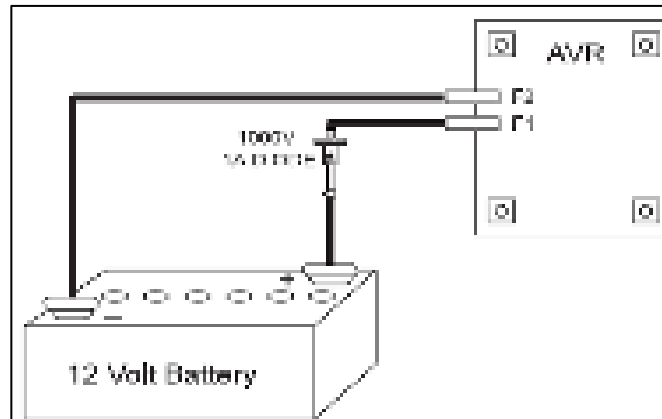


Fig. D2.6 Illustration of Residual Voltage Check

To check the residual voltage, follow the below mentioned procedure:

- i. With the GENSET stationary, remove the AVR access cover and leads F1 and F2 from the AVR.
- ii. Start the set and measure the voltage across AVR terminals 7-8. A minimum level of 5 V is required at these terminals.
- iii. If the voltage is less than 5 V, stop the GENSET because it will be necessary to carry out Field Flashing.

To carry out the field flashing, follow the below mentioned procedure:

- i. Replace leads F1 and F2 terminals on the AVR with 12 V DC battery supply. Connect battery negative to F2 and from battery positive through a diode to F1.
- ii. Start the GENSET and note the output voltage from the main stator. It should be approximately the nominal voltage, or voltage at AVR terminals 7 & 8 which should be between 170 and 250 V.
- iii. Stop the GENSET; remove the battery supply from terminals F1 and F2.
- iv. Restart the GENSET. The GENSET should now operate normally.
- v. If no voltage builds up is obtained it can be assumed that a fault exists either in the alternator or AVR circuit.
- vi. Follow separate excitation procedure to check the alternator windings, rotating diodes and AVR.



2.8.5 Separate Excitation Test Procedure

The alternator windings, diode assembly and AVR can be checked using appropriate procedures given in this section.

2.8.5.1 Checking Alternator windings and rotating diodes:

The procedure mentioned below is carried out with leads F1 and F2 disconnected at the AVR and using a 12 Volt DC supply to leads F1 and F2.

- a. Start the set and run at rated speed, on no-load.
- b. Measure the voltages at the main output terminals U, V and W. These should be balanced and within 10% of the generator nominal voltage.

1. Balanced Main Terminal Voltage: If all voltages are balanced with 1% at the main terminals, it can be assumed that all exciter windings, main windings and main rotating diodes are in good order, and the fault is in the AVR. If voltages are balanced but low, there is a fault in the main excitation windings or rotating diode assembly. Proceed as follows to identify:

- a. **Rotating Diodes:** The diodes on the main rectifier assembly can be checked with a multi-meter. The flexible leads connected to each diode should be disconnected at the terminal end, and the forward and reverse resistance checked. A healthy diode will indicate a very high resistance (infinity) in the reverse direction, and a low resistance in the forward direction. A faulty diode will give a full deflection reading in both directions with the test meter on the 10,000 ohms scale, or an infinity reading in both directions. On an electronic digital meter a healthy diode will give a low reading in one direction, and a high reading in the other.
- b. **Replacement of Faulty Diodes:** The rectifier assembly is split into two plates, the positive and negative, and the main rotor is connected across these plates. Each plate carries 3 diodes, the negative plate carrying negative biased diodes and the positive plate carrying positive biased diodes. Care must be taken to ensure that the correct polarity diodes are fitted to each respective plate. When fitting the diodes to the plates they must be tight enough to ensure a good mechanical and electrical contact, but should not be over tightened. The recommended torque tightening is 4.06 - 4.74 Nm (36-42 lb-in).



- c. **Surge Suppressor:** The surge suppressor is a metal-oxide varistor connected across the two rectifier plates to prevent high transient reverse voltages in the field winding from damaging the diodes. This device is not polarized and will show a virtually infinite reading in both directions with an ordinary resistance meter. If defective this will be visible by inspection, since it will normally fail to short circuit and show signs of disintegration. Replace if found faulty.
 - d. **Main Excitation Winding:** If after establishing and correcting any fault on the rectifier assembly the output is still low when separately excited, then the main rotor, exciter stator and exciter rotor winding resistances should be checked, as the fault must be in one of these windings. The exciter stator resistance is measured across leads F1 and F2. The exciter rotor is connected to six studs which also carry the diode lead terminals. The main rotor winding is connected across the two rectifier plates. The respective leads must be disconnected before taking the readings. Incorrect resistances indicate faulty windings and component replacement is necessary.
2. **Unbalanced Main Terminal Voltage:** If voltages are unbalanced, this indicates a fault on main stator winding or main cables to the circuit breaker. Measure insulation resistance between sections and each section to earth. Unbalanced or incorrect winding resistances and/ or low insulation resistances to the earth indicate rewinding or the stator will be necessary.



Important Note! Faults on the stator winding or cables may also cause noticeable load increase on the engine when excitation is applied. Disconnect the main cables and separate the winding leads U1-U2, U4-U6, V1-V2, V5-V6, W1-W2, and W5-W6 to isolate each winding section.



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2.8.5.2 Excitation Control Test:

AVR function test procedure is as mentioned below:

- i. Remove exciter field leads F1 & F2 from the AVR terminals F1 & F2.
- ii. Connect a 60W, 240V household lamp to AVR terminals F1 & F2.
- iii. Set the AVR Volts control potentiometer fully clockwise.
- iv. Connect a 12 V; 1.0 A DC supply to the exciter field leads F1 & F2 with F1 to the positive.
- v. Start the generating set and run at rated speed.
- vi. Check that the generator output voltage is within $\pm 10\%$ of rated voltage.
- vii. Voltage at AVR terminals 7-8 should be between 170 and 250 volts. If the generator output voltage is correct but the voltage on terminal 7-8 found low, check auxiliary leads and connections to main terminals.

The lamp connected across F1-F2 should glow. In the case of this AVR the lamp should glow continuously. Failure to turn off indicates faulty protection circuit and the AVR should be replaced. Turning the 'VOLTS' control potentiometer fully anti-clockwise should turn off the lamp. If the lamp failed to light, the AVR is faulty and must be replaced.



Important Note! After excitation control test turn the VOLTS control potentiometer anti-clockwise.



2.9 Troubleshooting Chart

Fault	Cause	Repair
No Voltage build-up when starting the set	Low speed	Check speed
	No residual voltage	Check residual voltage, follow separate excitation procedure to check the alternator and AVR
Unstable voltage either on no load or with load	Unstable speed	Check speed stability, Check stability setting
High voltage either on no load or with load	Low speed	Check speed
	Capacitive load (leading power factor)	Remove capacitive load
High voltage on load	Capacitors on the load side	Disconnect Power Factor improvement capacitors
	Faulty AVR setting or faulty AVR	Correct the setting/Replace the AVR
Low voltage on no load	Low speed	Check speed, Check link 1-2 or external hand trimmer leads for continuity



Chapter 3 Standard Reference Conditions

3.1 Temperature

The Alternators are designed for an ambient temperature of 40°C. Outputs are normally quoted at 40°C. These outputs must be multiplied by the following factors for higher ambient temperatures. (Refer table D3.1)

Temperature in Deg. Celsius	Multiplier
45	0.97
50	0.94
55	0.91
60	0.88

Table D3.1

3.2 Altitude

Above 1000 m, the effectiveness of the air is reduced sufficiently to make derating necessary. For altitudes above 1000 m, outputs must be multiplied by the following factors. (Refer table D3.2)

Altitude in Meters	Multiplier
1500	0.97
2000	0.94
2500	0.91
3000	0.88
3500	0.85
4000	0.82

Table D3.2



Chapter 4 Optional Equipment

4.1 Anti-Condensation Heaters (Space Heaters)

Space Heaters are recommended in areas of high humidity. In such areas, condensation or dew forms on surfaces that are cooler than ambient temperature. To avoid this, space heaters can be fitted which ensure that the winding temperature remains few degrees above the ambient temperature, thus avoiding condensation. Note that the space heaters should be ON only when the GENSET is off and they should be turned off when the GENSET is in use. The space heaters can be retrofitted at site.

4.2 Air Filters

At site conditions where the air may be heavily loaded with fine dust or sand, it is strongly recommended that an air filter be fitted at the alternator air inlet. The sizing of these air filters is important to avoid airflow restrictions and advice should be sought from authorized Greaves Sales and Service dealer.



Chapter 5 General Comments on the Load Conditions

It is advisable to forward a completed copy of specification (if available) to the works for study of the actual requirement for which the GENSET is required. As a result of such an assessment, it is sometimes possible to incorporate design changes to provide a more economic system that will meet your specifications. There are two basic conditions that should be checked while sizing the machines:

- I. The Steady-State Condition, and
- II. The Transient Condition

Steady state condition is mainly concerned with normal operation of the machine within temperature rise limits for specified class of insulation.

The transient condition refers to terminal voltage variations during sudden application of high current loads like induction motor starting, etc.

It is essential that both these conditions are checked, as sometimes a rating sufficient for steady state condition is not large enough to meet the motor starting or voltage dip requirements.

5.1 Selection of Generator for different Load Applications

The GENSET'S should be capable of supplying sufficient power to different types of loads that exist at the sites. For this, a suitable rating generator selection is very important. The types of loads that generally exist at sites can be broadly classified under following categories:

- i. Linear Loads
- ii. Motor Loads (Part of Linear load, considered separately)
- iii. Non-Linear Loads
- iv. Special Loads



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5.1.1 Linear Loads

Linear Loads can be identified from the following characteristics:

- iii. Load impedance is always constant regardless of the applied voltage.
- iv. The load current increases proportionately as the voltage increases and decreases as the voltage decreases.

Examples of linear loads are motor, incandescent lighting and heating loads.

5.1.1.1 Selection of Alternator for Linear Loads

To select the rating of Alternator for linear loads, the maximum connected load and the base load which is always connected is to be considered. In arriving at a total load figure it is always advisable to select the standard rating larger than that estimated, despite the fact that all the loads may not be operating at the same time hence a smaller machine could have been selected. Future operating conditions and future growth requirement is very difficult to estimate. An allowance of 15% to 20% excess capacity is in general recommended to accommodate the future growth in power requirement.

5.1.1.2 Power Factor

The nature of applied load dictates the system power factor.

- i. **Unity Power Factor:** The loads which operate at or are very close to unity (1.0) power factor include most forms of lighting, heating elements and rectifier type loads.
- ii. **Lagging Power Factor:** For all remaining loads, some knowledge on their operating power factor is required. For induction motors, the operating power factor is lagging and it depends on their size and load conditions.
- iii. **Leading Power Factor:** For Capacitor loads, the power factor is leading.

The Crompton Greaves alternators are designed for 0.8 lag operating power factor of load. Also, these alternators can operate satisfactorily at any power factor in the range of 0.8 to unity, but care should be taken for engine rating for pure resistive loads to operate the GENSET on its full capacity. Under leading power factor loads, these alternators will not perform satisfactorily and the terminal voltage may shoot up or oscillate. Hence care should be taken to disconnect the power factor improvement capacitors or to compensate with inductive loads such that the overall operating power factor lies between unity to 0.8 lag.



5.1.2 Motor Loads

Induction motors are the most commonly used loads. During the starting of an induction motor, a very large current is demanded from the power source which is known as the starting or locked rotor current. For sizing alternators which have to cater motor loads, following guidelines can be referred as detailed out in table D5.1.

Method of Starting	Starting Current
Direct on Line (DOL)	6 to 7 times full load of motor (if starting current is not given, starting KVA is 7 times the HP rating of the motor)
Star/Delta	2 to 2.5 times full load of motor
Rotor/Transformer Starting	
40% tapping	1.2 times full load current
60% tapping	4 times full load current
80% tapping	4.5 times full load current

For Motor starting following information should be furnished:

- i. Rating of the motors(s)
- ii. Type of motor (slip ring/squirrel cage)
- iii. Method of starting
- iv. Rated full load current
- v. Starting power factor
- vi. Any restriction on Transient Voltage Dip (Details of the same)
- vii. Frequency of starting
- viii. Base load at the time of starting induction motor
- ix. Any other load apart from the motor loads (Details thereof)
- x. Sequence of starting the motors



5.1.3 Non Linear Loads

Non-linear loads are generally electronic loads such as Rectifier loads, Thyristor controlled drives, UPS, Battery chargers etc. The basic characteristics of non-linear loads are:

- i. The load current is not proportional to the instantaneous voltage. Often load current is not continuous.
- ii. These are essentially electronic loads such as Computers, UPS equipment, variable speed drives etc.

5.1.3.1 Effects of Non-Linear Loads

- i. Non-linear loads generate harmonics in their current waveform which in turn leads to distortion of the Generator waveform. This results in excessive heating of the magnetic cores because of heavy hysteresis and eddy current losses.
- ii. Odd order of harmonics cause overload of neutral conductors.
- iii. These create problem of hunting of terminal voltage, which makes paralleling of generators difficult or at times impossible.
- iv. Non-Linear loads cause damage of the power factor improvement capacitors.
- v. Correct measurement of electrical parameters like voltage, current etc. becomes difficult.
- vi. Depending on the degree of voltage waveform distortion, non-linear loads can lead to instability of the excitation system and impact other loads that are powered by the GENSET.

5.1.3.2 General Guidelines on Duration for Non-Linear Loads

Load Type	Deration Factor
Fluorescent lamps	No deration required
UPS & Telecom load controlled by a 12 pulse thyristor bridge plus a filter	Non-Linear Load should not exceed 90% of alternator rating
UPS & Telecom load controlled by a 6 pulse thyristor bridge plus a filter	Non-Linear Load should not exceed 66% of alternator rating
UPS & Telecom load controlled by a 3 pulse thyristor bridge plus a filter	Non-Linear Load should not exceed 66% of alternator rating
Variable speed 6 pulse thyristor bridge controlled drive	Non-Linear Load should not exceed 50% of alternator rating

Table D5.1



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The above percentage figures mentioned in table D5.1 are merely guidelines. Better sizing of the GENSET is possible on considering the following parameters:

- i. Number of pulses of Thyristor drive: 3, 6 or 12
- ii. What is the level of current distortion produced by the non-linear load?
- iii. What is the maximum acceptable level of voltage distortion the non-linear load can accept?
- iv. What is the operating voltage and frequency?
- v. If non-linear load power requirement is stated in kW, then some guidance regarding operating power factor and system efficiency is required to establish the alternator load.

5.1.4 Special Loads

Apart from Linear and Non-Linear loads there are certain types of loads which needs consideration during the alternator selection. Some of these are explained below:

5.1.4.1 Computer Loads

Computer loads are very sensitive to the characteristics such as voltage variation, harmonic contents, voltage unbalance etc. of the power supply. If these characteristics do not match with the stipulated figures, malfunctioning of the computers may result. For this reason, the selection of alternator for this application required careful study. It is recommended to have separate GENSET'S for computer loads.

Following information should be supplied for selecting a suitable alternator for computer loads:

- i. Total kVA rating of the computer load and its operating power factor.
- ii. Acceptable steady state and transient state voltage and frequency variation.
- iii. Details of other types of loads existing.



5.1.4.2 Welding Loads

Welding loads draw heavy intermittent current from the alternator. Most of the welding loads are designed for single phase 240 V or two phase 415 V. Welding loads stress the alternator because of their low power factor.

Following information should be supplied for selecting a suitable alternator for welding loads:

- i. kVA rating (Name plate details)
- ii. Rated power factor
- iii. Whether single phase (240 V) or two phase (415 V)
- iv. Primary rated transient current
- v. Details of other voltage sensitive loads, if any.



SECTION E

CONTROL PANEL



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Chapter 1 Control System and Operation

1.1 Control System

The Control System consists of:

- i. A Control Panel providing a means of starting and stopping the GENSET, monitoring its operation and output, and causing the engine to automatically shut down in the event of a circuit fault condition arising from any of the protection controls such as low oil pressure, high coolant temperature, over speed, etc.
- ii. An Alternator Circuit Breaker providing a means of switching the Generator output, and automatically disconnecting the load in event of short circuit.

1.2 Operation

The operation of the control panel involves preparing for operation, initial start-up, normal start-up, and normal shutdown. They are described below:

1.2.1 Preparing for Operation

- i. Before starting your GENSET be sure that it is positioned on a levelled surface so that, proper liquid levels can be maintained. Check engine oil, radiator coolant, battery electrolyte and fuel levels.
- ii. Be sure that the GENSET will be operated in a well-ventilated area with all exhaust fumes piped away.
- iii. Before connecting batteries, ensure that the control panel is switched off.



WARNING! Prolonged inhalation of exhaust fumes may result in serious illness or death.

- iv. Prolonged exposure to the noise levels of a diesel engine can impair hearing unless proper ear protection is worn.
- v. Before any attempt is made to operate the machine, be sure that engine and alternator are properly earthed.
- vi. Local and national regulations for the grounding of GENSET should be adhered to, as well as those regulations which describe the methods of connection and minimum sizes of grounding conductors based on the size of the load cables.



Important Note! Adequate grounding of the GENSET is necessary for both stationary and wheel mounted units to prevent the possibility of injury or death in the event of electrical fault.

- vii. When filling the fuel tank, do not smoke or use an open flame in the vicinity. Also the tank should never be filled when the GENSET is operating or while the engine is hot. Spilled or vaporized fuel could get ignited easily.
- viii. Never attempt to disconnect a load connection or perform maintenance while the GENSET is in operation.
- ix. To avoid an accidental start of the engine, always disconnect the battery when performing major operations.
- x. As the battery system is negative earth. The negative connection should be disconnected first and reconnected last.
- xi. The door of the control panel should not be removed while the GENSET is in operation. Otherwise, you will be exposed to live electrical connections.
- xii. Maintenance on the control panel should only be carried out by a qualified technician.



Important Note! Always shut down the GENSET and switch off circuit breaker prior to connecting, or disconnecting load cables. Only restart when a sound connection has been made.



Important Note! Procedure disclosed henceforth in topic *1.2.2 Initial Start-up*, *1.2.3 Normal Start-up*, and *1.2.4 Normal Shutdown*, is most generic in nature. However, user is expected to read either of the chapter 2, 3, 4, and 5 of Section E to get operational details of the concerned Controller provided in their GENSET.

1.2.2 Initial Start-up

The following procedure should be used when starting the GENSET for the first time or when it has been out of service for a long time. These steps are critical and must be followed closely to avoid complications in operating the GENSET. To start-up the GENSET follow the procedure as mentioned below:

- i. Check the engine oil and coolant levels and replenish if necessary.
- ii. Fill the fuel tank.



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- iii. Prime the fuel system using the hand priming pump and bleed entrapped air from the fuel filter. See Section C on Diesel Engine for more details in this regard.
- iv. Ensure the circuit breaker is switched OFF.
- v. Connect the batteries to the engine with correct polarity.
- vi. Turn the Control switch to ON position.
- vii. Wait for until the controller displays READY. The READY state implies that the engine and alternator parameters are as expected. If the conditions are not as expected, an appropriate warning or alarm is displayed on the controller. The warning or alarm condition must be cleared before the GENSET can be started.
- viii. Press the START button on control panel till engine starts or press start button momentarily on controller. The controller will perform following sequence as follows:
 - a. FUEL-ON
 - i. If ETR (Energise to Run) fuel control is configured, the controller will control the fuel output and display FUEL ON and proceed to the CRANK state.
 - ii. For ETS (Energise to Stop) the sequence does not activate the output but proceeds immediately to the CRANK state.
 - b. CRANK
 - i. The crank output is deactivated when the unit has detected a speed signal above the crank disconnect speed specified in the settings, or has detected oil pressure above the minimum oil pressure specified in the settings or Excitation is present.
 - ii. If the GENSET does not start, the LCD will show 'Stopping', controls the Fuel and Crank outputs accordingly, and return to READY. No retries are done.
 - iii. If the unit loses power due to battery voltage drop during cranking, and the engine fires, then on regaining adequate battery voltage, the unit will continue to allow the engine to run.
 - c. RUN UP
 - i. When the engine starts, the display shows 'Run Up' with a countdown in seconds. This allows the engine measurement system to stabilize. Over speed and loss of speed signal are the only parameters checked during Run Up.



d. WARM UP

- i. Allows the engine to stabilize at full speed before going on load. Oil pressure and Over-speed are monitored. The display shows 'Warm Up' with a countdown time.

e. RUNNING

- i. The display shows 'RUNNING'. Operating parameters are scrolled onto the display.
- ix. After the engine is started, check for any abnormal noise or vibration.
- x. Check fluid leakage or high temperature.
- xi. Check the control panel for indications of abnormal operation, in particular above normal engine temperature or below normal oil pressure.
- xii. Once the engine reaches full operating speed check that the GENSET voltage has reached the correct operating level. The voltage is factory set on the voltage regulator and needs no further adjustment. Should the output voltage be incorrect, adjustment of the voltage should only be carried out by a qualified technician. Voltage adjustment is achieved by varying the setting of a potentiometer mounted inside the automatic voltage regulator which is fitted in the alternator terminal box.
- xiii. The frequency of the output should also be checked. No load frequency should be approximately 52 Hz for a 50 Hz system.
- xiv. After the voltage and frequency checks have been made, shut down the GENSET by pressing the STOP push button provided on the control panel.

1.2.3 Normal Start-Up

To start the GENSET for subsequent loading operation, follow the procedure as mentioned below.

- i. Make a visual check of the entire GENSET. Watch for leaks in the fuel system, cooling system and lubrication system.
- ii. Be sure that no dust/ sand remain on the air inlet side of the canopy.
- iii. Be sure that all tools and any loose items are removed from the canopy.
- iv. Check the engine oil, fuel and coolant levels, replenish if necessary.
- v. Check the battery terminals for corrosion, clean them if necessary. Also check the battery electrolyte level and if necessary, fill it with distilled water.
- vi. Turn the Control switch to ON position.



- vii. Wait for until the controller displays READY. The READY state implies that the engine and alternator parameters are as expected. If the conditions are not as expected, an appropriate warning or alarm is displayed on the controller. The warning or alarm condition must be cleared before the GENSET can be started.
- viii. Press the START button on the controller momentarily. The controller will perform following sequence as follows:
 - a. FUEL-ON
 - i. If ETR (Energise to Run) fuel control is configured, the controller will control the fuel output and display FUEL ON and proceed to the CRANK state.
 - ii. For ETS (Energise to Stop) the sequence does not activate the output but proceeds immediately to the CRANK state.
 - b. CRANK
 - i. The crank output is deactivated when the unit has detected a speed signal above the crank disconnect speed specified in the settings, or has detected oil pressure above the minimum oil pressure specified in the settings or excitation is present.
 - ii. If the GENSET does not start, the LCD will show 'Stopping', controls the Fuel and Crank outputs accordingly, and return to READY. No retries are done.
 - iii. If the unit loses power due to battery voltage drop during cranking, and the engine fires, then on regaining adequate battery voltage, the unit will continue to allow the engine to run.
 - c. RUN UP
 - i. When the engine starts, the display shows 'Run Up' with a countdown in seconds. This allows the engine measurement system to stabilise. Over speed and loss of speed signal are the only parameters checked during Run Up.
 - d. WARM UP
 - i. Allows the engine to stabilize at full speed before putting on load. Oil pressure and Over-speed are monitored.
 - ii. The display shows 'Warm Up' with a countdown time.



e. RUNNING

- i. The display shows 'RUNNING'. Operating parameters are scrolled onto the display.
- ix. Run the GENSET on no load for at least 2-4 minutes.
- x. Turn on the Main Circuit Breaker. The GENSET output is available to the load. Load may be now applied on the GENSET.



Important Note! If at any time the GENSET stops because of a fault, the fault should be rectified before trying to restart the GENSET.

1.2.4 Normal Shutdown

To shut down the GENSET at the end of the operation, follow the procedure as mentioned below.

- i. Turn off the load using the circuit breaker.
- ii. Press the STOP push button on the controller. The controller will perform following stopping sequence:
 - a. STOPPING
 - i. The display will show 'STOPPING'.
 - ii. If ETR (Energise to Run) fuel control has been configured, consequently the fuel output will be de-energised.
 - iii. If ETS (Energise to Stop) fuel control has been selected then the fuel output will be energised for the Max Fuel Time or until the engine stops. The stopping process will retry if the engine fails to stop for the first time. During the 'ETS Rest period' the Fuel output is deactivated.
 - iv. The fuel output is controlled until the engine stops rotating and oil pressure decays. If the Oil Pressure has not been reduced by the end of the 'Max Fuel Time', the fuel output is deactivated and the controller waits until the oil pressure reduces, or for the rest of the 'Stop Time'. The speed must remain zero and the oil pressure must be below the alarm set point for the 'Stop Rest Time' before the engine is considered stopped.



- v. If the GENSET does not stop then the alarm output is activated and 'STOP FAIL' is displayed on the LCD.
- b. READY
 - i. Once the engine stops, READY icon will be displayed on the LCD indicating the engine is ready to start again.

Chapter 2 PROCOM Controller

2.1 Introduction

The PROCOM controller comes with a state of art microcontroller based system with 16 bit RISC (Reduced instruction set computing) featuring in it. Controller is built up with Back lit LCD display for easy reading of quantitative measure and acts as an interface while setting the parameters. There is no need to refer or revert back to user manual of the controller while programming the unit.

Procom controller requires 4 Volt power supply for full functioning, also it can withstand voltage dip up to 0V for a period of 1 sec. All the parameters concerned to performance of a GENSET are user defined in nature. It can hold the record of 20 failures in its memory. This controller is designed to meet versatile needs of the customer and suitable for any type of engine.

2.2 Major Parts of PROCOM Controller

The major parts of PROCOM controller are explained in two aspects, which are as mentioned below.

2.2.1 Components on the Door of Control Panel

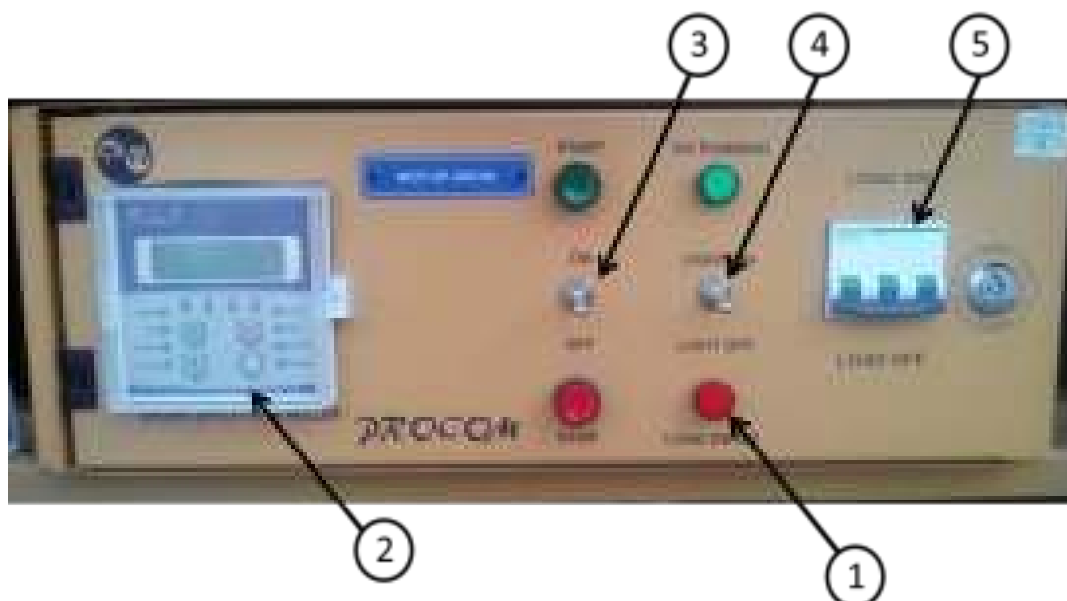


Fig. E2.1 Exterior Illustration of PROCOM Control Panel



Ref. No.	Description of Part	Ref. No.	Description of Part
1	Load on the GENSET	4	Canopy Light Switch
2	PROCOM Controller	5	Power MCB
3	Control ON		

Table E2.1 Part List for External Components of PROCOM Control Panel

- 1) Load on GENSET Indication Lamp: The green indication lamp turns on when the supply is available to the load.
- 2) Procom Controller: The electronic controller is provided to operate the system. It also contains an LCD display that that displays various GENSET parameters, faults, status, etc.
- 3) Control ON selector switch: When this switch is turned on, control supply is turned on and provided to the controller and other control components.
- 4) DG Light switch: It is provided to turn on the lamp inside the GENSET canopy.
- 5) Power MCB: This is the main circuit breaker between the alternator output and load. The breaker will carry the rated current continuously. In case of a short circuit or even if over current flows for specified amount of time, the breaker will trip. The breaker must then be moved to “OFF” position before re-closing.

2.2.2 Components inside the Control Panel

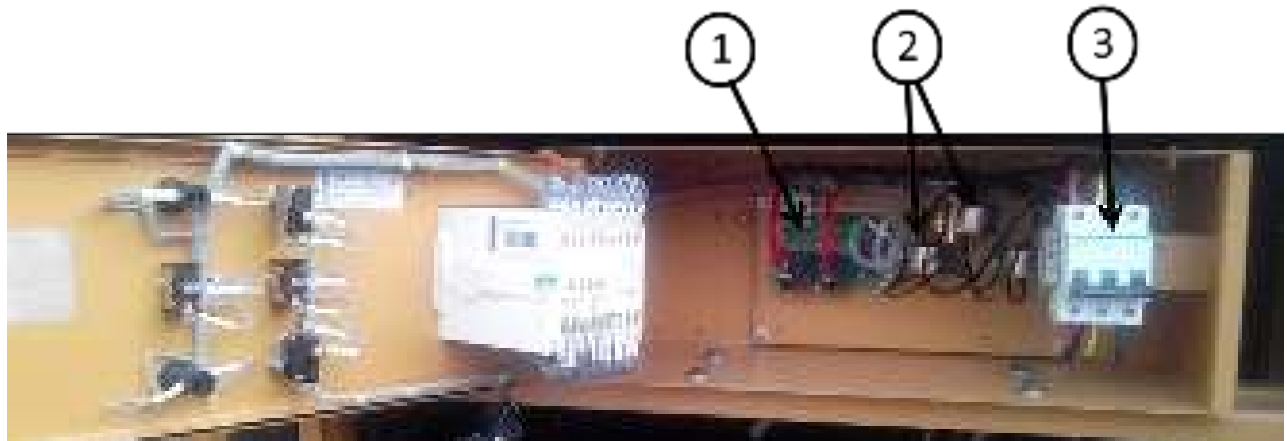


Fig. E2.2 Interior Illustration of PROCOM Control Panel

Ref. No.	Description of Part	Ref. No.	Description of Part
1	3-C Relay Board	4	Battery Charger (Optional-Not Shown)
2	Current Transformers		
3	3 Pole MCB		

Table E2.2 Part List for Internal Components of PROCOM Control Panel

- 1) Control MCB: A three pole control MCB is provided for protection of the control circuit.
- 2) Power Relay Board: The power relay board consists of three power relays on each for the fuel solenoid, crank solenoid, and the hooter.
- 3) Current Transformers: Three current transformers, one for each phase, are provided for sensing current.
- 4) Hooter: The hooter operates in case of any fault is sensed by the controller.




2.3 Protection & Supervision Salient Features

- i. Voltage monitoring and protection for under/over voltage and over speeding.
- ii. Oil Pressure
- iii. HWT
- iv. Canopy Temperature/RWL
- v. Over Load
- vi. Emergency
- vii. Low Fuel
- viii. Charging Alternator Fail/V-Belt
- ix. Fan Fault protection(1Ph model B)

2.4 Measurement and Display

PROCOM's DES-11 controller is equipped with LCD display and it displays following:

- i. Generator voltage (Ph-N, Ph-Ph)
- ii. Generator Frequency
- iii. Generator Current
- iv. Fan Current(1Ph Model B)
- v. Battery Voltage
- vi. Generator Run Hour
- vii. RPM
- viii. Oil Pressure in KG/cm
- ix. Radiator Temperature in degree centigrade(Model -A)
- x. Fuel Level
- xi. Programmed settings
- xii. kW, PF, & kWh

Normally the display auto scrolls and displays a set of parameter for 10 seconds, but any time the Next key  can be pressed to select the next parameter window.

2.5 Annunciations

PROCOM's DES-11 controller is equipped with the following annunciations for system status and faults finding:

- i. LLOP
- ii. HWT(Model A)
- iii. HCT (Model B)



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- iv. Fuel
- v. RWL (Radiator Water Level-Model A)
- vi. Canopy Temperature (Model -B)
- vii. DG Under Voltage
- viii. DG Over Voltage
- ix. DG Over/Under Frequency
- x. Charging Alternator/ V-Belt
- xi. DG Overload
- xii. Emergency

2.6 Contacts

The following digital Output is provided. Annunciation contacts are available in models requested with Annunciation features.

- i. Crank (NO Contact)
- ii. Solenoid (NO Contact)
- iii. Hooter (NO Contact)
- iv. Electrical Feed for Charger ON (+12V)

2.7 Timers

PROCOM's DES-11 controller is equipped with the following timers:

- i. Generator voltage supervision timer
- ii. Generator over speed supervision timer
- iii. Generator Over load supervision time
- iv. Stop Solenoid on time
- v. Fuel supervision time
- vi. LLOP supervision time
- vii. HWT supervision time (Model-A)
- viii. RWL supervision time (Model-A)
- ix. HCT supervision time (Model-B)
- x. Canopy Temperature Time (Model-B)
- xi. Hooter Reset Time
- xii. Service Time
- xiii. Charging Alternator contact on time
- xiv. Crank Timer

2.8 Switches Description

Four switches are provided on front panel of DES-11. Switch can have more than one function assigned to it. The exhibit table E2.3 below describes the operation of these.






S.No	Switch Symbol	Switch Function	Description
1		Normal	Normal operation mode: In this mode, it is used to change the parameters being displayed on LCD. Programming Mode: No Key is used to select the next parameter to be programmed.
2		Increase	Programming Mode: It is used to increase the value of the parameters under programming. Normal operation mode: It is used to Start the Engine.
3		Decrease	Programming Mode: It is used to decrease the value of the parameters under programming. Normal operation mode: It is used to Stop the Engine.
4		Reset	Reset key resets the High and Low Fault signals. The time delay shall reset the heater and fuel cut reset delay timer. A long press of 1 Sec shall reset both.
5		Programming Mode Entry	Press "R" Key and then press "+" while the "R" Key is pressed to enter the programming mode.

Exhibit Table E2.3

2.9 Operations

DES-11 is an engine monitoring and supervisor unit. The engine can be Started/Stopped from the front panel of DES-11 or externally by means of key Switch, etc. The start / stop from the front or remote is one touch operation, meaning that once the switch is pressed the start /stop command shall be operational till the “Crank time or DG start detection / Stop Sol Time”, as programmed, has expired . DES-11 automatically detects that the engine on conditions by monitoring the generator voltage and starts monitoring the engine for under/over voltage, LLOP, HWT and emergency faults. On detection of any of these faults for the pre-programmed duration the engine is automatically shut down and fault along with run hour is recorded in non-volatile memory. The run hour time of engine is recorded in internal non-volatile memory.



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2.10 Setting Procedure

DES-11 has provision to program the operating parameters, resetting the service hours and viewing the last 20 fault history.

Press R & switches simultaneously.

The LCD shall display, “Enter Para Mode”

To enter parameter setting mode press

To go to next menu press

The LCD shall display “View Fault Records”.

This menu can be entered by pressing

To go to next menu press

This menu can be entered by pressing

Pressing shall reset the service hours. Pressing shall terminate the menu.

2.10.1 Parameter Mode

Sl. No.	Display	Explanation of Parameter	Factory Setting	Setting Range
1	Generator O/V	Max permissible voltage, above this the voltage is treated unhealthy & the Generator is stopped.	270 V	80-300 V
2	Generator U/V	Min permissible voltage, below this the voltage is treated unhealthy & the Generator is stopped.	180 V	80-300 V
3	Gen Sup Delay	The time for which the Generator voltage should, continuously be unhealthy to generate a fault condition.	10 Sec	1-999 Sec
4	CT Ratio	Available in models having provision for /5 CTs. Not required for Procom Make CT's	1	1-999
5	Generator O/C*	Max permissible current, above this the Current is treated unhealthy & the Generator is stopped.	6 (For /5 A CT) 42A (For Procom CT)	1-999 (For /5 A CT) 1-199 A (For Procom CT)



Sl. No.	Display	Explanation of Parameter	Factory Setting	Setting Range
6	Gen O/C Delay	The time for which the Generator Current should, continuously be unhealthy to generate a fault condition.	5Sec	1-999 Sec
7	Generator S/C*	Max permissible current, above this the Current is treated unhealthy & the Generator is stopped.	6(For /5 A CT) 42A(For Procom CT)	1-999 (for /5 A CT) 1-199 A (for Procom CT)
8	Gen S/C Delay	The time for which the Generator Current should, continuously be unhealthy to generate a fault condition.	5Sec	1-999 Sec.
9	Generator O/F*	Over frequency setting	65 Hz	40 - 80 Hz
10	Gen O/F	Delay Monitoring time for Over frequency	5 Sec	1-999Sec
11	Generator U/F*	Under frequency setting	45 Hz	40 - 80 Hz
12	Gen U/F Delay	Monitoring time for Under frequency	10 Sec	1-999Sec
13	Available Sensor	This selects the installed sensors in the GENSETS. The display shall only display the parameters for the sensor installed and uninstalled sensor data shall not be displayed. The protection for the function with no measurement sensor installed shall be through switch. E.g. If Oil pressure sensor is not installed the unit shall provide protection for LLOP through oil pressure switch and not through the oil pressure sensor (linear measurement)	All sensors	All sensors, Fuel &HWT, Fuel & LLOP, LLOP & HWT, Fuel Only, HWT Only, LLOP Only, No sensor



Sl. No.	Display	Explanation of Parameter	Factory Setting	Setting Range
14	Fuel < Level in %	Level of fuel at which the audio visual warning is issued without initiating shut down.	25% Sec	10-100%
15	Fuel < delay	Monitoring time of Fuel Fault	5 Sec	1-999 Sec
16	Fuel<< Level in %	Level of fuel at which the Engine shall shut down	15% Sec	10-100%
17	Low Lube Oil Pressure	Level of LLOP at which the Engine shall shut down	2.0 Kg /Cm ²	0-8.5 Kg /Cm ²
18	High Water Temperature	Temperature of water at which the Engine shall shut down	80° C	0-150° C
19	Sensor Type	A : For engines other than SDEC B : SDEC Engine	A	A,B
20	Fuel << delay	Monitoring time of Fuel << Fault	5 Sec	1-999 Sec
21	LLOP delay	Monitoring time of LLOP Fault	5 Sec	1-999 Sec
22	HWT delay	Monitoring time of HWT Fault	5 Sec	1-999 Sec
23	Radiator Water Delay	Monitoring time of RWL Fault	5 Sec	1-999 Sec
24	Charging Delay*	Time delay after which the charging Alternator/V-Belt fault shall be activated.	5 Sec	1-999 Sec
25	Hooter Reset Time	Time for which the Hooter is active if not reset manually	30 Sec	1-999 Sec
26	Stop Solenoid On Time	Time for which the fuel solenoid is activated for shutting the engine	30 Sec	1-100 Sec
27	Emergency Solenoid Time	This setting is to protect the fuel solenoid in case the Stop button or Emergency key is kept pressed. In such a case the solenoid shall be released after this time.	40 Sec	1-100 Sec



Sl. No.	Display	Explanation of Parameter	Factory Setting	Setting Range
28	Gen. Pick-up Voltage	Voltage of generator above which the generator is assumed to be ON	100 V	80-150 V
29	Service Time Hrs.	Time, in hours, after which the service is due	250 Hrs.	1-999 Hrs.
30	Display Auto Scroll	Setting ON will enable Auto Scroll of display. OFF: No scroll and next parameter can be viewed by pressing next	ON/OFF	ON
31	Voltage Display Format	DES-9A Can display either Phase to Phase OR Phase to Neutral Voltage	Phase-Neutral	Phase-Neutral, Phase-Phase
32	Engine RPM	Engine RPM selection	1500	1500/3000
33	Charging Alternator Relay Time	Time for which the magnetizing relay of charging alternator will be switched on after the engine has started.(Model A only)	5 Sec	5-100 Sec
34	Crank Time	Maximum duration for which the crank is activated after the start command is given	5Sec	1-25Sec
35	Communication 232 Or SMS	Selection of communication mode either on RS232, Or SMS via GSM modem	RS232	RS232/SMS
36	Start SMS	Activated only in SMS communication mode for activating / disabling the SMS communication	Disable	Enable / Disable
37	Crank Cut Method	Only Voltage based / Voltage or LOP based	Voltage	Voltage/ LOP Or Voltage

Table E2.4

* This parameter can be disabled while programming.



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2.10.2 Fault History

To view the last 20 fault histories, enter in this mode as explained above. Maximum of last 20 faults along with Run Hour stamp shall be displayed on the LCD. The first row shall display the fault and the next row shall display the run hour at which the fault has occurred. The next fault can be viewed by pressing “NEXT”. The mode shall exit to normal mode after the last fault recording is displayed. Absence of any fault recording shall not display any fault data.

2.10.3 Resting Service Hours

Service due, warning is issued by DES-11, by flashing the Service LED. This LED shall keep flashing till it is not reset by entering this mode.

2.10.4 Programming Solenoid Mode

For changing the solenoid mode first press (R) (reset) button, than press + button while the reset button is pressed.

Fuel Solenoid: In this mode fuel solenoid contact changes from Open to close at the time of cranking and remains close till the GENSET is running. For stopping the generator this contact opens.

Stop Solenoid: In this mode fuel solenoid contact remains open at the time of cranking and till the GENSET is running. For stopping the generator this contact closes for a user programmed time.

Don't change the mode while generator is running. It's a good practice to switch OFF and then switch ON the battery supply after changing this mode.

2.11 Faults

There are two categories of faults, v.i.z.

- i. Internal Faults
- ii. External Faults

2.11.1 Internal Faults

Internal faults are the faults, which do not need any external signals and are detected by the system itself. They are:



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- i. Generator Voltage Unhealthy
- ii. Generator Over & under frequency.
- iii. Generator Over Load
- iv. LLOP
- v. Fuel
- vi. HWT (Model -A)

2.11.2 External Faults

Those faults which cannot be sensed by the unit itself (these faults are not reflected by the generator voltage) and are to be provided externally. They are:

- i. Canopy Temperature (Model-B)
- ii. RWL (Model-A)
- iii. HCT (Model-B)

2.11.3 Fault Reset

All internal faults can be reset by pressing (R) switch after the generator is stopped. In case the engine fails to stop “STOP KEY” can be pressed for manual attempt to stop engine.

2.12 Communication Setup

DES-11 can be used in 2 modes of communication:

- a) RS232 mode: For connection to a PC or a MODEM.
- b) SMS Mode: If a GSM modem, with SIM, is connected to the RS232 link of the unit, the unit shall be able to send alarm through SMS. The GENSET can also be controlled remotely via SMS.

2.12.1 SMS Operation

DES-11 can store up to five GSM enabled telephone numbers. In case of any fault, or starting/stopping of the generator, a SMS shall be send to all the active telephone numbers. This SMS shall include the fault details, the engine running/not running information, the voltage, current, battery voltage and run hour information. The owner of the first 2 telephone numbers can, on demand, access the above information through SMS by sending an SMS to AC3. The SMS is “STATUS”, without quotes and all capital.



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2.12.2 Feeding Telephone Numbers

Up to five telephone numbers can be stored in DES-11.

To feed the numbers switch off DES-11, press the Reset and Switch and while they are pressed power on the unit.

The display shall display

X C. No

+91ZZZZZZZZZZ

The first row "X" indicates the cursor position.

The second row displays the telephone number.

The first number is always +.

If the next digit is 0. It signifies that this particular number is not in use.

The digit at the cursor positions can be modified by pressing key. The digits shall change from 0-9 and blank.

The blank digit signifies the end of the telephone number. The digits after this shall be discarded.

To go to next digit press key.

Continue till the desired number is programmed.

Make sure that the last digit after the valid number is a blank.

To go to next telephone number press Key.

The process can be terminated and all previous programmed numbers can be stored by pressing R (Reset) Key



2.13 Terminal Description

Terminal Number	Description
1	Generator R Phase Voltage
2	Generator Y Phase Voltage
3	Generator B Phase Voltage
4	Generator neutral
5	LLOP Sensor
6	HWT Sensor (Model-A), HCT Logic Level Low (Model-B)
7	Fuel Sensor
8	RWL / Canopy Temperature
9	Charging Alternator Input
10	Auxiliary supply + VE
11	Auxiliary supply - VE
12	Crank NO Contact
13	Solenoid NO Contact
14	Charging Alternator On
15	Hooter
16	Common for All Contacts
17	Remote Start
18	Remote Stop
19,20	R Phase CT (For /5 Unit. 5Amps Unit)
21,22	Y Phase CT (For /5 Unit. 5Amps Unit)
23,24	B Phase CT (For /5 Unit. 5Amps Unit)
19	R Phase CT (For Whole Current Unit with Procom Make CT's)
20	Y Phase CT (For Whole Current Unit with Procom Make CT's)
21	B Phase CT (For Whole Current Unit with Procom Make CT's)
22	Common Point Of CTs (For Whole Current Unit with Procom Make CT's)
20-22	Fan Current input for Single Phase Model-B

Table E2.5 Terminal Description



2.14 Specifications

AC Voltage withstand	330 VAC (Phase to neutral)
Measurement Accuracy	
Voltage & Current	1%
Power & KWh	2%
Surge 1.2/50Usec	2.5KV
Battery Voltage	Suitable for 12V/24 VDC System
Min. voltage to power on	9V
Min Running Voltage after Power on	4V
Max. Battery Voltage	35V
DC Interruption time	1 Sec.
Digital Output	+ 12V
Cut out Dimensions	92mm X 92mm
Depth	120mm
Digital Input Level which is battery supply	Battery Voltage (Negative) except Charging Alt,

Table E2.6



Chapter 3 Deep Sea 4520 Controller

3.1 Introduction

The Deep Sea (DSE4520) Controller is designed to provide differing levels of functionality across a common platform. This allows the generator OEM greater flexibility in the choice of controller to use for a specific application.

The DSE4520 controller has been designed to allow the operator to start and stop the generator, and if required, transfer the load to the generator either manually or automatically. Additionally, the DSE4520 automatically starts and stops the generator set depending upon the status of the mains (utility) supply. The user also has the facility to view the system operating parameters via the LCD display. The said controller monitors the engine, indicating the operational status and fault conditions, automatically shutting down the engine and giving a true first up fault condition of an engine failure by the LCD display. The powerful ARM microprocessor contained within the module allows for incorporation of a range of complex features:

- i. Icon based LCD display
- ii. True RMS Voltage
- iii. Current and Power monitoring (Not applicable to the DSE45xx-01 variant)
- iv. USB Communications
- v. Engine parameter monitoring
- vi. Fully configurable inputs for use as alarms or a range of different functions
- vii. Engine ECU interface to electronic engines

Using a PC and the DSE Configuration Suite software allows alteration of selected operational sequences, timers, alarms and operational sequences. Additionally, the module's integral front panel configuration editor allows adjustment of this information. A robust plastic case designed for front panel mounting houses the module. Connections are via locking plug and sockets. Access to critical operational sequences and timers for use by qualified engineers, can be protected by a security code. Module access can also be protected by PIN code. Selected parameters can be changed from the module's front panel. The module is housed in a robust plastic case suitable for panel mounting. Connections to the module are via locking plug and sockets.

Auxiliary Power Business

3.2 Major Parts of Deep Sea (DSE4520) Controller

The major parts of Deep Sea (DSE4520) control panel & power panel are explained in two aspects, which are as mentioned below.

3.2.1 Components on the Door of Control Panel & Power Panel

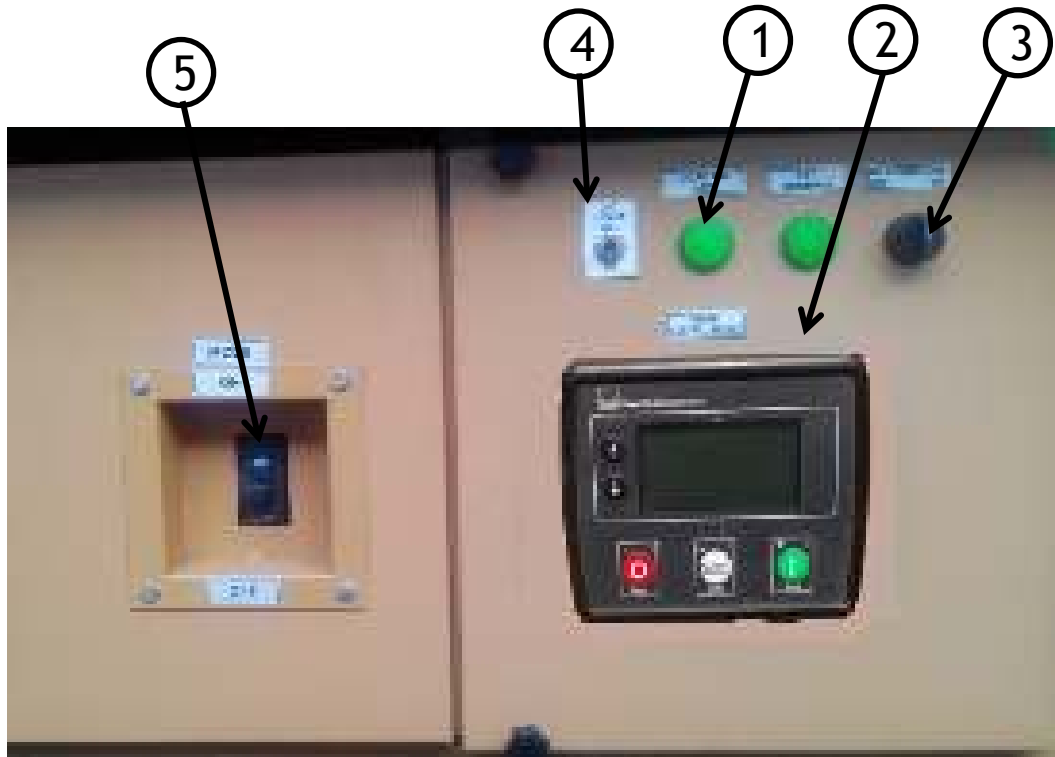


Fig. E3.1 Exterior Illustration of DSE4520 Control Panel

Ref. No.	Description of Part	Ref. No.	Description of Part
1	Load ON GENSET	4	Canopy Light Switch
2	Deep Sea (DSE4520) Controller	5	Power MCB / MCCB
3	Control Switch (ON/OFF)		

Table E3.1 Part List for External Components of DSE4520 Control Panel & Power Panel

Auxiliary Power Business

- 1) Load ON GENSET Indication Lamp: The green indication lamp turns on when the supply is available to the load.
- 2) Deep Sea (DSE4520) Controller: The electronic controller is provided to operate the system. It also contains an LCD display that displays various GENSET parameters, faults, status etc.
- 3) Control ON Selector Switch: When this switch is turned on, control supply is turned on and provided to the controller and other control equipment's.
- 4) DG Light switch: Provided to turn on the DG lamp inside the canopy.
- 5) Power MCB/ MCCB: This is the main circuit breaker between the alternator output and load. The breaker will carry the rated current continuously. In case of a short circuit or if over current flows for specified amount of time, the breaker will trip. The breaker must then be moved to "OFF" position before re-closing.

3.2.2 Components inside the Control Panel & Power Panel

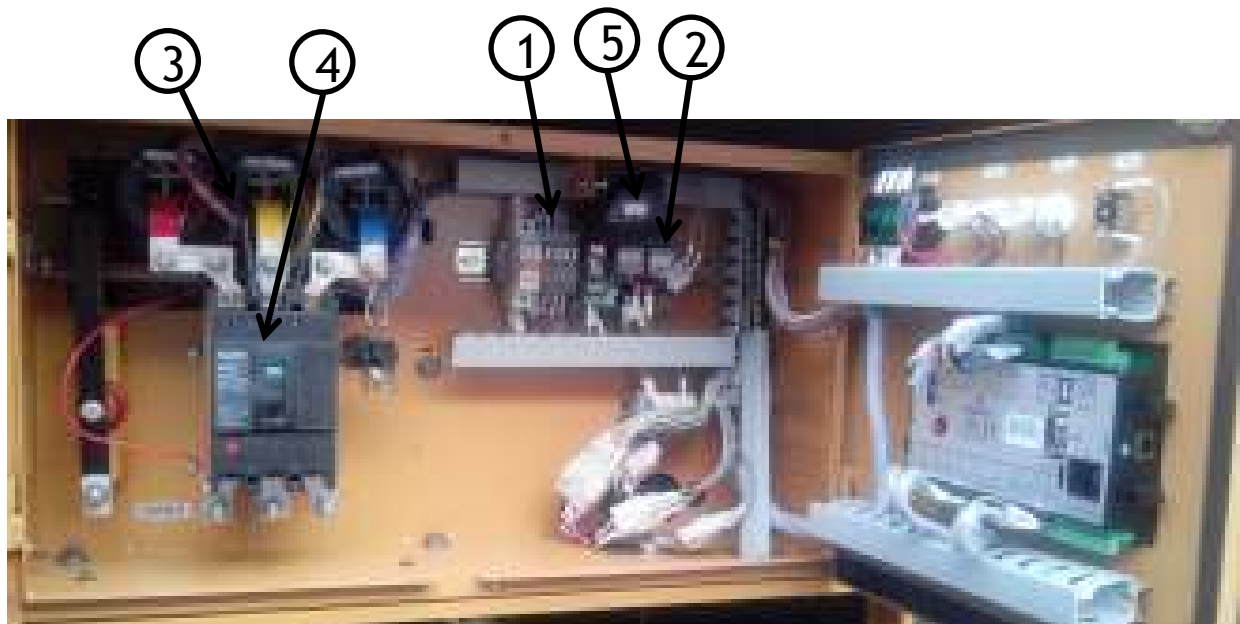


Fig. E3.2 Interior Illustration of DSE4520 Control Panel



Ref. No.	Description of Part	Ref. No.	Description of Part
1	Control MCB/Fuse	4	Power MCB/MCCB
2	Power Relay Board	5	Hooter
3	Current Transformers		

Table E3.2 Part List for Internal Components of DSE4520 Control Panel & Power Panel

- 1) Control MCB / Controller: A single pole control MCB is provided for protection of the control circuit.
- 2) Power Relay Board: The power relay board consists of three power relays, on each for the fuel solenoid, crank solenoid and hooter.
- 3) Current Transformers: Three current transformers, one for each phase, are provided for sensing current.
- 4) Hooter: The hooter operates in case of any fault is sensed by the controller.

3.3 Specifications

3.3.1 Short Names

DSE4500, DSE45xx	All modules in the DSE4500 range
DSE4520	DSE4520 module/controller

3.3.2 Operating Temperature

DSE45xx	-30°C to +70°C (-40°C to +70°C for variants fitted with display heaters)
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3.3.3 Power Supply Requirements

Minimum Supply Voltage	8V continuous
Cranking Dropouts	Able to survive 0V for 100ms providing the supply was at least 10V before the dropout and recovers to 5V afterwards.
Maximum Supply Voltage	35V continuous (60V protection)
Reverse Polarity Protection	-35V continuous
Maximum Operating Current	96mA at 12V 85mA at 24V
Maximum Standby Current	51mA at 12V 47mA at 24V
Maximum Current When In Sleep Mode	35mA at 12V 32mA at 24V
Maximum Current When In Deep Sleep Mode	Less than 10µA at 12V Less than 10µA at 24V

Table E3.3 Power Supply Requirements

3.3.3.1 Module Supply Instrumentation Display

Range	0V-70V DC (note Maximum continuous operating voltage of 35V DC)
Resolution	0.1V
Accuracy	1% full scale (±0.7V)

Table E3.4 Module Supply Instrumentation Display



3.3.4 Voltage & Frequency Sensing

Measurement Type	True RMS conversion
Sample Rate	5kHz or better
Harmonics	Up to 11th or better
Input Impedance	300k_ phase to neutral
Phase To Neutral	15V (minimum required for sensing frequency) to 415V AC (absolute maximum) Suitable for 345V nominal ($\pm 20\%$ for under/overvoltage detection)
Phase To Phase	25V (minimum required for sensing frequency) to 720V AC (absolute maximum) Suitable for 600V nominal ($\pm 20\%$ for under/overvoltage detection)
Common Mode Offset From Earth	100V AC (max)
Resolution	1V AC phase to neutral 2V AC phase to phase
Accuracy	$\pm 1\%$ of full scale phase to neutral $\pm 2\%$ of full scale phase to phase
Minimum Frequency	3.5 Hz
Maximum Frequency	75.0 Hz
Frequency Resolution	0.1 Hz
Frequency Accuracy	± 0.2 Hz

Table E3.5 Voltage & Frequency Sensing

3.3.5 Current Sensing



Important Note! Current Sensing is not available on the DSE45xx-01 variant.



Measurement Type	True RMS conversion
Sample Rate	5KHz or better
Harmonics	Up to 10th or better
Nominal CT Secondary Rating	5A
Maximum Continuous Current	5A
Overload Measurement	3 x Nominal Range setting
Absolute Maximum Overload	50A for 1 second
Burden	0.25VA (0.01_ current shunts)
Common Mode Offset	±1V peak plant ground to CT common terminal
Resolution	0.5% of 5A
Accuracy	±1% of Nominal (5A) (excluding CT error)

Table E3.6 Current Sensing

3.3.6 Inputs

3.3.6.1 Digital Inputs

Number	4 configurable digital inputs (7 when Analogue Inputs are configured as digital inputs)
Arrangement	Contact between terminal and ground
Low Level Threshold	3.2 V minimum
High Level Threshold	8.1 V maximum
Maximum Input Voltage	+60 V DC with respect to plant supply negative
Minimum Input Voltage	-24 V DC with respect to plant supply negative
Contact Wetting Current	6 mA typical
Open Circuit Voltage	15 V typical

Table E3.7 Digital Inputs



3.3.6.2 Analogue Inputs

3.3.6.2.1 Oil Pressure

Measurement Type	Resistance measurement by measuring voltage across sensor with a fixed current applied
Arrangement	Differential resistance measurement input
Measurement	Current 11mA \pm 10%
Full Scale	240 Ω
Over Range / Fail	270 Ω
Resolution	0.1 Bar (1-2 PSI)
Accuracy	\pm 2% of full scale resistance (\pm 4.8 Ω) excluding transducer error
Max Common Mode Voltage	\pm 2V
Display Range	0 bar - 17.2 bar (0PSI - 250PSI) subject to limits of the sensor

Table E3.8

3.3.6.2.2 Coolant Temperature

Measurement Type	Resistance measurement by measuring voltage across sensor with a fixed current applied
Arrangement	Differential resistance measurement input
Measurement Current	11mA \pm 10%
Full Scale	480 Ω
Over Range / Fail	540 Ω
Resolution	1 $^{\circ}$ C (2 $^{\circ}$ F)
Accuracy	+/-2% of full scale resistance (\pm 9.6 Ω) excluding transducer error
Max Common Mode Voltage	\pm 2V
Display Range	0 $^{\circ}$ C - 250 $^{\circ}$ C (32 $^{\circ}$ F - 482 $^{\circ}$ F) subject to limits of the sensor

Table E3.9



3.3.6.2.3 Fuel Level Sensor

Measurement Type	Resistance measurement by measuring voltage across sensor with a fixed current applied
Arrangement	Differential resistance measurement input
Measurement Current	11mA ±10%
Full Scale	480 Ω
Over Range / Fail	540 Ω
Resolution	1%
Accuracy	+/-2% of full scale resistance (±9.6 Ω) excluding transducer error
Max Common Mode Voltage	±2V
Display Range	0% - 250% subject to limits of the sensor

Table E3.10

3.3.6.2.3 Flexible Sensor (When Configured)

Number	1 when Fuel Level Sender is configured as a flexible
Measurement Type	Resistance measurement by measuring voltage across sensor with a fixed current applied
Arrangement	Differential resistance measurement input
Measurement Current	11mA ±10%
Full Scale	480 Ω
Over Range / Fail	540 Ω
Resolution	1%
Accuracy	+/-2% of full scale resistance (±9.6 Ω) excluding transducer error
Max Common Mode Voltage	±2V
Display Range	0% - 250%, 0°C - 250°C (32°F - 482°F) or 0 bar - 17.2 bar (0 PSI - 250 PSI) subject to limits of the sensor and sensor configuration

Table E3.11



3.3.6.3 Charge Fail Input

Minimum Voltage	0V
Maximum Voltage	35V (plant supply)
Resolution	0.2V
Accuracy	± 1% of max measured voltage
Excitation	Active circuit constant power output
Output Power	2.5W nominal at 12V and 24V
Current	At 12V 210mA
Current	At 24V 105mA

Table E3.12

The charge fail input is actually a combined input and output. Whenever the generator is required to run, the terminal provides excitation current to the charge alternator field winding. When the charge alternator is correctly charging the battery, the voltage of the terminal is close to the plant battery supply voltage. In a failed charge situation, the voltage of this terminal is pulled down to a low voltage. It is this drop in voltage that triggers the charge failure alarm. The level at which this operates and whether this triggers a warning or shutdown alarm is configurable using the DSE Configuration Suite Software.

3.3.7 Outputs

3.3.7.1 DC Outputs A & B (Fuel & Start)

Type	Normally used as Fuel & Start outputs. Fully configurable for other purposes if the module is configured to control an electronic engine.
Rating	10A resistive for 10secs, 5A resistive continuous at 35V

Table E3.13

Auxiliary Power Business

3.3.7.2 Configurable DC Outputs C & D

Type	Fully configurable, supplied from DC supply terminal 2.
Rating	2A resistive continuous at 35V

Table E3.14

3.3.7.3 Configurable DC Outputs E & F (DSE 4520 Only)

Type	Fully configurable, supplied from DC supply terminal 2.
Rating	2A resistive continuous at 35V

Table E3.15

3.3.8 Dimensions and Mounting

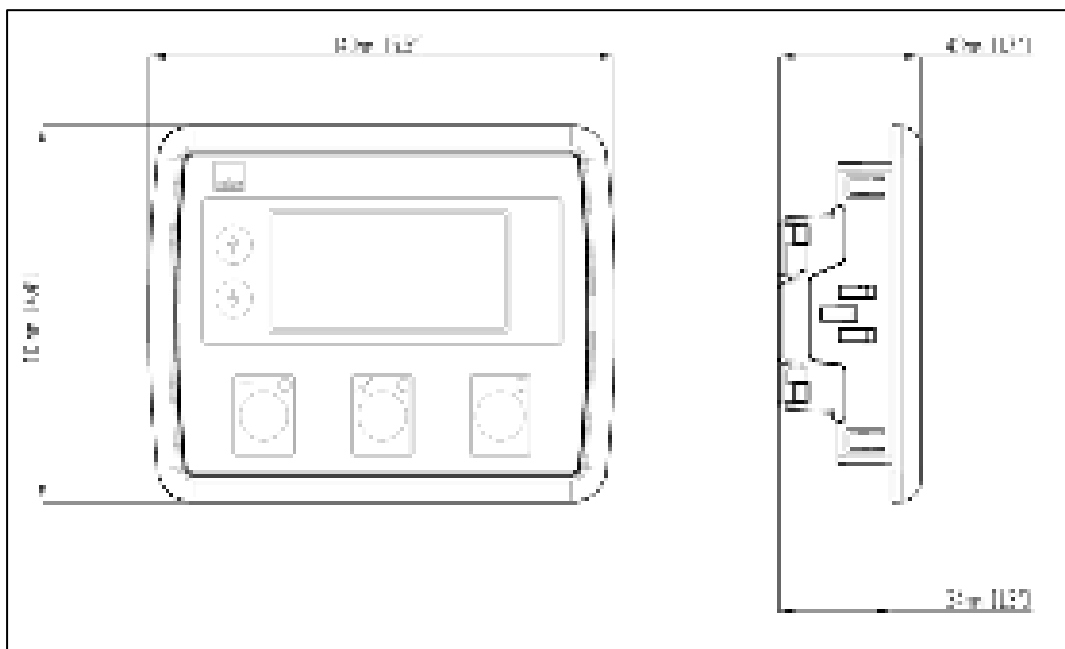


Fig. E3.5

3.3.8.1 Dimensions

140.0mm x 113mm x 43mm (5.5" x 4.4" x 1.7")

3.3.8.2 Panel Cut-out

118mm x 92mm (4.6" x 3.6")

Auxiliary Power Business

3.3.8.3 Weight

0.16kg (0.35lb)

3.3.8.4 Fixing Clips

The module is held into the panel fascia using the supplied fixing clips.

- i. Withdraw the fixing clip screw (turn anticlockwise) until only the pointed end is protruding from the clip.
- ii. Insert the three 'prongs' of the fixing clip into the slots in the side of the module case.
- iii. Pull the fixing clip backwards (towards the back of the module) ensuring all three prongs of the clip are inside their allotted slots.
- iv. Turn the fixing clip screws clockwise until they make contact with the panel fascia.
- v. Turn the screws a little more to secure the module into the panel fascia. Care should be taken not to over tighten the fixing clip screws.

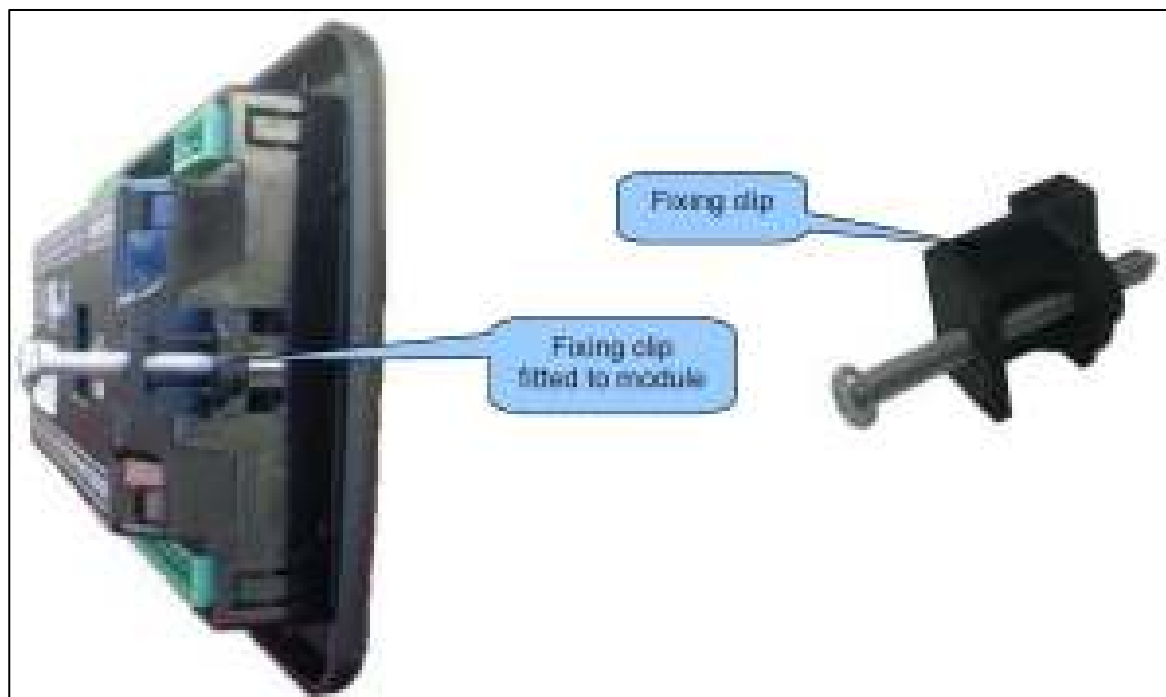



Fig. E3.6



Important Note! In conditions of excessive vibration, mount the module on suitable anti-vibration mountings.

3.3.8.5 Silicon Sealing Gasket

	<p>Important Note! For purchasing an additional silicon gasket from DSE, please see the chapter entitled Maintenance, Spares, Repair and Servicing in this Section E.</p>
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The optional silicon gasket provides improved sealing between module and the panel fascia. The gasket is fitted to the module before installation into the panel fascia. Take care to ensure the gasket is correctly fitted to the module to maintain the integrity of the seal.

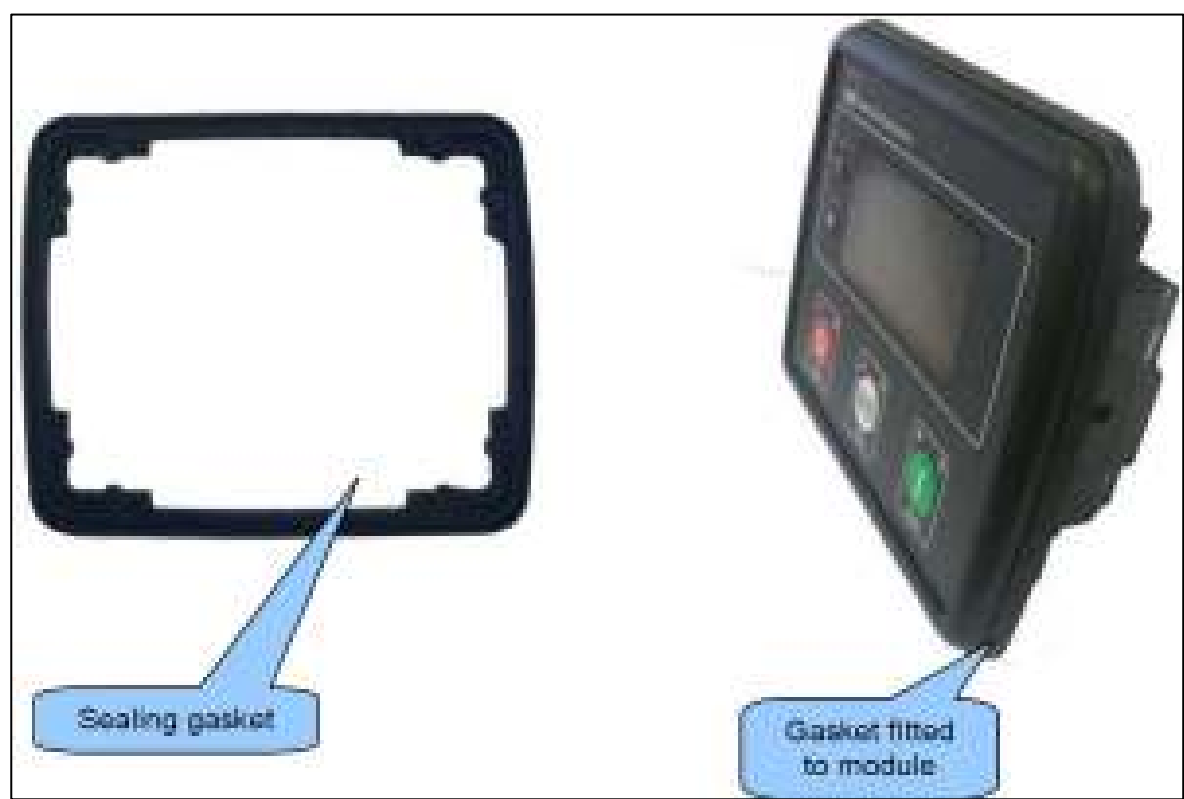


Fig. E3.7

3.4 Installation

The module is designed to be mounted on the panel fascia. For dimension and mounting details, see the topic entitled Specifications, Dimension and mounting in this chapter.

3.4.1 Terminal Description

To aid user connection, icons are used on the rear of the module to help identify terminal functions. An example of this is shown below.

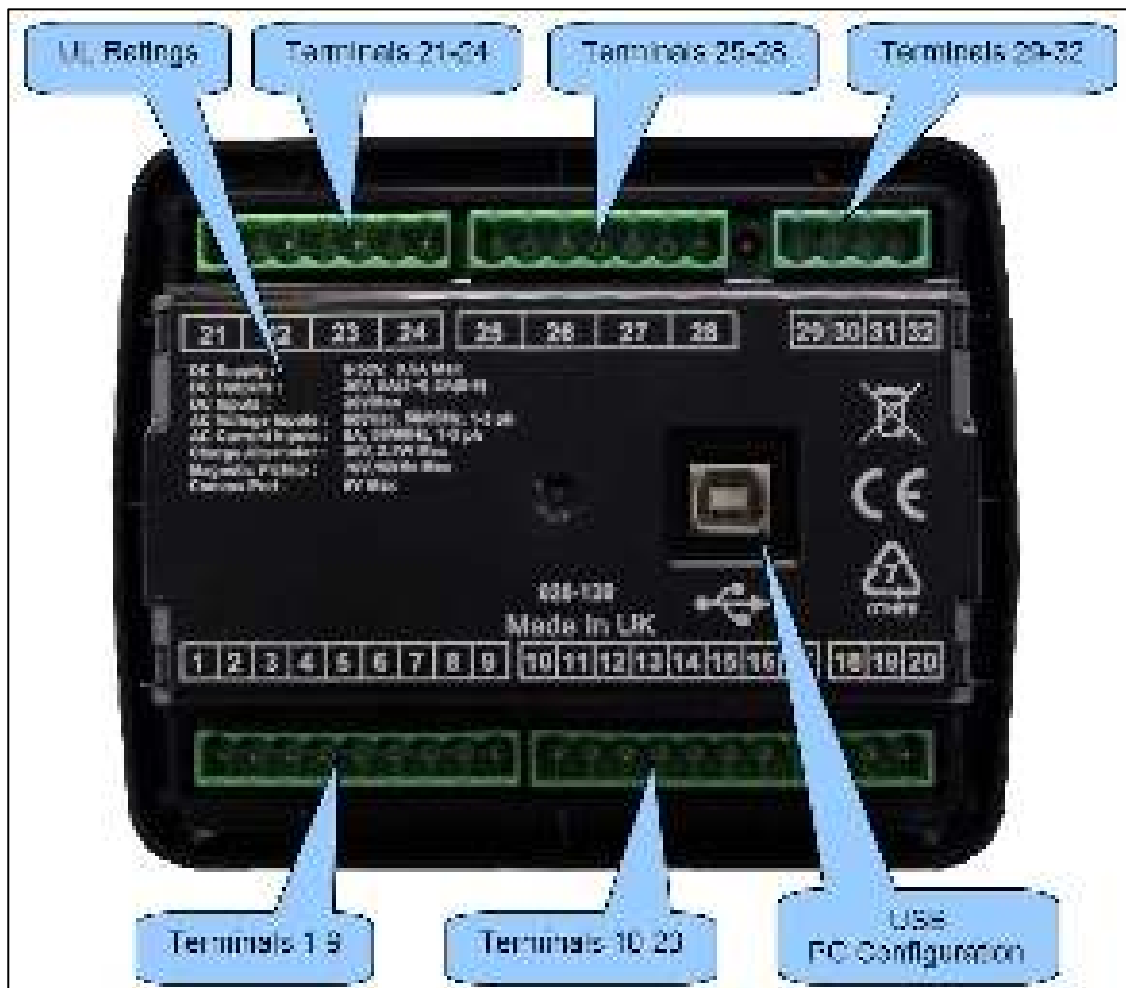



Fig. E3.8

3.5 Description of Controls

	<p>Important Note! The following descriptions detail the sequences followed by a module/controller containing the standard ‘factory configuration’. Always refer to your configuration source for the exact sequences and timers observed by any particular module/controller in the field.</p>
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Control of the module is via push buttons mounted on the front of the module with Stop/Reset Mode,  Auto Mode,  and Manual/Start Mode  functions. For normal operation, these are the only controls which need to be operated. Details of their operation are provided later in this document.





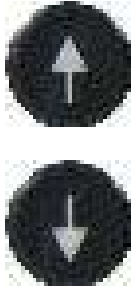


Fig. E3.9 Illustration of DSE4520 Module / Controller

	<p>CAUTION! The module may instruct an engine start event due to external influences. Therefore, it is possible for the engine to start at any time without warning. Prior to performing any maintenance on the system, it is recommended that steps are taken to remove the battery and isolate supplies.</p>
---	---



3.5.1 Control Push-Buttons

Icon	Description
	<p>Stop / Reset Mode</p> <p>This button places the module into its Stop/Reset Mode.  This will clear any alarm conditions for which the triggering criteria have been removed. If the engine is running and the module is put into Stop mode, the module will automatically instruct the generator to unload ('Close Generator' and 'Delayed Load Output 1, 2, 3 & 4' become inactive (if used)). The fuel supply de-energises and the engine comes to a standstill. Should any form of remote start signal be present while operating in this mode, a start will <u>not</u> occur.</p>
	<p>Auto Mode</p> <p>This button places the module into its Auto Mode.  This mode allows the module to control the function of the generator automatically. The module will monitor the remote start input and battery charge status and once a start request is made, the set will be automatically started and placed on load ('Close Generator' and 'Delayed Load Output 1, 2, 3 & 4' become active in order from lowest to highest (if used)).</p> <p>Upon removal of the starting signal, the module will remove the load from the generator and shut the set down observing the stop delay timer and cooling timer as necessary ('Close Generator' and 'Delayed Load Output 1, 2, 3 & 4' become inactive at once (if used)). The module will then await the next start event. For further details, please see the more detailed description of 'Auto operation' elsewhere in this manual.</p>
	<p>Menu Navigation</p> <p>Used for navigating the instrumentation, event log and configuration screens.</p>







Icon	Description
	<p>Manual / Start Mode</p> <p>This button will start the engine and run off load. To place the generator on load, digital inputs are required to be assigned to perform this function.</p> <p>If the engine is running off-load in Manual/Start Mode  button and a remote start signal becomes present, the module will automatically instruct the changeover device to place the generator on load ('Close Generator' and 'Delayed Load Output 1, 2, 3 & 4' becomes active (if used)). Upon removal of the Remote Start Signal, the generator remains on load until either selection of the Stop/Reset Mode  or Auto Mode. </p>

Table E3.16

3.5.2 Instrumentation Icons




















Icon	Details
	The default home page which displays generator voltage and mains voltage (DSE4520 only)
	Generator voltage and frequency instrumentation screen
	Mains voltage and frequency instrumentation screen (DSE4520 only)
	Generator current instrumentation screen
	Mains current instrumentation screen (DSE4520 only when CT in load location)
	Load power instrumentation screen
	Engine speed instrumentation screen
	Hours run instrumentation screen
	Battery voltage instrumentation screen
	Oil pressure instrumentation screen
	Coolant temperature instrumentation screen
	Flexible sender instrumentation screen
	Appears when the event log is being displayed
	Current time held in the unit
	The current value of the scheduler run time and duration
	ECU diagnostic trouble codes
	Oil Filter maintenance timers
	Air Filter maintenance timers
	Fuel Filter maintenance timers

Exhibit Table E3.17 Instrumentation Icons

Auxiliary Power Business

3.5.3 Mode Icons

An icon is displayed in the Mode Icon section to indicate the mode the controller is currently in.









Icon	Details
	Appears when the engine is at rest and the unit is in stop mode.
	Appears when the engine is at rest, and the unit is in auto mode.
	Appears when the engine is at rest and the unit is waiting for a manual start.
	Appears when a timer is active, for example cranking time, crank rest etc.
	Appears when the engine is running, and all timers have expired, either on or off load. The start/stop speed is reduced when running in idle mode.
	Appears when the unit is in the front panel editor.
	Appears when a USB connection is made to the controller.
	Appears if either the configuration file or engine file has become corrupted.

Exhibit Table E3.18 Mode Icons

3.5.4 Load Switching Icons

An icon is displayed in the Load Switching Icon section to indicate the current operation status of the controller.









Icon	Details
	Appears when the generator is not available and when the generator breaker is open.
	Appears when the generator is at rest or not available and the generator breaker has failed to open.
	Appears when the generator is available and the generator breaker is open.
	Appears when the generator is available and the generator breaker is closed.
	Appears when the mains supply is not available and the mains breaker is open. (USL4520 Only)
	Appears when the mains supply is not available and the mains breaker is closed. (DF4500 Only)
	Appears when the mains supply is available and the mains breaker is open. (USL4520 Only)
	Appears when the mains supply is available and the mains breaker is closed. (DF4500 Only)

Exhibit Table E3.19 Load Switching Icons

Auxiliary Power Business

3.5.5 Backlight

The LCD backlight is on if the unit has sufficient voltage while the unit is turned on, unless the unit is cranking for which the backlight is turned off.

3.5.6 Warning Alarm Icons

Warnings are non-critical alarm conditions and do not affect the operation of the generator system, they serve to draw the operators attention to an undesirable condition.

By default, warning alarms are self-resetting when the fault condition is removed. However enabling 'all warnings are latched' will cause warning alarms to latch until reset manually. This is enabled using the DSE Configuration Suite in conjunction with a compatible PC.











Icon	Fault	Description
	Auxiliary Inputs	The module detects that an auxiliary input which has been user configured to create a fault condition has become active.
	Analogue Input Configured As Digital	The analogue inputs can be configured to digital inputs. The module detects that an input configured to create a fault condition has become active.
	Fail To Stop	The module has detected a condition that indicates that the engine is running when it has been instructed to stop. NOTE: 'Fail to Stop' could indicate a faulty oil pressure sensor. If engine is at rest check oil sensor wiring and configuration.
	Charge Failure	The auxiliary charge alternator voltage is low as measured from the V/L terminals.
	Low Fuel Level	The level detected by the fuel level sensor is below the low fuel level pre-set pre-alarm setting.
	High Fuel Level	The level detected by the fuel level sensor is above the high fuel level pre-set pre-alarm setting.
	Battery Under Voltage	The DC supply has fallen below or risen above the low volts pre-set pre-alarm setting.
	Battery Over Voltage	The DC supply has risen above the high volts pre-set pre-alarm setting.
	Generator Under Voltage	The generator output voltage has fallen below the pre-set pre-alarm setting after the Safety On timer has expired.
	Generator Over Voltage	The generator output voltage has risen above the pre-set pre-alarm setting.

Exhibit Table E3.20 (a) Warning Alarm Icons












	Generator Under Frequency	The generator output frequency has fallen below the preset pre-alarm setting after the Safety On timer has expired.
	Generator Over Frequency	The generator output frequency has risen above the preset pre-alarm setting.
	CAN ECU Fault	The engine ECU has detected an alarm
	CAN Data Fail	The module is configured for CAN operation and does not detect data on the engine CAN data link.
	Immediate Over Current	The measured current has risen above the configured trip level.
	Delayed Over Current	The measured current has risen above the configured trip level for a configured duration.
	Oil Filter Maintenance Alarm	Maintenance due for oil filter
	Air Filter Maintenance Alarm	Maintenance due for air filter
	Fuel Filter Maintenance Alarm	Maintenance due for fuel filter

Exhibit Table E3.20 (b) Warning Alarm Icons

3.5.7 Electrical Trip Alarm Icons

Electrical trips are latching and stop the Generator but in a controlled manner. On initiation of the electrical trip condition the module de-energises all the ‘Delayed Load Output’ and the ‘Close Gen Output’ outputs to remove the load from the generator. Once this has occurred the module starts the Cooling timer and allows the engine to cool off-load before shutting down the engine. The alarm must be accepted and cleared, and the fault removed to reset the module.

Electrical trips are latching alarms and to remove the fault, press the Stop/Reset Mode  button on the module.

	<p>CAUTION! The alarm condition must be rectified before a reset will take place. If the alarm condition remains, it is not possible to reset the unit (The exception to this is the Low Lube Oil Pressure alarm and similar ‘active from safety on’ alarms, as the oil pressure is low with the engine at rest).</p>
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Icon	Fault	Description
	Auxiliary Inputs	The module detects that an auxiliary input which has been user configured to create a fault condition has become active.
	Analogue Input Configured As Digital	The analogue inputs can be configured to digital inputs. The module detects that an input configured to create a fault condition has become active.
	Low Fuel Level	The level detected by the fuel level sensor is below the low fuel level pre-set alarm setting.
	High Fuel Level	The level detected by the fuel level sensor is above the high fuel level pre-set alarm setting.
	Delayed Over Current	The measured current has risen above the configured trip level for a configured duration.
	kW Overload	The measured kW has risen above the configured trip level for a configured duration.

Exhibit Table E3.21 Electrical Trip Alarm Icons

3.5.8 Shutdown Alarm Icons

Shutdown alarms are latching and immediately stop the Generator. On initiation of the shutdown condition the module de-energises all the ‘Delayed Load Output’ and the ‘Close Gen Output’ outputs to remove the load from the generator. Once this has occurred, the module shuts the generator set down immediately to prevent further damage. The alarm must be accepted and cleared, and the fault removed to reset the module.

Shutdowns are latching alarms and to remove the fault, press the Stop/Reset Mode  button on the module.









Icon	Fault	Description
	Auxiliary Inputs	The module detects that an auxiliary input which has been user configured to create a fault condition has become active.
	Analogue Input Configured As Digital	The analogue inputs can be configured to digital inputs. The module detects that an input configured to create a fault condition has become active.
	Fail To Start	The engine has failed to start after the configured number of start attempts.
	Low Oil Pressure	The module detects that the engine oil pressure has fallen below the low oil pressure pre-alarm setting level after the Safety On timer has expired.
	Engine High Temperature	The module detects that the engine coolant temperature has exceeded the high engine temperature pre-alarm setting level after the Safety On timer has expired.
	Under Speed	The engine speed has fallen below the under speed pre alarm setting.
	Over Speed	The engine speed has risen above the over speed pre alarm setting.
	Charge Failure	The auxiliary charge alternator voltage is low as measured from the W1, terminal.

Exhibit Table E3.22 (a) Shutdown Alarm Icons

















Icon	Fault	Description
	Generator Under Frequency	The generator output frequency has fallen below the pre-set alarm setting after the Safety On timer has expired.
	Generator Over Frequency	The generator output frequency has risen above the pre-set alarm setting.
	Delayed Over Current	The measured current has risen above the configured trip level for a configured duration.
	kW Overload	The measured kW has risen above the configured trip level for a configured duration.
	CAN ECU Fault	The engine ECU has detected an alarm – CHECK ENGINE LIGHT Contact Engine Manufacturer for support.
	CAN Data Fail	The module is configured for CAN operation and was not detect data on the engine Can data link.
	Emergency Stop	The emergency stop button has been depressed. This failsafe (normally closed) to emergency stop input and immediately stops the set should the signal be removed.
	Oil Sender Open Circuit	The oil pressure sensor has been detected as being open circuit.
	Coolant Temperature Sender Open Circuit	The coolant temperature sensor has been detected as being open circuit.
	Oil Filter Maintenance Alarm	Maintenance due for oil filter.
	Air Filter Maintenance Alarm	Maintenance due for air filter.
	Fuel Filter Maintenance Alarm	Maintenance due for fuel filter.
	Low Fuel Level	The level detected by the fuel level sensor is below the low fuel level pre-set alarm setting.
	High Fuel Level	The level detected by the fuel level sensor is above the high fuel level pre-set alarm setting.
	Generator Under Voltage	The generator output voltage has fallen below the pre-set alarm setting after the Safety On timer has expired.
	Generator Over Voltage	The generator output voltage has risen above the pre-set alarm setting.

Exhibit Table E3.22 (b) Shutdown Alarm Icons

3.5.8 Navigation Menu Icons









Icon	Description
	Generator and mains voltage instrumentation (DSE4020 only)
	Generator instrumentation
	Mains instrumentation (DSE4020 only)
	Current and load instrumentation (Not available in on the DGD-5xx 20 variant)
	Engine instrumentation
	Module information
	Engine DTCs (Diagnostic Trouble Codes) if active
	Event Log

Exhibit Table E3.23 Navigation Menu Icons

3.5.9 ECU Alarm Icons (Engine DTC [Diagnostic Trouble Codes])








Icon	Fault	DTC Description
	Check Engine Fault	The engine ECU has detected a fault not recognised by the DSE module, contact engine manufacturer for support.
	Low Oil Pressure	The engine ECU has detected that the engine oil pressure has fallen below its configured low oil pressure alarm level.
	Under Speed	The engine ECU has detected that the engine speed has fallen below its configured under speed alarm level.
	Over Speed	The engine ECU has detected that the engine speed has risen above its configured over speed alarm level.
	Charge Failure	The engine ECU has detected that the engine's charge alternator output has fallen below its configured alarm level.
	Low Fuel Level	The engine ECU has detected that the engine's fuel level has fallen below its configured low fuel level alarm.
	Battery Under/Over Voltage	The engine ECU has detected that the engine's DC supply has fallen below or risen above its configured alarm level.

Exhibit Table E3.24 ECU Alarm Icons and DTC Description

3.5.10 Event Log

This module's/controller's event log contains a list of the last 15 record electrical trip or shutdown events and the engine hours at which they occurred. Once the log is full, any subsequent electrical trip or shutdown alarms overwrites the oldest entry in the log. Hence, the log always contains the most recent shutdown alarms. The module logs the alarm, along with the engine running hours.

3.6 Operation

3.6.1 Quick Start Guide

This sub-topic provides a quick start guide to the module's/controller's operation.

3.6.1.1 Starting the Engine

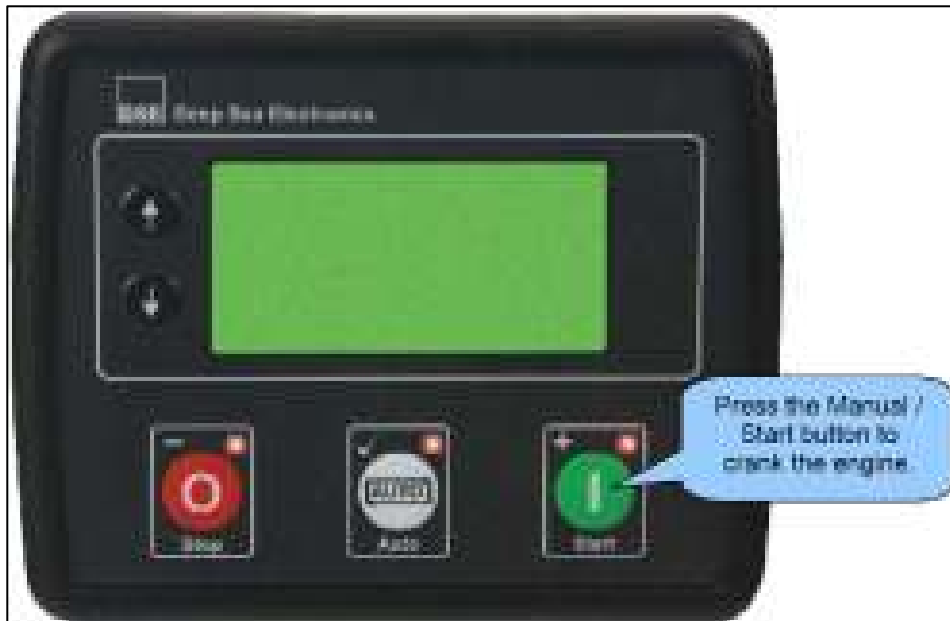


Fig. E3.10

3.6.1.2 Stopping the Engine



Fig. E3.11





3.6.2 Stop/Reset Mode



Important Note! If a digital input configured to panel lock is active, changing module modes will not be possible. Viewing the instruments and event logs is NOT affected by panel lock.


Stop/Reset Mode is activated by pressing the Stop/Reset Mode  button.



The Stop/Reset icon  is displayed to indicate Stop/Reset Mode operations.

In Stop/Reset Mode,  the module removes the generator from load (if necessary) before stopping the engine if it is already running. If the engine does not stop when requested, the FAIL TO STOP alarm is activated (subject to the setting of the Fail to stop timer). To detect the engine at rest the following must occur:

- i. Engine speed is zero as detected by the CAN bus ECU
- ii. Generator AC Voltage and Frequency must be zero
- iii. Engine Charge Alternator Voltage must be zero
- iv. Oil pressure sensor must indicate low oil pressure

When the engine has stopped, it is possible to send configuration files to the module from DSE Configuration Suite PC software and to enter the Front Panel Editor to change parameters.

Any latched alarms that have been cleared are reset when Stop/Reset Mode  is entered.

The engine is not started when in Stop/Reset Mode.  If remote start signals are given, the input is ignored until Auto Mode  is entered.




When left in Stop/Reset Mode  with no presses of the fascia buttons and configured for Power Save Mode, the module enters Power Save Mode. To 'wake' the module, press any fascia control buttons or activate Digital Input A. The same is true for Deep Sleep Mode.



Fig. E3.12

3.6.3 Automatic Mode

Auto Mode is activated by pressing the Auto Mode  button. The Auto Mode icon  is displayed to indicate Auto Mode operations if no alarms are present. Auto mode allows the generator to operate fully automatically, starting and stopping as required with no user intervention.

3.6.3.1 Waiting in Auto Mode

If a starting request is made, the starting sequence begins.

Starting requests can be from the following sources:


- i. Activation of an auxiliary input that has been configured to remote start
- ii. Activation of the inbuilt exercise scheduler

3.6.3.2 Starting Sequence

To allow for 'false' start requests, the start delay timer begins.

Should all start requests be removed during the start delay timer, the unit returns to a stand-by state.


If a start request is still present at the end of the start delay timer, the fuel relay is energised and the engine is cranked.

If the engine fails to fire during this cranking attempt then the starter motor is disengaged for the crank rest duration after which the next start attempt is made. If this sequence continues beyond the set number of attempts, the start sequence is terminated and the display shows fail to start! .



Important Note! If the unit has been configured for CAN, compatible ECU's receive the start command via CAN and transmit the engine speed to the DSE controller.

3.6.3.3 Engine Running

Once the engine is running and all starting timers have expired, the animated Engine Running icon  is displayed. The generator is placed on load if configured to do so. If all start requests are removed, the stopping sequence will begin.



Important Note! The load transfer signal remains inactive until the Oil Pressure has risen. This prevents excessive wear on the engine.


3.6.3.4 Stopping Sequence

The return delay timer operates to ensure that the starting request has been permanently removed and isn't just a short term removal. If another start request is made during the cooling down period, the set returns on load.




If there are no starting requests at the end of the return delay timer, the load is removed from the generator to the mains supply and the cooling timer is initiated. The cooling timer allows the set to run off load and cool sufficiently before being stopped. This is particularly important where turbo chargers are fitted to the engine. After the cooling timer has expired, the set is stopped.

3.6.4 Manual/Start Mode

3.6.4.1 Waiting in Manual Mode

To begin the starting sequence, press the Manual/Start Mode  button. If 'protected start' is disabled, the start sequence begins immediately.

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If 'Protected Start' is enabled, the Waiting in Manual Mode  icon is displayed and the LED above the Manual/Start Mode  button flashes to indicate Waiting in Manual Mode. The Manual/Start Mode  button must be pressed once more to begin the start sequence.

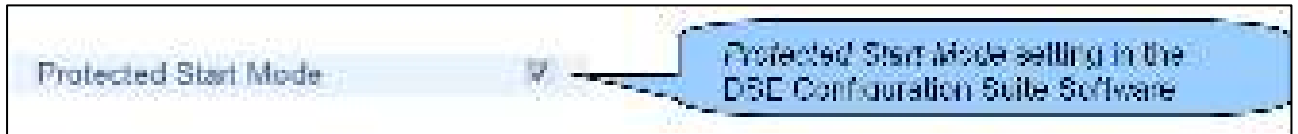


Fig. 3.13

3.6.4.2 Starting Sequence



Important Note! There is no start delay in this mode of operation. If the unit has been configured for CAN, compatible ECU's receives the start command via CAN.

The fuel relay is energised and the engine is cranked.

If the engine fails to fire during this cranking attempt then the starter motor is disengaged for the crank rest duration after which the next start attempt is made. If this sequence continues beyond the set number of attempts, the start sequence is terminated and the display shows fail to Start.


When the engine fires the starter motor is disengaged. Speed detection is factory configured to be derived from the main alternator output frequency.

Additionally, rising oil pressure can be used disconnect the starter motor (but cannot detect under speed or over speed).

After the starter motor has disengaged, the Safety On timer activates, allowing Oil Pressure, High Engine Temperature, Under-speed, Charge Fail and any delayed Auxiliary fault inputs to stabilise without triggering the fault.





3.6.4.3 Engine Running

Once the engine is running and all starting timers have expired, the animated Engine Running icon  is displayed.

In manual mode, the load is not transferred to the generator unless a 'loading request' is made. A loading request can come from a number of sources.



- i. Activation of an auxiliary input that has been configured to Remote Start on Load or Auxiliary Mains Fail.
- ii. Activation of the inbuilt exercise scheduler if configured for 'on load' runs.

Once the generator has been placed on load, it is not automatically removed. To manually remove the load either:

- i. Press the Auto Mode  button to return to automatic mode. The set observes all auto mode start requests and stopping timers before beginning the Auto Mode Stopping Sequence.
- ii. Press the Stop/Reset Mode  button to remove load and stop the generator.
- iii. Activation of an auxiliary input that has been configured to Generator Load Inhibit.

3.6.4.4 Stopping Sequence

In manual/start mode the set will continue to run until either:

- i. The Stop/Reset Mode button  is pressed - The delayed load outputs are de-activated immediately and the set immediately stops.
- ii. The Auto Mode button  is pressed. The set observes all auto mode start requests and stopping timers before beginning the Auto Mode Stopping Sequence.

3.7 Front Panel Configuration

This configuration mode allows the operator to fully configure the module through its display without the use of the DSE Configuration Suite PC Software. Use the module's fascia buttons to traverse the menu and make value changes to the parameters:

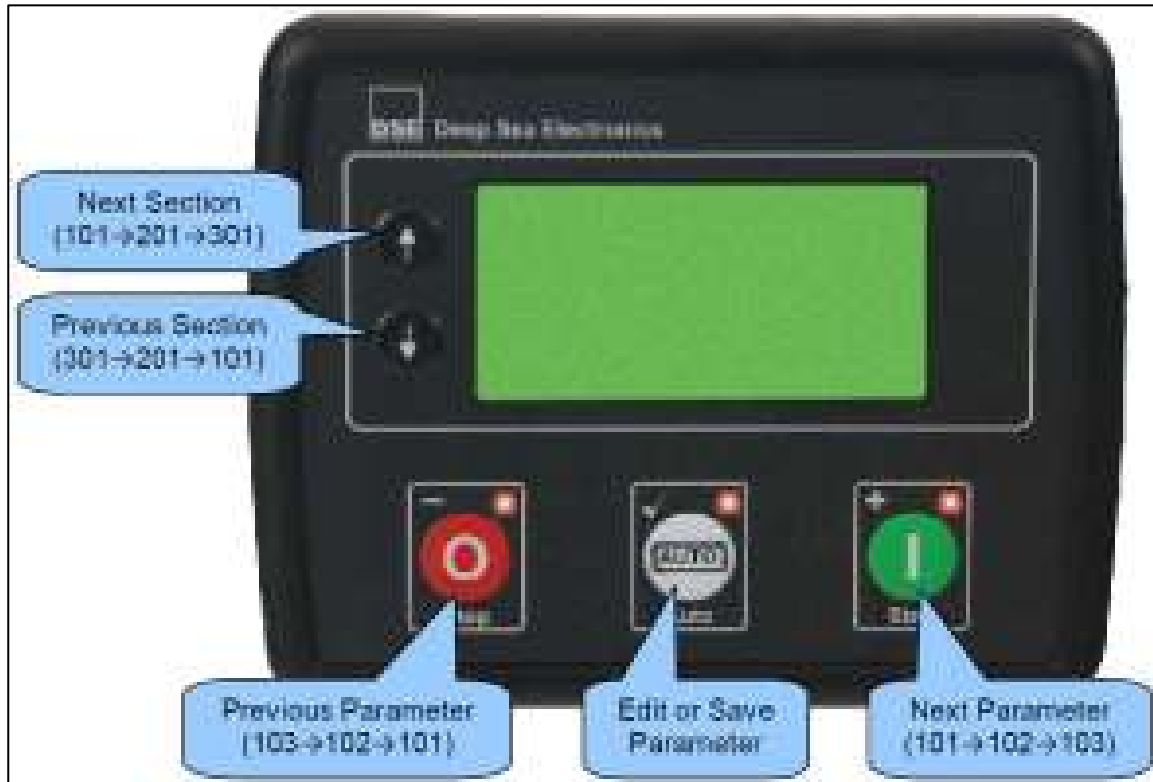









Fig. E3.14

3.7.1 Accessing the Front Panel Configuration Editor


Press the  (-) and  buttons together to enter the editor  mode.

Press  or  navigation buttons to cycle through the front panel editor to select the required page in the configuration tables.



Press the  (+) to select the next parameter or  (-) to select the previous parameter within the current page.

When viewing the parameter to be edited, press the  button, the value begins to flash.



Press the  (+) or  (-) buttons to adjust the value to the required setting.

Press the  button to save the current value, the value ceases flashing.

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Press and hold the  button to save and exit the editor, the configuration icon  is removed from the display.



Important Note! Pressing and holding the  (+) or  (-) buttons will give auto-repeat functionality. Values can be changed quickly by holding the buttons for a prolonged period of time.



Important Note! The editor automatically exits after 5 minutes of inactivity to ensure security.



Important Note! The PIN number is not set by DSE when the module leaves the factory. If the module has a PIN code set, this has been affected by your generator supplier who should be contacted if you require the code. If the code has been 'lost' or 'forgotten', the module must be returned to the DSE factory to have the module's code removed. A charge will be made for this procedure.
NB - This procedure cannot be performed away from the DSE factory.



Important Note! The PIN number is automatically reset when the editor is exited (manually or automatically) to ensure security.



Important Note! More comprehensive module configuration is possible via PC configuration software. For further details of module configuration, refer to DSE Publication: 057-172 DSE45xx configuration software manual.



3.8 Fault Finding

3.8.1 Starting


Symptom	Possible Remedy
Unit is inoperative. Read/Write configuration does not operate.	Check the battery and wiring to the unit. Check the DC supply. Check the DC fuse.
Unit shuts down	Check DC supply voltage is not above 35 Volts or below 9 Volts. Check the operating temperature is not above 70°C. Check the DC fuse.
Fail to Start is activated after pre-set number of attempts to start.	Check wiring of fuel solenoid. Check fuel. Check battery supply. Check battery supply is present on the Fuel output of the module. Check the speed-sensing signal is present on the module's inputs. Refer to engine manual.
Continuous starting of generator when in the Auto Mode 	Check that there is no signal present on the "Remote Start" input. Check configured polarity is correct. Check the mains supply is available and within configured limits.
Generator fails to start on receipt of Remote Start signal.	Check Start Delay timer has timed out. Check signal is on "Remote Start" input. Confirm correct configuration of input is configured to be used as "Remote Start". Check that the oil pressure switch or sensor is indicating low oil pressure to the controller. Depending upon configuration, then set will not start if oil pressure is not low.
Pre-heat inoperative	Check wiring to engine heater plugs. Check battery supply. Check battery supply is present on the Pre-heat output of module. Check pre-heat configuration is correct.
Starter motor inoperative	Check wiring to starter solenoid. Check battery supply. Check battery supply is present on the Starter output of module. Ensure oil pressure switch or sensor is indicating the "low oil pressure" state to the controller.

Table E3.25 Fault Finding during Starting



3.8.2 Loading

Symptom	Possible Remedy
Engine runs but generator will not take load.	Check Warm up timer has timed out. Ensure generator load inhibit signal is not present on the module inputs. Check connections to the switching device. Note that the set will not take load in manual mode unless there is an active load signal.
Incorrect reading on Engine Gauges Fail to stop alarm when engine is at rest	Check engine is operating correctly. Check that sensor is compatible with the module and that the module configuration is suited to the sensor.

Table E3.26 Fault Finding while Loading

3.8.3 Alarms

Symptom	Possible Remedy
Low oil Pressure fault operates after engine has fired.	Check engine oil pressure. Check oil pressure switch/sensor and wiring. Check configured polarity (if applicable) is correct (i.e. Normally Open or Normally Closed) or that sensor is compatible with the module and is correctly configured.
High engine temperature fault operates after engine has fired.	Check engine temperature. Check switch/sensor and wiring. Check configured polarity (if applicable) is correct (i.e. Normally Open or Normally Closed) or that sensor is compatible with the module.
Shutdown fault operates	Check relevant switch and wiring of fault indicated on LCD display. Check configuration of input.
Electrical Trip fault operates	Check relevant switch and wiring of fault indicated on LCD display. Check configuration of input.
Warning fault operates	Check relevant switch and wiring of fault indicated on LCD display. Check configuration of input.
CAN ECU WARNING CAN ECU SHUTDOWN	This indicates a fault condition detected by the engine ECU and transmitted to the DSE controller.
CAN DATA FAIL	Indicates failure of the CAN data link to the engine ECU. Check all wiring and termination resistors (if required).



Symptom	Possible Remedy
Incorrect reading on Engine gauges Fail to stop alarm when engine is at rest.	Check engine is operating correctly. Check sensor and wiring paying particular attention to the wiring to terminal 10 (refer to appendix). Check that sensor is compatible with the module and that the module configuration is suited to the sensor.

Table E3.27 Fault Finding during Alarms

3.8.4 Communications

Symptom	Possible Remedy
CAN DATA FAIL	Indicates failure of the CAN data link to the engine ECU. Check all wiring and termination resistors (if required).

Table E3.28 Fault Finding in Communications

3.8.5 Instruments

Symptom	Possible Remedy
Inaccurate generator measurements on controller display	<p>Check that the CT primary, CT secondary and VT ratio settings are correct for the application.</p> <p>Check that the CTs are wired correctly with regards to the direction of current flow (p1,p2 and s1,s2) and additionally ensure that CTs are connected to the correct phase (errors will occur if CT1 is connected to phase 2).</p> <p>Remember to consider the power factor ($kW = kVA \times \text{power factor}$).</p> <p>The controller is true RMS measuring so gives more accurate display when compared with an 'averaging' meter such as an analogue panel meter or some lower specified digital multi-meters.</p> <p>Accuracy of the controller is better than 1% of full scale. Generator voltage full scale is 415V ph-N, accuracy is $\pm 4.15V$ (1% of 415V).</p>

Table E3.29 Fault Finding in Instruments



3.8.6 Miscellaneous




Symptom	Possible Remedy
Module appears to 'revert' to an earlier configuration	When editing a configuration using the PC software it is vital that the configuration is first 'read' from the controller before editing it. This edited configuration must then be "written" back to the controller for the changes to take effect. When editing a configuration using the fascia editor, be sure to press the Auto Mode  () button to save the change before moving to another item or exiting the fascia editor.

Table E3.30 Miscellaneous Fault Finding

	<p>Important Note! The above fault finding is provided as a guide check-list only. As the module/controller can be configured to provide a wide range of different features, always refer to the source of your module/controller configuration if in doubt or speak to Greaves authorized service personnel.</p>
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3.9 Maintenance, Spares, Repair and Servicing

The controller is Fit and Forget. As such, there are no user serviceable parts within the controller. In the case of malfunction, you should contact your original equipment manufacturer (OEM).

3.9.1 Purchasing Additional Connector Plugs From DSE

If you require additional plugs from DSE, please contact our Sales department using the part numbers below.

3.9.1.1 Pack of Plugs

Module Type	Plug Pack Part Number
4510-01	100-400-41
4520-01	100-400-42
4510-02, 4510-03 & 4510-04	100-400-47
4520-02, 4520-03 & 4520-04	100-400-46

Table E3.31



3.9.1.2 Individual Plugs


Module Terminal Designation	Plug Description	Part No.
1-9 DSE4520 Only	9 way 5.08mm	007-166
1-7 DSE4510 Only	7 way 5.08mm	007-155
10-20	11 way 5.08mm	007-451
21-24	4 way 10.16mm	007-003
25-28 DSE4520 Only	4 way 10.16mm	007-003
29-32 Not fitted on 45xx-01	4 way 5.08mm	007-282
	PC Configuration interface lead (USB type A - USB type B)	016-125

Table E3.32

3.9.2 Purchasing Additional Fixing Clips from DSE


Item	Description	Part No.
	Module Fixing Clips (Packet Of 2)	020-406

Table E3.33

3.9.3 Purchasing Additional Sealing Gasket from DSE


Item	Description	Part No.
	Module Silicon Sealing Gasket	020-282

Table E3.34



Chapter 4 Deep Sea 6123 Controller

4.1 Introduction

The DSE 6100 series module has been designed to allow the operator to start and stop the engine/generator, and if required, transfer the load. The user also has the facility to view the system operating parameters via the LCD display. The DSE 6100 module / controller monitors the engine, indicating the operational status and fault conditions, automatically shutting down the engine and giving a true first up fault condition of an engine failure. The LCD display indicates the fault.

The powerful microprocessor contained within the module allows for incorporation of a range of enhanced features:

- i. Text based LCD display
- ii. True RMS Voltage monitoring.
- iii. Engine parameter monitoring.
- iv. Fully configurable inputs for use as alarms or a range of different functions.
- v. Engine ECU interface to **electronic engines** (specify on ordering)
- vi. Magnetic pickup interface for engine only applications (specify on ordering)

Using a PC and the 6000 series configuration software allows alteration of selected operational sequences, timers and alarm trips.

Additionally, the module's / controller's integral fascia configuration editor allows adjustment of this information.

A robust plastic case designed for front panel mounting houses the module. Connections are via locking plug and sockets.

4.2 Major Parts of Deep Sea (DSE6123) Controller

The major parts of Deep Sea (DSE6123) control panel & power panel are explained in two aspects, which are as mentioned below.

4.2.1 Components on the Door of Control Panel & Power Panel



Fig. E4.1 Exterior Illustration of DSE6123 Control Panel



Ref. No.	Description of Part	Ref. No.	Description of Part
1	Load ON GENSET	4	Canopy Light Switch
2	Deep Sea (DSE4520) Controller	5	Hooter Switch
3	Control Switch (ON/OFF)	6	Power MCCB

Table E4.1 Part List for External Components of DSE6123 Control Panel & Power Panel

- 1) Load ON GENSET Indication Lamp: The green indication lamp turns on when the supply is available to the load.
- 2) Deep Sea (DSE6123) Controller: The electronic controller is provided to operate the system. It also contains an LCD display that that displays various GENSET parameters, faults, status etc.
- 3) Control ON Selector Switch: When this switch is turned on, control supply is turned on and provided to the controller and other control equipment's.
- 4) DG Light switch: Provided to turn on the DG lamp inside the canopy.
- 5) Power MCCB: This is the main circuit breaker between the alternator output and load. The breaker will carry the rated current continuously. In case of a short circuit or if over current flows for specified amount of time, the breaker will trip. The breaker must then be moved to "OFF" position before re-closing.

4.2.2 Components inside the Control Panel & Power Panel

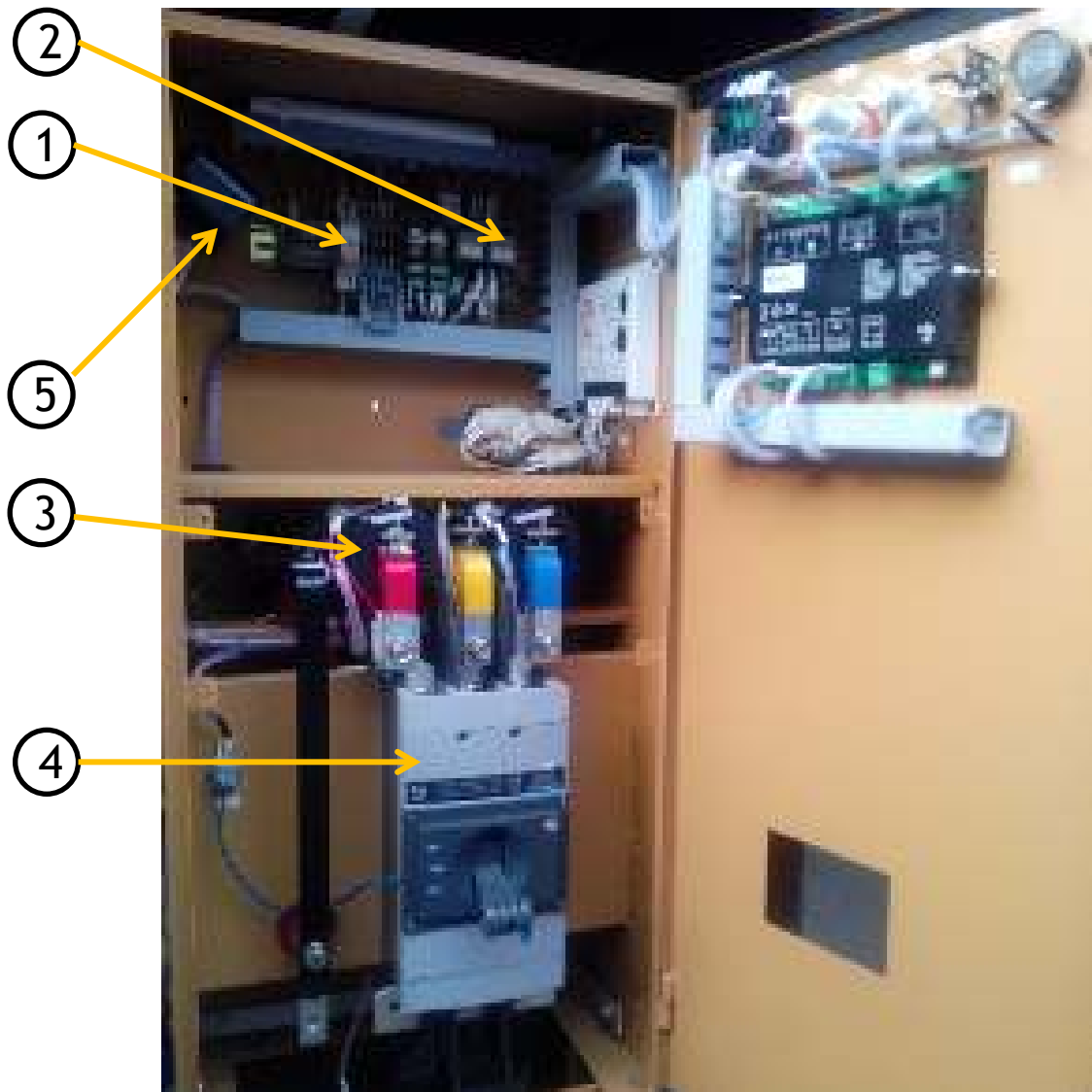


Fig. E4.2 Interior Illustration of DSE6123 Control Panel

Ref. No.	Description of Part	Ref. No.	Description of Part
1	Control MCB/Fuse	4	Power MCCB
2	Power Relay Board	5	Hooter
3	Current Transformers		

Table E4.2 Part List for Internal Components of DSE6123 Control Panel & Power Panel



- 1) Control MCB / Controller: A single pole control MCB is provided for protection of the control circuit.
- 2) Power Relay Board: The power relay board consists of three power relays, on each for the fuel solenoid, crank solenoid and hooter.
- 3) Current Transformers: Three current transformers, one for each phase, are provided for sensing current.
- 4) Hooter: The hooter operates in case of any fault is sensed by the controller.

4.3 Specifications

4.3.1 Short Names

61xx	DSE 6100 series control module
61x0-xxx-01	DSE6100 series control module (Magnetic pickup version)
61x0-xxx-02	DSE6100 series control module (CAN bus version)

4.3.2 Power Supply Requirements

Minimum supply voltage	8V continuous
Cranking dropouts	Able to survive 0V for 50mS providing the supply was at least 10V before the dropout and recovers to 5V afterwards. This is more than sufficient to allow the module to operate during engine cranking where the battery supply often falls as low as 4V (on a 12V system!) This is achieved without the need for internal batteries or other external requirements.
Maximum supply voltage	35V continuous (60V protection)
Reverse polarity protection	-35V continuous
Maximum operating current	160mA at 24V; 340mA at 12V
Maximum standby current	80mA at 24V; 160mA at 12V
Current when in Sleep Mode	50mA @ 12V; 32mA @ 24V



4.3.2.1 Plant Supply Instrumentation Display

Range	0V-70V DC (note Maximum continuous operating voltage of 35V DC)
Resolution	0.1V
Accuracy	±1% full scale (±0.7V)

4.3.3 Generator Voltage/Frequency Sensing

Measurement type	True RMS conversion
Sample Rate	5KHz or better
Harmonics	Up to 11th or better
Input Impedance	300K Ω ph-N
Phase to Neutral	15V to 333V AC (max)
Phase to Phase	25V to 576V AC (max)
Common mode offset from Earth	100V AC (max)
Resolution	1V AC phase to neutral 2V AC phase to phase
Accuracy	±1% of full scale phase to neutral ±2% of full scale phase to phase
Minimum frequency	3.5Hz
Maximum frequency	75.0Hz
Frequency resolution	0.1Hz
Frequency accuracy	±0.2Hz

4.3.4 Inputs

4.3.4.1 Digital Inputs

Number	6
Arrangement	Contact between terminal and ground
Low level threshold	40% of DC supply voltage
High level threshold	60% of DC supply voltage
Maximum input voltage	DC supply voltage positive terminal
Minimum input voltage	DC supply voltage negative terminal
Contact wetting current	2.5mA @12V typical; 5mA @ 24V typical
Open circuit voltage	Plant supply

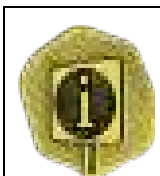
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4.3.4.2 Charge Fail Input

Minimum voltage	0V
Maximum voltage	35V (plant supply)
Resolution	0.2V
Accuracy	± 1% of max measured voltage
Excitation	Active circuit constant power output
Output Power	2.5W Nominal @12V and 24V
Current at 12V	210mA
Current at 24V	105mA

4.3.4.3 Magnetic Pick-up

Type	Single ended input, capacitive coupled
Minimum voltage	0.5V RMS
Max common mode voltage	±2V
Maximum voltage	Clamped to ±70V by transient suppressers, dissipation not to exceed 1W.
Maximum frequency	10,000Hz
Resolution	6.25 RPM
Accuracy	±25 RPM
Flywheel teeth	10 to 500



Important Note! DSE can supply a suitable magnetic pickup device, available in two body thread lengths :

DSE Part number 020-012 - Magnetic Pickup probe 5/8 UNF 2½” thread length

DSE Part number 020-013 - Magnetic Pickup probe 5/8 UNF 4” thread length

Magnetic Pickup devices can often be ‘shared’ between two or more devices. For example, one device can often supply the signal to both the DSE6100 series module and the engine governor. The possibility of this depends upon the amount of current that the magnetic pickup can supply.



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4.3.5 Outputs

4.3.5.1 Outputs A & B (Fuel & Start)

Type	Fuel (A) and Start (B) outputs. Supplied from DC supply terminal 2. Fully configurable when CAN engine is selected.
Rating	2A @ 35V
Protection	Protected against over current & over temperature. Built in load dump feature.

4.3.5.2 Configurable Outputs C, D, E, & F

Type	Fully configurable, supplied from DC supply terminal 2.
Rating	2A @ 35V
Protection	Protected against over current & over temperature. Built in load dump feature.

4.3.6 Accumulated Instrumentation



Important Note! When an accumulated instrumentation value exceeds the maximum number as listed below, it will reset and begin counting from zero again.

Engine hours run	Maximum 99999 Hrs. 59 minutes (approximately 11yrs 4months)
Number of starts	1,000,000 (1 million)

The number of logged Engine Hours and Number of Starts can be set/reset using the DSE Configuration Suite PC software. Depending upon module configuration, this may have been PIN number locked by your generator supplier.

Auxiliary Power Business

4.3.7 Dimensions & Mounting

4.3.7.1 Dimensions

216mm x 158mm x 42mm
(8.5" x 6.2" x 1.6")

4.3.7.2 Panel Cut-out

182mm x 137mm
(7.2" x 5.4")

4.3.7.3 Weight

510g (0.51kg)



4.3.7.4 Fixing Clips

The module is held into the panel fascia using the supplied fixing clips.

- i. Withdraw the fixing clip screw (turn anticlockwise) until only the pointed end is protruding from the clip.
- ii. Insert the three 'prongs' of the fixing clip into the slots in the side of the 6000 series module case.
- iii. Pull the fixing clip backwards (towards the back of the module) ensuring all three prongs of the clip are inside their allotted slots.
- iv. Turn the fixing clip screws clockwise until they make contact with the panel fascia.
- v. Turn the screws a little more to secure the module into the panel fascia. Care should be taken not to over tighten the fixing clip screws.

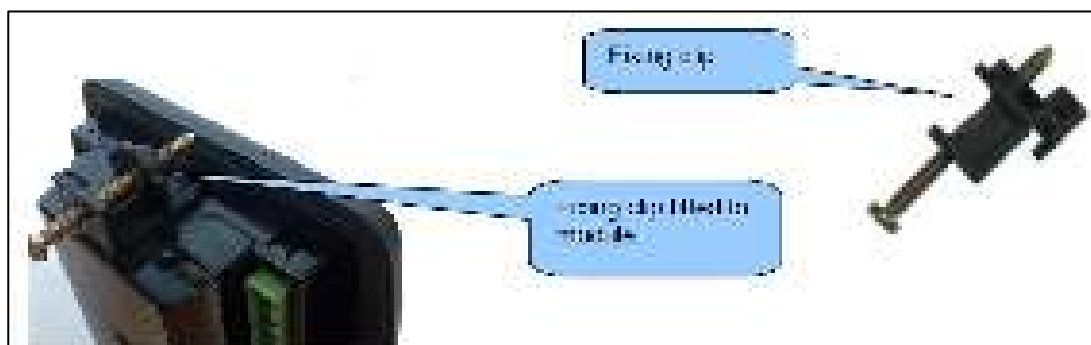


Fig. E4.5 Fixing Clips

4.3.7.5 Optional Silicon Sealing Gasket

The optional silicon gasket provides improved sealing between the 6000 series module and the panel fascia. The gasket is fitted to the module before installation into the panel fascia. Take care to ensure the gasket is correctly fitted to the module to maintain the integrity of the seal.

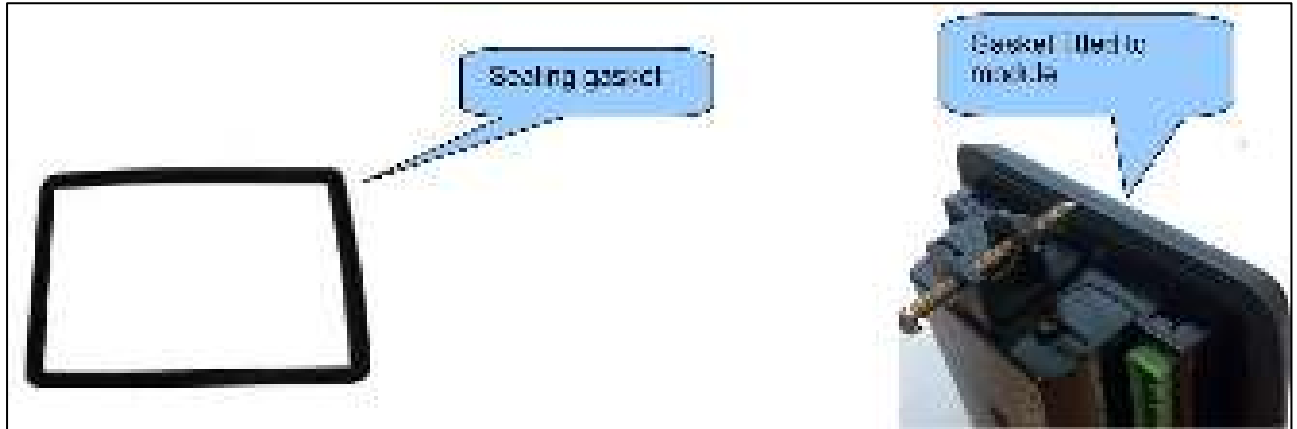


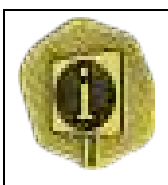
Fig. E4.6

4.4 Installation

The DSE6000 Series module/controller is designed to be mounted on the panel fascia. For dimension and mounting details, see the topic entitled Specification, Dimensions and mounting in this chapter.

4.4.1 Terminal Description

4.4.1.1 DC Supply, Fuel, and Start Outputs

	<p>Important Note! When the module/controller is configured for operation with an electronic engine, FUEL and START output requirements may be different. Avail advice in this regard from Greaves expert technical team.</p>
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Auxiliary Power Business






	PIN No	DESCRIPTION	CABLE SIZE	NOTES
	1	DC (Main Supply Input) (Negative)	2.5mm ² AWG 18	
	2	DC (Main Supply Input) (Positive)	2.5mm ² AWG 18	(Maximum rated Maximum Power 15A at 24Vdc) Supply the module (24Vdc) voltage even when no load or output is open
	3	Emergency Stop	1.0mm ² AWG 18	Plant Supply Positive from terminal 2. 3 A supplied
	4	Output A	1.0mm ² AWG 18	Plant Supply Positive from terminal 2. 3 A supplied Normally used for EIEI control
	5	Output B	1.0mm ² AWG 18	Plant Supply Positive from terminal 2. 3 A supplied Normally used for START control
	8	Charge cell (Positive)	2.5mm ² AWG 18	Do not connect to ground (battery negative). If charge indicator is not fitted, leave this terminal disconnected.
	7	System earth	1.0mm ² AWG 18	
	9	Output C	1.0mm ² AWG 18	Plant supply Positive from terminal 2. 3 A supplied. Normally used for Generator load switch control.
	10	Output D	1.0mm ² AWG 18	Plant supply Positive from terminal 2. 3 A supplied. Normally used for Motor load switch control (RSC10)
	11	Output E	1.0mm ² AWG 18	Plant supply Positive from terminal 2. 3 A supplied.
	11	Output F	1.0mm ² AWG 18	Plant supply Positive from terminal 2. 3 A supplied.

Exhibit Table E4.3

4.4.1.2 Generator / Mains Voltage Sensing



	PIN No	DESCRIPTION	CABLE SIZE	NOTES
	19	Generator L1 (U) voltage monitoring	1.0mm ² AWG 18	Connect to generator L1 (U) output (AC) (Recommended 2A fuse)
	20	Generator L2 (V) voltage monitoring	1.0mm ² AWG 18	Connect to generator L2 (V) output (AC) (Recommended 2A fuse)
	21	Generator L3 (W) voltage monitoring	1.0mm ² AWG 18	Connect to generator L3 (W) output (AC) (Recommended 2A fuse)
	22	Generator Neutral (N) input	1.0mm ² AWG 18	Connect to generator Neutral terminal (AC)
	23	Mains L1 (R) voltage monitoring	1.0mm ² AWG 18	Connect to Mains L1 (R) output (AC) (Recommended 2A fuse)
	24	Mains L2 (S) voltage monitoring	1.0mm ² AWG 18	Connect to Mains L2 (S) output (AC) (Recommended 2A fuse)
	25	Mains L3 (T) voltage monitoring	1.0mm ² AWG 18	Connect to Mains L3 (T) output (AC) (Recommended 2A fuse)
	26	Mains Neutral (N) input	1.0mm ² AWG 18	Connect to Mains Neutral terminal (AC)

Exhibit Table E4.4

4.4.1.3 Digital Inputs

PIN No	DESCRIPTION	CABLE SIZE	NOTES
22	Configurable digital input A	0.9mm ² AWG 22	Switch to negative
23	Configurable digital input B	0.9mm ² AWG 22	Switch to negative
24	Configurable digital input C	0.9mm ² AWG 22	Switch to negative
25	Configurable digital input D	0.9mm ² AWG 22	Switch to negative
26	Configurable digital input E	0.9mm ² AWG 22	Switch to negative
27	Configurable digital input F	0.9mm ² AWG 22	Switch to negative

Exhibit Table E4.5

4.5 Description of Controls

The following section details the function and meaning of the various controls on the module.

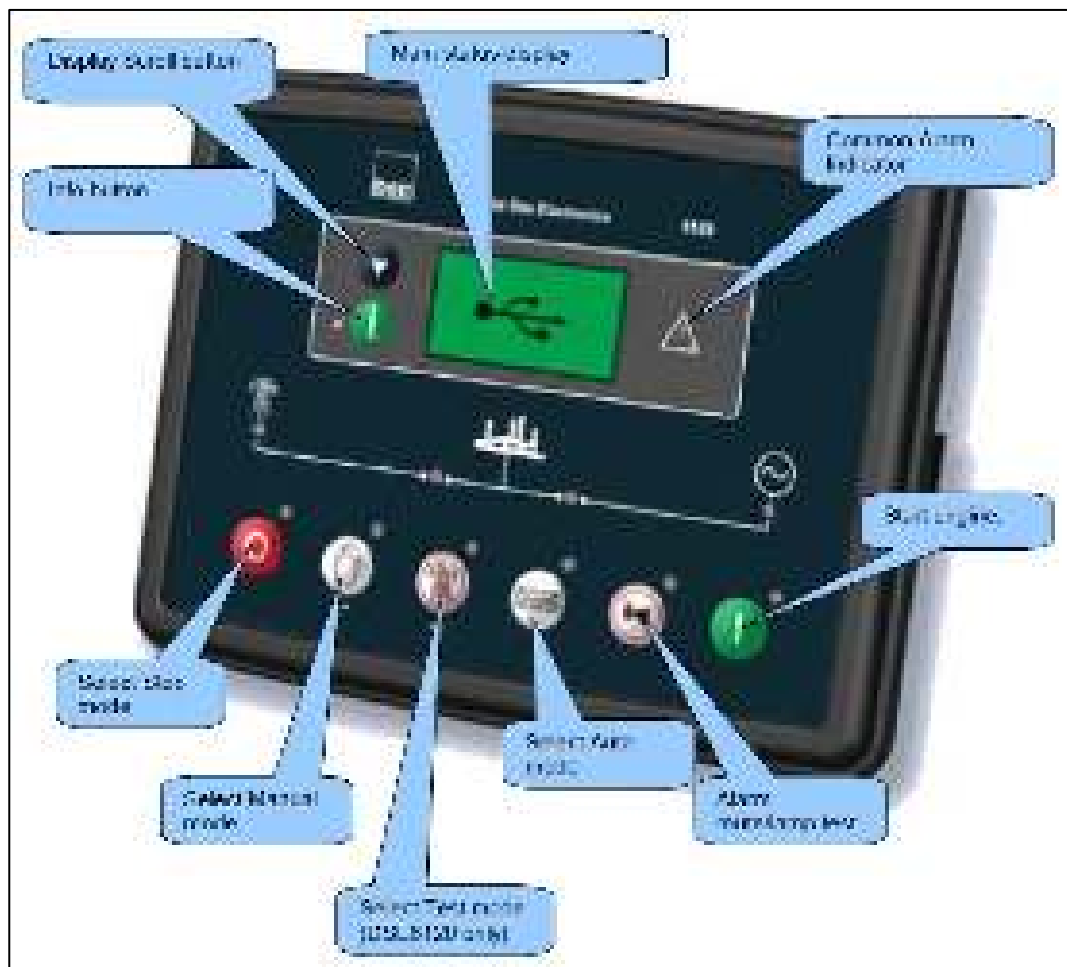


Fig. E4.7

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4.5.1 Quick Start Guide

This topic provides a quick start guide to the module's operation.

4.5.1.1 Starting the Engine




Fig. E4.8

4.5.1.2 Stopping the Engine



Fig. E4.9






	<p>Important Note! For further details, see the topic entitled ‘OPERATION’ in this chapter.</p>
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4.5.2 Graphical Display

- i. 4-Line, 64 x 132 small Graphic Display with LED Backlight
- ii. Icon and numeric display. Switch to select ‘Icon’ or ‘English’ display
- iii. Software controlled contrast
- iv. Mimic of Text insert / 4x indicators required via LCD

4.5.3 Controls

Icon	Description
	<p>Stop / Reset Mode</p> <p>This button places the module into its Stop/Reset mode. This will clear any alarm conditions for which the triggering criteria have been removed. If the engine is running and the module is in Stop mode, the module will automatically instruct the changeover device to unload the generator (‘Close Generator’ becomes inactive (if used)). The fuel supply de-energises and the engine comes to a standstill. Should a remote start signal be present while operating in this mode, a remote start will not occur.</p>
	<p>Manual</p> <p>This mode allows manual control of the generator functions. Once in Manual mode the module will respond to the start  button, start the engine, and run off load. If the engine is running off-load in the Manual mode and a remote start signal becomes present, the module will automatically instruct the changeover device to place the generator on load (‘Close Generator’ becomes active (if used)). Upon removal of the remote start signal, the generator remains on load until either selection of the ‘STOP/RESET’ or ‘AUTO’ modes. For further details, please see the more detailed description of ‘Manual operation’ elsewhere in this chapter.</p>



Icon	Description
	<p>Auto Mode</p> <p>This button places the module into its ‘Automatic’ mode. This mode allows the module to control the function of the generator automatically. The module will monitor the remote start input and mains supply status and once a start request is made, the set will be automatically started and placed on load. Upon removal of the starting signal, the module will automatically transfer the load from the generator and shut the set down observing the stop delay timer and cooling timer as necessary. The module will then await the next start event. For further details, please see the more detailed description of ‘Auto operation’ elsewhere in this manual.</p>
	<p>Start</p> <p>This button is only active in STOP/RESET  or MANUAL  mode. Pressing this button in manual or test mode will start the engine and run off load (manual) or on load (test). Pressing this button in STOP/RESET mode will turn on the CAN engine ECU (when correctly configured and fitted to a compatible engine ECU)</p>
	<p>Mute / Lamp Test</p> <p>This button silences the audible alarm if it is sounding and illuminates all of the LEDs as a lamp test feature/ When correctly configured and fitted to a compatible engine ECU, pressing this button in STOP/RESET mode after pressing the START  button (to power the ECU) will cancel any “passive” alarms on the engine ECU.</p>
	<p>Scroll</p> <p>This buttons scrolls through the instrument display pages.</p>

4.6 Operation

4.6.1 Stop Mode

STOP mode is activated by pressing the  button.

In STOP mode, the module will remove the generator from load (if necessary) before stopping the engine if it is already running.


If the engine does not stop when requested, the FAIL TO STOP alarm is activated (subject to the setting of the Fail to stop timer). To detect the engine at rest the following must occur:

- i. Engine speed is zero as detected by the Magnetic Pickup or CAN bus ECU (depending upon module variant).
- ii. Generator frequency must be zero.
- iii. Oil pressure switch must be closed to indicate low oil pressure (MPU version only)

When the engine has stopped, it is possible to send configuration files to the module from DSE Configuration Suite PC software and to enter the Front Panel Editor to change parameters.

Any latched alarms that have been cleared will be reset when STOP mode is entered.

The engine will not be started when in STOP mode. If remote start signals are given, the input is ignored until AUTO mode is entered.

When configured to do so, when left in STOP mode for five minutes with no presses of the fascia buttons, the module enters low power mode. To 'wake' the module, press the  button or any other fascia control button.

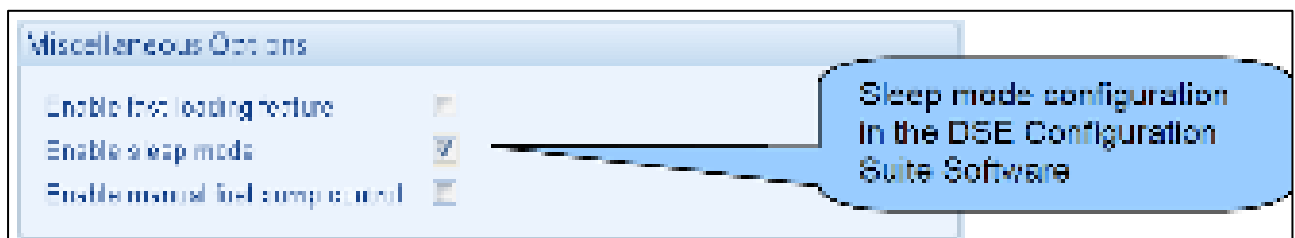


Fig. E4.10



4.6.1.1 ECU Overdrive





Important Note! ECU Override function is only applicable to the CAN variant of the 6100 series controller.



Important Note! Depending upon system design, the ECU may be powered or unpowered when the module is in STOP mode. ECU override is only applicable if the ECU is unpowered when in STOP mode.

When the ECU powered down (as is normal when in STOP mode), it is not possible to read the diagnostic trouble codes or instrumentation. Additionally, it is not possible to use the engine manufacturers' configuration tools.

As the ECU is usually unpowered when the engine is not running, it must be turned on manually as follows:

- i. Select STOP  mode on the DSE controller.
- ii. Press and hold the START  button to power the ECU. As the controller is in STOP mode, the engine will not be started.
- iii. Continue to hold the start button for as long as you need the ECU to be powered.
- iv. The ECU will remain powered until a few seconds after the START button is released.

This is also useful if the engine manufacturer's tools need to be connected to the engine, for instance to configure the engine as the ECU needs to be powered up to perform this operation.



4.6.2 Automatic Mode



Important Note! If a digital input configured to panel lock is active, changing module modes will not be possible. Viewing the instruments and event logs is NOT affected by panel lock.



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Activate auto mode by pressing the  pushbutton. The  icon is displayed to indicate Auto Mode operation if no alarms is present.

Auto mode will allow the generator to operate fully automatically, starting and stopping as required with no user intervention.

4.6.2.1 Waiting in Auto Mode

If a starting request is made, the starting sequence will begin. Starting requests can be from the following sources:

- i. Mains failure
- ii. Activation of an auxiliary input that has been configured to remote start
- iii. Activation of the inbuilt exercise scheduler

4.6.2.2 Starting Sequence


To allow for 'false' start requests, the start delay timer begins.

Should all start requests be removed during the start delay timer, the unit will return to a stand-by state.

If a start request is still present at the end of the start delay timer, the fuel relay is energised and the engine will be cranked.



Important Note! If the unit has been configured for CAN, compatible ECU's will receive the start command via CAN.

If the engine fails to fire during this cranking attempt then the starter motor is disengaged for the crank rest duration after which the next start attempt is made. If this sequence continues beyond the set number of attempts, the start sequence will be terminated and the display shows fail to Start. 



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When the engine fires the starter motor gets disengaged. Speed detection is factory configured to be derived from the main alternator output frequency but can additionally be measured from a Magnetic Pickup mounted on the flywheel (Selected by PC using the 3000 series configuration software). Additionally, rising oil pressure can be used to disconnect the starter motor (but cannot detect under speed or over speed).

After the starter motor has disengaged, the Safety On timer activates, allowing Oil Pressure, High Engine Temperature, Under-speed, Charge Fail and any delayed Auxiliary fault inputs to stabilise without triggering the fault.



Important Note! If the unit has been configured for CAN, speed sensing is via CAN.

4.6.2.3 Engine Running

Once the engine is running and all starting timers have expired, the animated icon  is displayed. If all start requests are removed, the stopping sequence will begin.




Important Note! The load transfer signal remains inactive until the Oil Pressure has risen. This prevents excessive wear on the engine.


4.6.2.4 Stopping Sequence

The return delay timer operates to ensure that the starting request has been permanently removed and isn't just a short term removal. Should another start request be made during the cooling down period, the set will return on load. If there are no starting requests at the end of the return delay timer, the load is removed from the generator to the mains supply and the cooling timer is initiated. The cooling timer allows the set to run off load and cool sufficiently before being stopped. This is particularly important where turbo chargers are fitted to the engine. After the cooling timer has expired, the set is stopped.






4.6.3 Manual Mode


	<p>Important Note! If a digital input configured to panel lock is active, changing module modes will not be possible. Viewing the instruments and event logs is NOT affected by panel lock.</p>
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Manual mode allows the operator to start and stop the set manually, and if required change the state of the load switching devices. Module mode is active when the  button is pressed.


4.6.3.1 Waiting in Manual Mode


To begin the starting sequence, press the  button. If 'protected start' is disabled, the start sequence begins immediately. If 'Protected Start' is enabled, the  icon is displayed to indicate Manual mode and the manual LED flashes. The  button must be pressed once more to begin the start sequence.

4.6.3.2 Starting Sequence

	<p>Important Note! There is no start delay in this mode of operation.</p>
---	--


The fuel relay is energised and the engine is cranked.

	<p>Important Note! If the unit has been configured for CAN, compatible ECU's will receive the start command via CAN.</p>
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	<p>Important Note! If the unit has been configured for CAN, speed sensing is via CAN.</p>
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If the engine fails to fire during this cranking attempt then the starter motor is disengaged for the crank rest duration after which the next start attempt is made. If this sequence continues beyond the set number of attempts, the start sequence will be terminated and the display shows  fail to start.

When the engine fires the starter motor is disengaged. Speed detection is factory configured to be derived from the main alternator output frequency but can additionally be measured from a Magnetic Pickup mounted on the flywheel (Selected by PC using the 3000 series configuration software).

Additionally, rising oil pressure can be used disconnect the starter motor (but cannot detect under speed or over speed).

After the starter motor has disengaged, the Safety On timer activates, allowing Oil Pressure, High Engine Temperature, Under-speed, Charge Fail and any delayed Auxiliary fault inputs to stabilise without triggering the fault.

4.6.3.3 Engine Running


In manual mode, the load is not transferred to the generator unless a 'loading request' is made. A loading request can come from a number of sources.

- i. Detection of mains failure
- ii. Activation of an auxiliary input that has been configured to remote start on load
- iii. Activation of the inbuilt exercise scheduler if configured for 'on load' runs.




Important Note! The load transfer signal remains inactive until the Oil Pressure has risen. This prevents excessive wear on the engine.

Once the load has been transferred to the generator, it will not be automatically removed. To manually transfer the load back to the mains either:



- i. Press the auto mode  button to return to automatic mode. The set will observe all auto mode start requests and stopping timers before beginning the Auto mode stopping sequence.

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- ii. Press the stop button 
- iii. De-activation of an auxiliary input that has been configured to remote start on load.

4.6.3.4 Stopping Sequence

In manual mode the set will continue to run until either:

- i. The stop button  is pressed - The set will immediately stop
- ii. The auto button  is pressed. The set will observe all auto mode start requests and stopping timers before beginning the Auto mode stopping sequence.

4.7 Front Panel Configuration

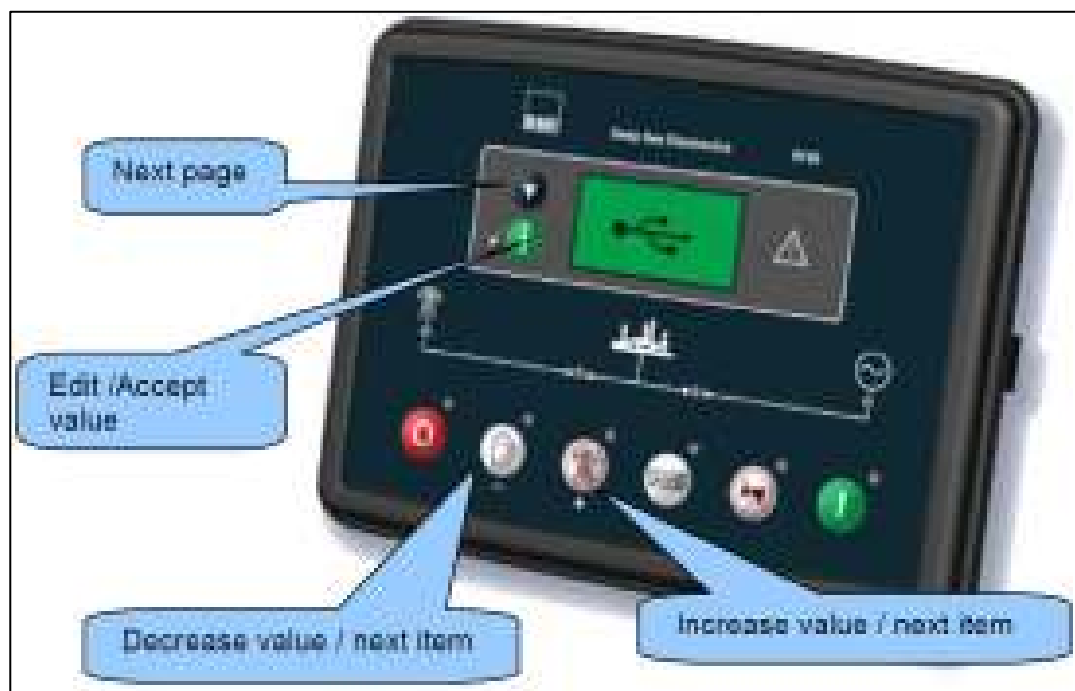




Fig. E4.11

This configuration mode allows the operator limited customising of the way the module operates. Use the module's navigation buttons to traverse the menu and make value changes to the parameters.

4.7.1 Accessing the Front Panel Editor (FPE)

The module must be in STOP mode with the engine at rest before configuration mode can be accessed. To enter the 'configuration mode' press the INFO  and STOP  buttons together.

4.7.1.1 Entering the Configuration Editor PIN Number

If the module PIN number has been set, the PIN number request is then shown. The configuration cannot be viewed or changed until the PIN number is correctly entered.

Enter either the 'main' PIN or the application PIN.

















	<p>The first * is flashing. Press  (+) or  (-) buttons to adjust it to the correct value for the first digit of the PIN number. Press  when the first digit is correctly entered. The entered digit will turn back to a * to maintain security.</p>
	<p>The second * is now flashing. Press  (+) or  (-) buttons to adjust it to the correct value for the second digit of the PIN number. Press  when the second digit is correctly entered. The entered digit will turn back to a * to maintain security.</p>
	<p>The third * is now flashing. Press  (+) or  (-) buttons to adjust it to the correct value for the third digit of the PIN number. Press  when the third digit is correctly entered. The entered digit will turn back to a * to maintain security.</p>
	<p>The fourth * is now flashing. Press  (+) or  (-) buttons to adjust it to the correct value for the fourth digit of the PIN number. Press  when the fourth digit is correctly entered. The entered digit will turn back to a * to maintain security.</p>

Table E4.6



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If the Configuration PIN has been entered successfully (or the PIN number has not been set in the module) the first configurable parameter is displayed.



Important Note! When is ✓ pressed after editing the final PIN digit, the PIN is checked for validity. If the number is not correct, the editor is automatically exited. To retry you must re-enter the editor as described above.



Important Note! To exit the front panel configuration editor at any time, press and hold the ■ (✓) button. Ensure you have saved any changes you have made by pressing the ✓ button first.



Important Note! When the editor is visible, it is automatically exited after 5 minutes of inactivity to ensure security.



Important Note! If the Application Menu PIN is entered, then only the Application Menu is displayed. If the Full Configuration PIN is entered, the entire configuration menu is displayed including the Application Menu.





Important Note! The PIN number is automatically reset when the editor is exited (manually or automatically) to ensure security.

4.7.1.2 Editing a Parameter

Enter the editor as described above.



Press  to select the required 'page' as detailed below.


Press  (+) to select the next parameter or  (-) to select the previous parameter within the current page.


When viewing the parameter to be changed, press the ■ (✓) button. The value begins to flash.



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Press  (+) or  (-) to adjust the value to the required setting.

Press  (✓) to save the current value, the value ceases flashing.

Press and hold the  (✓) button to exit the editor.



Important Note! Values representing pressure will be displayed in Bar. Values representing temperature are displayed in degrees Celsius.



Important Note! When adjusting values in the FPE a press and hold of the increment button will cover the full range of the item being adjusted (min to max) in less than 20 seconds.



Important Note! When the editor is visible, it is exited after 5 minutes of inactivity to ensure security.



4.8 Fault Finding

Symptom	Possible Remedy
Unit is inoperative Read/Write configuration does not operate	Check the battery and wiring to the unit. Check the DC supply. Check the DC fuse.
Unit shuts down	Check DC supply voltage is not above 35 Volts or below 9 Volts. Check the operating temperature is not above 70° C. Check the DC fuse.
Unit locks out on Emergency Stop	If no Emergency Stop Switch is fitted, ensure that a DC positive signal is connected to the Emergency Stop input. Check emergency stop switch is functioning correctly. Check Wiring is not open circuit.
Intermittent Magnetic Pick-up sensor fault	Ensure that Magnetic pick-up screen only connects to earth at one end, if connected at both ends, this enables the screen to act as an aerial and will pick up random voltages. Check pickup is correct distance from the flywheel teeth.
Low oil Pressure fault operates after engine has fired	Check engine oil pressure. Check oil pressure switch/sensor and wiring. Check configured polarity (if applicable) is correct (i.e. Normally Open or Normally Closed) or that sensor is compatible with the 3310 Module and is correctly configured.
High engine temperature fault operates after engine has fired.	Check engine temperature. Check switch/sensor and wiring. Check configured polarity (if applicable) is correct (i.e. Normally Open or Normally Closed) or that sensor is compatible with the 6000 series module.
Shutdown fault operates	Check relevant switch and wiring of fault indicated on LCD display. Check configuration of input.
Warning fault operates	Check relevant switch and wiring of fault indicated on LCD display. Check configuration of input.



Symptom	Possible Remedy
Fail to Start is activated after preset number of attempts to start	Check wiring of fuel solenoid. Check fuel. Check battery supply. Check battery supply is present on the Fuel output of the module. Check the speed-sensing signal is present on the 6000 series module inputs. Refer to engine manual.
Continuous starting of generator when in AUTO	Check that there is no signal present on the “Remote Start” input. Check configured polarity is correct.
Generator fails to start on receipt of Remote Start signal.	Check Start Delay timer has timed out. Check signal is on “Remote Start” input. Confirm correct configuration of input is configured to be used as “Remote Start”. Check that the oil pressure switch or sensor is indicating low oil pressure to the controller. Depending upon configuration, the set will not start if oil pressure is not low.
Pre-heat inoperative	Check wiring to engine heater plugs. Check battery supply. Check battery supply is present on the Pre-heat output of module. Check pre-heat configuration is correct.
Starter motor inoperative	Check wiring to starter solenoid. Check battery supply. Check battery supply is present on the Starter output of module. Ensure that the Emergency Stop input is at Positive. Ensure oil pressure switch or sensor is indicating the “low oil pressure” state to the 6000 series controller.
Engine runs but generator will not take load	Check Warm up timer has timed out. Ensure generator load inhibit signal is not present on the module inputs. Check connections to the switching device. Note that the set will not take load in manual mode unless there is an active remote start on load signal.




Symptom	Possible Remedy
Incorrect reading on Engine gauges Fail to stop alarm when engine is at rest	Check engine is operating correctly. Check sensor and wiring.
Module appears to 'revert' to an earlier configuration	When editing a configuration using the PC software it is vital that the configuration is first 'read' from the controller before editing it. This edited configuration must then be "written" back to the controller for the changes to take effect. When editing a configuration using the Front Panel Editor, be sure to press the Save button  to save the change before moving to another item or exiting the Front Panel Editor.
Set will not take load	Ensure the generator is available. Check that the output configuration is correct to drive the load switch device and that all connections are correct. Remember that the set will not take load in manual mode unless a remote start on load input is present.
Inaccurate generator measurements on controller display	The 3000 series controller is true RMS measuring so gives more accurate display when compared with an 'average' meter such as an analogue panel meter or some lower specified digital multi-meters. Accuracy of the controller is better than 1% of full scale. Gen volts full scale is 333V ph-n so accuracy is $\pm 3.33V$ (1% of 333V).

Table E4.7 Fault Finding



Important Note! The above fault finding is provided as a guide check-list only. As the module can be configured to provide a wide range of different features, always refer to the source of your module configuration if in doubt or avail assistance from Greaves Technical Team.

4.9 Maintenance, Spares, Repair, and Servicing

The DSE6000 Series controller is designed to be Fit and Forget. As such, there are no user serviceable parts within the controller. In the case of malfunction, you should contact your original equipment supplier (OEM).

4.9.1 Purchasing Additional Connector Plugs from DSE

If you require additional plugs from DSE, please contact our Sales department using the part numbers below.

4.9.1.1 DSE6123








R110 series terminal description	Plug description	Part No.
1-11 	11 way 5.08mm	007-431
12-15 	4 way 5.08mm	007-434
16-18 	3 way 5.08mm	007-434
19-20 	2 way 7.62mm	007-434
27-31 	5 way 5.08mm	007-440
32-37 	6 way 5.08mm	007-440


Exhibit Table E4.8

4.9.2 Purchasing Additional Fixing Clips from DSE

Item	Description	Part No.
	6000 series fixing clips (packet of 4)	020-294

4.9.3 Purchasing Additional Sealing from DSE

The optional sealing gasket is not supplied with the controller but can be purchased separately.

Item	Description	Part No.
	6000 series silicon sealing gasket	020-389