Portable Power

# G80XW/XF, G115XW/XF, G150XW/XF, G200XW/XF - 50Hz
# G100XW/XF, G135 XW/XF, G170XW/XF, G225XW/XF - 60Hz
# OPERATION & MAINTENANCE MANUAL

**Original Instruction**

**This manual contains important safety information and must be made available to personnel who operate and maintain this machine.**

**46689183_en_B_05/19**


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**REFERENCE INFORMATION**

Write the correct information for YOUR DIPP generator in the spaces below. Always use these numbers when referring to your DIPP generator.

Generator Serial Number _____

Engine Serial Number _____

NOTES:

_____

_____

_____

_____

YOUR DIPP DEALER:

_____

ADDRESS:

_____

PHONE:

_____

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Portable Power

# FOREWORD

The contents of this manual are considered to be proprietary and confidential to and should not be reproduced without the prior written permission of the company.

Nothing contained in this document is intended to extend any promise, warranty or representation, expressed or implied, regarding the products described herein. Any such warranties or other terms and conditions of sale of products shall be in accordance with the standard terms and conditions of sale for such products, which are available upon request.

This manual contains instructions and technical data to cover all routine operation and scheduled maintenance tasks by operation & maintenance staff. Major overhauls are outside the scope of this manual and should be referred to an authorised service department.

The use of repair parts / lubricants / fluids other than those included within the approved parts list may create hazardous conditions over which the company has no control. Therefore the company cannot be held responsible for equipment in which non-approved repair parts are installed.

The company reserves the right to make changes and improvements to products without notice and without incurring any obligation to make such changes or add such improvements to products sold previously.

The intended uses of this machine are outlined below and examples of unapproved usage are also given, however the company cannot anticipate every application or work situation that may arise.

**IF IN DOUBT CONSULT SUPERVISION.**

This machine has been designed and supplied for use only in the following specified conditions and applications:

- Operation within the ambient temperature range specified in the *GENERAL INFORMATION* section of this manual.

**The use of the machine in any of the situation types listed in table 1:**

**a) Is not approved,**

**b) May impair the safety of users and other persons, and**

**c) May prejudice any claims made against the company.**

| **TABLE 1** |
|---|
| Use of the machine outside the ambient temperature range specified in the *GENERAL INFORMATION SECTION* of this manual. |
| This machine is not intended and must not be used in potentially explosive atmospheres, including situations where flammable gases or vapours may be present. |
| Use of the machine fitted with non approved components / lubricants / fluids. |
| Use of the machine with safety or control components missing or disabled. |
| Use of the machine for storage or transportation of materials inside or on the enclosure except when contained within the toolbox. |
| **GENERATOR** |
| Use of the generator to supply load(s) greater than those specified. |
| Use of unsafe or unserviceable electrical equipment connected to the generator. |
| Use of electrical equipment: (a) Having incorrect voltage and / or frequency ratings. (b) Containing computer equipment and / or similar electronics. |

The company accepts no responsibility for errors in translation of this manual from the original English version.


Portable Power

# GENERAL DATA

## CONTENTS

## GENERAL DATA

| UNIT MODEL 50HZ | G80XW/XF | G115XW/XF | G150XW/XF | G200XW/XF |
|---|---|---|---|---|
| Engine Speed - RPM | 1500 | 1500 | 1500 | 1500 |
| **UNIT MODEL 60HZ** | **G100XW/XF** | **G135XW/XF** | **G170XW/XF** | **G225XW/XF** |
| Engine Speed - RPM | 1800 | 1800 | 1800 | 1800 |
| Engine Fuel | Diesel | Diesel | Diesel | Diesel |
| Manufacturer | Doosan | Doosan | Doosan | Doosan |
| Model | D1146 | D1146T | DP086TA | P086TI |
| Number of cylinders / Displacement (litres) | 6 / 8 | 6 / 8 | 6 / 8 | 6 / 8 |
| **FLUID CAPACITIES** | | | | |
| Engine Crankcase Lubricant (litres) | Max. 15,5 Min.12 | Max. 15,5 Min.12 | Max. 15,5 Min.12 | Max. 15,5 Min.12 |
| Fuel Tank (litres) | TBA | TBA | TBA | TBA |
| Radiator & Engine Coolant (litres) | 48 | 48 | 48 | 48 |
| Electrical System | 24VDC | 24VDC | 24VDC | 24VDC |
| **UNIT MEASUREMENTS / WEIGHTS (XW)** | | | | |
| Overall length (mm) | 3200 | 3200 | 4400 | 3940 |
| Overall width (mm) | 1100 | 1100 | 1370 | 1370 |
| Overall height (mm) | 1850 | 1850 | 2100 | 2100 |
| Weight (with fuel) (kg) | TBA | TBA | TBA | TBA |
| Weight (without fuel) (kg) | 2190 | 2350 | 2800 | 2800 |

## ELECTRICAL DATA

| UNIT MODEL | G80XW/XF | G115XW/XF | G150XW/XF | G200XW/XF |
|---|---|---|---|---|
| Prime Power Rating @ 400V-3Ø, 0.8PF, 50Hz | 118 A<br>82,00 kVA<br>65,60 kW | 166 A<br>115,00 kVA<br>92,00 kW | 211 A<br>146,00 kVA<br>116,80 kW | 284 A<br>197,00 kVA<br>157,60 kW |
| Standby Power Rating @ 400V-3Ø, 0.8PF, 50Hz | 131 A<br>91,00 kVA<br>72,80 kW | 180 A<br>125,00 kVA<br>100,00 kW | 235 A<br>163,00 kVA<br>130,40 kW | 320 A<br>222,00 kVA<br>177,60 kW |
| Rated Voltage (V) | 400,220/380/ 480-3Ø | 400,220/380/ 480-3Ø | 400,220/380/ 480-3Ø | 400,220/380/ 480-3Ø |
| Rated Frequency (Hz) | 50 | 50 | 50 | 50 |
| Rated Power Factor | 0.8 | 0.8 | 0.8 | 0.8 |

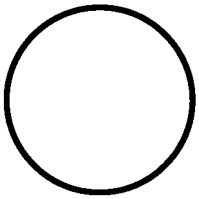
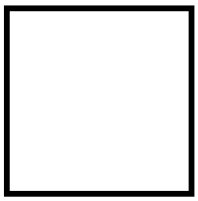
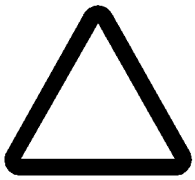
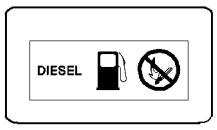
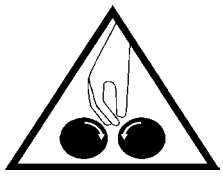
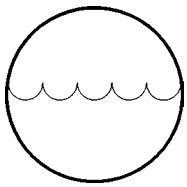
| UNIT MODEL | G100XW/XF | G135XW/XF | G170XW/XF | G225XW/XF |
|---|---|---|---|---|
| Prime Power Rating @ 480V-3Ø, 0.8PF, 60Hz | 117 A<br>97,00 kVA<br>77,60 kW | 158 A<br>131,00 kVA<br>104,80 kW | 204 A<br>170,00 kVA<br>136,00 kW | 268 A<br>223,00 kVA<br>178,40 kW |
| Standby Power Rating @ 480V-3Ø, 0.8PF, 60Hz | 126 A<br>105,00 kVA<br>84,00 kW | 174 A<br>145,00 kVA<br>116,00 kW | 223 A<br>185,00 kVA<br>148,00 kW | 292 A<br>243,00 kVA<br>194,40 kW |
| Rated Voltage (V) | 400,220/380/ 480-3Ø | 400,220/380/ 480-3Ø | 400,220/380/ 480-3Ø | 400,220/380/ 480-3Ø |
| Rated Frequency (Hz) | 60 | 60 | 60 | 60 |
| Rated Power Factor | 0.8 | 0.8 | 0.8 | 0.8 |

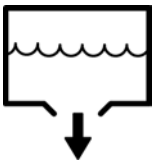
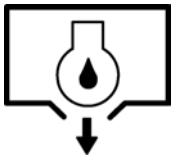
# SAFETY

**CONTENTS**

## SAFETY DECALS

### GRAPHIC FORM AND MEANING OF ISO SYMBOLS

|  |  |  |
|---|---|---|
| **PROHIBITION / MANDATORY** | **INFORMATION / INSTRUCTIONS** | **WARNING** |
|  |  |  |
| WARNING: Electrical shock risk | WARNING - Hot surface. | Tie down point |
|  |  |  |
| Lifting point. | On (power). | Off (power). |
|  |  |  |
| Read the Operation & Maintenance manual before operation or maintenance of this machine is undertaken. | Diesel fuel<br>No open flame. | Crush Warning |
|  |  |  |
| No Water | Coolant Fill | Earthing Point |

| | | |
|---|---|---|
|  Warning: Hot Liquid |  Coolant Drain |  Engine Oil Drain |
|   Flammable Liquid | | |

## ⚠ DANGER

**This machine is not designed for operating life-sustaining equipment. It is equipped with a safety shutdown system that will cause the machine to stop operating whenever a shutdown condition is present.**

**Never operate the machine inside a building without adequate ventilation. Avoid breathing exhaust fumes when working on or near the machine.**

## ⚠ WARNING

**A battery contains sulfuric acid and can give off gases which are corrosive and potentially explosive. Avoid contact with skin, eyes, and clothing. In case of contact, flush area immediately with water.**

## ⚠ WARNING

**Improper operation of this equipment can cause severe injury or death. Read the Operation & Maintenance manual supplied with this machine before operation or service.**

**Modification or alteration of this machine CAN result in severe injury or death. Do not alter or modify this machine without the express written consent of the manufacturer.**

## ⚠ WARNING

**This machine is equipped with an Auto Start System, which can cause the machine to start at any time. Follow all safety recommendations outlined in this manual to avoid injury to personnel. DISCONNECT BATTERY BEFORE SERVICING.**

## ⚠ CAUTION

**Exercise extreme caution when using booster battery. To jump battery, connect ends of one booster cable to the positive (+) terminal of each battery. Connect one end of other cable to the negative (-) terminal of the booster battery and other end to a earth connection away from dead battery (to avoid a spark occurring near any explosive gases that may be present). After starting unit, always disconnect cables in reverse order.**

## ⚠ WARNING

**Never inspect or service unit without first disconnecting battery cable(s) to prevent accidental starting.**

**Wear eye protection while cleaning unit with compressed air, to prevent debris from injuring eyes.**

## ⚠ WARNING

**HOT PRESSURISED FLUID - Remove cap slowly to relieve PRESSURE from HOT radiator. Protect skin and eyes. HOT water or steam and chemical additives can cause serious personal injury.**

## ⚠ WARNING

**Flammable Fuels - Do not fill tank when engine is running.**

**Do not smoke or use an open flame in the vicinity of the generator set or fuel tank. Do not permit smoking, open flame, or sparks to occur near the battery, fuel, cleaning solvents or other flammable substances and explosive gases.**

**Do not operate Genset if fuel has been spilled inside or near the unit.**

## ⚠ WARNING

**Electrical Shock -**

**Do not operate electrical equipment while standing in water, on wet earth or with wet hands or shoes.**

**Use extreme caution when working on electrical components. Battery voltage (12V / 24V DC) is present unless the battery cables have been disconnected. Higher voltage (potentially 480V) is possibly present at all times.**

## ⚠ WARNING

**Always treat electrical circuits as if they were energised.**

**Disable Start Control before attempting any repair service, disconnect all leads to electrical power requirements and disconnect battery to prevent start up.**

**EARTHING**

Comply with applicable electrical codes.

## ⚠ WARNING

**The Generator Set can produce high voltages, which can cause severe injury or death to personnel and damage to equipment. The Generator Set should have proper internal and external earth when required by IEC 364-4-41.**

**The Generator Set is internally earthed neutral to the frame of the Generator Set. This internal earth connection is essential for proper Generator Set performance and personal protection.**

**External earthing consists of connecting the generator neutral to a solid earth, and is the responsibility of the operator, when earthing is required by IEC 364-4-41 Protection Against Electric Shock, and other local codes as applicable.**

**Several methods are employed to externally earth portable generator sets, depending on the intended use and code requirements. In all cases, a continuous length of splice-free copper cable, no smaller than 10 $mm^2$, shall be used for the external earth conductor, when earthing is required.**

**A qualified, licensed electrical contractor, knowledgeable in local codes, should be consulted.**

## ⚠ WARNING

**Failure to properly earth the Generator Set can result in severe injury or death.**

**IF USED AS ALTERNATE POWER SUPPLY**

Connect only after the main service entrance switch has been DISCONNECTED and LOCKED OPEN. In addition, circuit overload protection must be provided in accordance with National Electrical Codes and local regulations.

## ⚠ CAUTION

**Welding -**

**Prior to any welding, disconnect alternator relays, diagnostic circuit board, voltage regulator circuit board, meters, circuit breakers and battery cables. Open all circuit breakers, and remove any external connections (except earthing rod). Connect the welding earth as close as possible to the area being welded.**

## ⚠ WARNING

**Electrical Loading -**

**Never make electrical connections with the unit running.**

**Before placing the unit in operation, verify the electrical rating of the Generator Set and do not exceed generator set ratings.**

**HAZARDOUS SUBSTANCE PRECAUTION**

# ⚠ CAUTION

**Use extreme care to avoid contacting hot surfaces (engine exhaust manifold and piping).**

Ensure that adequate ventilation of the cooling system and exhaust gases is maintained at all times.

The following substances are used in the manufacture of this machine and may be hazardous to health if used incorrectly.

Avoid ingestion, skin contact and breathing fumes for the following substances: Antifreeze, Engine Lubricating Oil, Preservative Grease, Rust Preventative, Diesel Fuel and Battery Electrolyte.

The following substances may be produced during the operation of this machine and may be hazardous to health:

- Avoid build-up of engine exhaust fumes in confined spaces.
- Avoid breathing exhaust fumes.
- Avoid breathing brake lining dust during maintenance.
- **Always operate in a well ventilated area.**

**WARNINGS**

Warnings call attention to instructions which must be followed precisely to avoid injury or death.

**CAUTIONS**

Cautions call attention to instructions which must be followed precisely to avoid damaging the product, process or its surroundings.

**NOTES**

Notes are used for supplementary information.

**GENERAL INFORMATION**

Ensure that the operator reads and understands the decals and consults the manuals before maintenance or operation.

Ensure that the Operation & Maintenance manual, and the manual holder, are not removed permanently from the machine.

Ensure that maintenance personnel are adequately trained, competent and have read the Maintenance Manuals.

Make sure that all protective covers are in place and that the canopy / doors are closed during operation.

The specification of this machine is such that the machine is not suitable for use in flammable gas risk areas. If such an application is required then all local regulations, codes of practice and site rules must be observed. To ensure that the machine can operate in a safe and reliable manner, additional equipment such as gas detection, exhaust spark arresters, and intake (shut-off) valves may be required, dependant on local regulations or the degree of risk involved.

A weekly visual check must be made on all fasteners / fixing screws securing mechanical parts. In particular, safety-related parts such as coupling hitch, drawbar components, road-wheels, and lifting bail should be checked for total security.

All components which are loose, damaged or unserviceable, must be rectified without delay.

**Electricity**

The human body has a low tolerance for electricity and is a very good conductor. Exposure to electrical shock can results in an interruption of normal heart activity, thermal burns, severe muscle contractions and even death.

Never operate the generator without all protections in place. Controller and busbar doors must be closed at any time during operation.

If life testing is necessary, it should only be performed by properly trained people.

While testing on life electrical equipment, rubber sole shoes and adequate rubber gloves must be worn, and all local regulations must be respected.

**Materials**

The following substances may be produced during the operation of this machine:

- engine exhaust fumes

AVOID INHALATION.

Ensure that adequate ventilation of the cooling system and exhaust gases is maintained at all times.

The following substances are used in the manufacture of this machine and may be hazardous to health if used incorrectly:

- anti-freeze
- engine lubricant
- preservative grease
- rust preventative
- diesel fuel
- battery electrolyte

AVOID INGESTION, SKIN CONTACT AND INHALATION OF FUMES.

Should engine lubricants or fuel come into contact with the eyes, then irrigate with water for at least 5 minutes.

Should engine lubricants or fuel come into contact with the skin, then wash off immediately.

Consult a doctor if large amounts of engine lubricants or fuel are ingested.

Consult a doctor if engine lubricants or fuel are inhaled.

Never give fluids or induce vomiting if the patient is unconscious or having convulsions.

Safety data sheets for engine lubricants and fuel should be obtained from the lubricant supplier.

**Battery**

Batteries contain corrosive liquid and produce explosive gas. Do not expose to naked lights. Always wear personal protective clothing when handling. When starting the machine from a slave battery ensure that the correct polarity is observed and that connections are secure.

DO NOT ATTEMPT TO SLAVE START A FROZEN BATTERY SINCE THIS MAY CAUSE IT TO EXPLODE.

**Radiator**

Hot engine coolant and steam can cause injury. Ensure that the radiator filler cap is removed with due care and attention.

**Transport**

When loading or transporting machines ensure that the specified lifting and tie down points are used.


Portable Power

# OPERATING INSTRUCTIONS

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## OPERATING INSTRUCTIONS

Never operate unit without first observing all safety warnings and carefully reading the operation & maintenance manual shipped from the factory with this machine.

### COMMISSIONING

Upon receipt of the unit, and prior to putting it into service, it is important to adhere strictly to the instructions given below in *PRIOR TO STARTING*.

Ensure that the operator reads and *understands* the decals and consults the manuals before maintenance or operation.

Ensure that the position of the *emergency stop* device is known and recognised by its markings. Ensure that it is functioning correctly and that the method of operation is known.

Attach the battery cables to the battery(s) ensuring that they are tightened securely. Attach the negative cable before attaching the positive cable.

The operating controls and instruments are arranged on the control panel as shown. A description of each panel device is as follows:

Ensure that all transport and packing materials are discarded.

Ensure that the correct fork lift truck slots or marked lifting / tie down points are used whenever the machine is lifted or transported.

When operating the machine ensure that there is sufficient clearance for ventilation and exhaust requirements, observing any specified minimum dimensions (to walls, floors etc.).

Adequate clearance needs to be allowed around and above the machine to permit safe access for specified maintenance tasks.

Ensure that the machine is positioned securely and on a stable foundation. Any risk of movement should be removed by suitable means, especially to avoid strain on any rigid discharge piping.

### CONNECTING THE LOAD

Make sure the wires are not cracked or damaged in any way.

Connect the proper phase wire to its corresponding bar L1–L2–L3. Mixing phases connections can result in equipment damage, accidents causing injuries or even death.

Make sure your installation is in compliance with local regulations.

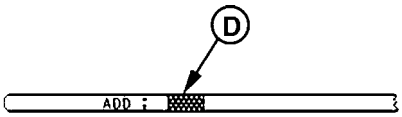
### PRIOR TO STARTING

Before starting the engine, carry out the following checks:

1. Engine oil level: Add as required.

**⚠ CAUTION**

**DO NOT fill above the top mark on the dipstick. Oil levels anywhere within crosshatch (D) are considered in the acceptable operating range.**




2. Engine coolant level: Add as required.
3. Fuel filter: Drain any accumulation of water. Clean or replace element as required.
4. Air cleaner service indicator (if equipped): Service immediately if showing "red" when the engine is running.
5. Fuel level in tank: Fill, using CLEAN DIESEL fuel, at the end of the day to minimise condensation.
6. Battery: Keep terminals clean and lightly greased.
7. Engine belts and hoses: Check for proper fit and / or damage. Service as required.
8. Air Vents / Grilles: Both engine radiator and generator cooling air. Check for obstructions (leaves, paper, etc.).
9. Visual inspection: Check for excessive fluid leaks, evidence of arcing around control panel, loose wire-routing clamps, etc.

**⚠ CAUTION**

**Call a qualified person to make electrical repairs.**

**⚠ WARNING**

**Do not remove the cap from a HOT engine radiator. The sudden release of pressure from a heated cooling system can cause severe injury or death.**

**STARTING**

**⚠ CAUTION**

**Use the EMERGENCY STOP button ONLY in the event of an emergency.**

**NEVER use it for normal shut-down.**

Verify the following:

1. All external electrical power loads are turned “OFF”.
2. Main Breaker is “OFF”.
3. Battery Disconnected Switch is “ON”.
4. Reset (pull to unlatch) Emergency Stop Button.
5. Push the controller “START” Button.

**⚠ DANGER**

**POWER is present upon cranking the engine.**

**⚠ CAUTION**

**Allow starter to cool for one minute between start attempts.**

**If engine shuts down, diagnostic lamps will indicate the problem. Correct the problem before continuing.**

6. Allow the engine to warm-up for 3 to 5 minutes.
7. Check the CONTROL Panel for proper voltages. No RED diagnostic lamps should be glowing.
8. With main breaker “ON” power is present and available for use.
9. Close side doors for optimum cooling of the unit while running.

**STOPPING**

1. Turn off all external electrical power loads.
2. Turn Main Breaker “OFF”.
3. Allow 5 minute cool down.
4. Push controller “STOP” Button.
5. Wait at least 15 seconds before restarting.
6. Fill fuel tank at end of working day to prevent condensate.

## CONTROLLER

### DESCRIPTION OF CONTROLS

**⚠ CAUTION**

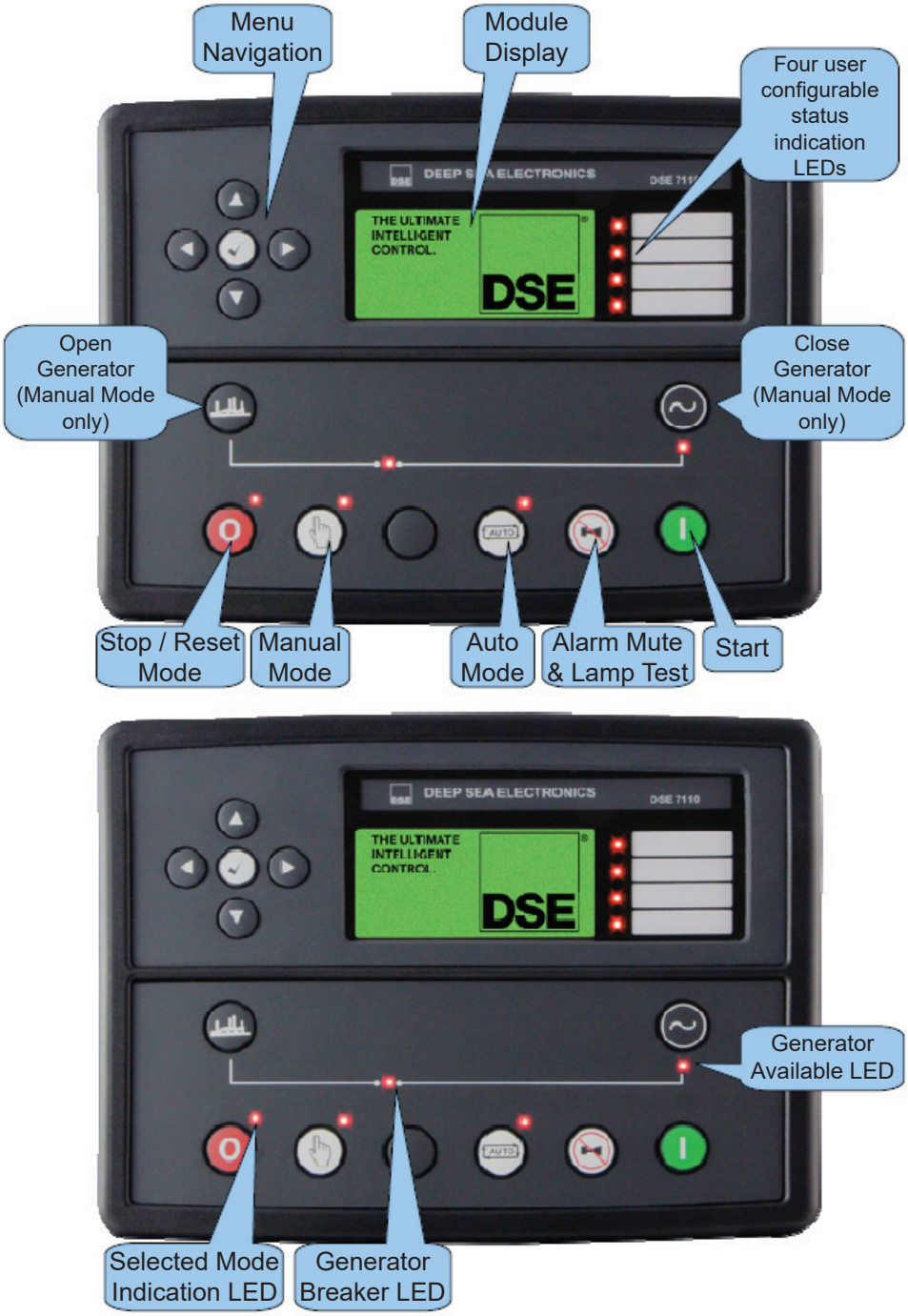
**The module may instruct an engine start event due to external influences. Therefore, it is possible for the engine to start at any time without warning. Prior to performing any maintenance on the system, it is recommended that steps are taken to remove the battery and isolate supplies.**

**If engine shuts down, diagnostic lamps will indicate the problem. Correct the problem before continuing.**

**Note: The following descriptions detail the sequences followed by a module containing the standard 'factory configuration'. Always refer to your configuration source for the exact sequences and timers observed by any particular module in the field.**

**Control of the module is via push buttons mounted on the front of the module with Stop/Reset Mode, Manual Mode, Test Mode, Auto Mode and Start functions. For normal operation, these are the only controls which need to be operated. Details of their operation are provided later in this document.**

**DSE7110 MKII**



## CONTROL PUSH-BUTTONS

| ICON | DESCRIPTION |
|---|---|
|  | **STOP / RESET MODE**<br>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 not occur. |
|  | **MANUAL MODE**<br>This button places the module into its ***Manual Mode***. Once in ***Manual Mode***, the module responds to the ***Start*** button to start the generator and run it off load.<br>To place the generator on load, use the ***Transfer to Generator*** button. The module automatically instructs the changeover device to place the generator on load *('**Close Generator**' and '**Delayed Load Output 1, 2, 3 & 4**' becomes active (if used))*. To place the generator off load, use the ***Transfer to Mains*** or ***Open Generator*** buttons. The module automatically instructs the changeover device to place the generator off load *('**Close Generator**' and '**Delayed Load Output 1, 2, 3 & 4**' becomes inactive (if used))*. Additional digital inputs can be assigned to perform these functions.<br>If the engine is running off-load in ***Manual Mode*** and a ***Remote Start Signal*** becomes present, the module automatically instructs 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***. |
|  | **AUTO MODE**<br>This button places the module into its ***Auto Mode***. This mode allows the module to control the function of the generator automatically. The module monitors the *remote start* input and once a start request is made, the set is 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))*.<br>Upon removal of the starting signal, the module removes 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 then waits for the next start event.<br>*For further details, please see section entitled 'Operation' elsewhere in this manual.* |
|  | **ALARM MUTE / LAMP TEST**<br>This button de-activates the audible alarm output (if configured) and illuminates all of the LEDs on the module's fascia. |
|  | **START**<br>This button is only active in the ***Stop/Reset Mode***, ***Manual Mode*** and ***Test Mode***.<br>Pressing the ***Start*** button in ***Stop/Reset Mode*** powers up the ECU but does not start the engine. This can be used to check the status of the CAN communication and to prime the fuel system.<br>Pressing the ***Start*** button in ***Manual Mode*** or ***Test Mode*** starts the generator and runs it off load in ***Manual Mode*** or on load in ***Test Mode***. |
|  | **MENU NAVIGATION**<br>Used for navigating the instrumentation, event log and configuration screens.<br>*For further details, please see section entitled 'Operation' elsewhere in this manual.* |

| ICON | DESCRIPTION |
|---|---|
|  | **TRANSFER TO GENERATOR**<br>This button is only active in the ***Manual Mode*** and allows the operator to transfer the load to the generator. |
|  | **OPEN GENERATOR**<br>This button is only active in the ***Manual Mode*** and allows the operator to open the generator breaker and remove the load. |

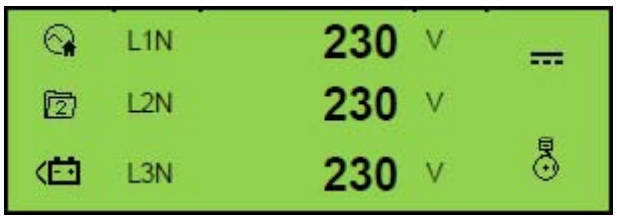
## MODULE DISPLAY

The module's display contains the following sections. A description of each section can be viewed in the sub sections.

**Note: Depending upon the module's configuration, some display screens may be disabled.**

| | | | |
|---|---|---|---|
| ***Inst. Icon*** | Instrumentation | *Unit* | ***Alarm Icon*** |
| ***Active Config*** | Instrumentation | *Unit* | |
| ***FPE / Auto Run*** | Instrumentation | *Unit* | ***Mode Icon*** |

### Example of DSE7110 MKII Home Page Display




### 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.

### Active Configuration

An icon is displayed in the ***Active Config*** section to indicate the active configuration within the currently selected within the controller.

| ICON | DETAILS |
|---|---|
|  | Appears when the main configuration is selected. |
|  | Appears when the alternative configuration is selected. |

**Instrumentation Icons**

When viewing instrumentation pages, an icon is displayed in the ***Inst. Icon*** section to indicate what section is currently being displayed.

| ICON | DETAILS |
|---|---|
|  | The default home page which displays generator voltage and mains voltage. |
|  | Generator voltage and frequency instrumentation screen. |
|  | Mains voltage and frequency instrumentation screen. |
|  | Generator current instrumentation screen. |
|  | Mains current instrumentation screen. |
|  | 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 sensor instrumentation screen. |
|  | Appears when the event log is being displayed. |

| ICON | DETAILS |
|---|---|
|  | 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. |

**Front Panel Editor (FPE) / Auto Run Icon**

**Note: For further details about the Front Panel Editor, see the section entitled 'Front Panel Editor' elsewhere in this manual.**

When running in ***Auto Mode*** and on the Home page, an icon is displayed in the ***FPE /Auto Run*** section to indicate the source of the auto start signal.

| ICON | AUTO RUN REASON |
|---|---|
|  | Appears when a remote start input is active. |
|  | Appears when a low battery run is active. |
|  | Mains failure. |
|  | Appears when a scheduled run is active. |

### Mode Icon

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/Reset Mode***. |
|  | Appears when the engine is at rest and the unit in ***Manual Mode***. |
|  | Appears when the engine is at rest and the unit is ***Test Mode***. |
|  | Appears when the engine is at rest and the unit is in ***Auto Mode***. |
|  | 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<br>The animation 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 becomes corrupted. |

### Alarm Icons (Protection)

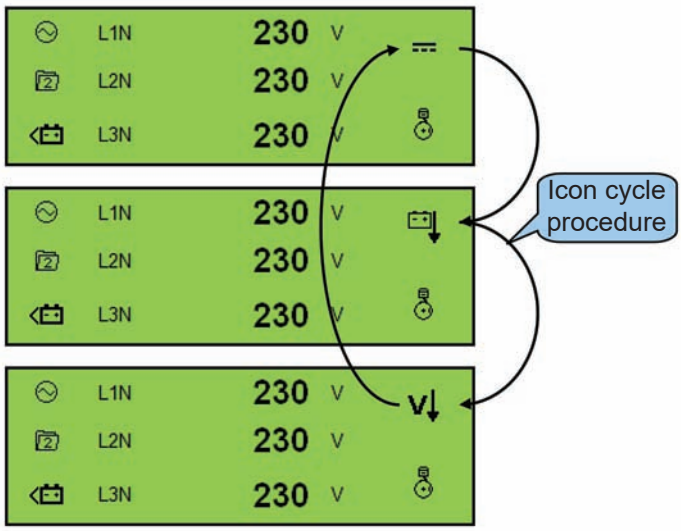
An icon is displayed in the ***Alarm Icon*** section to indicate the alarm that is current active on the controller.

In the event of a warning alarm, the LCD only displays the ***Alarm Icon***. In the event of an electrical trip or shutdown alarm, the module displays the ***Alarm Icon*** and the *Stop/Reset Mode* button LED begins to flash.

If multiple alarms are active at the same time, the ***Alarm Icon*** automatically cycles through all the appropriate icons to indicate each alarm which is active.

**Example:**

If the DSE controller was sensing a charge alternator failure alarm, delay over current alarm and an AC under voltage alarm at the same time, it would cycle through all of the icons to show this.



### 1. Warning Alarm Icons

Warnings are non-critical alarm conditions and do not affect the operation of the generator system. They serve to draw the operator's 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** | 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.<br>**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 W /L terminal. |
|  | **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. |
|  | **Generator Under Frequency** | The *generator output frequency* has fallen below the *pre-set* prealarm setting after the Safety On timer has expired. |

| ICON | FAULT | DESCRIPTION |
|---|---|---|
|  | **Generator Over Frequency** | The *generator output frequency* has risen above the *pre-set* prealarm 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. |

**2. 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.

**Note: The alarm condition must be rectified before a reset takes place. If the alarm condition remains, it is not possible to reset the unit (The exception to this is the *Low Oil Pressure alarm* and similar *'active from safety' on* alarms, as the oil pressure is low with the engine at rest).**

| 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** | 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. |

### 3. 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.

**Note: 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 Oil Pressure alarm and similar 'active from safety on' alarms, as the oil pressure is low with the engine at rest).**

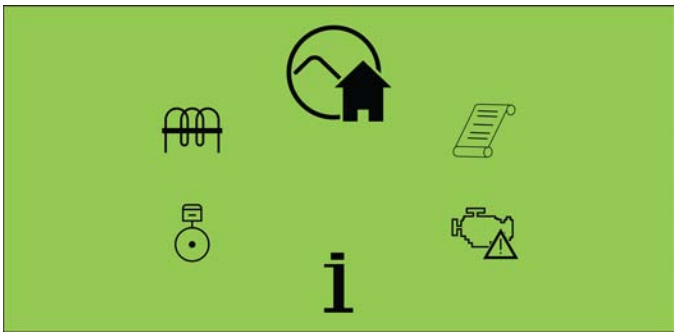
| ICON | FAULT | DESCRIPTION |
|---|---|---|
|  | **Auxiliary Inputs** | The module detects that an auxiliary input which has been user configured to create a fault condition has become active. |
|  | **Analogue Input** | The module detects that an input configured to create a fault condition has become 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 W/L terminal. |
|  | **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. |

| ICON | FAULT | DESCRIPTION |
|---|---|---|
|  | **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. |
|  | **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 does not detect data on the engine Can data link. |
|  | **Emergency Stop** | The emergency stop button has been depressed. This fail-safe (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. |

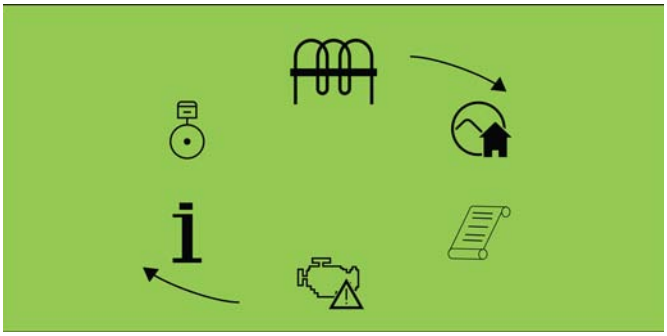
## VIEWING THE INSTRUMENT PAGES

### Navigation Menu

To enter the navigation menu, press both the Up and Down buttons simultaneously.



To select the required icon, press the Up button to cycle right or the Down button to cycle left until the desired instrumentation section is reached.



Once the desired icon is at the top, press the *Auto Mode* button to enter that instrumentation section.


If the *Auto Mode* button is not pressed, the display automatically returns to the Home Page after the configured setting of the *LCD Scroll Timer*.


### Navigation Menu Icons

| ICON | DESCRIPTION |
|---|---|
|  | Generator and mains voltage instrumentation. |
|  | Generator instrumentation. |
|  | Mains instrumentation (DSE7110 MKII only). |
|  | Current and load instrumentation. |
|  | Engine instrumentation. |
|  | Module information. |
|  | Engine DTCs (Diagnostic Trouble Codes) if active. |
|  | Event Log. |

## General Navigation

Example:


It is possible to scroll through the display to view different pages of information by repeatedly operating the Up or Down navigation buttons.

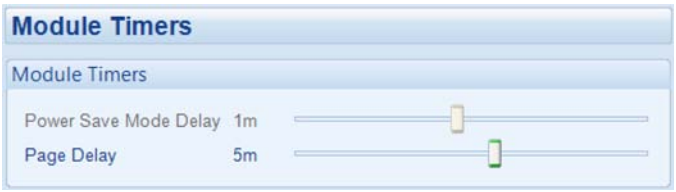
And so on until the last page is reached.

A further press of the navigation Down button returns the display to the Home Page.

Once selected, the page will remain on the LCD display until the user selects a different page or, after an extended period of inactivity (*Page Delay Timer)*, the module reverts back to the Home Page.

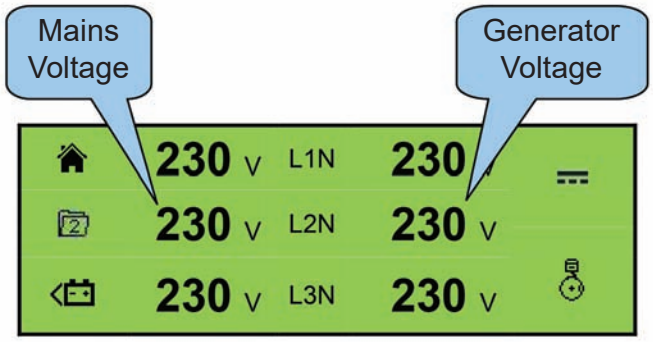
**Note: If you want to view one of the instrument pages towards the end of the list, it may be quicker to scroll up through the pages rather than down.**

The *Page Delay Timer* is configured using the DSE Configuration Suite Software or by using the Front Panel Editor.




## Home

This is the page that is displayed when no other page has been selected and is automatically displayed after a period of inactivity (*Page Delay Timer*) of the module fascia buttons. It also contains the voltage reading of the generator and mains that is measured from the module's voltage inputs.




- **Generator Voltage (ph-N / ph-ph)**
- **Mains Voltage (ph-N / ph-ph)**

## Generator

These pages contain electrical values of the generator, measured or derived from the module's voltage inputs.


- **Generator Voltage (ph-N)**
- **Generator Voltage (ph-ph)**
- **Generator Frequency**

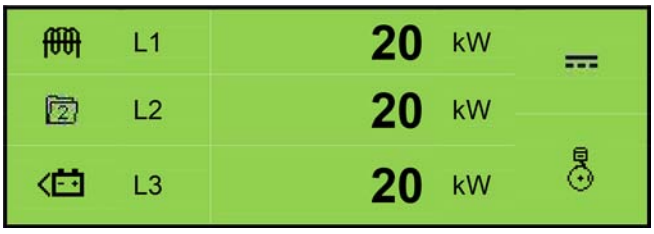
## Mains

These pages contain electrical values of the mains, measured or derived from the module's voltage inputs.


- **Mains Voltage (ph-N)**
- **Mains Voltage (ph-ph)**
- **Mains Frequency**

### Load

These pages contain electrical values of the load, measured or derived from the module's voltage and current inputs. The power values displayed depend on which supply is on load.




- **Generator Current (A)**
- **Mains Current (A) (DSE7110 MKII only)**
- **Load ph-N (kW)**
- **Total Load (kW)**
- **Load ph-N (kVA)**
- **Total Load (kVA)**
- **Load ph-N (kVAr)**
- **Total Load (kVAr)**
- **Power Factor ph-N**
- **Power Factor Average**
- **Accumulated Load (kWh, kVAh, kVArh)**

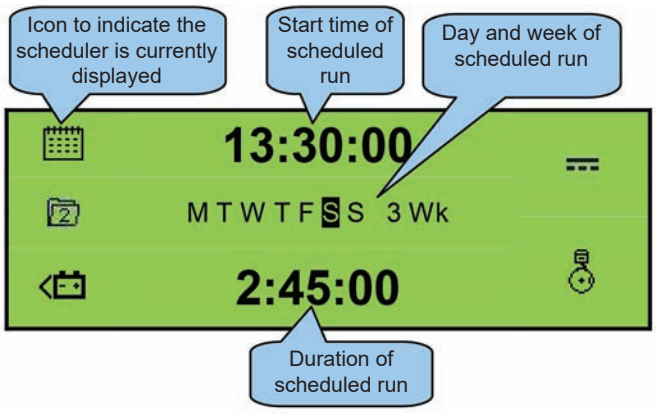
### Engine

These pages contain instrumentation gathered about the engine measured or derived from the module's inputs, some of which may be obtained from the engine ECU.


- **Engine Speed**
- **Engine Run Time**
- **Engine Battery Volts**
- **Engine Coolant Temperature**
- **Engine Oil Pressure**
- **Engine Fuel Level**
- **Flexible Sensor**
- **Engine Maintenance Due - Oil**
- **Engine Maintenance Due - Air**
- **Engine Maintenance Due - Fuel**

### Info

These pages contain information about the controller.




- **Module's date and time**
- **Scheduler settings**
- **Product description and USB identification number**
- **Application and Engine Version**

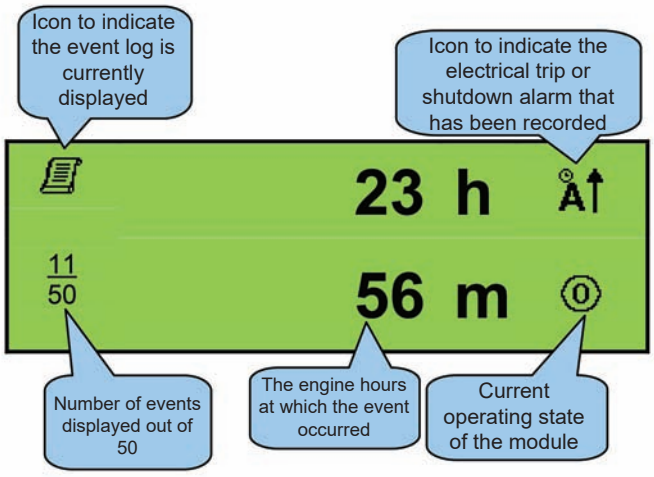
### Event Log

This module's event log contains a list of the last 50 recorded events and the engine hours at which they occurred. The events recorded are customisable via the DSE Configuration Suite PC Software.

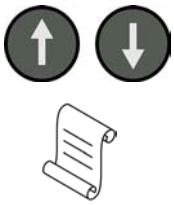
Example below shows the possible configuration of the event log (DSE Configuration Suite Software). This also shows the factory settings of the module.


Once the log is full, any subsequent event overwrites the oldest entry in the log. Hence, the log always contains the most recent events. The module logs the alarm, along with the engine running hours.

**Viewing the event log:**




To view the event log, press both (up) and (down) buttons simultaneously, the navigation menu is then displayed. Once entered, cycle to the event log section and enter.



To view the event log, repeatedly press the (up) or (down) buttons until the LCD screen displays the desired event.

Continuing to press down the (up) or (down) buttons cycles through the past alarms after which the display shows the most recent alarm and the cycle begins again.

To exit the event log, press the (up) and (down) buttons simultaneously to enter the navigation menu. Once entered, cycle to the desired instrumentation section.

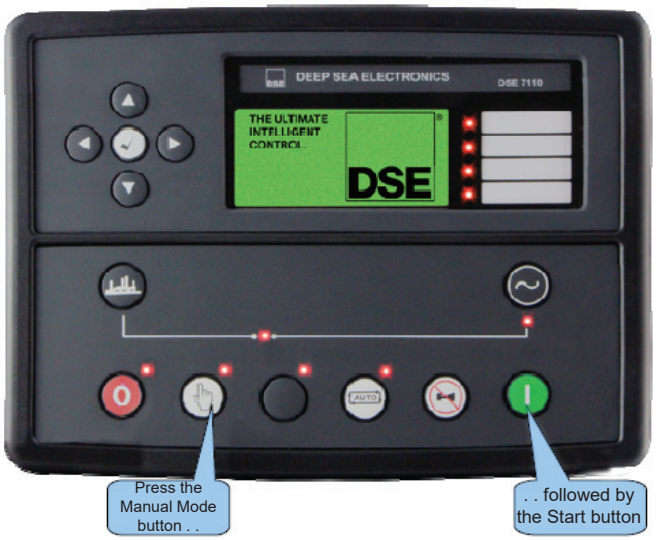
# OPERATION

**Note: The following descriptions detail the sequences followed by a module containing the standard 'factory configuration'. Always refer to your configuration source for the exact sequences and timers observed by any particular module in the field.**

## QUICKSTART GUIDE

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

### Starting the engine




### Stopping the engine


### STOP/RESET MODE

**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* Mode 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:

- Engine speed is zero as detected by the CANbus ECU.
- Generator AC Voltage and Frequency must be zero.
- Engine Charge Alternator Voltage must be zero.
- 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.

Power Save Mode in the DSE Configuration Suite Software.

## MANUAL MODE

Manual Mode is activated by pressing the *Manual Mode* button. The *Manual Mode* icon is displayed to indicate *Manual Mode* operations. In *Manual Mode*, the set does not start automatically. To begin the starting sequence, press the Start button.

### Starting Sequence

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 Timer* duration after which the next start attempt is made. Should this sequence continue beyond the set *Number Of Attempts*, the start sequence is terminated and the display shows *Fail to Start*.

The starter motor is disengaged when the engine fires. Speed detection is factory configured to be derived from the AC alternator output frequency, but can additionally be measured from a Magnetic Pickup mounted on the flywheel or from the CANbus link to the engine ECU depending on module configuration.

Additionally, rising oil pressure can be used to disconnect the starter motor (but cannot detect underspeed or overspeed). After the starter motor has disengaged, the *Safety On Delay* timer activates, allowing Oil Pressure, High Engine Temperature, Under-speed, Charge Fail and any delayed Auxiliary fault inputs to stabilise without triggering the fault.

### Engine Running

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

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.

- Press the *Transfer to Generator* button.

- 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:

- Press the *Open Generator* button.

- 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*.


- Press the *Stop/Reset Mode* button to remove load and stop the generator.

- Activation of an auxiliary input that has been configured to Generator Load Inhibit.

In Manual Mode the set does not continue to run until either:

- The *Stop/Reset Mode* button is pressed - The delayed load outputs are de-activated immediately and the set immediately stops.

- The *Auto Mode* button is pressed. The set observes all *Auto Mode* start requests and stopping timers before beginning the *Auto Mode Stopping Sequence*.

## AUTOMATIC MODE

**Note: If a digital input configured to *Panel Lock* is active, changing module modes is not be possible. Viewing the instruments and event logs is NOT affected by *Panel Lock*.**

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


### Waiting In Auto Mode

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

- Activation of the inbuilt exercise scheduler.

### 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. Should this sequence continue beyond the *Set Number Of Attempts*, the start sequence is terminated and the display shows *Fail to Start*. The starter motor is disengaged when the engine fires. Speed detection is factory configured to be derived from the AC alternator output frequency, but can additionally be measured from a Magnetic Pickup mounted on the flywheel or from the CAN link to the engine ECU depending on module.

Additionally, rising oil pressure can be used to disconnect the starter motor (but cannot detect underspeed or overspeed).

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

### Engine Running

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

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.

### 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 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.

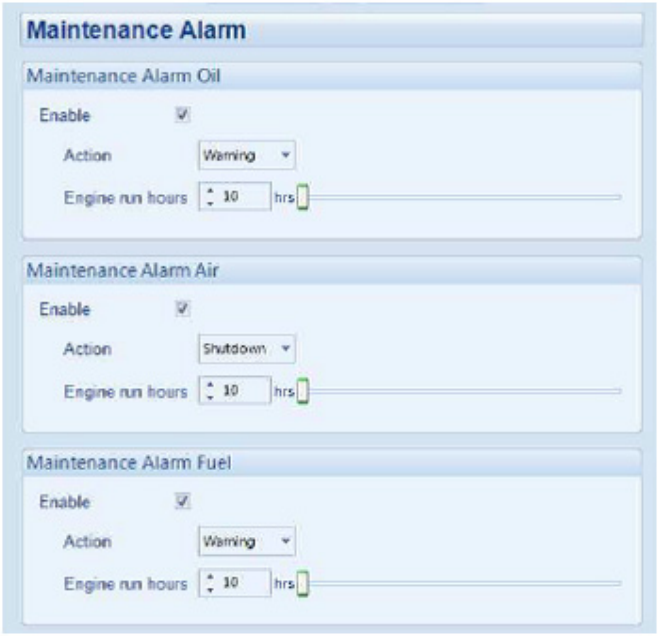
The *Cooling Down* timer allows the set to run off load and cool sufficiently before being stopped. This is particularly important where turbo chargers are fitted to the engine.

After the *Cooling Down* timer has expired, the set is stopped.

## MAINTENANCE ALARM

Depending upon module configuration one or more levels of engine maintenance alarm may occur based upon a configured schedule.

**Example 1**



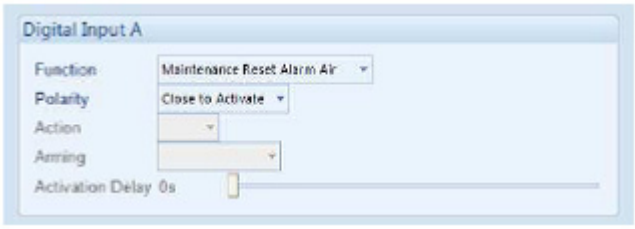

Screen capture from DSE Configuration Suite Software showing the configuration of the Maintenance Alarm for Oil, Air and Fuel.

When activated, the maintenance alarm can be either a ***Warning*** (set continues to run) or ***Shutdown*** (running the set is not possible).

Resetting the *Maintenance Alarm* is normally actioned by the site service engineer after performing the required maintenance. The method of reset is either by:

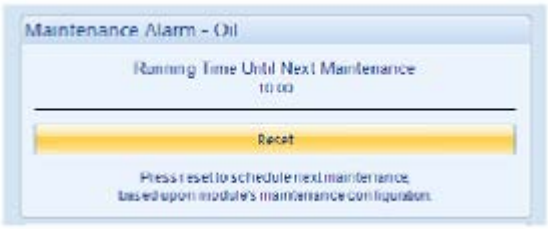
- Activating an input that has been configured to *Maintenance Reset Alarm* x, where x is the type of maintenance alarm (Air, Fuel or Oil).
- Pressing the maintenance reset button in the DSE Configuration Suite, Maintenance section.
- Pressing and holding the *Stop/Reset Mode* button for 10 seconds on the desired Maintenance Alarm status page. This can be protected by a PIN number.

**Example 2**




Screen capture from DSE Configuration Suite Software showing the configuration of a digital input for Maintenance Reset Alarm Air.

**Example 3**

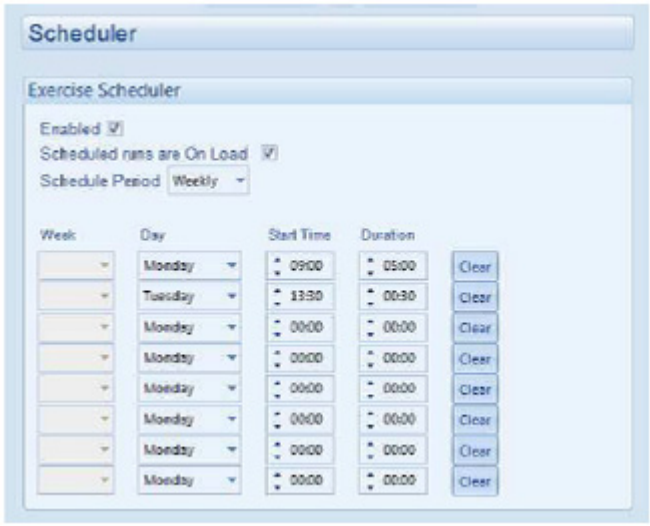



Screen capture from DSE Configuration Suite Software showing the Maintenance Alarm Reset 'button' in the DSE Configuration Suite SCADA I MAINTENANCE section.

## SCHEDULER

The controller contains an inbuilt exercise run scheduler, capable of automatically starting and stopping the set. Up to 8 scheduled start/stop sequences can be configured to repeat on a 7-day or 28-day cycle. Scheduled runs may be on load or off load depending upon module configuration.

**Example**




Screen capture from DSE Configuration Suite Software showing the configuration of the Exercise Scheduler. In this example the set will start at 09:00 on Monday and run for 5 hours, then start at 13:30 on Tuesday and run for 30 minutes.

### Stop Mode

- Scheduled runs do not occur when the module is in *Stop/Reset Mode*.

### Manual Mode

- Scheduled runs do not occur when the module is in *Manual Mode* waiting for a start request.

- Activation of a Scheduled Run 'On load' when the module is operating OFF LOAD in *Manual Mode* will force the set to run ON LOAD.

### Test Mode

- Scheduled runs do not occur when the module is in *Test Mode* waiting for a start request.

### Auto Mode

- Scheduled runs operate ONLY if the module is in *Auto Mode* with no Shutdown or Electrical Trip alarm present.


- If the module is in *Stop/Reset Mode* or *Manual Mode* when a scheduled run begins, the engine is not started. However, if the module is moved into *Auto Mode* during a scheduled run, the engine will be called to start.


- Depending upon configuration by the system designer, an external input can be used to inhibit a scheduled run.
- If the engine is running OFF LOAD in *Auto Mode* and a scheduled run configured to 'On Load' begins, the set is placed ON LOAD for the duration of the Schedule.

## FAULT FINDING

### STARTING

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

**LOADING**

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

**ALARMS**

| SYMPTOM | POSSIBLE REMEDY |
|---|---|
| **Low oil Pressure fault operates after engine has fired** | Check engine oil pressure.<br>Check oil pressure switch/sensor and wiring.<br>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.<br>Check switch/sensor and wiring.<br>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.<br>Check configuration of input. |
| **Electrical Trip fault operates** | Check relevant switch and wiring of fault indicated on LCD display.<br>Check configuration of input. |
| **Warning fault operates** | Check relevant switch and wiring of fault indicated on LCD display.<br>Check configuration of input. |
| **CAN ECU WARNING**<br>**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.<br>Check all wiring and termination resistors (if required). |
| **Incorrect reading on Engine gauges**<br>**Fail to stop alarm when engine is at rest** | Check engine is operating correctly.<br>Check sensor and wiring paying particular attention to the wiring to terminal 10 (refer to appendix).<br>Check that sensor is compatible with the module and that the module configuration is suited to the sensor. |

**INSTRUMENTS**

| SYMPTOM | POSSIBLE REMEDY |
|---|---|
| **Inaccurate generator measurements on controller display** | Check that the CT primary, CT secondary and VT ratio settings are correct for the application.<br><br>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).<br><br>Remember to consider the power factor (kW = kVA x powerfactor).<br><br>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 multimeters.<br><br>Accuracy of the controller is better than 1% of full scale. Generator voltage full scale is 415V ph-N, accuracy is ±4,15V (1% of 415V). |

**MISCELLANEOUS**

**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.**

| 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.<br><br>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.<br><br>  |


Portable Power

# ENGINE GENERAL INTRODUCTION

## CONTENTS

## GENERAL INFORMATION

This Operation and Maintenance Manual provides the most efficient methods for engine maintenance as well as quick, efficient methods to determine the cause of engine faults to ensure that any actions taken by authorized skilled technicians are done in the most efficient and efficient way possible. If maintenance is performed by unskilled technicians, or maintenance without the specified tools and facilities, serious bodily injury or critical faults in engine performance may occur.

Regular inspection and maintenance are required to maintain long-term optimal engine conditions and best performance. In the event that a part must be replaced, only genuine parts as defined by the parts list (PARTS BOOK) should be used. Doosan shall not be held liable for any critical damage or faults which may be caused by the use of unauthorized or remanufactured parts.

The maintenance methods stated in this Operation and Maintenance Manual are the most efficient and safest work procedures. Some work procedures require special tools.

For questions about genuine parts and special tools, please contact us.

This Operation and Maintenance Manual includes 'Danger,' 'Warning,' and 'Caution' in order to reduce possible injuries and engine faults which may occur while performing maintenance. If workers do not follow the instructions, critical faults in engine performance and operation or serious bodily injury may occurred. 'Danger,' 'Warning,' and 'Caution' instructions must be followed. However, we inform you that it is not possible to describe all possible and unexpected dangers which may arise while performing engine maintenance.

## DANGER, WARNING, CAUTION AND NOTE

### GENERAL INFORMATION

This Operation & Maintenance manual divides maintenance operations such as performing engine checks, troubleshooting, or diagnosing faults into three categories, "Danger," "Warning," and "Caution." In addition, Note) is used to provide additional descriptions and information required for maintenance technicians to successfully operate Doosan engines.
The recommended repair methods and 'Danger,' 'Warning,' and 'Caution' can enhance the degree of completion of engine maintenance and prevent bodily injury which may occur to workers. However, this manual cannot predict all possible risks.

**⚠ DANGER**

**Operators must observe instructions, otherwise fatal or serious injuries to operators and other persons may occur.**

**⚠ WARNING**

**Operators must follow this instruction as failing to do so may result in the death or serious bodily harm of operators or others.**

**⚠ CAUTION**

**Operators must observe this instruction since failing to do so may cause critical faults which can have impact on the engine performance and operation.**

**NOTE:** Indicates additional description, information, and references for operators' easy understanding.

### GENERAL INSTRUCTIONS

1. In order to maintain the best long term performance and safety, please read and understand this manual and execute routine inspections and regular inspections.

2. We have divided the content of this manual into causes of bodily injury and damage to assets and causes of pollution.

**⚠ WARNING**

**If skin contact with corrosive acids, fuel or hot oil occurs seek immediate medical attention.**

**⚠ WARNING**

**If fuel or antifreeze comes into contact with eyes seek immediate medical attention.**

**⚠ WARNING**

**During operation of the engine, be careful not to touch the cooling fan safety guard as the rotating fan may cause serious injury.**

**⚠ WARNING**

**During operation of the engine, be careful not to touch the v-belt safety guard as the rotating belt may cause serious injury.**

**⚠ WARNING**

**The v-belt safety guard is an optional item for customers. In order to prevent accidents while the engine is running you should install a v-belt safety guard. If a v-belt safety guard is not installed, you should not access the engine while running. The engine manufacturer will not be responsible for accidents or injury arising without the installation of a v-belt safety guard.**

**⚠ WARNING**

**Do not touch the turbocharger when engine is running, or immediately after it has stopped. The turbocharger will be hot and can cause severe burns. Always allow the turbocharger to cool before carrying out any maintenance.**

## ⚠ DANGER

**Do not touch the exhaust manifold or heat screen when engine is running, or immediately after it has stopped. The exhaust manifold and heat screen will be hot and can cause severe burns. Always allow the exhaust manifold and heat screen to cool before carrying out any maintenance. Pay particular attention to the heat screen as this will be extremely hot.**

## ⚠ WARNING

**If you need to perform an emergency stop of the engine, use the electronic emergency stop device installed on the generator before attempting a mechanical emergency stop. It is difficult to operate the mechanical emergency stop device which is mounted on a fuel pump. Serious burns can occur if the operator comes into contact with the exhaust manifold. The operator is required to install a separate cable for operating the mechanical emergency stop. The engine manufacturer will not be responsible for accidents or injury arising without the installation of separate auxiliary cable.**

**PRECAUTIONS IN STARTING THE ENGINE**

1. Before starting the engine, please read this manual carefully and fully understand 'Danger,' 'Warning,' and 'Caution'. If you cannot fully understand it or have any question, please contact us.

2. For safety reasons, attach "Warning" signs around engines in operation to keep people other than workers from accessing the engines. Let engine operators know that they are responsible for the safety of the engine room.

3. Only authorized people may start and operate engines. Unauthorized people should not be allowed to handle engines.

4. Do not get close to moving or rotating parts while the engine is in operation.

5. Do not touch the hot engine during operation.

6. Exhaust gas is poisonous. Fully ventilate before starting engine. If the space is enclosed, ensure that it is well ventilated.

7. Keep vicinity of engine, ladders and stairways free of oil and grease. Accidents caused by slipping can have serious consequences.

**CAUTIONS FOR INSPECTION AND REPAIR**

1. Inspection and repair of engine should be performed only when the engine is stopped.

2. If it is inevitable to perform inspection or repair on the operating engine, do not get close to the rotating parts.

## ⚠ WARNING

**When accessories such as necklaces, rings, watches, or gloves become stuck in rotating parts while the engine is running, serious bodily injury may occur.**

## ⚠ WARNING

**Do not exchange or disassemble a pipe or hose (from the engine fuel circuit, engine oil circuit, coolant circuit, or compressed air circuit) while the engine is running. The leaked liquid may cause bodily injuries.**

3. Use an engine oil drain container that is large enough to prevent the overflow of engine oil while draining.

4. Open the engine coolant cap after fully cooling the engine to exchange or replenish coolant.

## ⚠ WARNING

**If the coolant cap is opened while the engine is still hot, hot water will spurt out and may cause burns. Open the engine coolant cap after fully cooling the engine.**

5. Fuel is highly flammable. Smoking, sparks or naked flames around an engine may cause fire.

## ⚠ WARNING

**Only refuel when the engine is stopped.**

6. Mark and separately manage the containers for storing coolant from beverage bottle for avoiding confusion. See a doctor immediately in case of drinking coolant.

7. Follow the instructions provided by the battery manufacturer when checking or handling batteries.

# ⚠ WARNING

**Battery fluid is corrosive and dangerous because of its explosiveness and toxicity. Therefore, it should only be handled by a skilled technician who specializes in battery fluid.**

8. Only authorized skilled technicians should repair and maintain engines.

9. Only appropriate tools should be used. If the jaws of a wrench are worn out, the wrench might slip during use, causing accidents or injury.

10. Do not allow other persons to stay or pass under an engine when lifting the engine with a crane. Before lifting the engine, ensure that there is no one around the engine and to ensure enough safe space.

11. Before inspecting or replacing the electrical apparatus, disconnect the battery ground wire first. Connect the battery ground wire after completing all required work for checking or replacing the electrical apparatus in order to prevent a short circuit.

12. Before performing electric welding work, turn off engine, block the power supply to the engine, and remove the wire harness connector.

13. Do NOT give any electric or mechanical shocks or perform welding works on the electrical apparatus or the ECU.

## GENERAL REPAIR

1. Wait until the engine is properly cooled down before starting work, as the engine will be hot and may cause serious burns.

2. Disconnect the battery ground wire from to prevent damage of wires and sensors caused by a short circuit.

3. Engine oil and coolant may damage paint and should be stored in a separate container and marked for safe management.

4. Store the disassembled parts in a specified space to avoid damage or pollution.

5. Use specified and special tools for efficient and safe repair.

6. If parts need to be replaced, use only genuine parts for replacement. Using unauthorized or remanufactured parts may cause critical damage and faults in engine performance.

7. Replace parts such as cotter pins, gaskets, O-rings, seal rings, oil seals, and washers with new ones during repairs. Reuse of parts may be the cause of engine faults and engine may not operate properly.

8. Group and store disassembled parts in disassembling order. As bolts and nuts vary in strength, shape and torque according to their assembly position, divide and store them accordingly to these characteristics.

9. Clean disassembled parts to remove foreign substances before inspecting or reassembling parts. Use compressed air to clean the oil galleries.

10. Thinly spread oil or grease on rotating parts or parts requiring lubrication, before assembling them.

11. If required, use a specified adhesive to assemble gaskets to prevent water or oil from leaking.

12. Assemble bolts and nuts with the specified tightening torque.

13. After completing repairs, conduct a final inspection and perform a test operation to check if all works have been successfully completed.

## OTHER SAFETY INSTRUCTIONS AND ENVIRONMENTAL POLLUTION

Observe the following instructions to protect workers from danger and to prevent the environmental pollution while performing engine repairs.

1. Good ventilation and low humidity should be maintained in the work space.

2. The work space should be clean, in good order and free of flammables.

3. Smoking is strictly forbidden in the workshop.

4. Workers should wear working clothes, protective goggles, and safety shoes.

5. Workers are not allowed to wear accessories such as necklaces, rings, watches, and earrings.

6. Start the engine in a well-ventilated space and fully ventilate the space before starting engine to prevent carbon monoxide poisoning.

7. Wait until the engine is properly cooled down before starting work, since you may get burned by the heated engine.

8. Do NOT work on rotating or running parts once the engine has been started.

9. Discard oil according to the regulations set forth by the relevant authorities.

10. If engine oil or fuel leaks on the floor or is improperly drained, serious environmental pollution of sea, river or underground water may occur.

11. Discard the undiluted anticorrosive agent, antifreeze, filter elements, and cartridges as special wastes.

12. Discard coolant and special waste according to the regulations of the appropriate authorities.

**⚠ WARNING**

**Failure to observe the regulations of the relevant authorities violates environmental pollution regulations and may be subject to legal penalties.**

## USE OF GENUINE PARTS

An engine consists of many parts which are mechanically harmonized. To prevent engine faults in advance and use engines with best performance for a long period, maintenance and replacement of expendable parts should be conducted regularly.

Use of genuine parts is recommended. Using unauthorized or remanufactured parts may cause critical damage and faults to engine for which Doosan shall not be held liable.

## ENGINE MAINTENANCE

### PREVENTION OF DAMAGE AND ABRASION

Using an engine for any purposes other than the designed purpose may cause critical faults to the engine for which Doosan shall not be held liable. For details concerning the usage and purpose of the engine, please direct questions to Doosan Sales Team. Do NOT adjust, convert, or change the ECU without Doosan authorization.

If a problem is found in an engine, figure out and solve the cause to prevent the critical faults in advance. Use of genuine parts is recommended. Using unauthorized or remanufactured parts may cause critical damage and faults to engine for which Doosan shall not be held liable.

Consider the following while managing engines:

1. Use clean, specified, and qualified fuel only. Use fuel recommended in this Operation and Maintenance Manual.

**⚠ CAUTION**

**Using inappropriate or unspecified fuel may cause critical damage and faults in engine performance.**

2. Do not operate an engine without lubrication oil or coolant. Use only the products (engine oil, cooling water, anticorrosive agent, and etc.) recommended by Doosan.

3. Always keep surroundings of the engine clean.

4. Use fuel recommended in this Operation & Maintenance manual.

5. Conduct inspections and exchanges regularly according to the regular inspection table.

6. If the engine is overheated, do not stop it immediately, but operate it at idle status for five minutes or more to lower the engine temperature to the proper level.

**⚠ WARNING**

**If the radiator cap is opened while the engine is still hot, hot water will spurt out and may cause burns.**

7. Check the engine oil level on a flat surface. Do not exceed the maximum of the oil level gauge.

**⚠ CAUTION**

**Immediately replenish engine oil when the engine oil level is below the lower limit of the engine oil gauge.**

8. If there are gauges for battery, oil pressure, coolant and temperature, check if they indicate a normal status.

9. Do not operate engine without coolant.

**⚠ CAUTION**

**Always use coolant mixed with antifreeze. If coolant without antifreeze is used, the coolant may freeze causing the coolant passage in the cylinder block to freeze and damage the engine.**

**PREVENTION OF POLLUTION**

Consider the following to manage engine without causing environmental pollution.

1. Drain oil and coolant using collection containers.

2. Discard oil and coolant according to the regulations of the relevant authorities.

3. Be careful not to let drained oil and cooling water flow into the ground or the sewer. Otherwise, serious pollution of the drinking water source may occur.

4. Classify the oil, filters, and filter cartridges as environmental pollution wastes and discards them according to regulations.

5. Classify the antifreeze, cooling water, and anticorrosive agent as hazardous wastes and discards them by observing the regulations.

**HANDLING OF ENGINE OIL**

Prolonged and repeated contact of skin with engine oil may cause skin to dry out and contract, causing dermatitis. Engine oil includes substances toxic to the human body. Handle engine oil by observing the following safety rules:

1. Do not expose skin to used engine oil for a long time.

2. Always wear working clothes and gloves.

3. If skin comes in contact with engine oil, immediately wipe it off with water, soap or hand cleaners.

4. Do not clean skin with gasoline, fuel, thinner, or solvent.

5. Apply a skin care cream after cleaning from oil.

6. Do not put oil-stained gloves or cloth in ones pocket.

**⚠ WARNING**

**Discard oil according to the regulations set forth by the relevant authorities. Disposing of drained oil into the ground, sewers, drains, rivers, or the sea will cause serious environmental pollution. Violation of regulations regarding discard of engine oil without observing the handling regulations, will be punished.**


Portable Power

# OPERATION AND MAINTENANCE

## CONTENTS

## STARTING AND STOPPING OF THE ENGINE

### PREPARING FOR START

Check the following before starting the engine for the first time after purchase.

1. Before starting an engine, check the levels of fuel, coolant, and oil and replenish those fluids if required.

2. Check if engine oil level is between the upper and lower limit of the oil level gauge. The upper and lower limit of the oil level gauge indicate the maximum and minimum of the engine oil level.

**⚠ CAUTION**

**When replenishing engine oil, do not exceed the maximum on the oil level gauge. Too much oil may cause damage to the engine.**

**The oil required to fill the oil filters and pipes depends upon the engine equipment and use and must be determined individually at the time of initial commissioning. Make a note of the determined quantity.**

3. Be careful not to mix foreign substances in fuel, engine oil, or coolant while adding the fluid, and keep the fluid clean while it is not in use. Use fuel, oil, and coolant recommended by Doosan. Otherwise, critical damage to the engine may occur.

### STARTING THE ENGINE

Observe the following when starting the engine.

1. Insert key in start switch.

2. Move control lever to idle speed.

3. Turn key switch clockwise.

4. Do not operate for longer than 10 seconds at a time.

5. When engine starts release the key switch.

6. Adjust control lever for desired speed.

7. If engine fails to start, release the key, wait approximately 1 minute, then operate starter again.

8. Avoid running the cold engine idle for any length of time as this may cause increased wear due to corrosion. Prolonged idling is harmful to the environment.

**⚠ CAUTION**

**On initial start of an overhauled engine or after long periods without use, press shutdown lever in “stop” position and operate starter motor for a few seconds (max. 10) until oil pressure is indicated.**

**Ensure that the engine can not be started by unauthorized persons.**

### RUNNING IN

It is recommended that new or overhauled engines should not be operated at a load higher than approximately 75% of the maximum load during the first few hours of operation. Initial run-in should be at varying speeds or load. After this initial run-in, the engine should be brought up to fuel output gradually.

### DURING OPERATION

**⚠ CAUTION**

**Do not overload the engine. Do not exceed the maximum permissible engine tilt. If faults occur, find their cause immediately and have them eliminated in order to prevent more serious damage.**

1. Oil pressure.
   During operation the oil pressure in the engine lubrication system must be monitored. if the monitoring devices register a drop in the lube oil pressure, switch off the engine immediately.

2. Coolant temperature.
   Operating an engine with too low coolant temperature increases fuel consumption, abrasion of the cylinder liner, and shortens the engine's life span.

3. Alternator.
   In order to avoid damage to the alternator, observe the following instructions while the engine is running.
   1) Do not switch off the main battery.
   2) Do not disconnect the battery or pole terminals or the cables.
   3) If during operation the battery charge lamp suddenly lights up, stop the engine immediately and remedy the fault in the electrical system.
   4) Do not short-circuit the connections of the alternator with those of the regulator or said connection with ground, not even by briefly bringing the connections into contact.
   5) Do not operate the alternator without battery connection of the alternator with those of the regulator or said connections with ground, not even by briefly bringing the connections into contact.
   6) Do not operate the alternator without battery connection.

### STOPPING THE ENGINE

Cut off the main circuit breaker of the generator control panel but do not stop the engine immediately. Keep running the engine at idle speed for approximately 5 minutes before stopping the engine.

## BREAK-IN PERIOD OF THE ENGINE

### GENERAL INFORMATION

Doosan engines are subjected to a final approval test to ensure the provision of high quality engines before being shipped. However, engines are not operated for a long period of time in this test. Therefore, new engines require a break-in period during the initial 50 hours after delivery. By properly breaking-in an engine, the highest levels of engine performance can be maintained long-term.

### BREAK-IN PERIOD OF A NEW ENGINE

If the engine's bearings are not properly broken in, they may be easily damaged and the lifetime of the engine may be shortened by overloading or high speeds. In order to prevent this, follow the guidelines below for the initial 50 hours after delivery of new engine.

1. Fully warm up the engine until the engine temperature reaches the normal operation condition, before starting normal operation of the engine.

2. Do not overload the engine or operate it at too high RPM.

3. Do not operate the engine with high speed at idle.

4. Do not rapidly start up or stop the engine.

5. Operate the engine with less than 70% of the engine load.

6. Inspection, check, and repair of engines should be managed by officially-certified technicians at certified service centers in compliance with corresponding rules.

### CHECK POINTS

Check the following during the break-in period of a new engine.

1. Periodically check if the engine oil level is between the minimum and maximum limit of the oil level gauge.

**⚠ CAUTION**

**If the oil level cannot be accurately checked through the oil level gauge, rotate the oil level gauge to 180 degrees, insert in the guide tube, and then withdraw to check.**

2. If the oil indicator lamp on the apparatus is turned on or blinks, the oil pressure may be insufficient. In this case, check the oil level and replenish oil if required. When replenishing engine oil, do not exceed the maximum on the oil level gauge. If the oil level is normal, check other related parts such as the oil pressure sensor, oil pump, or oil line.

**⚠ CAUTION**

**The oil pressure may increase with high rpm and decrease with low rpm. In addition, the pressure of cold oil may be higher at a specific rpm than that of warm oil. This condition may occur when the engine operates properly.**

3. Check the coolant level to check if the coolant circulates properly. If there is insufficient coolant in the radiator, the coolant level indicated may not be accurate.

4. Exchange engine oil and oil filter after the break-in period.

**⚠ CAUTION**

**If engine oil and oil filter need to be replaced, use only genuine engine oil and parts recommended by Doosan.**

### COLD START OPERATION

Slowly warm up the engine in case of starting up in cold weather or in areas with cold climate. Do not rapidly raise the rpm or load before the engine has been warmed up. The engine may consume oil until its piston ring is in position. Check the engine oil level frequently for the initial 50 hours of the break-in period.

### INSPECTION AFTER STARTING THE ENGINE

Check the pressure of the engine lubrication system by using the engine oil pressure gauge mounted on the apparatus while the engine is in operation. If pressure decreases on oil pressure gauge, immediately stop the engine. In addition, make sure that the recharge alarm indicator lamp of the alternator is turned off while the engine is operating.

1. Tightly connect the +/- terminals to prevent gaps between them. The sheath of battery connection cables should not be damaged or broken.

2. If the recharge alarm indicator lamp suddenly turns on or blinks during engine operation and the engine stops, fix the fault of the electric apparatus.

3. If color or odor of exhaust gas is unusual during operation, stop the engine, diagnose the cause and fix the fault.

4. Check the engine status through the alarm indicator lamp and gauges mounted on the apparatus during operation.

## OPERATION IN WINTER

### COLD START

Periodically check and inspect freezing of coolant and viscosity of lubrication oil.

### PREVENTING COOLANT FROM FREEZING

When only water is used as coolant, without mixing with antifreeze, corrosion in the engine, degradation of cooling efficiency, and freezing of the engine in winter may occur. If the engine is not operated for a long period during cold weather or in areas with cold climate, fully drain the coolant from the engine. Freezing of coolant leads to critical damage to the engine. Use a mixture of coolant with antifreeze at revised ratio when replacing or replenishing the coolant. The antifreeze prevents coolant from freezing.

### PREVENTING OVERCOOLING OF THE ENGINE

When the engine is cooled below the normal operating temperature, thermal efficiency is lowered and fuel consumption as well as abrasion of the cylinder liner may increase. Therefore, the engine should be operated within the normal operating temperature. If the engine has been sufficiently operated, but the temperature of coolant remains below the normal operating temperature, check the water temperature controller or other parts related to the cooler.

### ENGINE OIL

When viscosity of engine oil increases due to its low temperature during cold weather or in areas with cold climate, the rpm may not be stable after starting the engine. To prevent this, replace oil with engine oil for cold weather or areas with cold climate. When replacing engine oil, use of Doosan genuine engine oil is recommended.

## INSPECTION AND REPAIR OF THE ENGINE

### CHECKING ENGINE PARTS AFTER PROLONGED OPERATION

Wear, corrosion, or degradation of engine elements and assemblies may occur, causing lowered performance of engine parts. To maintain high engine performance, check the engine after prolonged operation to enhance durability of the engine.

Unexpected faults may occur in some weak engine parts after normal operation of the engine, when operation time is prolonged. In this case, it is difficult to maintain high engine performance by simply repairing some parts. It is recommended to replace or repair the entire related parts in order to diagnose the causes more accurately and maintain high engine performance.

To prevent engine failure in advance and use the engine safely for a long period, perform periodic replacements and inspections.

It is recommended to perform engine adjustments and preventive inspections during spring after the engine was exposed to winter or cold weather. This allows economic, long-term use of the engine without faults.

As the following parts affect the engine output and performance, they should be regularly checked and inspected.

1. Parts affecting intake and exhaust:
   - Air filter
   - Inter cooler
   - Turbocharger, Silencer
   - Other parts

2. Parts affecting lubrication and cooling:
   - Air filter
   - Oil filter
   - Antifreeze
   - Other parts

### INSPECTION AND REPAIR OF TURBOCHARGER

As performance of the turbocharger significantly affects the engine performance, regular inspection and repair should be made and inspection and maintenance regulations should be observed.

### INTAKE SYSTEM

Be careful to handle the air filter carefully. In regards to the dry air filter, intake resistance should be small to ensure a smooth intake of air.

### EXHAUST SYSTEM

If exhaust gas is leaked from the connections in the exhaust pipe, the turbocharger efficiency is lowered, causing degraded engine output and seizure of related parts in the worst case. As parts related to exhaust and turbocharger are used at high temperature, be careful not to mix the bolts and nuts with other parts when performing repair.

### LUBRICATION SYSTEM

Inspection and exchange of oil and oil filter should be performed while considering their exchange cycle. Overheated engine oil significantly affects the engine performance as well as the engine itself.

# PERFORMANCE AND SPECIFICATIONS

**CONTENTS**

# ENGINE SPECIFICATIONS AND PERFORMANCE

## ENGINE SPECIFICATION

| Items | | D1146 | D1146T | DP086TA | P086TI | Remarks |
|---|---|---|---|---|---|---|
| Engine type | | 4stroke, in-line, water-cooled type, naturally aspirated | 4stroke, in-line, water-cooled type, turbo charged | 4stroke, in-line, water-cooled type, turbo charged inter cooled | | |
| Combustion chamber type | | Direct injection type | | | | |
| Cylinder liner type | | Replaceable dry liner | | | | |
| Timing gear system | | Gear driven type | | | | |
| No. of piston ring | | Compression ring 2, oil ring 1 | | | | |
| No. of cylinder - bore x stroke (mm) | | 6 - 111 × 139 | | | | |
| Total piston displacement (cc) | | 8,071 | | | | |
| Compression ratio | | 17.6 : 1 | 16.8 : 1 | 16.7 : 1 | | |
| Engine dimension (length x width x height) (mm) | | 1,224 x 830 x 974 | 1,224 x 830 x 1,082 | 1,242 x 746 x 1,113 | 1,242 x 1,122 x 1,113 | |
| Engine weight (kg) | | 720 / 780 | 780 / 780 | 790 | | |
| Rotation | | Counter clockwise | | | | Viewed from flywheel |
| Fuel injection order | | 1 - 5 - 3 - 6 - 2 - 4 | | | | |
| Fuel injection timing | | 18° | 18° / 12° | 19° | 14° | BTDC static |
| Injection pump type | | Zexel in - line “AD” type | | Weifu in-line “P” type | | |
| Governor type | | Mechanical governor type (RSV) | | Electrical governor type (FUCHANG) | | |
| Injection nozzle type | | Multi-hole type (5 hole) | | | | |
| Fuel injection pressure (kg/cm$^2$) | | 214 | | | | at 200 rpm |
| Compression pressure (kg/cm$^2$) | | 28 | | | | |
| Valve clearance (mm) | Intake | 0.3 | | | | at cold |
| | Exhaust | 0.3 | | | | at cold |

**ENGINE SPECIFICATION (CONT'D)**

| Items | | D1146 | D1146T | DP086TA | P086TI | Remarks |
|---|---|---|---|---|---|---|
| Intake valve | Open at | 16° | | | | BTDC |
| | Close at | 36° | | | | ABDC |
| Exhaust valve | Open at | 46° | | | | BBDC |
| | Close at | 14° | | | | ATDC |
| Lubrication method | | Full forced pressure feed type | | | | |
| Oil pump type | | Gear type driven by camshaft | | | | |
| Oil filter type | | Full-flow, cartridge type | | | | |
| Lubricating oil capacity (litres) | Max. | 15.5 | | | | |
| | Min. | 12 | | | | |
| Oil specification | Oil class (API) | Above API CD or CE | | | | |
| | SAE | 15W40 | | | | |
| Oil cooler type | | Water cooled | | | | |
| Water pump | | Centrifugal type driven by belt | | | | |
| Cooling Method | | Fresh water forced circulation | | | | |
| Cooling water capacity (litres) | | 14 / 11 | | | | engine only |
| Thermostat type | | Wax pallet type | | | | |
| Alternator voltage - capacity (V - A) | | 24 - 45 | | | | |
| Starting motor voltage - output (V - kW) | | 24 - 4.5 | | 24 - 6.0 | | |

**ENGINE OUTPUT**

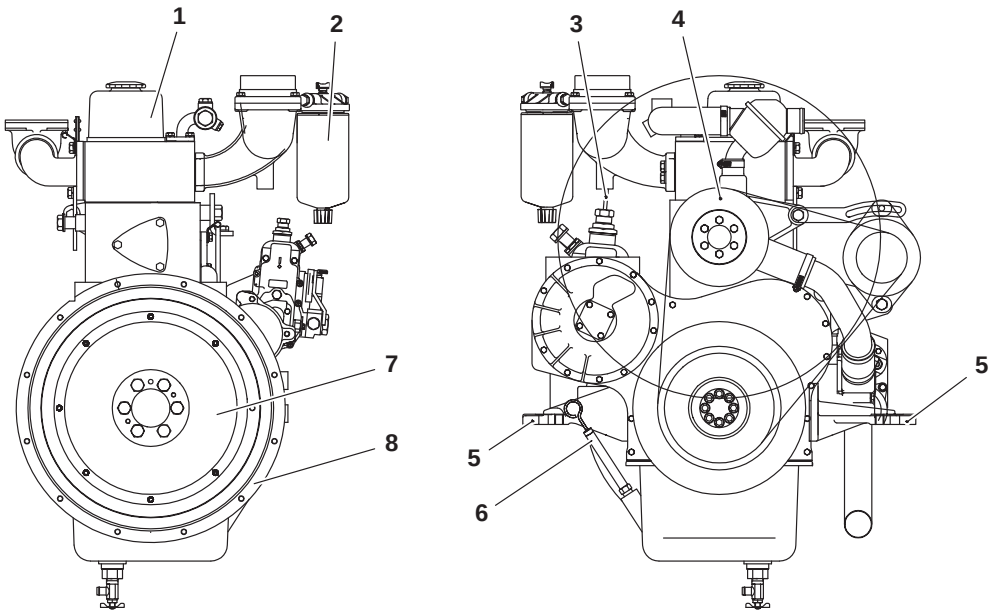
(Production tolerance: ±5%)

| Generating-Set Engines | | | Condition | | | Remarks |
|---|---|---|---|---|---|---|
| | | | Continuous | Prime | Stand by | |
| D1146 | Standard | 50Hz (1,500 rpm) | - | 105PS (77kW) | 116PS (85kW) | |
| | | 60Hz (1,800 rpm) | - | 130PS (96kW) | 143PS (105kW) | |
| D1146T | Standard | 50Hz (1,500 rpm) | - | 145PS (107kW) | 160PS (118kW) | |
| | | 60Hz (1,800 rpm) | - | 170PS (125kW) | 187PS (138kW) | |
| P086T | P086T Power Up | 50Hz (1,500 rpm) | - | 186PS (137kW) | 207PS (152kW) | |
| | | 60Hz (1,800 rpm) | - | 228PS (168kW) | 254PS (187kW) | |
| P086TI | Standard | 50Hz (1,500 rpm) | 205PS (151kW) | 240PS (177kW) | 270PS (199kW) | |
| | | 60Hz (1,800 rpm) | 253PS (186kW) | 279PS (205kW) | 303PS (223kW) | |
| | P086TI-1 | 50Hz (1,500 rpm) | - | 203PS (149kW) | 223PS (164kW) | |
| | | 60Hz (1,800 rpm) | - | 237PS (174kW) | 260PS (164kW) | |
| | P086TI Power Up | 50Hz (1,500 rpm) | - | 273PS (201kW) | 305PS (224kW) | |
| | | 60Hz (1,800 rpm) | - | 310PS (228kW) | 344PS (253kW) | |

**NOTE:** All data is based on operation without cooling fan at ISO 3046. (Production tolerance: ±5%)

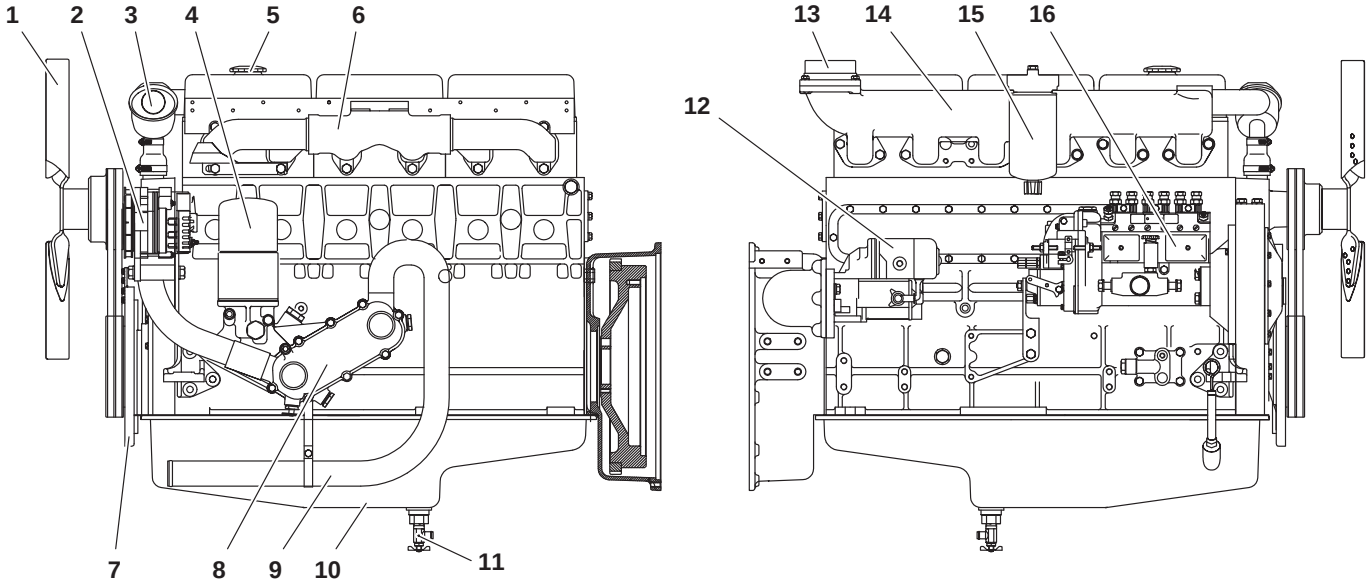
## EXTERIOR VIEW DRAWING OF THE ENGINE (D1146)

### FRONT/REAR (D1146)




1. Cylinder head cover
2. Cooling water pipe
3. Fuel injection pipe
4. Water pump
5. Mounting bracket
6. Oil level gauge
7. Flywheel
8. Flywheel housing

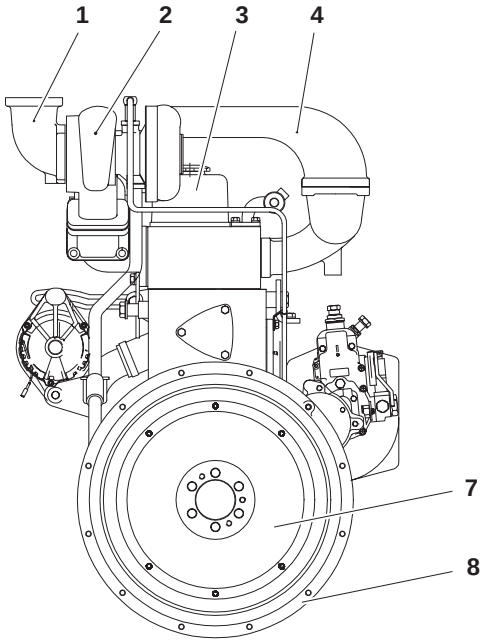
### LEFT/RIGHT (D1146)

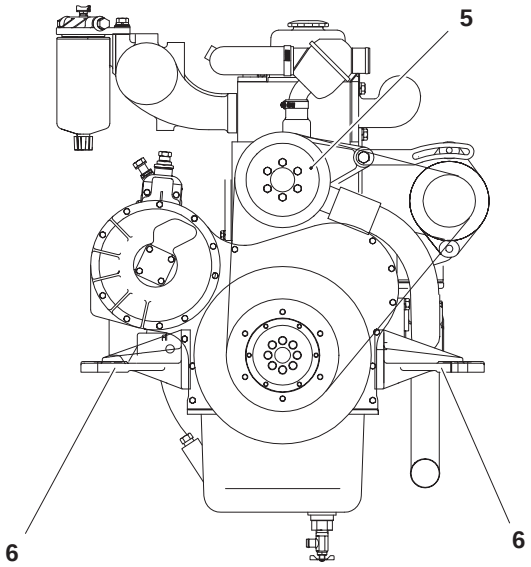



1. Cooling fan
2. Alternator
3. Thermostat
4. Oil filter
5. Oil filler cap
6. Exhaust manifold
7. Vibration damper
8. Oil cooler
9. Cooling water pipe
10. Oil pan
11. Oil drain valve
12. Starter
13. Intake stake
14. Intake manifold
15. Fuel filter
16. Fuel injection pump

## EXTERIOR VIEW DRAWING OF THE ENGINE (D1146T)

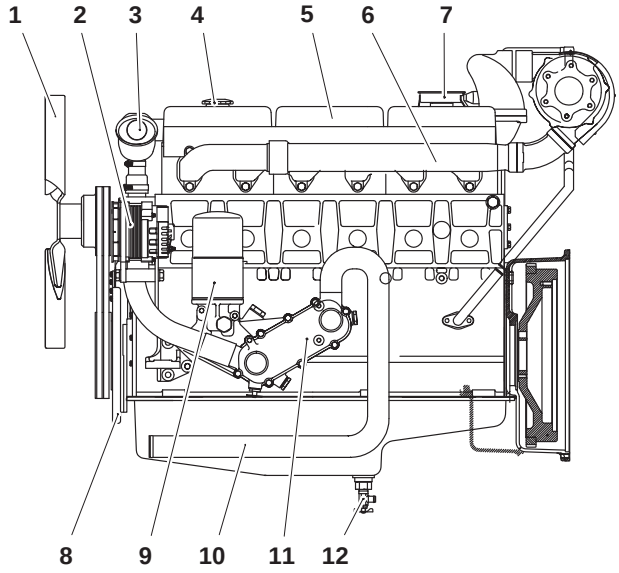
### FRONT/REAR (D1146T)

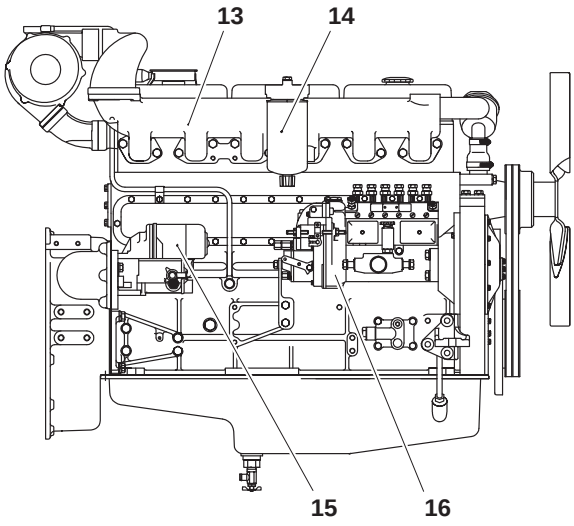



1. Exhaust elbow
2. Turbocharger
3. Cylinder head cover
4. Air pipe
5. Water pump
6. Mounting bracket
7. Flywheel
8. Flywheel housing

### LEFT/RIGHT (D1146T))

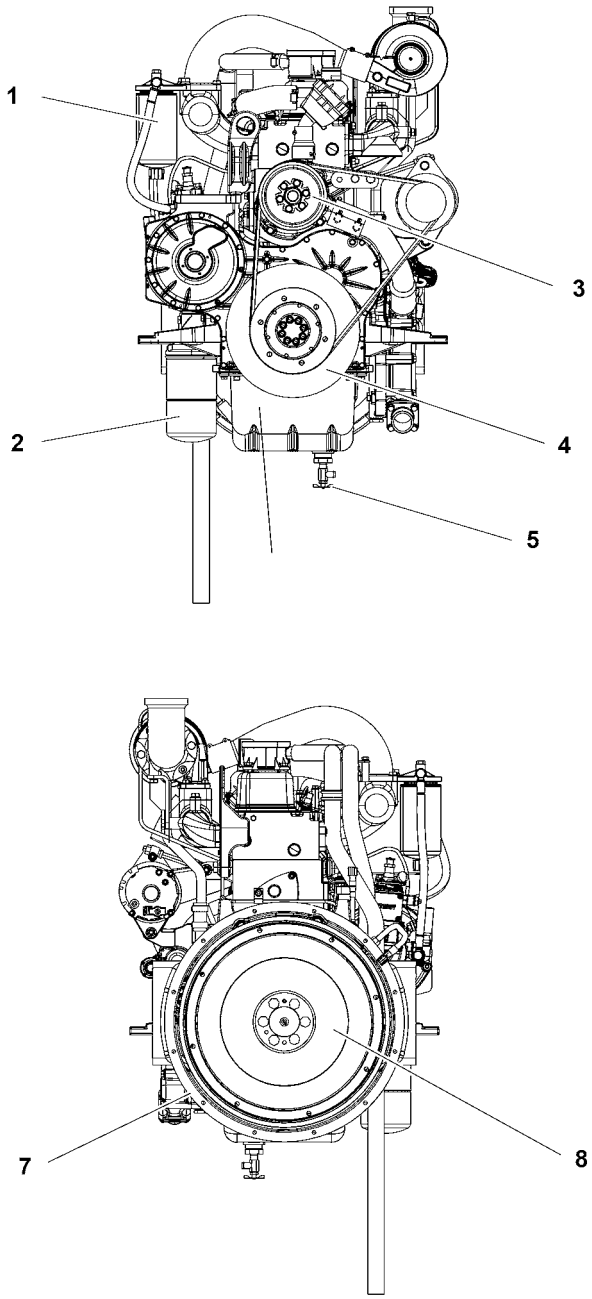



1. Cooling fan
2. Alternator
3. Thermostat
4. Oil filler cap
5. Cylinder head cover
6. Exhaust manifold
7. Breather
8. Vibration damper
9. Oil filter
10. Cooling water pipe
11. Oil cooler
12. Oil drain valve
13. Intake manifold
14. Fuel filter
15. Starter
16. Fuel injection pump

# EXTERIOR VIEW DRAWING OF THE ENGINE (DP086TA)

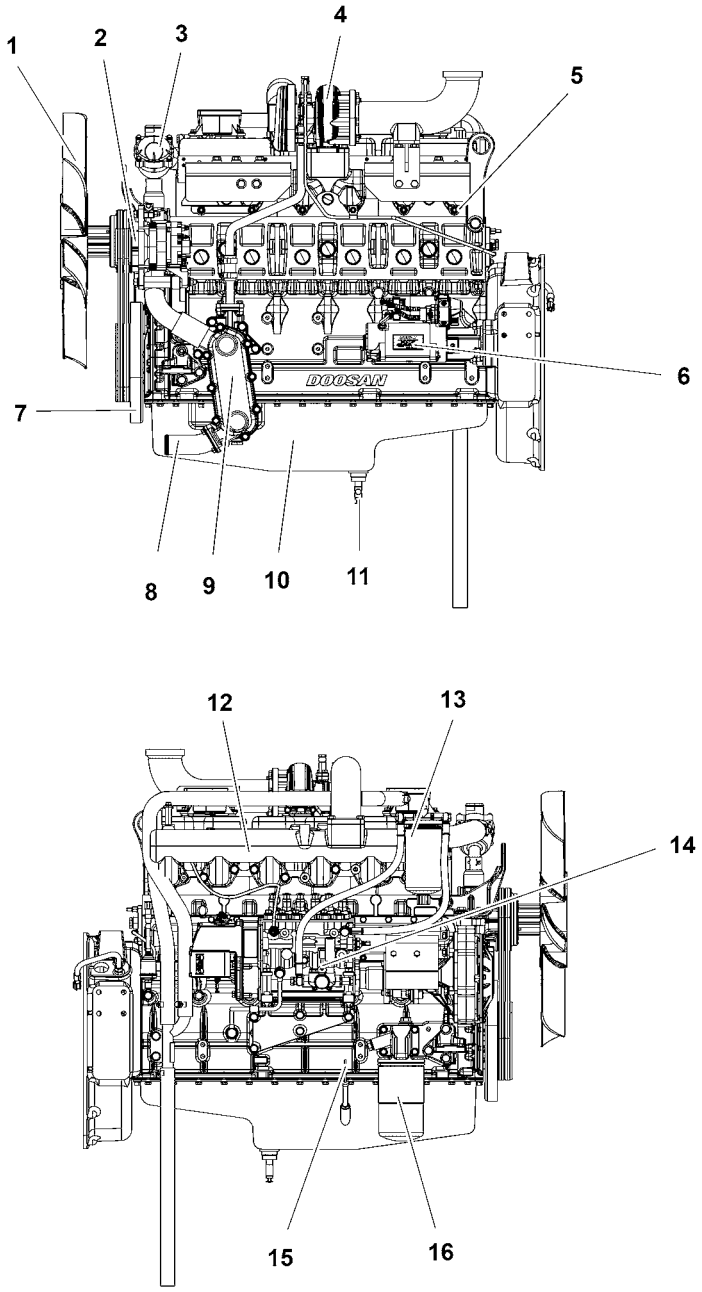
## FRONT/REAR (DP086TA)




EK00345A

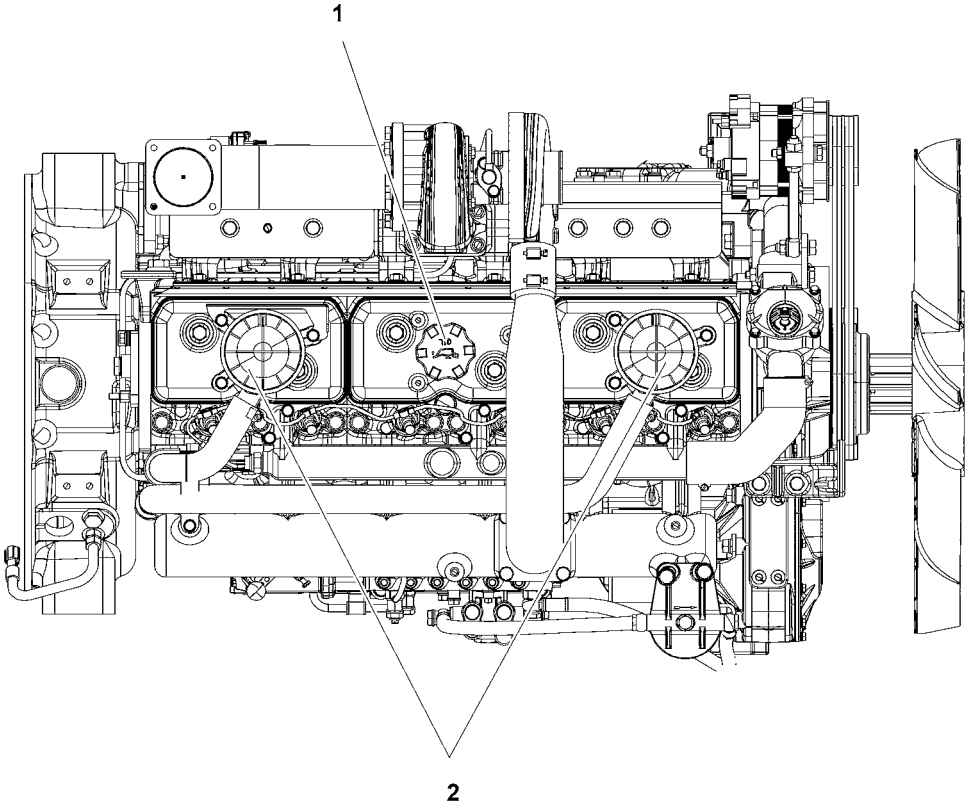
1. Fuel filter
2. Oil filter
3. Cooling fan pulley
4. Crankshaft pulley
5. Oil drain plug
6. Oil pan
7. Flywheel housing
8. Flywheel

**LEFT/RIGHT (DP086TA)**




EK00346A

1. Cooling pan
2. Alternator
3. Thermostat
4. Turbocharger
5. Exhaust manifold
6. Starter
7. Vibration damper
8. Cooling water pipe
9. Oil cooler
10. Oil pan
11. Oil drain valve
12. Intake manifold
13. Fuel filter
14. Fuel injection pump
15. Oil level gauge
16. Oil filter

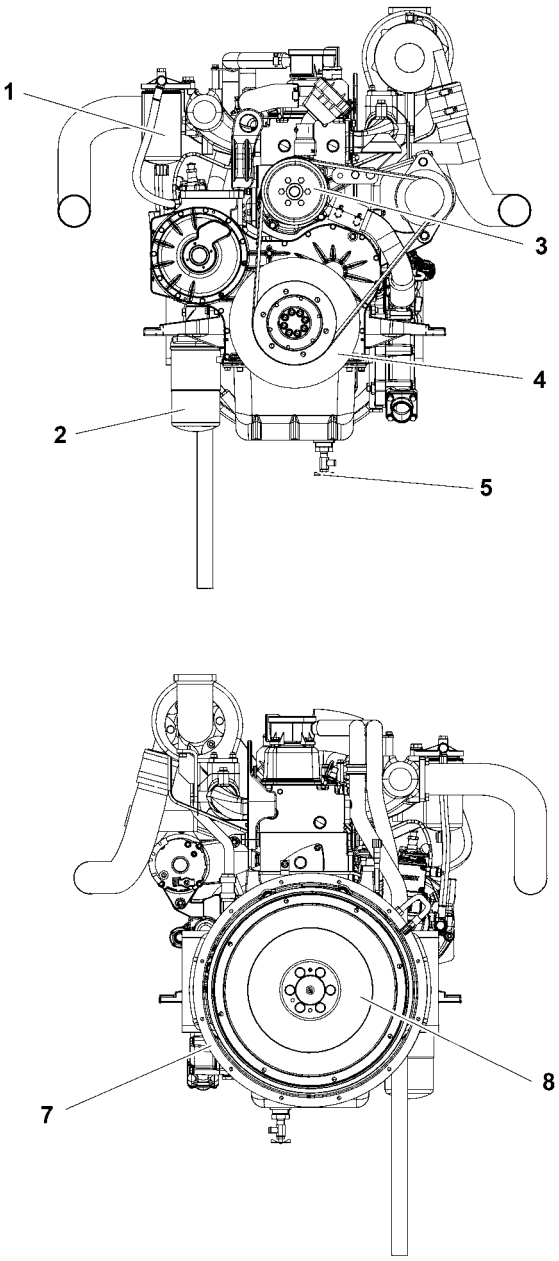



EK00347A

1. Oil cap
2. Breather

## EXTERIOR VIEW DRAWING OF THE ENGINE (P086TI POWER UP)

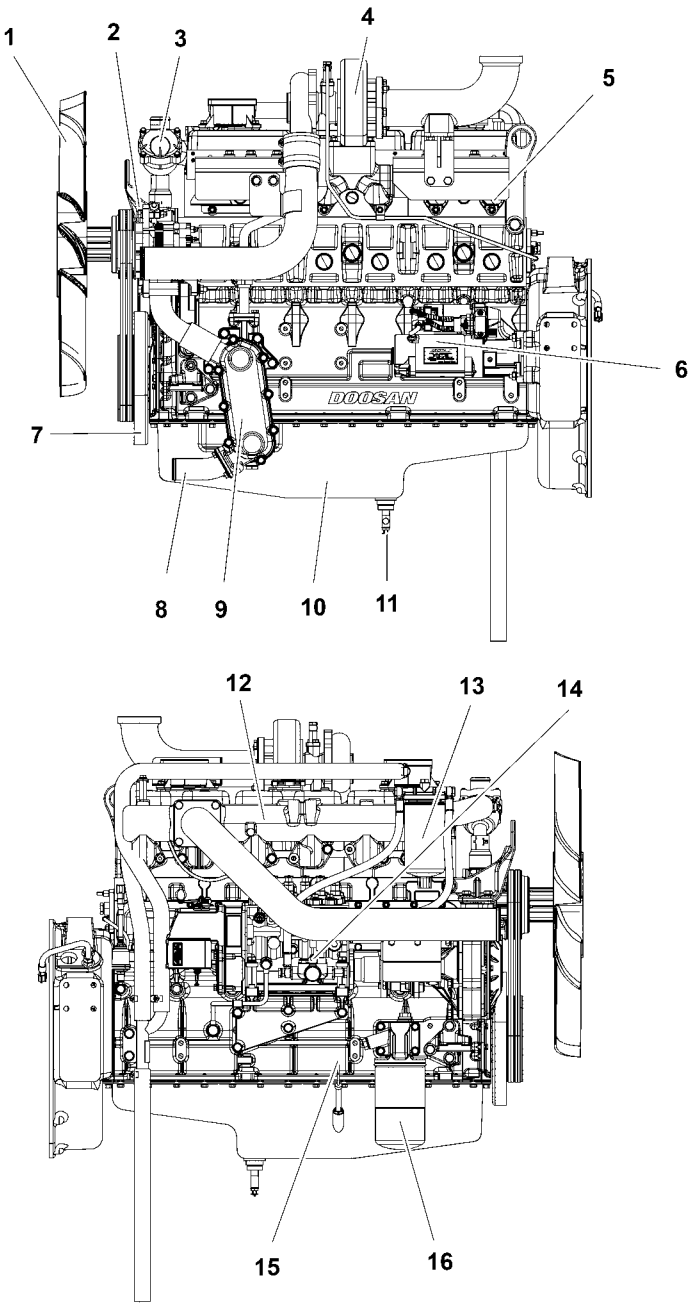
### FRONT/REAR (P086TI)




EK00348A

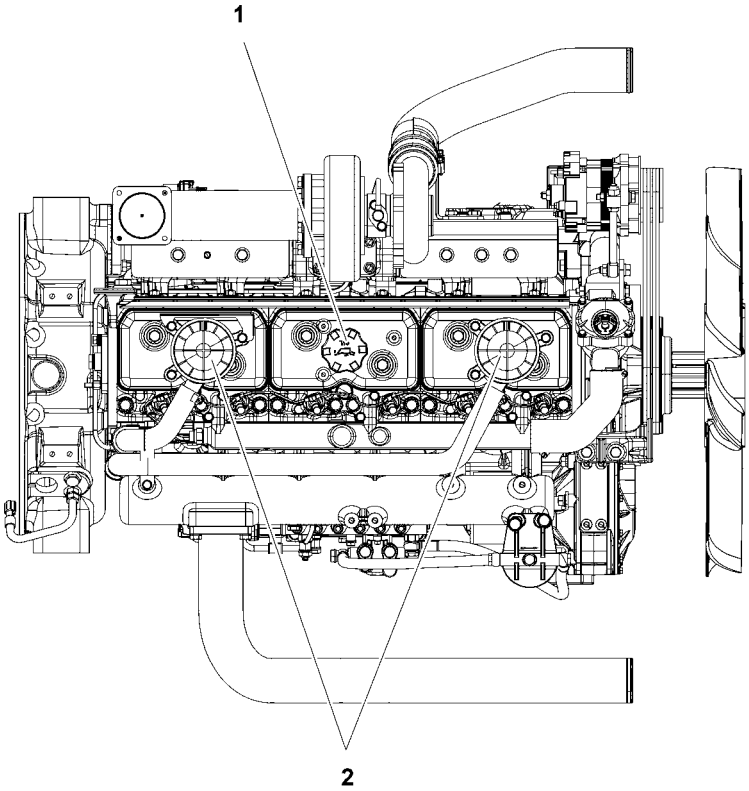
1. Fuel filter
2. Oil filter
3. Oil pan pulley
4. Crankshaft pulley
5. Oil drain plug
6. Oil pan
7. Flywheel housing
8. Flywheel

**LEFT/RIGHT (P086TI)**




EK00349A

1. Cooling pan
2. Alternator
3. Thermostat
4. Turbocharger
5. Exhaust manifold
6. Starter
7. Vibration damper
8. Cooling water pipe
9. Oil cooler
10. Oil pan
11. Oil drain valve
12. Intake manifold
13. Fuel filter
14. Fuel injection pump
15. Oil level gauge
16. Oil filter



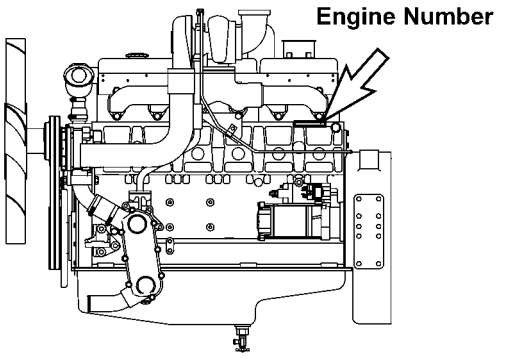

EK00350A

1. Oil cap
2. Breather

# ENGINE IDENTIFICATION NUMBER

## ENGINE CODE AND MANUFACTURING NUMBER

The engine model and serial number are located on the engine as illustrated. These numbers are required when requesting warranty and ordering parts.




EA9O2001

## ENGINE NUMBER ENGRAVING

- **Type 1**

□□□□□ □ □□□□□
(A) (B) (C)

A Engine Model SUFFIX (5 digits)
B Production Year (1 digit)
C Serial Number (5 digits)

- **Type 2**

□□□□□□□ □ □□□□□ □□
(A) (B) (C) (D)

A Sales Model name (4-7 digits)
B Production Year (1 digit)
C Serial Number (5 digits)
D After engine model SUFFIX (2 digits)

- **Type 3**

□□□□□ □□□ □ □□□□□ □□
(A) (B) (C) (D) (E)

A Sales Model name (5 digits)
B Engine output (3 digits)
C Production Year (1 digit)
D Serial Number (5 digits)
E After engine model SUFFIX (2 digits)

- **Type 4**

□□□□□□□□□ □ □□□□□
(A) (B) (C)

A New representative specification (9 digits)
B Production Year (1 digit)
D Serial Number (5 digits)

- **Type 5**

□□□□□□□ □ □□□□□ □□□
(A) (B) (C) (D)

A Sales Model name (4-7 digits)
B Production Year (1 digit)
C Serial Number (5 digits)
D After new representative specification (3 digits)

- **Type 6**

□□□□□ □□□ □ □□□□□ □□□
(A) (B) (C) (D) (E)

A Sales Model name (5 digits)
B Engine output (3 digits)
C Production Year (1 digit)
D Serial Number (5 digits)
E After new representative specification (3 digits)


Portable Power

# REGULAR INSPECTION

## CONTENTS

## CONTENTS (CONT'D)

# GENERAL INFORMATION

## GENERAL INFORMATION

After purchasing an engine over time, each of the engine's parts will age and the initial engine performance cannot be maintained.

Regular inspection and replacement of components according to the recommended regular inspection table allows you to maintain an engine with the optimum conditions and best performance for a long period and prevent unexpected accidents in advance.

Users are responsible for the proper operation and maintenance of engines. Engines should be inspected and replaced by officially-certified technicians in a work space with the specified tools and facilities. Observe the following instructions to perform inspections.

1. Perform inspections on a flat floor without a slope.
2. Excluding extreme circumstances, only perform inspection while the engine is stopped.
3. Disconnect the '-' terminal of the battery before performing an inspection.
4. Perform inspection in a well ventilated space.
5. Use a wooden prop or lift when working under the engine.

**⚠ DANGER**

**Wait until the engine is sufficiently cooled before starting inspection after operating the engine. Failure to observe this may result in serious burns.**

**You may be poisoned by the emissions when starting an engine in a closed space. Perform inspection in a well-ventilate space.**

**unless it is absolutely necessary, do not perform inspection under an engine.**

**When carrying out engine inspection or maintenance, ensure there are no naked flames within the vicinity of the machine. Fuel, oil, or batteries may generate gas, causing fire.**

**If inspecting the engine while it is running, do not wear accessories such as necklaces, rings, watches or gloves. Such accessories may become stuck in rotating parts while the engine is running and may cause serious bodily injury.**

**⚠ CAUTION**

**Incorrect inspection methods may cause engine faults.**

**Cleaning an engine with liquids such as water or wax may cause breakdown of electrical parts.**

**Be careful when handling batteries, cables, and electrical wirings because current flows through those parts.**

**Do not put heavy things or apply excessive force or impact on the fuel-related units.**

**Ensure that the battery terminals ('+' and '-') are connected to the correct terminal. Connecting the '+' and '-' terminals to the wrong terminal may cause damage to the electrical unit parts and fire.**

## ROUTINE INSPECTION

Routine inspection is an inspection performed by an engine operator before operating the engine. It should be performed to protect operator's safety, as well as the engine.

The following is a minimal check list.

1. Check whether the engine smoothly starts and the levels of fuel, oil, and coolant are within the normal range.
2. Check if any discharged emissions are colored and if the exhaust contains toxic gas elements.
3. Check whether abnormal noise occurs after starting an engine or not.
4. Check whether oil or water is leaking.

## REGULAR INSPECTION TABLE

### GENERAL CONDITIONS

Regular inspection and replacement according to the recommended regular inspection table allows you to maintain the engine with optimum conditions and best performance for a long period and prevent unexpected accidents in advance.

( o : Inspection and Adjustment • : Replacement)

| Check Points | | Daily | Inspection interval (Hours) | | | | | Remarks |
|---|---|---|---|---|---|---|---|---|
| | | | First 50 | 200 | 400 | 600 | 1,200 | |
| Cooling system | Check for leakage (hoses, clamp) | o | | | | | | |
| | Check the coolant water level | o | | | | | | |
| | Change the coolant water | | | | | | • | |
| | Adjust the V-belt tension | o | | | | | | Every 2,000hrs |
| | Clean the radiator | | | | | | o | |
| Lubrication system | Check for leakage | o | | | | | | |
| | Check the oil level gauge | o | | | | | | |
| | Change the lubricating oil | | | •[a] | • | | | |
| | Replace the oil filter cartridge | | | •[a] | • | | | |
| Fuel system | Check the fuel line for leakage | o | | | | | | |
| | Clean the fuel strainer of fuel feed pump | | | o | | | | |
| | Remove sediment from fuel tank | | | | | | o | |
| | Drain the water in separator | | | o | | | | |
| | Replace the fuel filter element | | | | • | | | |
| | Check fuel Injection timing | | | o | | | | When necessary |
| | Check the injection nozzles | | | o | | | | When necessary |
| Intake / Exhaust system | Check the intercooler for leakage (hoses, clamp) | o | | | | | | |
| | Clean and change the air cleaner element | | | o[b] | • | | | |
| | Clean the inter-cooler air fins | | | | | o | | |
| | Clean the turbocharger | | | | | | | Every 2,000hrs |
| Engine adjust | Check the state of exhaust gas | o | | | | | | |
| | Check the battery charge | o | | | | | | |
| | Check the compression pressure | | | | | | o | When necessary |
| | Adjust Intake/Exhaust valve clearance | | o[a] | | | | | When necessary |

a. First 50hr
b. Clean

## USE OF GENUINE PARTS

An engine consists of many parts which are mechanically harmonized. To prevent engine faults in advance and use engines with best performance for a long period, maintenance and replacement of expendable parts should be conducted regularly.

Use of genuine parts is recommended. Using unauthorized or remanufactured parts may cause critical damage and faults to engine for which Doosan shall not be held liable.

## COOLING SYSTEM

### GENERAL INFORMATION

The coolant should be replaced according to the cycle specified in the inspection interval table. If the coolant gets dirty, the engine is overheated, and the coolant overflows in the thermal expansion tank.

### COOLANT STANDARDS

It is recommended that the antifreeze is added in a concentration of approximately 40~50% of the entire coolant. The antifreeze prevents the freezing and corrosion of the system, and increases the boiling point of coolant. In winter, the amount of antifreeze may need to be changed to suit the ambient temperature as shown in the table below. The freezing point per antifreeze ratio shown in the table may differ slightly depending on the antifreeze type. For more information, see the specifications provided by the manufacturer. Whenever coolant (water) is added to replenish the amount reduced by engine operation, the antifreeze portion is decreased. Therefore, the antifreeze level must be increased to the proper level after replenishing the coolant.

- concentration of antifreeze during winter

| Ambient temperature (°C) | Coolant (°C) | Antifreeze (%) |
|---|---|---|
| Antifreeze (%) | 85 | 15 |
| -10 | 80 | 20 |
| -15 | 73 | 27 |
| -20 | 67 | 33 |
| -25 | 60 | 40 |
| -30 | 56 | 44 |
| -40 | 50 | 50 |

### CAPACITY OF COOLANT

| Engine Mode | Coolant capacity (litres) |
|---|---|
| D1146 | 14/11 |
| D1146T | |
| DP086TA | |
| P086TI | |

### CHECKING THE COOLANT

**⚠ DANGER**

**If the radiator cap is opened to exchange or replenish coolant while the engine is overheated, hot water will spurt out and may cause serious burns. If it is absolutely necessary to open the radiator cap while the engine is overheated, wrap the radiator cap with a cloth and slowly open the cap in two steps until the steam pressure has been released from the inside. After the steam pressure has been completely released, remove the radiator cap.**

1. Use clean tap water for the engine coolant.
2. Add 40% of antifreeze to the coolant to prevent corrosion and freezing.
3. Periodically check coolant to maintain the concentration of antifreeze and additives.

**⚠ CAUTION**

**If the antifreeze and corrosion inhibitor is kept at the proper level, corrosion of the engine will be prevented effectively and engine quality will be maintained. Be careful that, if managed improperly, it can give a fatal impact on the coolant pump and cylinder liner.**

4. Check the concentration of antifreeze and corrosion inhibitor using the coolant test sheet.

### MEASUREMENT OF COOLANT CONCENTRATION

- Special Tools

| Figure | Product Number/Name |
|---|---|
|  | 60.99901-0038<br>COOLANT TEST SHEET |

The coolant concentration can be measured as follows:

1. If the engine coolant temperature is within a range of 10 ~ 55°C, drain the coolant and fill half a plastic cup with it.

**⚠ CAUTION**

**When taking out a sample of coolant from the supplementary tank, it is difficult to measure the precise concentration. Always take out sample by opening the drain plug of coolant.**

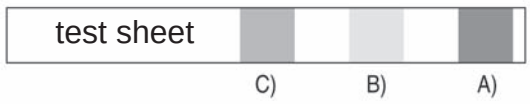
2. Soak the test sheet in the coolant and take it out after 3 ~ 5 seconds. Shake the sheet to remove the remaining coolant.

3. Wait for approximately 45 seconds until the test sheet changes its colour.

**⚠ CAUTION**

**Measurement time should not exceed 75 seconds. The color changes as time passes.**

4. Check the color on test sheet.



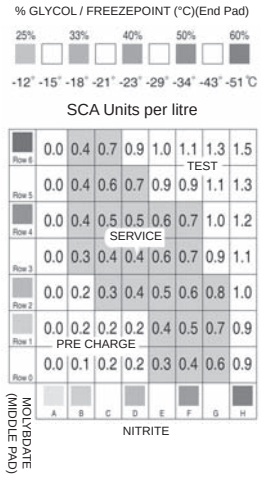

EDL0213002A

1) Compare the color of part (A) on the test sheet to the color of GLYCOL/FREEZEPOINT (End pad) of the standard color table.

2) Compare the color of the test sheet (B) to the color of MOLYBDATE (Middle pad) of the standard color table.

3) Compare the color of the test sheet (C) to the color of NITRITE of the standard color table.

5. Compare and confirm the parts with identical colors on the test sheet and the standard color table.




1) Compare the changed pink color part A of the test sheet with the GLYOOL/FREEZEPOINT (End pad) of the standard color table on top of the container and confirm the concentration. The concentration indication has to be within the color scope of 33~50%

2) It should be maintained at the optimum range, in the green section between 0.3 to 0.8 where the color of MOLYBDATE (Middle pad) on the standard color table (which is identical with the Middle (B) of the test sheet) is crossed with the color of NITRITE on the standard color table (which is identical with the (C) of the test sheet).

3) If it is above 0.8, drain a little coolant and then add clean tap water to adjust the concentration.

**⚠ CAUTION**

**If the color on the test sheet does not match the color of the standard color table, find a middle color on the standard color table. For example, if the color of (C) of the test sheet matches D and F on the NITRITE of the standard color table, select E.**

**To prevent corrosion inside of the engine cooling unit, drain the coolant and replace it with new coolant once a year.**

**DISCHARGING THE COOLANT**

The coolant can be drained as follows:

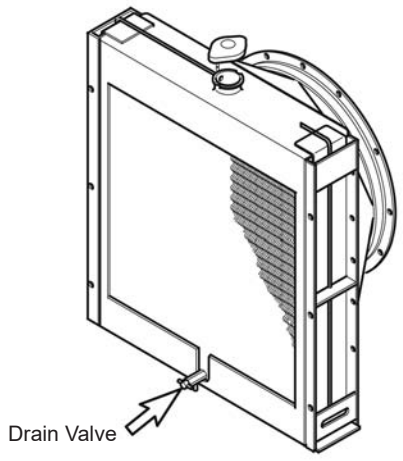
1. Ensure that the engine and radiator are cooled.
2. Open the radiator cap.

**⚠ WARNING**

**Never open the radiator cap while the engine is overheated. If the radiator cap is opened while the engine is overheated, hot water will spurt out and may cause serious burns. Open the radiator cap after ensuring that the engine has been cooled sufficiently.**

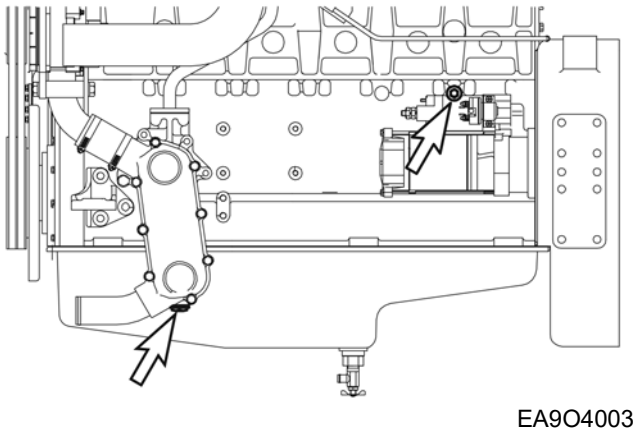
**Mark and separately manage the containers for storing coolant from beverage containers to avoid confusion. If coolant is ingested, see a doctor immediately.**

3. Loosen the drain valve located under the radiator to drain the coolant.




EA5O4002

4. Disassemble the coolant drain plug of the cylinder block, and drain it to a container.



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5. Drain cooling water in the oil cooler.

**CHARGING THE COOLANT**

1. Ensure that the engine is cooled.
2. Open the radiator cap.

**⚠ DANGER**

**Never open the radiator cap while the engine is overheated. If the radiator cap is opened while the engine is overheated, hot water will spurt out and may cause serious burns. Open the radiator cap after ensuring that the engine has been cooled sufficiently.**

**Mark and separately manage the containers for storing coolant from beverage containers to avoid confusion. If coolant is ingested, see a doctor immediately.**

3. Pour in the coolant in slowly.

**⚠ CAUTION**

**Be careful not to let foreign substances flow into the engine when replenishing coolant.**

4. Ensure that there is no air in the cooling system.
5. After checking the coolant level when the engine is warmed up, replenish coolant if necessary.

**⚠ DANGER**

**If the engine is hot, wrap the coolant pressure cap with a cloth upon opening it so that the steam may be discharged. This can prevent burning from the hot steam coming out of the cap inlet.**

**⚠ CAUTION**

**Do not mix antifreezes from different manufacturers.**

**Do not mix the coolant with different concentrations.**

**Do not add antirust which is not recommended by Doosan.**

**As insufficient coolant concentration may cause corrosion or freezing, alternatively, an excessive concentration may degrade the cooling performance. Mix coolant with 40% antifreeze to prevent corrosion.**

# ⚠ WARNING

**Discard exchanged coolant according to the regulations set forth by the relevant authorities. Disposing of exchanged coolant into the ground, sewers, drains, rivers, or the sea will cause serious environmental pollution. Violation of regulations regarding discard of coolant without observing the handling regulations, will be punished.**

**CLEANING THE COOLING CIRCUIT**

If the internal coolant circuit is contaminated by corrosion or foreign substances, the cooling effect is reduced. The resistance in the coolant circuit may damage the mechanical seal of the coolant pump.

The reduced performance in the cooling circuit may be caused by use of incorrect type or quantity of antifreeze or corrosion inhibitor, or by use of coolant without such ingredients. If the coolant pump leaks or the coolant is severely contaminated within the first 6 months of operation (e.g., the coolant color becomes discolored - brown, grey or black depending on the degree of contamination), clean the cooling system in the following way before removing the cooling pump.

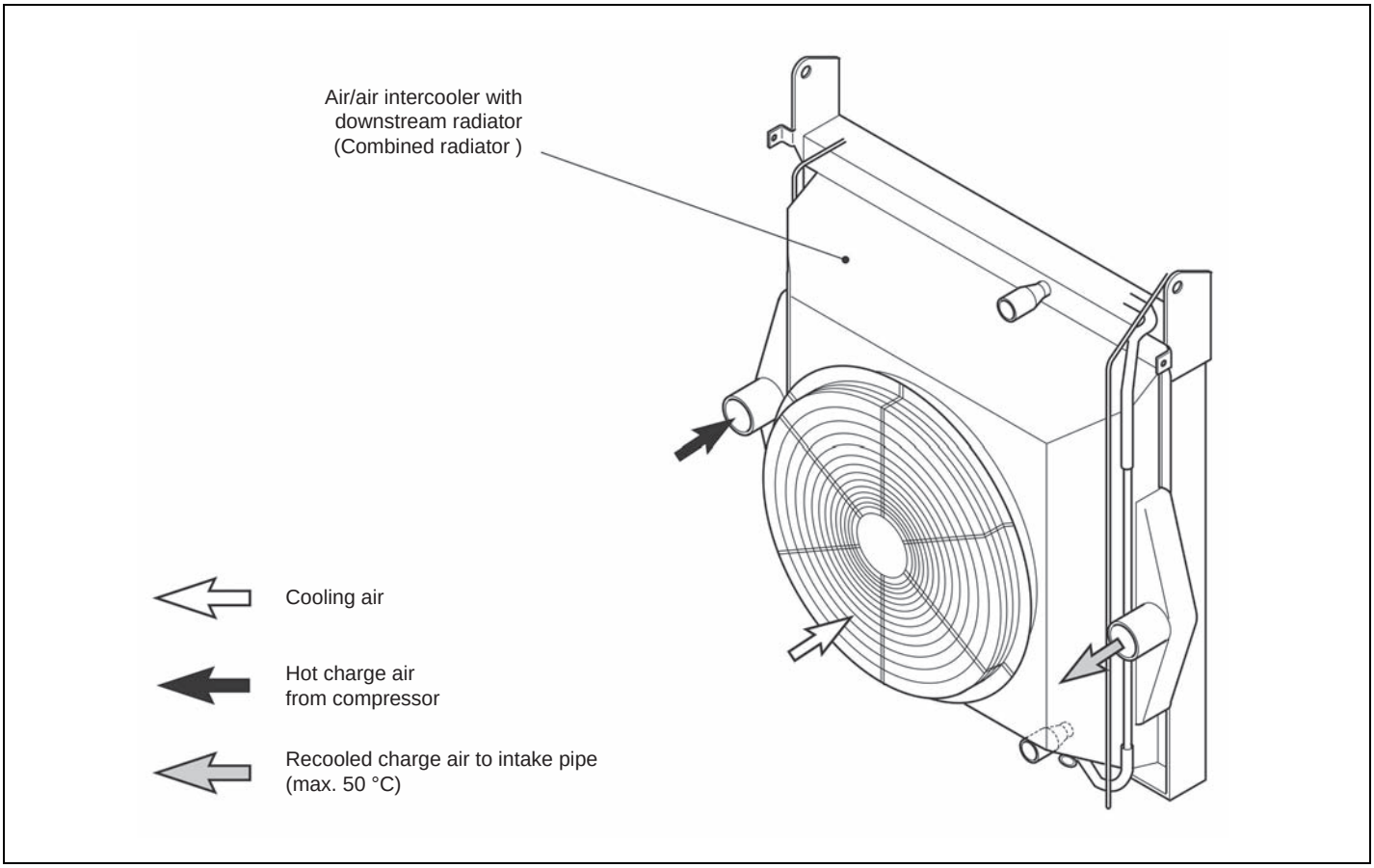
1. Drain the coolant.
2. To clean the cooling circuit swiftly, remove the thermostat.
3. Mix water and 1.5% of cleaning solution and fill the cooling circuit with this liquid.
4. Load the engine. When the coolant temperature reaches 60°C, run the engine for approximately 15 minutes.
5. Drain the cleansing solution.
6. Repeat step 3 and 4 above.
7. Fill the cooling circuit with hot water.
8. While running the engine at idle speed for 30 minutes, check if there is any leakage in the drain plug and coolant line. If the coolant is insufficient, replenish it.

# ⚠ CAUTION

**Clean the cooling circuit regularly with cleansing solution.**

**INTER COOLER**

The air cooler adopts an air cooling fan, which has sufficient cooling capacity. The life and performance of an air cooler greatly depends on the intake air conditions. Dirty air may contaminate and clog the cooling pins. This results in reduced engine power or engine failure. Always check the intake system for air leaks, damage or contamination of the air filter.




**⚠ CAUTION**

**To keep the optimum performance of the air cooler, clean it regularly.**

## LUBRICATION SYSTEM

### GENERAL INFORMATION

Engine oil lubricates, cools, seals, prevents corrosion, and cleans engines, enhancing engine performance and extending the engine's lifetime. If a vehicle is continuously driven while engine oil is insufficient, the moving parts of the engine may get stuck, causing engine faults.

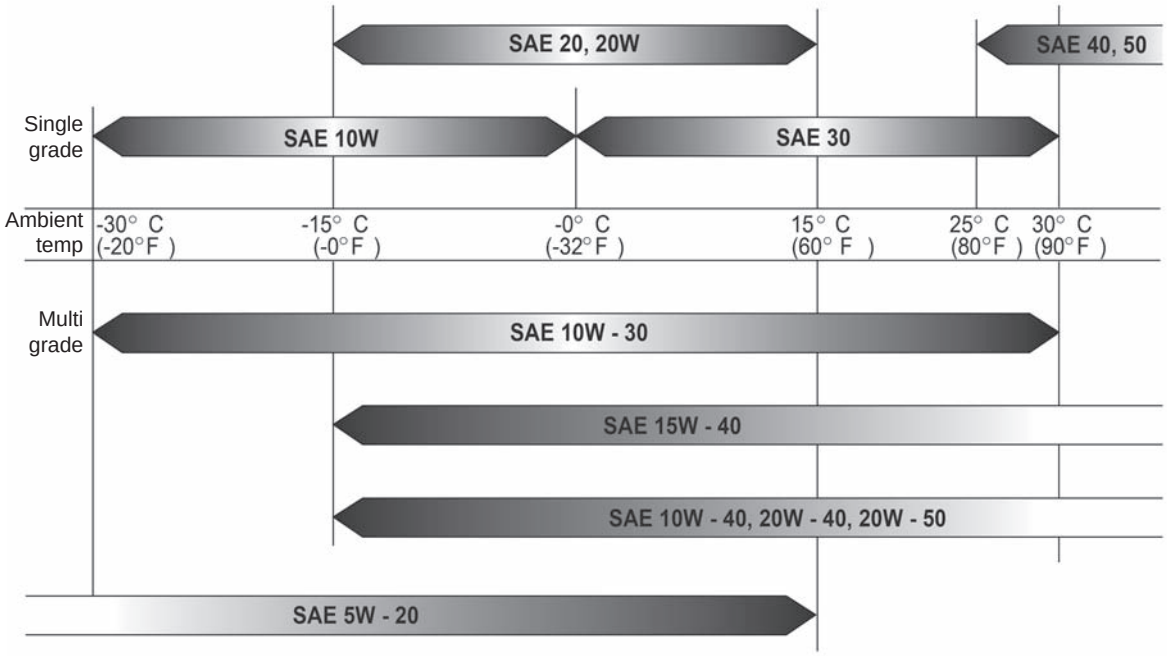
Engine oil should be checked through the oil level gauge and replenished if required. Oil level should be checked while the engine is stopped. To check the oil level, turn off the engine while it is running and wait for 5 ~10 minutes to allow the engine oil to flow back into the oil pan. The engine oil level should indicate between the upper limit and the lower limit of the oil level gauge.

Engine oil should be periodically replaced based on the regular inspection table. The oil filter and the cartridge should be replaced as the engine oil is replaced.

### ENGINE OIL STANDARDS

Use the specified engine oil suitable for the environment and conditions of the site where the engine will be used.

**Engine oil viscosity - ambient temperature**

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Use the engine oil which satisfies the following recommended specifications.

| Engine Model and Product Code | SAE Classification | Oil Class |
|---|---|---|
| D1146 | SAE 15W40 | API CD OR CE ABOVE |
| D1146T | SAE 15W40 | API CD OR CE ABOVE |
| DP086TA | SAE 15W40 | API CD OR CE ABOVE |
| P086TI | SAE 15W40 | API CD OR CE ABOVE |

**NOTE:** Use of Doosan genuine engine oil is recommended.

**ENGINE OIL CAPACITY**

Replenish the engine oil based on the following recommended oil amount.

| Engine Model and Product Code | Engine oil capacity (litres) | |
|---|---|---|
| | Engine only | |
| | Max. | Min. |
| D1146 | 15.5 | 12 |
| D1146T | 15.5 | 12 |
| DP086TA | 15.5 | 12 |
| P086TI | 15.5 | 12 |

**CHECKING THE ENGINE OIL**

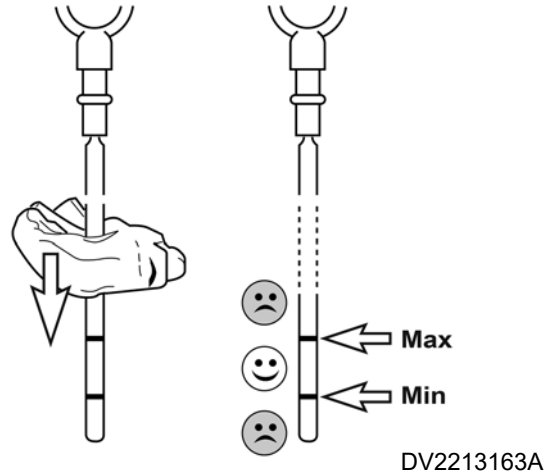
Check the oil level every day using an oil level gauge.

1. The oil level should be checked when the engine is stopped and on an even level. If the engine has been running prior to checking, wait for 5~10 minutes to allow the engine oil to flow back into the oil pan.

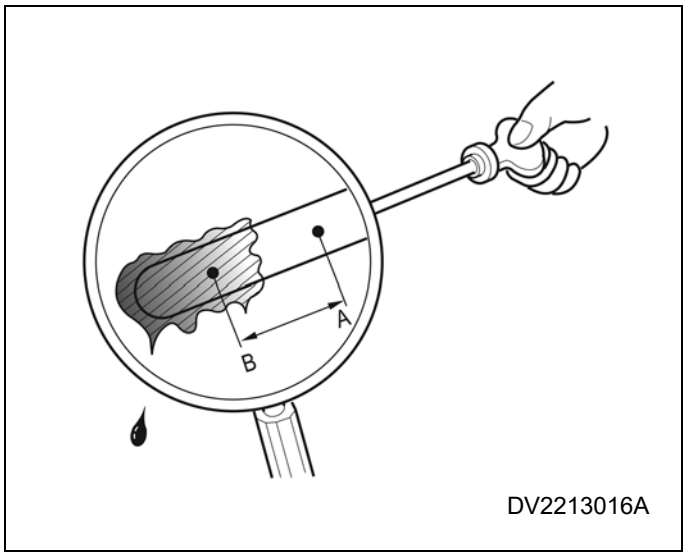
2. Pull out the oil level gauge, and clean the indication line of the oil level gauge with a clean cloth.

**⚠ CAUTION**

**Cleaning the indication line of the oil level gauge with a dirty cloth allows foreign substances to get into the engine, causing damage to the engine.**




3. Insert the oil level gauge, and then remove it to check the engine oil level, viscosity, and contamination. Replenish or replace the engine oil if required.




1) Check the oil level everyday using the oil level gauge.

2) Check if the oil level is between the upper limit (A) and the lower limit (B) of the oil level gauge.

3) If engine oil level is below the lower limit (B) or not on the gauge at all, replenish engine oil.

4) Check condition of engine oil. If it is polluted, replace it with new oil.

**⚠ CAUTION**

**Do not fill the engine oil above the upper limit. Exceeding the upper limit may damage the engine.**

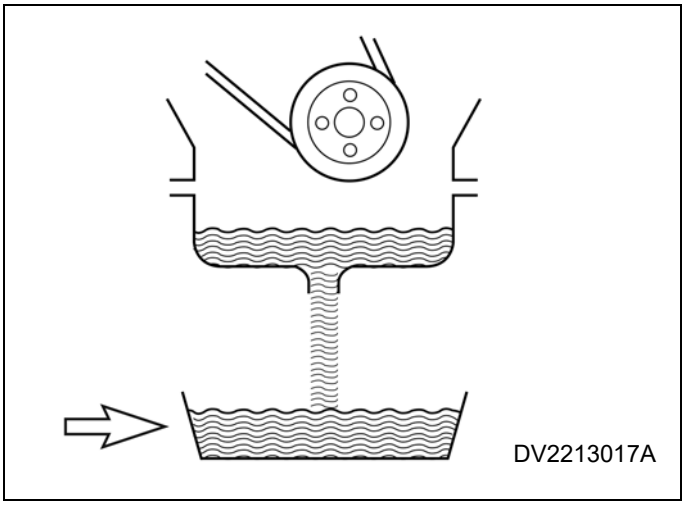
**Be careful not to let foreign substances flow into the engine when replenishing engine oil.**

### REPLACEMENT OF ENGINE OIL

Check the oil level using the oil level gauge and replenish it if required. Replace the engine oil in the following steps when the engine is warm after running.

1. Pull out the oil level gauge.

2. Open the drain plug of the oil pan to drain the engine oil from the container.




3. After draining the engine oil, replace the drain plug of the oil pan.

4. Fill the engine oil into the cartridge of the oil filter.

5. Fill the engine oil through the oil filler cap.

6. Run the engine at idle speed for several minutes so the oil can circulate through the lubrication system.

7. Stop the engine and wait for approximately 10 minutes. Check the oil level and fill the oil if required.

**⚠ DANGER**

**Prolonged and repeated contact of skin with engine oil may lead to shrinking, dryness of skin and even cause dermatitis.**

**Do not expose skin with exchanged engine oil for a long period.**

**Always wear work clothes and gloves.**

**When skin is stained with engine oil, immediately wash it with water, soap or hand cleaners.**

**Do not clean skin with gasoline, fuel, thinner, or solvent.**

**Apply a skin protective cream after cleaning from oil.**

**Do not put oil-stained gloves or cloth in pockets.**

**⚠ WARNING**

**Discard exchanged oil according to the regulations set forth by the relevant authorities. Disposing of discharged oil into the ground, sewers, drains, rivers, or the sea will cause serious environmental pollution. Violation of regulations regarding discard of engine oil without observing the handling regulations, will be punished.**

### REPLACEMENT OF ENGINE FILTER

Check the oil pressure and leakage, and replace the oil filter if required. Whenever replacing the oil, the oil filter cartridge should also be replaced.

1. Using an oil filter wrench, loosen the cartridge by turning it counterclockwise.

2. Wipe the oil filter head and cartridge contact thoroughly, and make sure that the oil filter cartridge is positioned properly.

3. Apply a small amount of oil to the O-ring area of the cartridge. Screw the cartridge on until the O-ring surface makes contact, and turn it 3/4 to 1 turn using a wrench until sealed.

**⚠ CAUTION**

**When replacing the oil filter cartridge, be sure to use the genuine Doosan part.**

## FUEL SYSTEM

### GENERAL INFORMATION

The fuel injection pump and nozzle are composed of very sophisticated components with high precision. If fuel is mixed with foreign substance, it may block the nozzle or the fuel injection pump components may become seized. Ensure the fuel system is clean at all times.

**⚠ CAUTION**

**Use clean, certified and qualified fuel only. Using irregular or unspecified fuel may cause critical damage and faults to the engine.**

**Replenish fuel while the engine is stopped.**

## FUEL STANDARDS

The quality of fuel is very important to satisfy the engine performance, extension of engine life and the allowable exhaust gas level. Doosan engines are designed to use diesel fuel available in the local market. If the optimum engine performance is required, select the proper fuel by referring to the fuel selection table below.

- Low Sulfur Diesel

| Fuel Ingredients | | Unit | Standard | Product |
|---|---|---|---|---|
| Specific Gravity | | (kg/litres) | **-** | **0.83** |
| Flash Point | | (°C) | > 40 | **47.8** |
| Viscosity (40°C) | | (cSt) | **1.955** | **2.459** |
| Sulfur content | | (wt%) | < 0.05 | 0.038 |
| Cloud point | | (°C) | **-** | **-3** |
| Pour Point | | (°C) | < -17.5 | -27.2 |
| Low temperature filter clogging point | | (°C) | < -12 | -18 |
| Colour (ASTM) | | | < 2.5 | 0.7 |
| Carbon Residue (10%) Distillation residue (wt) | | (%) | < 0.15 | 0.08 |
| Total acid value | | (mg KOH/g) | < 0.40 | 0.03 |
| Copper corrosion (100°C, 3 hrs) | | | < 1 | 1 - a |
| Ash content (wt) | | (%) | < 0.01 | 0.001 |
| Moisture and Precipitate | | (vol. %) | < 0.01 | 0.005 |
| Cetane Index | | | > 45 | **52** |
| Distillation test temperature | 50% Distillation Point | (°C) | **-** | 264.4 |
| | 90% Distillation Point | (°C) | < 360 | 344.3 |

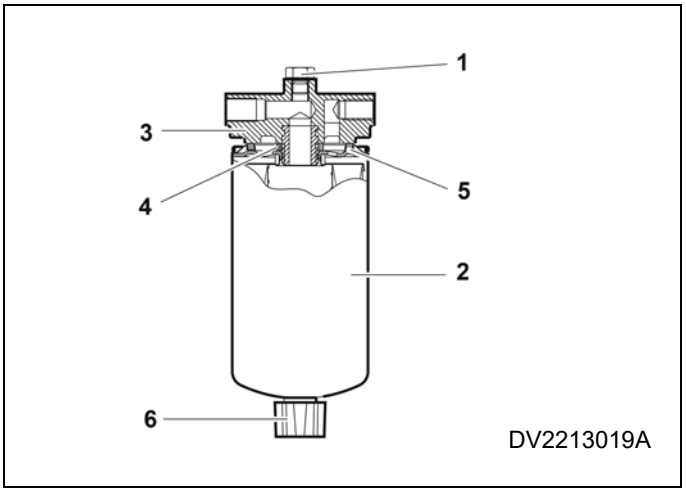
**NOTE:** High sulphur content in diesel fuel - Doosan diesel fuel engines can be operated with fuels whose sulphur content is max. 0.05wt%. Fuels with a sulphur content of > 0.05wt% are not permitted as they result in increased corrosion and greatly reduce the service life of engines. The oil change intervals must be halved if the sulphur content is > 0.02wt%.

## WATER DRAINING FROM FUEL FILTER

An oil filter has two functions: oil filtering and water separation.

1. The water separation function of the fuel filter drains water and sediment from the water separator.

2. Stop the engine, and loosen the drain plug for water separation manually.




3. Turn the drain plug (6) for water separation counterclockwise 2~3 times until water is drained. Drain the water in the cartridge until fuel is discharged.

4. Tighten the drain plug for water separation by turning it clockwise.

**⚠ DANGER**

**Fuel may be drained when water is drained from the fuel filter. Fuel is highly inflammable. Fire may occur if there are naked flames or sparks near the engine when draining water from the fuel filter.**

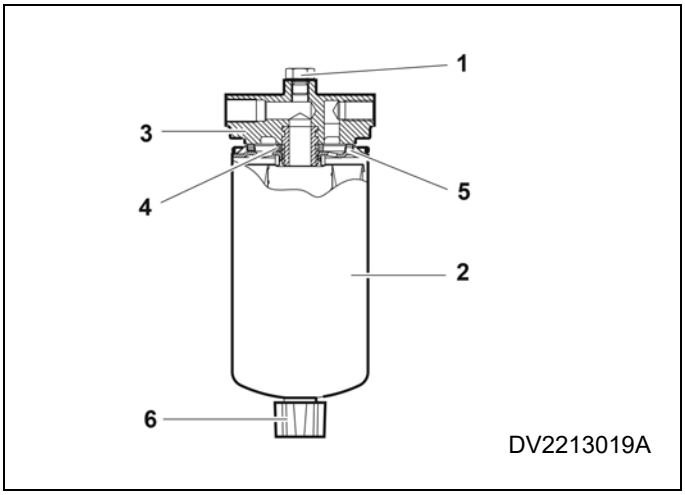
**⚠ CAUTION**

**Do not tighten the plug excessively because it may damage the screw.**

**Check the fuel filter regularly and drain the water in the fuel filter. If water enters the fuel system it will cause serious failure and may damage the fuel filter or reduce performance. Water in the fuel system may stop the engine.**

**Use approved fuel only. Use of non approved fuel may result in increased water in the fuel filter.**

## REPLACING FUEL FILTER




1. Clean the area around the fuel filter head (3).

2. Disassemble the cartridge (2) by turning it counterclockwise with a fuel filter wrench.

**⚠ CAUTION**

**Do not reuse the cartridge; replace them with new ones.**

3. Remove the fuel filter screw adapter seal ring (4).

4. Clean the gasket contact of the fuel filter head (3).

5. Check the position of the new cartridge adapter seal ring (4).

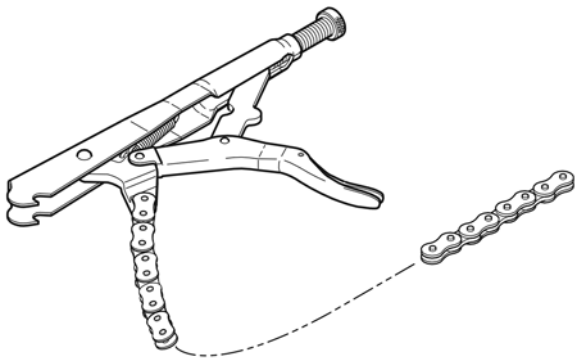
6. Screw the cartridge to the fuel filter head.

**⚠ CAUTION**

**Assemble the new fuel filter without fuel. Do not inject fuel into the new fuel filter. After replacing the fuel filter, do air bleeding in the fuel circuit.**

7. Tighten the cartridge by hand until the O-ring contacts the fuel filter head surface.

8. Tighten it by 3/4 to 1 turn with a fuel filter wrench.



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## ⚠ CAUTION

**If the cartridge is tightened excessively, the screw may be distorted or the O-ring damaged.**

**PREVENTING FUEL CONTAMINATION**

Most of the fuel contaminations encountered while using the alternator engine are caused by water and propagation of microbes.

Improper handling of fuel can lead to contamination. Propagation of microbes requires water contained in the fuel. To prevent propagation of microbes, keep the water level as low as possible in the storage tank.

**FUEL INJECTION PUMP**

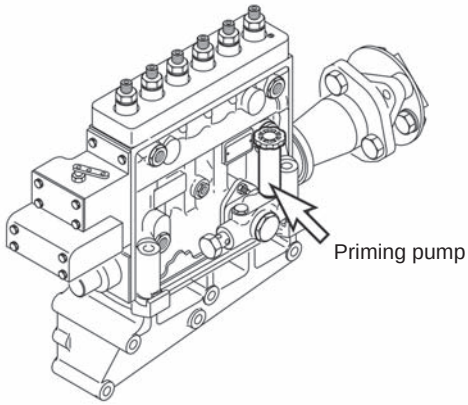
- If the fuel injection pump housing is cracked or damaged, replace it.
- Ensure the idle operation and speed control lever's sealing device was not removed.
- Ensure the idling or speed control lever's sealing line is not damaged.
- Do not modify the fuel injection pump if the sealing line is damaged, such modifications will void the warranty.
- If the fuel injection pump is found to be damaged, it should only be repaired by authorised personnel.
- The adjustment and test of the fuel injection pump must be conducted using an appropriate tester.

## ⚠ CAUTION

**If any parts that contain a seal ring (copper seal ring, rubber coating seal ring, etc.) are disassembled, then replace the seal ring with a new one. Failure to do so may cause leakage in the fuel filter connections preventing normal functioning.**

**AIR BLEEDING IN THE FUEL CIRCUIT**

Air must be bled from the fuel system when the fuel filter or injection pump are replaced, or air has entered the fuel system due to insufficient fuel.




EA9O4005

1. Turn the priming pump cap.
2. Bleed the fuel by manually operating the priming pump with fuel filter outlet joint bolt and injection pump bleeder screw loosened.
3. Press the feed pump cap repeatedly until fuel without bubbles overflows from the bleeding plug screw.
4. After the air is removed, close the plug screws of the filter and the pump.
5. Confirm the resistance of fuel delivery by repeatedly pressing the feed pump cap. Apply pressure to the priming pump cap and turn.

## ⚠ DANGER

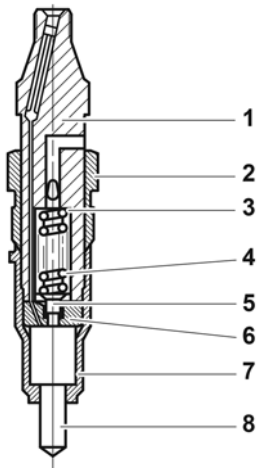
**Fuel is highly inflammable. Fire may occur if there are naked flames or sparks near the engine when air is bleeding into the fuel circuit from the priming pump.**

# ⚠ CAUTION

**If any parts that contain a seal ring (copper seal ring, rubber coating seal ring, etc.) are disassembled, then replace the seal ring with a new one. Failure to do so may cause leakage in the fuel filter connections preventing normal functioning.**

**FUEL INJECTION NOZZLE**

- The injectors are designed to spray the fuel delivered by the injection pump directly into the spherical combustion chamber in the piston crown.
- The injector consists of the nozzle and the nozzle holder.



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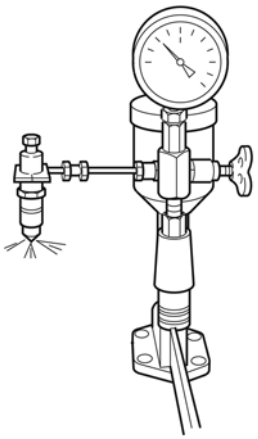
1. Nozzle holder
2. Union nut
3. Shim
4. Coil spring
5. Guide bush
6. Washer
7. Cap nut
8. Nozzle

**CHECK FUEL INJECTION NOZZLE PRESSURE**

1. Install a nozzle to the nozzle tester.

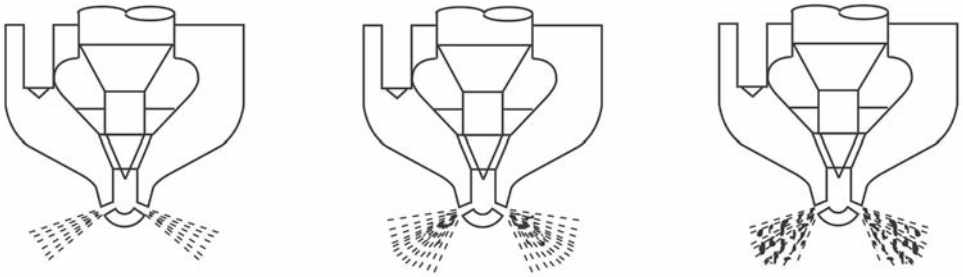

DV2213023A

2. Check injection pressure by cranking to meet the correct pressure.
3. Check the nozzle spray status. If it is defective, replace the nozzle.

# ⚠ CAUTION

**As the injection nozzle is designed to operate under high pressure, it should be handled with care.**

**Always keep hands away from the fuel jet, as there is a risk of injury. Do not inhale the atomized fuel oil. If possible, work under an extraction system.**



DV2213024A

| Engine Model | Opening pressure ($kg/cm^2$) | Remarks |
|---|---|---|
| D1146 | 214 | at 200 rpm |
| D1146T | 214 | at 200 rpm |
| DP086TA | 214 | at 200 rpm |
| P086TI | 214 | at 200 rpm |

**REMOVAL OF NOZZLE**

1. Assemble the cap nut and nozzle to the nozzle tester.

2. Remove the nozzle nut and components inside.

**INSTALLATION NOZZLE**

1. After removing carbon deposit, submerge the nozzle in diesel oil and clean it.

2. Replace all the gaskets with new ones.

3. Assemble the parts and tighten them to specified torque.

**ADJUSTMENT NOZZLE**

1. The cap nut and assemble a nozzle to a nozzle tester.

2. With the adjusting screw loosened, operate the nozzle 2 ~ 3 times to bleed it.

3. Operate the nozzle tester lever at the specified rate.

4. Adjust the injection pressure to the standard pressure using the adjusting screw.

5. After adjusting the injection pressure, tighten the cap nut to the specified torque.

6. Re-check the injection pressure and ensure the spray pattern is normal. the spray pattern should be uniform and free of spattering.

**NOTE FOR CLEANING NOZZLE**

- Clean nozzle body externally of soot and carbon. When cleaning several nozzles at the same time, make sure nozzle bodies and needles are not mixed up. Visually inspect needle and body.

- Do not clean the nozzle if the seat of the needle is indented or the pintle is damaged. If this occurs the nozzle should be replaced.

- Clean annular groove with scraper over full circumference. Wash out dislodged carbon deposits and dirt.

- Scrape needle seat with cleaning cutter. Dip cutter in test oil before use. The cutter can also be clamped in a lathe.

- Polish needle seat with wooden cleaning tool by chucking the needle in a lathe at the pintle end.

- Clean the spray holes of nozzles by chucking a cleaning needle of suitable diameter in the collet. If the carbon deposits in the spray holes cannot be removed by rotating and pressing, have the needle project only slightly from the collet and drive out the carbon by lightly tapping on the tool.

- Before reassembly thoroughly wash nozzle body and needle in clean test oil.

- Hold the needle at the pintle end only; to avoid corrosion do not touch the lapped surfaces of the needle with your fingers.

- Thoroughly clean all other parts of the nozzle holder with clean fuel.

- Check nozzle discharge pressure in the nozzle tester. The edge-type filter should not be pressed into the nozzle holder by more than approximately 5mm. If this depth is exceeded the injector must be replaced.

**ADJUSTING INJECTION TIMING**

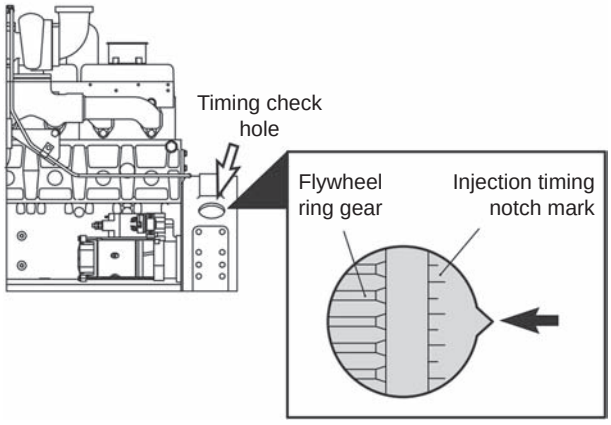
1. Bring the piston of #1 cylinder to the compression TDC (OT) by turning the crankshaft. Again, turn 60° in the reverse direction of engine rotation.

2. Disassemble the fuel injection pipe that connects the fuel injection pump and #1 injection nozzle.

3. Disassemble the fuel injection pump delivery valve holder. After removing the valve and valve spring, assemble the valve holder. Finally, assemble the "U" shaped pipe.

4. Operating the priming pump of supply pump, turn the crankshaft slowly in the direction of engine rotation until the fuel drops at the rate of one drop every 6 ~8 sec.

5. Ensure the indication point at the flywheel housing inspection hole coincides with the specified injection angle. If the injection timing is not correct, adjust as follows.



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a) As shown in the above method, ensure the indication point at the flywheel housing's inspection hole and the flywheel's inspection angle coincide.

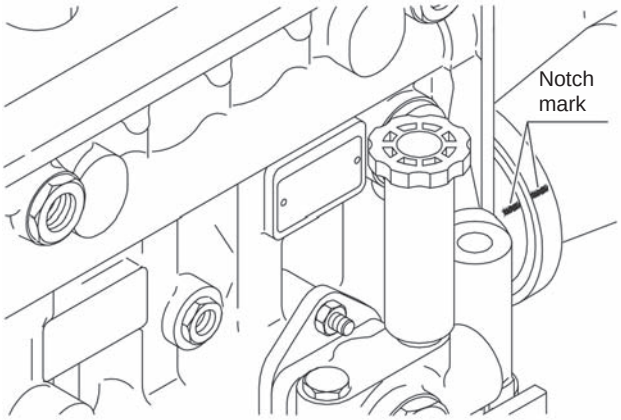
| Engine Model | Injection timing | Remarks |
|---|---|---|
| D1146 | 18° | BTDC |
| D1146T | 18°/12° | BTDC |
| DP086TA | 19° | BTDC |
| P086TI | 14° | BTDC |

b) Slightly loosen the drive gear fixing bolt of injection pump.

c) Slowly turn the coupling of the injection pump until the fuel drops from #1 plunger at the rate of one drop every 6 ~ 8 sec. Tighten the driving gear fixing bolt of the fuel pump.

6. After adjusting the injection timing, disassemble the "U" shape pipe and readjust the delivery valve and the valve spring.

7. Turn the coupling until the notch mark of the indicator plate attached to the fuel injection pump is aligned with the notch mark of the coupling.



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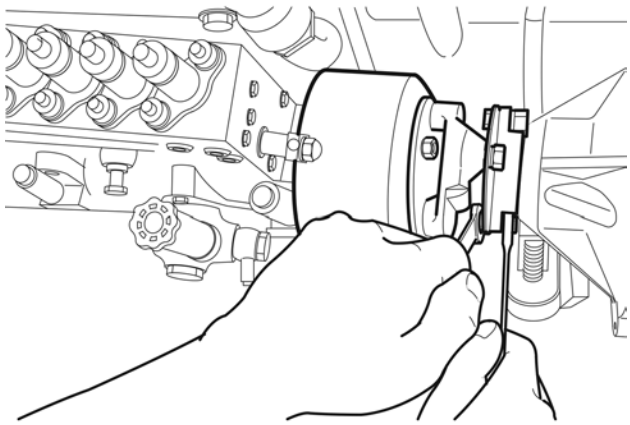
8. Tighten the Coupling fixing bolts and nuts to the specified torque.

| Torque | 6.0 ~ 6.5 kgf·m |
|---|---|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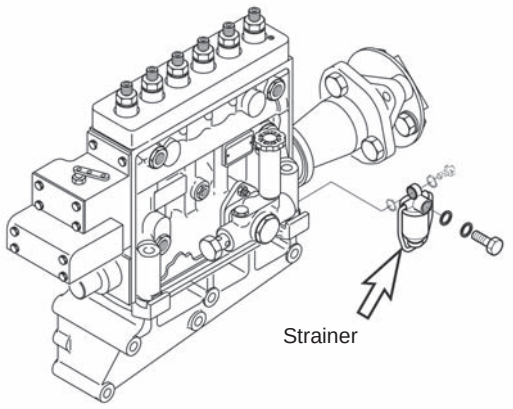
9. Install the oil delivery pipe and return pipe.

**PRIMING PUMP STRAINER CLEANING**

1. Clean the priming pump strainer filter frequently.

2. The strainer filter is incorporated in the priming pump inlet side.




EA9O4004

## INTAKE/EXHAUST SYSTEM

**GENERAL INFORMATION**

The air filter purifies dust and foreign substances included in the air and supplies clean air into the engine. The air filter is directly related to engine lifetime, emissions, and engine output. Periodically check, clean, and replace the air filter.

**⚠ CAUTION**

**Do not operate the engine without the air filter.**

**Use specified air filters only. Using unauthorized or remanufactured air filters may result in critical faults.**

**Foreign substances in the engine may cause abrasion inside the engine.**

**Immediately exchange a damaged air filter with a new one.**

**Be careful not to let foreign substances flow into engine or damage the air filter related electric apparatus when replacing an air filter.**

**Be careful not to let dust inside when assembling the air filter.**

**AIR FILTER**

- Air cleaner is mounted on the engine to purify the air for combustion.
- The intervals at which the air cleaner requires servicing depend on the specific operating conditions encountered.
- Clogged air filters may cause black smoke and reduce power.
- A check should be made from time to time to see that the fastening elements securing the air cleaner to the intake manifold seal the connection tightly.
- Any ingress of unfiltered air is liable to cause a high rate of cylinder and piston wear.

**DISASSEMBLY OF AIR FILTER**

**⚠ DANGER**

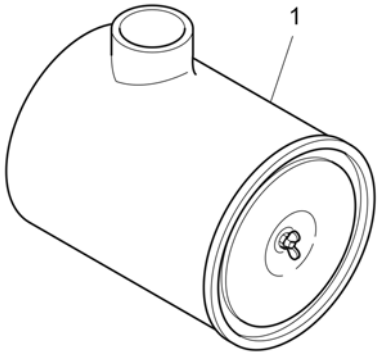
**Only disassemble the air filter when the engine is stopped.**

1. Empty the dust bucket periodically. The dust should not exceed half of the dust bucket capacity.

2. Disassemble the dust bucket by removing the two clamps. Remove the dust bucket cover and empty the dust inside.

3. Assemble the cover and dust bucket accurately with care.

4. For easy alignment, the cover has a dent and the dust collector has a protrusion. Here is the position where a filter is mounted horizontally, check the “TOP” mark on the air filter canister.



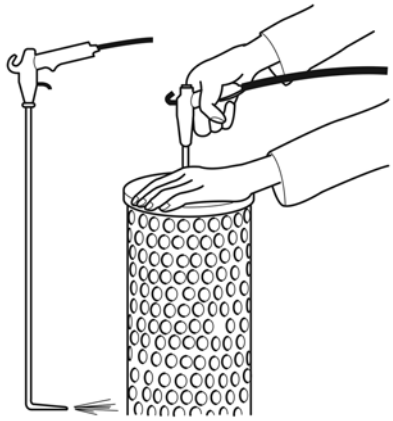

DV2213029A

1. Air cleaner assembly.

**CLEANING OF THE AIR FILTER ELEMENT**

Clean the air filter element by using the most suitable method for the work environment among the three methods stated below.

1. Use compressed air to clean the air filter element.



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a) Use an air gun at a 90° angle from the inside of the element.

b) Move air gun up and down the element to blow air out through the element until there is no more dust in the element.

c) Do not use compressed air with pressure exceeding 5 bars.

**⚠ DANGER**

**Always wear protective goggles before starting work in order to prevent injury from dust or foreign substances in the element.**

2. Clean the element by washing it.

EDL022156A

a) Before washing the element, clean the element by using compressed air as described above.

b) Soak the element in the warm cleaning solvent for 10 minutes and then shake it back and forth for approximately 5 minutes.

c) Rinse the element with clean water, drain the water, and then dry it at room temperature. Fully dry the element before reassembling.

**⚠ CAUTION**

**Never use steam spray, gasoline, alkali or hot cleansing solution to clean the element.**

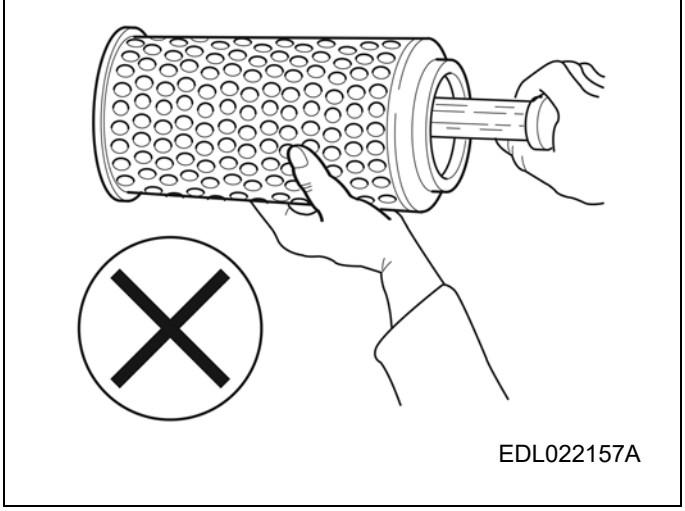
3. In an emergency, temporarily clean the element by using the following method.

a) Tap the end plate of the element to clean it temporarily.

**⚠ CAUTION**

**This method should only be used in an emergency when cleaning of element is necessary and no compressed air or cleansing solution is available.**

**Under no circumstances should the surface of the element be hit or beaten with a hard object to shake the dust off.**



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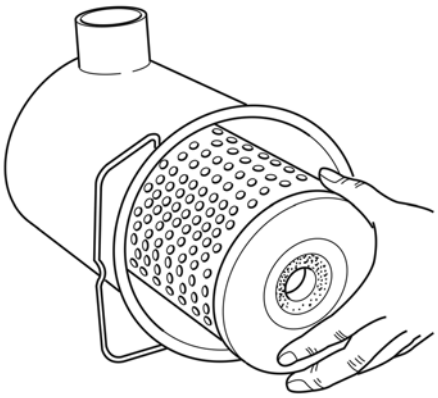
**NOTE:** Before reassembling the element, make sure that the filter paper is not wrinkled, the state of rubber sealing is good, and the element is not deformed.

**NOTE:** Do not reuse damaged elements under and circumstances. When in doubt, replace the element with a new one.

## CHANGING THE AIR FILTER ELEMENT

1. Remove the hex nut, remove the dirty element.



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2. Clean or replace with new element.

3. Clean the inside of the filter housing with a damp cloth.

4. Replace end cap.

**⚠ DANGER**

**Do not let dust enter the end of air filter.**

## TURBOCHARGER

The Turbocharger does not need specific maintenance. When replacing the engine oil, check the oil pipe for leakage or clogging.

- Handle the air filter with special care to prevent foreign substances from getting in.

- The turbocharged compressed air and exhaust gas pipe should be checked periodically for air leakage. Any air leakage can cause the engine to overheat.

**⚠ CAUTION**

**Be careful not to bend the turbocharged compressed air and exhaust gas pipe.**

- If the impeller is severely contaminated, soak only the wheel in a solvent and clean it thoroughly with a rigid brush. Be sure to soak only impeller. The turbocharger should be supported by a bearing housing and not by an impeller.

## ROUTINE CHECK AND SERVING THE TURBOCHARGER

The turbocharger performance is affected by the maintenance state of the engine. Regularly perform inspection and maintenance as specified in order to maintain turbocharger performance.

1. Intake system
   The air filter should be carefully managed. For a wet type air filter, the intake resistance should be as small as possible.

2. Exhaust system
   When exhaust gas leaks from the exhaust pipe or turbocharger joint, supercharging efficiency is lowered. Ensure there is no gas leakage as this can cause serious burns. Heat resistant nuts are used for parts which become hot during operation, such as the turbine seal. These nuts must not be mixed with other nuts. The screw burn prevention paint should be applied to the assembly nuts at the specified positions.

3. Fuel system
   If the spray status of the fuel injection nozzle is not good, or the injection timing is not correct, the exhaust gas temperature increases to give a negative impact on the turbocharger. Ensure that the nozzle is tested.

4. Lubrication system
   Ensure that the correct grade of oil is used and the oil filter cartridge is replaced according to the maintenance schedule. Degradation of engine oil has a negative effect on the turbocharger, as well as the engine body.

## DISASSEMBLY AND CLEANING A TURBOCHARGER

The turbocharger can be removed from the engine to clean or inspect it. Be sure to seal the oil inlet and outlet with tape, etc.

## CYLINDER BLOCK/HEAD

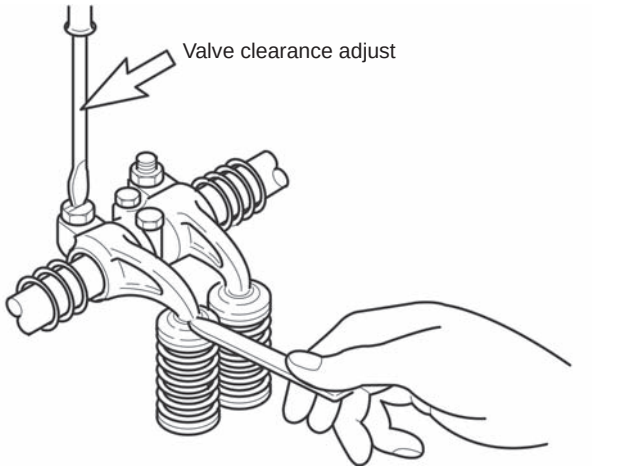
### VALVE CLEARANCE

Adjust the valve clearance.

- When disassembling the engine or cylinder head.
- When there is excessive noise in the valve connection.
- When the engine runs abnormally even if the fuel injection system is normal.

### HOW TO ADJUST THE VALVE CLEARANCE

1. Loosen the lock nuts of rocker arm adjusting screws.
2. Push the feeler gauge of specified value between a rocker arm and a valve stem (to measure the clearance of the valve and rocker arm contacting part).
3. Adjust the clearance with adjusting screw respectively and then tighten with the lock nut.

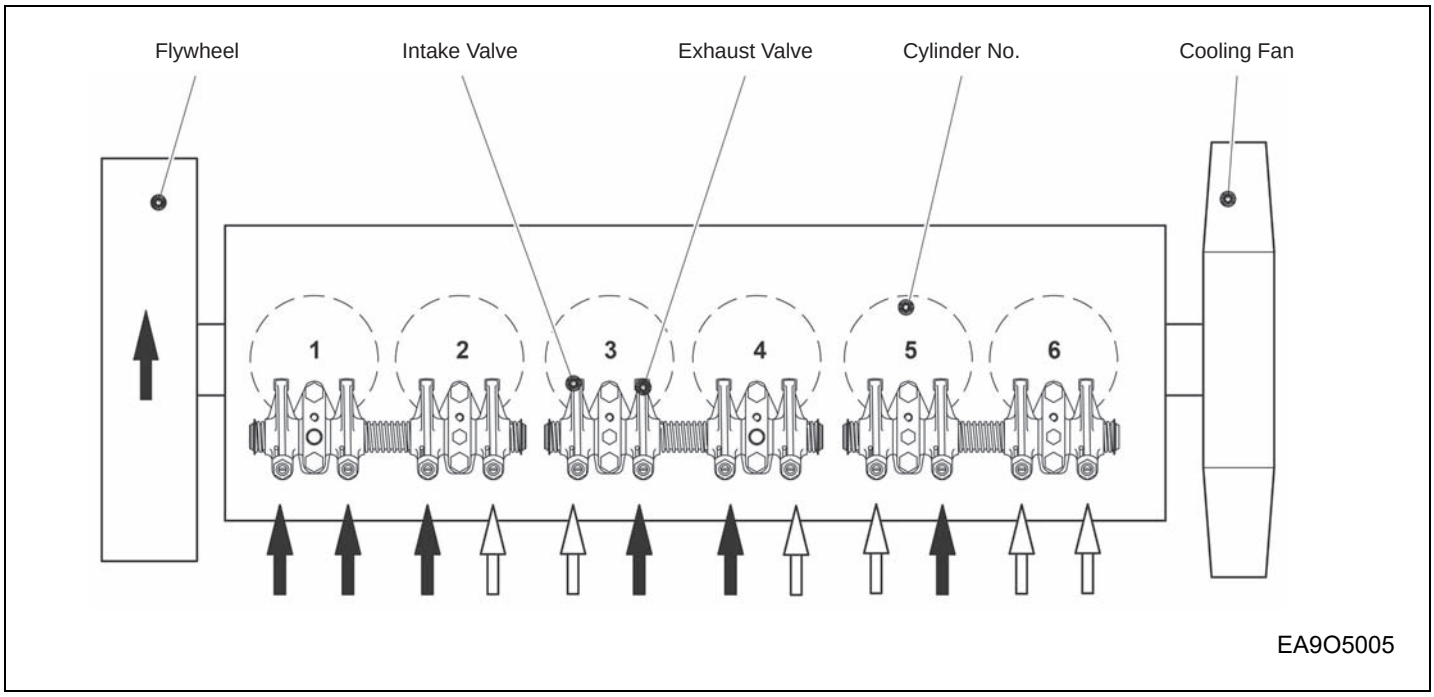



4. Adjust valve clearance with a feeler gauge and tighten the fixing nuts to the specified torque.

| | |
|---|---|
| Torque | 5.0 kgf·m |

## ADJUSTING THE VALVE CLEARANCE

Guide for valve clearance adjustment




1. Rotate the crankshaft so that #1. cylinder may be positioned at the compression TDC (Top Dead Center). Then adjust the valves corresponding to mark " • " in the below table.

**NOTE:** #1. cylinder is located at the side near the flywheel.

**NOTE:** #6. cylinder is positioned at the valve overlap when #1. cylinder is positioned at the compression TDC (Top Dead Center).

2. Rotate the crankshaft one rotation (360°) so that #6. cylinder may be positioned at the compression TDC (Top Dead Center). Then adjust the valves corresponding to mark " o " in the below table.

**NOTE:** #6. cylinder is located at the side near the cooling fan.

**NOTE:** #1. cylinder is positioned at the valve overlap when #6. cylinder is positioned at the compression TDC (Top Dead Center).

(I: Intake, E: Exhaust)

| Cylinder No. | #1 | | #2 | | #3 | | #4 | | #5 | | #6 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | I | E | I | E | I | E | I | E | I | E | I | E |
| #1 TDC | • | • | • | | | • | • | | | • | | |
| #6 TDC | | | | o | o | | | o | o | | o | o |

3. Only adjust the valve clearance when the engine is cold.

| Engine Model | Intake Valve (mm) | Exhaust Valve (mm) |
|---|---|---|
| D1146 | 0.3 | 0.3 |
| D1146T | 0.3 | 0.3 |
| DP086TA | 0.3 | 0.3 |
| P086TI | 0.3 | 0.3 |

**⚠ CAUTION**

**Crankshaft revolution is done by hand without using a starting motor.**

**Turn it to the direction of engine rotation, but do not use the installing bolts at the turn.**

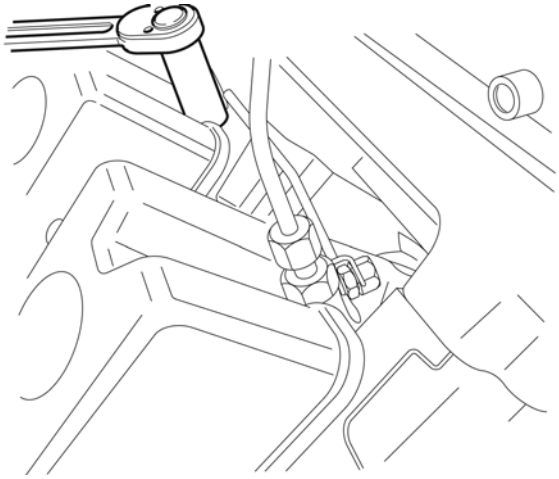
**The cylinder no. and the order of intake and exhaust can be determined from the flywheel housing.**

**CYLINDER COMPRESSION PRESSURE**

1. Start and warm up the engine.

2. Stop the engine and disassemble the fuel injection nozzle holder assembly.

3. Install a special tool, compression pressure gauge adapter in the fuel injection nozzle holder hole.

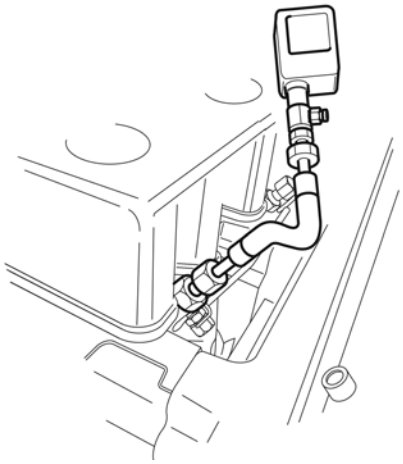


DV2213046A

4. Connect the compression pressure gauge to the adapter.

| | |
|---|---|
| Standard | Above 28kg/cm$^2$ |
| Tolerance limit | 24kg/cm$^2$ |
| Difference between each cylinder | Within ±10% |

**NOTE:** Testing conditions: at water temperature of 20°C and speed of 200 rpm (10 turns)



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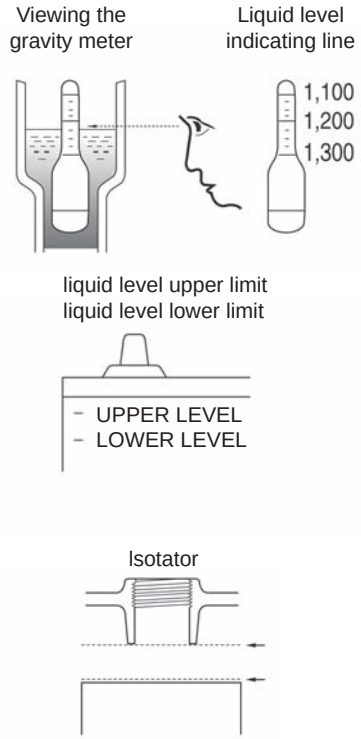
## ELECTRICAL SYSTEM

**BATTERY**

- Check the battery for cracks and ensure there is no electrolyte leakage. Replace the battery if defective.

- Check the amount of electrolyte, and replenish distilled water if insufficient.

- Check the specific gravity of electrolyte. If it is below the specified value (1.12 ~ 1.28), replenish it.




**STARTER**

When servicing the engine, immerse the starter motor's pinion gear and ring gear in the fuel, wash them completely, and apply grease again. When cleaning the surrounding of engine, ensure that no water enters the starter.

**⚠ CAUTION**

**Starter should be protected from humidity at all times.**

**Before working on the electric system, be sure to disconnect the ground wire ("-" minus wire) of the battery. Short circuit may occur while working on the electrical system. Reconnect the ground wire last after completing all of work.**

## OTHERS/DRIVING SYSTEM

### V-BELT

The tension of the V-belts should be checked daily.

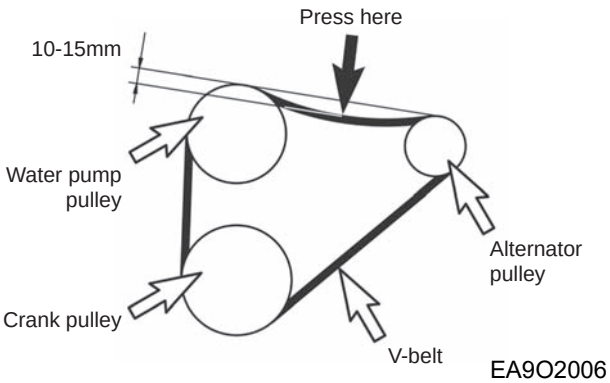
1. Change the V-belts if necessary.

   a) If wear or differing tensions are found in a multiple V-belt drive, always replace the complete set of V-belts.

2. Checking condition.

   a) Check V-belts for cracks, oil, overheating and wear.

3. Testing by hand.

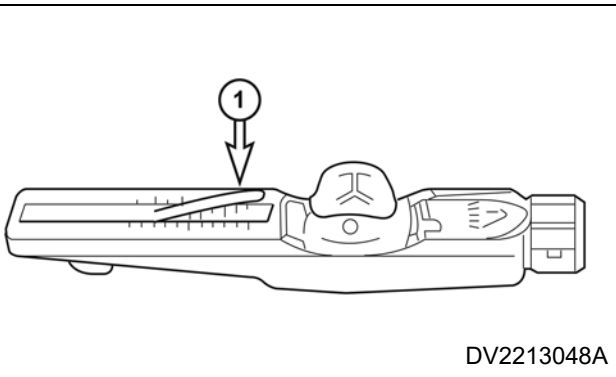



   a) Test the V-belt tension by pressing the V-belt in the centre between pulleys. 10~15mm deflection is normal.

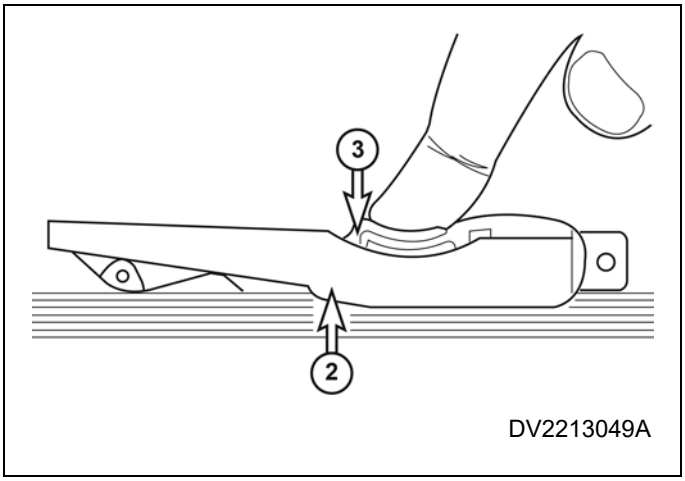
   b) To check the V-belt tension more accurately, use a V-belt tension gauge.

4. Tension measurement.

   a) Lower indicator arm (1) into the scale.




   b) Apply tester to belt at a point midway between two pulleys so that edge of contact surface (2) is flush with the V-belt.




   c) Slowly depress pad (3) until the spring can be heard to disengage. This will cause the indicator (1) to move upwards.

**NOTE:** If pressure is maintained after the spring has disengaged a false reading will be obtained.

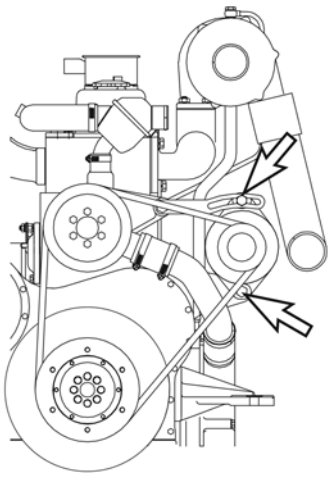
   d) Read the tension value at the point that the top surface of indicator arm(1) intersects with the scale.

   e) Before taking readings, ensure that the indicator arm remains in its position.

**NOTE:** If the value measured deviates from the setting value specified, the V-belt tension must be corrected according to the following table.

| Type | Belt width (mm) | Tension from a Tension Meter | | |
|---|---|---|---|---|
| | | New belt (kg) | | Replacement required |
| | | Upon installation | After 10 minutes | |
| M | 8.5 | 50 | 45 | 40 |
| A | 11.8 | 55 | 50 | 45 |
| B | 15.5 | 75 | 70 | 60 |
| C | 20.2 | 75 | 70 | 60 |
| 3V-2 | 18.8 | 90~100 | 70~80 | 60 |
| 3V-4 | 39.4 | 180~200 | 140~160 | 120 |
| 3V-6 | 60.0 | 270~300 | 210~240 | 180 |

5. Tension adjustment and V-belt replacement.



EA9O2007

a) Loosen fixing bolts and nuts.

b) Adjust the alternator until V-belts have correct tensions.

c) Tighten fixing bolts and nuts.

d) To change the V-belts loosen fixing bolts and nuts. Then push the alternator toward water pump pulley by hand.

# DIGITAL SPEED CONTROLLER (DSC-1000)

## PRODUCT OVERVIEW AND GENERAL SPECIFICATION

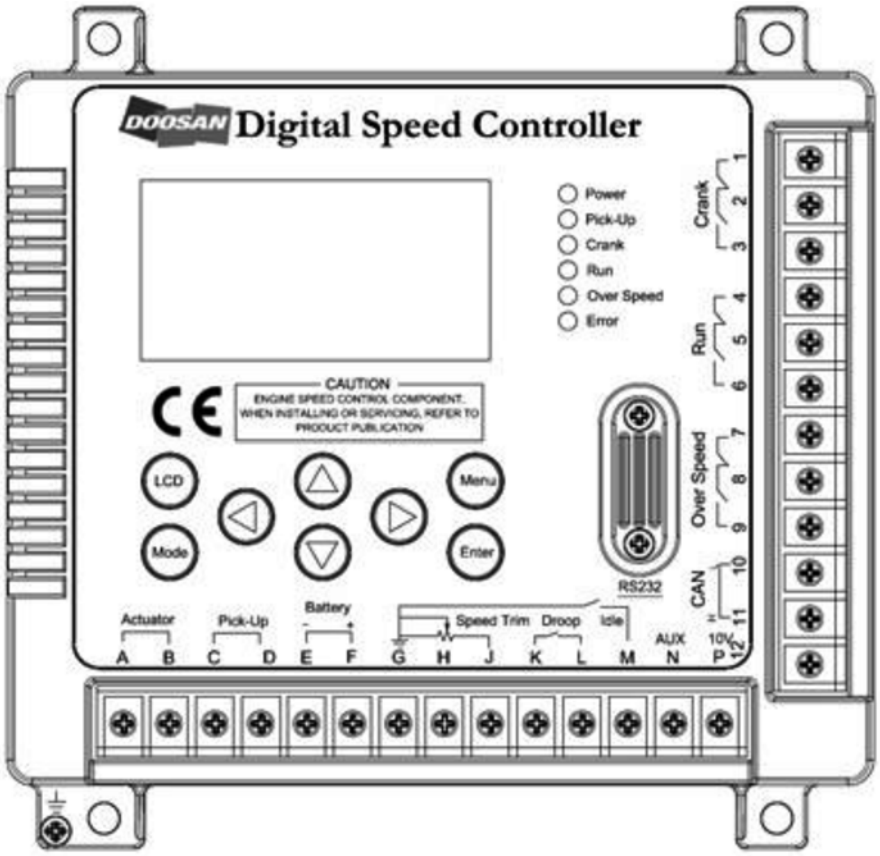
**Digital Speed Controller (DSC-1000)** is applicable to generator engines as a high performance embedded electronic control system designed based on PID control for fast and precise control of engine speed with an enhanced micro controller unit (MCU) that minimizes analogue circuits vulnerable to user environments.

This product features PID auto setting functions along with battery voltage, pick-up sensors and actuator condition checking. It also has a black box function that manages engine operation records when faults are detected for users to have more convenience in operating this precise digital speed controller.

### Product Features

- Rigid and stable case structure and easily recognizable front design
- Readily understandable GUI (graphic user interface) with graphic LCD displays
- Easy and simple setup with 8 button keys without manual controls by users
- Fast setting available by migrating initial settings depending on types of the engines
- Listing fault messages (over speed, pick-up error, etc.) and recording messages
- RS232 and CAN ports available for communication
- Digital inputs and PID auto setup functions for PID control parameters
- Application of digital clock for fault timing and engine operating hours

**Product Specification**

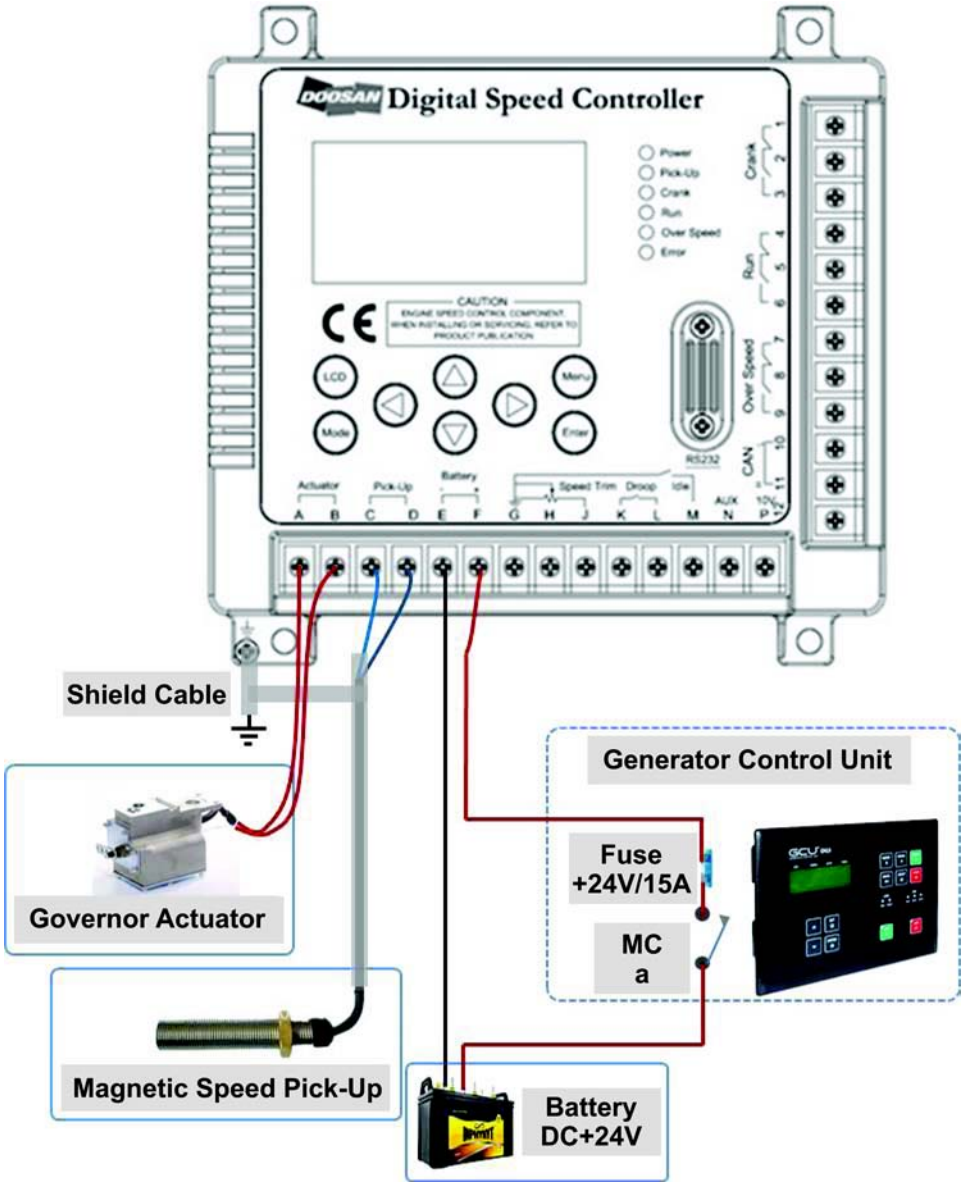



| NO. | ITEM | DESCRIPTION |
|---|---|---|
| **1** | MCU | 16-bit DSC dsPIC33FJ256 |
| **2** | Display | Graphic LCD 128*64 |
| | | LED: 6 EA |
| **3** | Keypad | 8 Button Keys |
| **4** | Output | 3 Contact Points (a and b) |
| **5** | Input | RMS 3V (Min) |
| **6** | Memory | 128Mb |
| **7** | Communication | RS232 57600bps |
| | | CAN (J1939) / 250kbps |
| **8** | Rated Power | DC 24V (12V to 30V) |
| **9** | Current Consumption | 120mA |
| **10** | Operating Temperature | -20 to +70°C |
| **11** | Storing Temperature | -30 to +80°C |
| **12** | Operating Humidity | 0 to 95% |

## INSTALLATION

### Connecting to the Engine Battery,

### Pick-Up and Actuator Connection Diagram




### Connecting to Batteries

Battery voltage is DC +24Vand the battery is connected to the controller matching **E(-)** and **F(+)** with the respective polarities of the battery. **E(-)** is connected to **(-)** of the battery and **F(+)** to **(+)** of the battery. Depending on cases, wiring can be done in a serial connection to the contact point a of MC and the fuse (DC +24V/15A) when connecting to system panels or generator control devices.

### Connecting to Actuators

The actuator is also called governor and controls the amount of the fuel spray to the engine cylinder. The controller is connected to the actuator attached on the engine by connecting two wires of the controller terminal to A and B of the actuator regardless of their polarities. Wiring should be 18AWG (105?) or better and the outside should be wrapped by plastic tubes for insulation or insulated mesh lines.

### Connecting to Pick-Up Sensors

The pick-up sensor lets users know the engine speed and is connected to terminals C and D that can receive signals of AC RMS 3Vor higher. Wiring should be twisted, or shielded cables connected to the ground together with the terminal D. Gap between the pick-up sensor and the gear tooth should be adjusted between 0.9 and 1.1mm.

## CONFIGURATION OF DIGITAL SPEED CONTROLLER

- **Power On/Off:** It means that DC +24V power is either supplied or terminated through **(-)** and **F(+)** of the battery matching with their respective polarities.

- **LCD On/Off:** It means to turn on or off the LCD display alone while DC +24V power is supplied through E(-)and F(+) of the battery matching with their respective polarities and the controller is in operation.

### Operating Sequence for the Controller

**Step 1)** When DC +24V power is supplied to the controller, the controller starts to operate. It indicates that power LED turns on and the power is being normally supplied.

**Step 2)** Inputs for speed trim, droop and idle functions are received.

**Step 3)** The controller checks the signals of the speed pick-up sensor.

**Step 4)** Actuator control signals are output together with designated values of other information for crank, run and over speed functions according to the PID control values.

**Step 5)** The controller checks the operation condition and displays LED outputs and fault messages according to the detected information.

### Configuration and Operation

The controller can be configured and operated by input keys according to the menus on the LCD display by selecting proper ones and assigning values in the selected menu to input control information to the system. Input information should immediately apply to the controller system once updated.

### Input Keys

The controller has 8 input keys including LCD, Mode, Menu, Enter, Up, Down, Left and Right.

Each key as respective functions as follows:


LCD key turns on and off the display.


Mode key switches the display to either operation mode or wave form display.


Menu key lets users change the menu display and go back to the previous menu.


Enter key applies designated values on the LCD display to the system.

Up key lets users go up or increase values in the selected menu on the LCD display.

Down key lets users go down or decrease values in the selected menu on the LCD display.

Left key lets users move to the left in the selected menu.

Right key lets users move to the right in the selected menu.

**LCD Displays After Powered On**

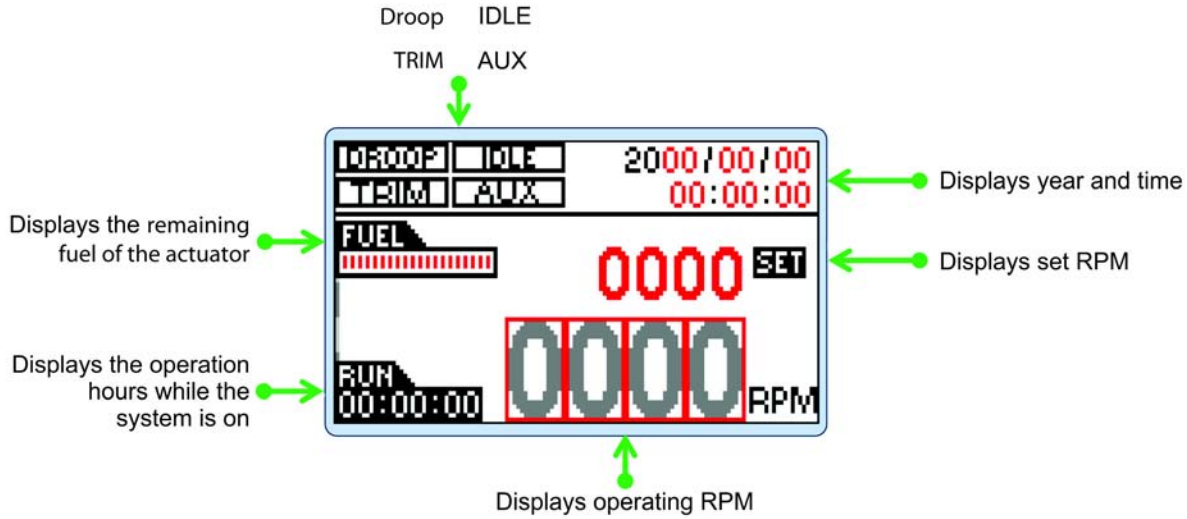
When DC +24V power is supplied to the battery terminal (E(-), F(+)) of the controller, the **power** LED in the front side of the controller turns on in **red** and the **error** LED turns on in **red** where there are fault conditions. At this moment, the LCD display is not activated, and Doosan logo will appear for 1 second followed by the operation display after pressing the **LCD** button.

The controller will start control based on information from pick-up sensor and other input devices and designated parameter values. At this moment, where breakdowns of the surrounding devices or system errors occur, the LCD display will show such errors and processing messages.

**Step 1) DC +24V power supply to the terminals E (-) and F (+)**

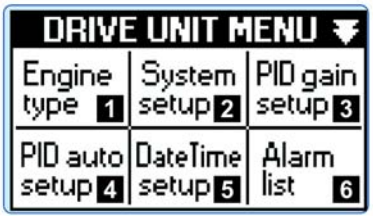
When DC +24V power is supplied to the terminals E (-) and F (+), the controller will start to operate with the LCD display off. After pressing the LCD button, Doosan logo will appear for 1 second as shown below followed by the controller operation display. Then, the LCD display will switch between on and off by pressing the LCD button.

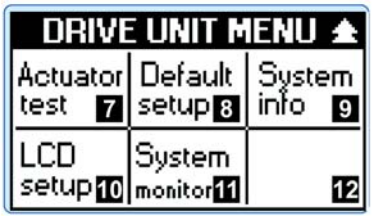

**Step 2) The operation display will show 1 second after the logo appears**



**LCD Main Menu Display**

The main menu of the controller has 10 sub-menus.




**1) Engine type**

The controller can start operation once the initial system values are configured.

Users can load preset values depending on types of the engines by selecting the type.

**2) System setup**

It consists of sub-menus related to system settings including

RUN/IDLE/OVERSPEED/CRANK/GEARNUMBER.

**3) PID gain setup**

It consists of sub-menus to designate Kp, Ki and Kd parameter values related to the engine PID control.

**4) PID auto setup**

It offers function for automatic designation of Kp, Ki and Kd parameter values related to the engine PID control.

**5) Date Time setup**

It offers function for users to move to the screen for designating year, month, day and hour.

**6) Alarm list**

It offers function for users to move to the alarm display for the alarm list.

**7) Actuator Test**

It offers menu to test the impedance (XL) of the actuator and any problems in operating load current. It displays current and voltage according to the duty values.

**8) Default setup**

It offers menu to apply designated default values to the selected engine.

**9) System info**

It offers menu that shows information of the controller. Such information includes the serial number, software version, last update date, alarm count and engine runs.

**10) LCD setup**

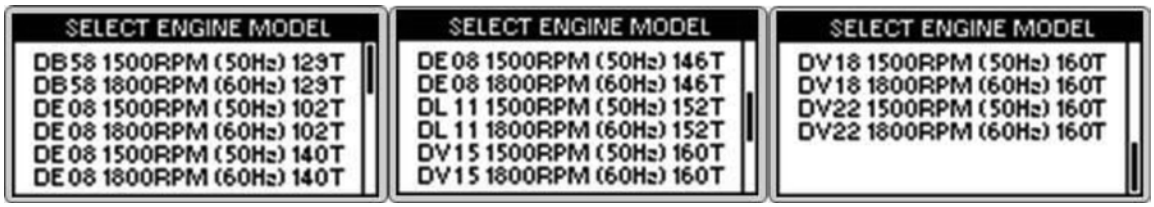
It offers menu to configure LCD operating conditions including brightness, auto on/off and off hours.

**11) System monitor**

It offers menu to monitor the controller operation. It shows values for Engine RPM, Valve Duty, Valve Current, Aux RPM Input, Pickup Voltage and Bat Voltage.

**Engine Type Setup Menu**

This menu offers function to configure setting values of the controller depending on types of the engines in advance and apply such pre-set values to the selected engine.




**System Setup Menu**

It consists of sub-menus for the system configuration items of the controller including the one for configuring RUN/IDLE/OVERSPEED/CRANK/GEARNUMBER related to RPM setting. Depending on additional functions, users can designate values for STARTING FUEL/SPEED RAMPING/ACTUATOR MAX/LOW BATTERY.

**1) SET RUN RPM**

Users can designate normal speed (target RPM) of the engine.

Users need to input different normal speed values depending on the specification of the selected engine.

**2) SET IDLE RPM**

Users can designate the idle speed values of the engine as RPM.

Users need to input values to control the idle operating speed of the engine.

**3) SET OVER SPEED**

Users can designate RPM values to activate engine protection function when the speed exceeds the normal level (target RPM) and reaches the overspeed range that may cause problems to the engine. When the engine RPM reaches the over speed RPM range, the engine immediately stops with error messages and alarms.

**4) CRANKING RPM**

Users can designate values to activate the actuator when the engine starts to operate.

**5) GEAR NUMBER**

Users can input the number of flywheel teeth in the engine to the controller so that the controller can calculate the accurate RPM depending on the values of the pick-up sensor from the engine.

**6) STARTING FUEL**

Users can designate the amount of fuels used when the engine starts to operate and the operating current for the controller to activate the actuator changes based on these values.

**7) AUX SPEED**

Users can adjust values to ensure safe operation of the engine based on the AUX signal values when AUX is enabled.

**8) SPEED RAMPING**

Users can input ratio values of speed changes when the speed increases or decreases in the idle condition of the engine.

**9) MAX CURRENT**

Users can designate the maximum operating current for the actuator of the engine.

**10) LOW BATTERY**

It measures the battery voltage supplied to the controller. When the measured values are lower than the present voltage values, it will be alarmed. Usually, the acceptable battery voltage is between 20 and 22V (without load).

**11) DROOP GAIN**

Users can designate the droop values applicable to maximum load based on the current consumption of the actuator.

**12) F-LOAD CURR**

Users can designate the maximum current values when the generator is in full load.

**13) N-LOAD CURR**

Users can designate the operating current values of the actuator when the generator has no load.

**Date/Time Setup Menu**

Users can designate year, month, day, hour and minute for the controller and the designated time will be used to monitor the system and manage fault messages.

**Step 1)** press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**. Use direction buttons to select **Date Time setup** menu.

**Step 2)** Use **Up, Down, Left** and **Right** buttons to input year, month, day and hour and then press **Enter** button.

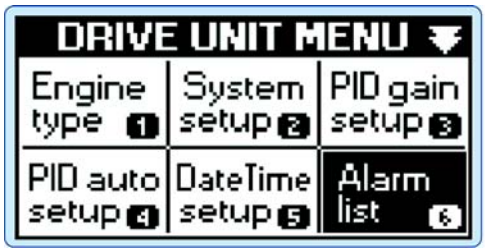


**Alarm List Menu**

This menu displays year, month, day, hour and minute for the errors in the controller and types of the faults in codes which are used in troubleshooting.

**Step 1)** press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**. Use direction buttons to select **Alarm List** menu and then press **Enter** button.

**Step 2)** Use **Up, Down, Left** and **Right** buttons in **ALARM LIST** menu to confirm the fault messages.





**Default Setup Menu**

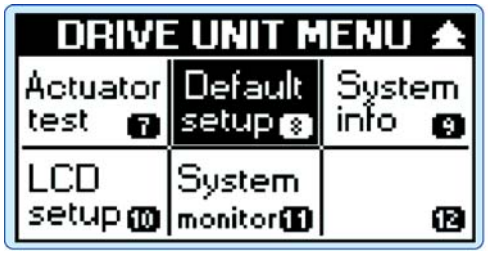
When you cannot identify the type of the control engine by the controller, this menu offers the most common parameter setting values.

**Step 1)** Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**. Use **Up, Down, Left** and **Right** buttons to select **Default setup** menu and then press **Enter** button.

At this moment, the system message **"Initialization system setting?"** will appear.

**Step 2)** Use **Left** and **Right** buttons to select either **YES** or **NO** in **System Message** and then press **Enter** button.

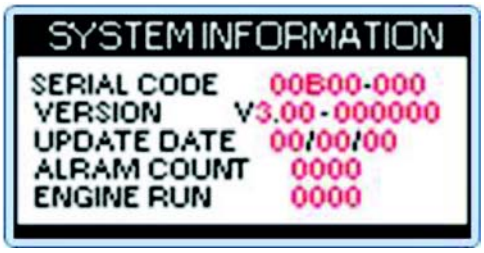
Default setup will change the configuration values of the engine to the default values. To initiate default setup, you need to select **YES** and then press **Enter** button. Press **No** button if you don't want to.




**System Info Menu**

The controller displays its information including the serial number, software version, last update date, alarm count and engine runs.

**Step 1)** Press **Menu** button of the controller and then you can see **DRIVE UNIT MENU**. Use **Up, Down, Left** and **Right** buttons to select **System info** menu and then press **Enter** button.


**HOW TO OPERATE**

**Step 1) Supply DC +24V power to the battery terminals (E (-), F (+)) of the controller.**

Power supply to the controller can be done by direct connection to the battery or power supply controlled by external control devices. Fuses (15A/24V) are required for power supply to the controller through the terminal.

When the controller displays **Low Battery** Fault message, you need to charge the battery or replace it with the one having normal voltage before starting the controller.

**Step 2) Configure parameter values required for selection of the engine type and control of the engine.**

There are3 ways to configure parameters required for the controller:

1. Using default setup

2. Designating the engine type in Engine Type menu

3. Configuring each parameter in System setup menu

**Step 3) Install the controller on the generator system and complete circuit wiring.**

Once the configuration is completed, the controller will be in **Stand By** condition preparing to receive input information from **pick-up** sensor and surrounding terminals and operate.

**Step 4) The controller will activate the actuator with power supply and pick-up sensor input.**

When the power is supplied, and the pick-up terminal delivers normal sensor inputs as the engine starts, the controller activates the actuator.

**TROUBLESHOOTING**

**Alarm List Check**

Where there are problems in the system operation, you need to review the alarm list menu of the controller and then check the engine and the system in reference to the alarm codes.

| ALARM CODE | ALARM ITEM | ALARM CONDITION | OUTPUT CONTROL | MEASURES |
|---|---|---|---|---|
| E01 | Battery Low | When the battery voltage continues to be lower than Low Battery voltage values for more than 5 seconds | 1. Alarm message pop-up on LCD<br>2. Error LED on | 1. Check the battery line<br>2. Replace the battery |
| E02 | Battery High | When the battery maintains its voltage exceeding 30VDC for more than 5 seconds | 1. Alarm message pop-up on LCD<br>2. Error LED on | 1. Check the battery line<br>2. Replace the battery |
| E03 | Pick-up Error | Problems in sensor signals when the engine starts (Engine RPM lower than 600) | 1. Alarm message pop-up on LCD<br>2. Error LED on<br>3. Actuator control signal off | 1. Check the RPM sensor and connecting circuits<br>2. Replace the RPM sensor |
| E04 | Pick-up Error | Problems in sensor signals during the engine operation (Engine RPM 600 or higher) | 1. Alarm message pop-up on LCD<br>2. Error LED on<br>3. Actuator control signal off | 1. Check the RPM sensor and connecting circuits<br>2. Replace the RPM sensor |
| E05 | Actuator Current Open | Disconnection in the actuator or the connecting circuits | 1. Alarm message pop-up on LCD<br>2. Error LED on | 1. Check the disconnection in the actuator and connecting circuits<br>2. Replace the actuator |
| E06 | Actuator Current short | Short-circuits in the actuator or the connecting circuits | 1. Alarm message pop-up on LCD<br>2. Error LED on | 1. Check the disconnection in the actuator and connecting circuits<br>2. Replace the actuator |
| E07 | Over Speed | Engine RPM exceeding the configured over speed values | 1. Alarm message pop-up on LCD<br>2. Error LED on<br>3. Actuator control off | 1. Check the speed setting<br>2. Adjust PID setting values |
| E08 | FET Drive Error | Damages to components in the actuator output section inside the controller | 1. Alarm message pop-up on LCD<br>2. Error LED on<br>3. Actuator output power cutoff | 1. Check the actuator and connecting circuits<br>2. Replace the controller |

1) When problems described in alarm codes E03, E04, E07 or E08 occur, the engine is not available for safe operation and therefore the engine will stop as the controller will turn off the actuator for safety.

2) When problems described in alarm codes E03, E04, E07 or E08 occur, the engine will not be able to restart as long as the alarm is not released.

3) When alarms occur, you can release them by turning off the power of the controller.

**System Checks and Measures**

For initial installation, it is recommended for you to check any disconnection in circuits before taking measures described below.

**Step 1)** Check the battery voltage whether it is higher than the Low Voltage setting value. If normal, supply power to the controller and then operate it. If the voltage is lower than the setting value, you need to charge the battery or replace it before operating the system.

**Step 2)** Check the input resistance in the DC +24V input terminals (-E, +F) of the battery whether the resistance is higher than approx. 10K Ohm. If the resistance does not meet this condition, do not supply power to the controller and contact our A/S center for service request.

**Step 3)** Check whether the power LED turns on or not after supplying power to DC +24V input terminals (-E, +F) of the battery. If the LED does not turn on, cut the power off and contact our A/S center for service request.

**Step 4)** Check whether the power LED turns on and Doosan logo appears on the LCD display after supplying power to DC +24V input terminals (-E, +F) of the battery. If you cannot see the logo, press LCD key button to check the LCD display once again. If you cannot still see the logo, cut the power off and contact our A/S center for service request.

**Step 5)** Check the controller terminals (C & D) with AC meter or oscilloscope to check whether signal inputs of AC RMS 3Vor higher are detected. If no signal detected, check whether the pick-up sensor maintains the gap between 0.9 and 1.1mm and then check whether the pick-up sensor has resistance of 110Ohms (±10%). If you cannot still detect no signal, replace the pick-up sensor and then operate the controller.


Portable Power

# ALTERNATOR INSTALLATION AND MAINTENANCE

**CONTENTS**

## FOREWORD

This section concerns the alternator which you have just purchased.

We wish to draw your attention to the contents of this maintenance chapter.

### SAFETY MEASURES

Before using your machine for the first time, it is important to read the whole of this installation and maintenance manual.

All necessary operations and interventions on this machine must be performed by a qualified technician.

Our technical support service will be pleased to provide any additional information you may require.

The various operations described in this manual are accompanied by recommendations or symbols to alert the user to the potential risk of accidents. It is vital that you understand and take notice of the different warning symbols used.


**Warning symbol for an operation capable of damaging or destroying the machine or surrounding equipment.**


**Warning symbol for general danger to personnel.**


**Warning symbol for electrical danger to personnel.**

### WARNING SYMBOLS

We wish to draw your attention to the following 2 safety measures which must be complied with:

a) During operation, do not allow anyone to stand in front of the air outlet guards, in case anything is ejected from them.

b) Do not allow children younger than 14 to go near the air outlet guards.

A set of self-adhesive decals depicting the various warning symbols is included with this maintenance manual. They should be positioned as shown in the drawing below once the machine has been fully installed.


**The alternators must not be put into service until the machines in which they are to be incorporated have been declared compliant with Directives EC and plus any other directives that may be applicable.**

# RECEIPT

## STANDARDS AND SAFETY MEASURES

Our alternators comply with most international standards. See the EC Declaration of Incorporation.

## INSPECTION

On receipt of your alternator, check that it has not suffered any damage in transit. If there are obvious signs of knocks, contact the transporter (you may be able to claim on their insurance) and after a visual check, turn the machine by hand to detect any malfunction.

## IDENTIFICATION

The alternator is identified by means of a nameplate fixed on the machine (see drawing). Make sure that the nameplate on the machine conforms to your order.

### Nameplate

So that you can identify your machine quickly and accurately, we suggest you write its specifications on the nameplate below.

## STORAGE

Prior to commissioning, machines should be stored:

- Away from humidity (< 90%); after a long period of storage, check the machine insulation (See “Electrical checks” on page 112) To prevent the bearings from becoming marked, do not store in an environment with significant vibration.

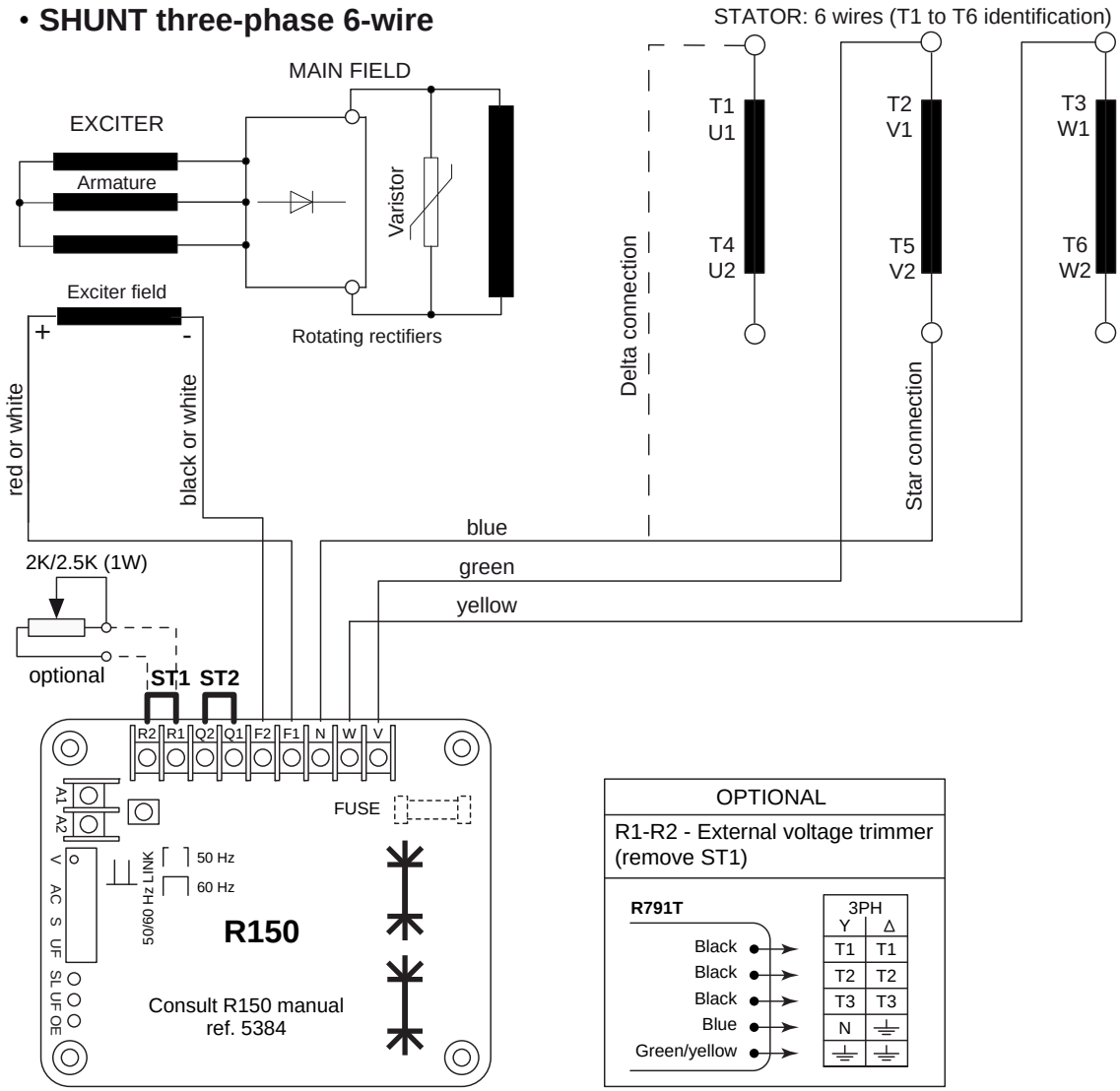
## APPLICATION

These alternators are mainly designed to produce electricity in the context of applications involving the use of generators.

## CONTRAINDICATIONS TO USE

Use of the machine is restricted to operating conditions (environment, speed, voltage, power, etc.) compatible with the characteristics indicated on the nameplate.

## • SHUNT three-phase 6-wire



## INSTALLATION

Personnel undertaking the various operations indicated in this section must wear personal protective equipment appropriate for mechanical and electrical hazards.

**ASSEMBLY**

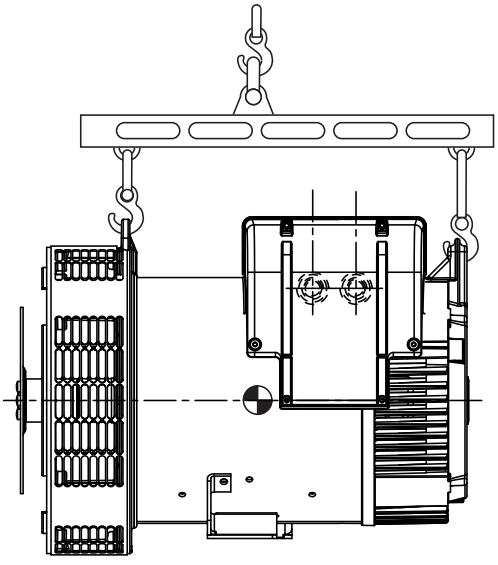
**⚠ WARNING**

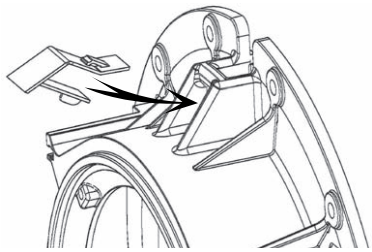
**All mechanical handling operations must be undertaken using suitable equipment and the machine must be horizontal. Check how much the machine weighs before choosing the lifting tool.**
**During this operation, do not allow anyone to stand under the load.**

**Handling**

The generously sized lifting rings are for handling the alternator alone. They must not be used to lift the genset. The choice of lifting hooks or handles should be determined by the shape of these rings. Choose a lifting system which respects the integrity and the environment of the alternators.

**During this operation, do not allow anyone to stand under the load.**





**⚠ CAUTION**

**After handling the machine using the lifting ring, snap on the plastic cover provided in the maintenance manual wallet.**

**Single-bearing coupling**

Before coupling the machines, check that they are compatible by:

- undertaking a torsional analysis of the transmission,
- checking the dimensions of the flywheel and its housing, the flange, coupling discs and offset.

**⚠ CAUTION**

**When coupling the alternator to the prime mover, do not use the fan to turn the alternator or rotor.**
**The holes of the coupling discs should be aligned with the flywheel holes by cranking the engine.**
**Make sure the alternator is securely bedded in position during coupling.**

Check that there is lateral play on the crankshaft.

**Double-bearing coupling**

**Semi-flexible coupling** - Careful alignment of the machines is recommended, checking that the lack of concentricity and parallelism of both parts of the coupling do not exceed 0.1 mm.

**This alternator has been balanced with a 1/2 key.**

**Location**

The room where the alternator is placed must be ventilated to ensure that the ambient temperature cannot exceed the data on the nameplate.

## CHECKS PRIOR TO FIRST USE

### Electrical checks

**WARNING**

**Under no circumstances should an alternator, new or otherwise, be operated if the insulation is less than 1 meg ohm for the stator and 100,000 ohms for the other windings.**

There are 2 possible methods for restoring the above minimum values.

a) Dry out the machine for 24 hours in a drying oven at a temperature of 110 °C (without the regulator).

b) Blow hot air into the air intake, having made sure that the machine is rotating with the exciter field disconnected.

**Note: Prolonged standstill: In order to avoid these problems, we recommend the use of space heaters, as well as turning over the machine from time to time. Space heaters are only really effective if they are working continuously while the machine is stopped.**

**WARNING**

**Ensure that the alternator has the degree of protection matching the defined environmental conditions.**

**WARNING**

**When the alternator's power output is ensured directly through cables, these must be connected before start-up.**

### Mechanical checks

Before starting the machine for the first time, check that:

- all fixing bolts and screws are tight.
- the cooling air is drawn in freely.
- the protective grilles and housing are correctly in place.
- the standard direction of rotation is clockwise as seen from the shaft end (phase rotation in order 1 - 2 - 3). For anti-clockwise rotation, swap 2 and 3.
- the winding connection corresponds to the site operating voltage (See the TERMINAL CONNECTION DIAGRAMS, which appear on the following pages).

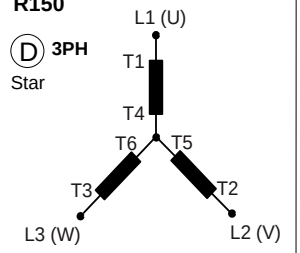
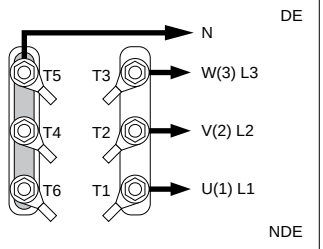
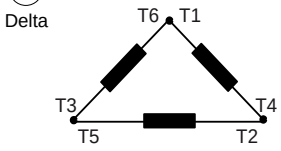
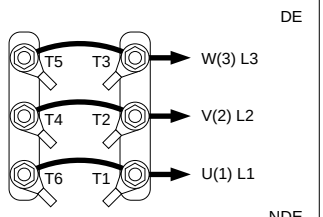
## TERMINAL CONNECTION DIAGRAM - TAL44, TAL46

**WARNING**

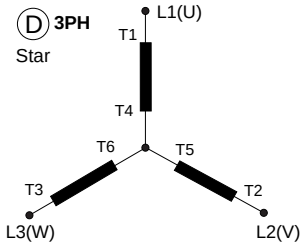
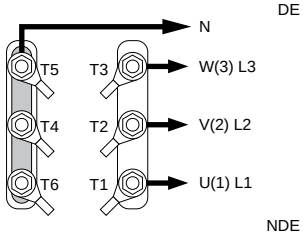
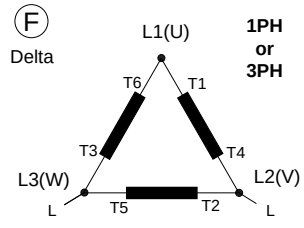
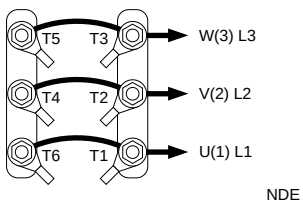
**Any intervention on the alternator terminals during connection or checks should be performed with the machine stopped.**
**In no case should the internal connections in the terminal box be subjected to stresses due to cables connected by the user.**

To modify the connection, change the position of the stator cables on the terminals. The winding code is specified on the nameplate.

### SHUNT three phase 6 wire

| Connection codes | Factory connection |
|---|---|
| **R150**<br>D **3PH**<br>Star<br>  |  |
| F **3PH**<br>Delta<br>  |  |

### SHUNT three phase 6 wire

| Connection codes | Voltage / Detection | Factory connection |
|---|---|---|
| D **3PH**<br>Star<br>  | Winding / 50 Hz / 60 Hz<br>6S: 380 - 415 / 380 - 480<br>8S: - / 380 - 416<br>**R 180 (380V < U < 480V) :**<br>V => T2, W => T3 |  |
| F<br>Delta<br>**1PH or 3PH**<br>  | Winding / 50 Hz / 60 Hz<br>6S: 220 - 240 / 220 - 240<br>8S: - / 220 - 240<br>**R 180 (220V < U < 240V) :**<br>L1 => T2, L2 => T3 |  |

In case of reconnection, ensure that the AVR voltage detection is correct !

**WARNING**

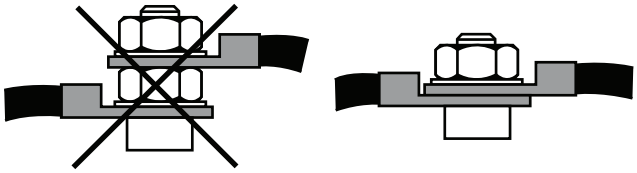
**Electrical installations must comply with the current legislation in force in the country of use.**

Check that:

- The residual circuit-breaker conforms to legislation on protection of personnel, in force in the country of use, and has been correctly installed on the alternator power output as close as possible to the alternator. (In this case, disconnect the wire of the interference suppression module linking the neutral).
- Any protection devices in place have not been tripped.
- If there is an external AVR, the connections between the alternator and the cabinet are made in accordance with the connection diagram.
- There is no short-circuit phase-phase or phase-neutral between the alternator output terminals and the generator set control cabinet (part of the circuit not protected by circuit breakers or relays in the cabinet).
- The machine should be connected with the busbar separating the terminals as shown in the terminal connection diagram.

- The alternator earth terminal inside the terminal box is connected to the electrical earth circuit
- The earth terminal (ref 28) is connected to the frame.

The connections inside the terminal box must never be subjected to stress due to cables connected by the user.



**COMMISSIONING**

**WARNING**

**The machine can only be started up and used if the installation is in accordance with the regulations and instructions defined in this manual.**

The machine is tested and set up at the factory. When first used with no load, make sure that the drive speed is correct and stable (see the nameplate). With the regreasable bearing option, we recommend greasing the bearings at the time of commissioning (See “BEARINGS” on page 116). On application of the load, the machine should achieve its rated speed and voltage; however, in the event of abnormal operation, the machine setting can be altered (follow the adjustment procedure (See “SETTING UP” on page 114). If the machine still operates incorrectly, the cause of the malfunction must be located (See “BEARINGS” on page 116).

**SETTING UP**

**WARNING**

**The various adjustments during tests must be made by a qualified engineer. Ensure that the drive speed specified on the nameplate is reached before commencing adjustment. After operational testing, replace all access panels or covers. The AVR is used to make any adjustments to the machine.**

## SERVICING - MAINTENANCE

### SAFETY MEASURES

**Servicing or troubleshooting must be carried out strictly in accordance with instructions so as to avoid the risk of accidents and to maintain the machine in its original state.**

**⚠ WARNING**

**All such operations performed on the alternator should be undertaken by personnel trained in the commissioning, servicing and maintenance of electrical and mechanical components, who must wear personal protective equipment appropriate for mechanical and electrical hazards.**

Before any intervention on the machine, ensure that it cannot be started by a manual or automatic system and that you have understood the operating principles of the system.

**⚠ WARNING**

**During and after running, the alternator will reach temperatures hot enough to cause injury, such as burns.**

### ROUTINE MAINTENANCE

#### Checks after start-up

After approximately 20 hours of operation, check that all fixing screws on the machine are still tight, plus the general state of the machine and the various electrical connections in the installation.

#### Electrical servicing

Commercially-available volatile degreasing agents can be used.

**⚠ CAUTION**

**Do not use: trichlorethylene, perchlorethylene, trichloroethane or any alkaline products.**

**⚠ WARNING**

**These operations must be performed at a cleaning station, equipped with a vacuum system that collects and flushes out the products used.**

The insulating components and the impregnation system are not at risk of damage from solvents. Avoid letting the cleaning product run into the slots.

Apply the product with a brush, sponging frequently to avoid accumulation in the housing. Dry the winding with a dry cloth. Let any traces evaporate before reassembling the machine.

#### Mechanical servicing

**⚠ CAUTION**

**Cleaning the machine using water or a high pressure washer is strictly prohibited. Any problems arising from such treatment are not covered by our warranty.**

Degreasing: Use a brush and detergent (suitable for paint work).

Dusting: Use an air gun.
If the machine is fitted with air inlet and outlet filters, the maintenance personnel should clean them routinely at regular intervals. In the case of dry dust, the filter can be cleaned using compressed air and / or replaced if it is clogged.

After cleaning the alternator, it is essential to check the winding insulation (See “CHECKS PRIOR TO FIRST USE” on page 112).

**BEARINGS**

| | |
|---|---|
| The bearings are permanently greased | Approximate life of the grease (depending on use) = 20,000 hours or 3 years. |

**MECHANICAL DEFECTS**

| | FAULT | ACTION |
|---|---|---|
| Bearing | Excessive temperature rise in one or both bearings (bearing temperature more than 80 °C) (With or without abnormal bearing noise) | - If the bearing has turned blue or if the grease has turned black, change the bearing |
| | | - Bearing not fully locked (abnormal play in the bearing cage) |
| | | - End shields incorrectly aligned |
| Abnormal temperature | Excessive temperature rise in the alternator housing (more than 40°C above the ambient temperature) | - Air flow (intake-outlet) partially clogged or hot air is being recycled from the alternator or engine |
| | | - Alternator operating at too high a voltage (> 105% of Un on load) |
| | | - Alternator overloaded |
| Vibration | Excessive vibration | - Misalignment (coupling) |
| | | - Defective mounting or play in coupling |
| | | - Rotor balancing fault (Engine - Alternator) |
| | Excessive vibration and humming noise coming from the machine | - Phase imbalance |
| | | - Stator short-circuit |
| Abnormal noise | Alternator damaged by a significant impact, followed by humming and vibration | - System short-circuit |
| | | - Mis-paralleling |
| | | Possible consequences: |
| | | - Broken or damaged coupling |
| | | - Broken or bent shaft extension |
| | | - Shifting and short-circuit of revolving field winding |
| | | - Fan fractured or coming loose on shaft |
| | | - Irreparable damage to rotating diodes/AVR, surge suppressor |

**ELECTRICAL FAULTS**

| FAULT | ACTION | EFFECT | CHECK / CAUSE |
|---|---|---|---|
| No voltage at no load on start-up | Connect a new battery of 4 to 12 volts to terminals E- and E+, respecting the polarity, for 2 to 3 seconds | The alternator builds up and its voltage is still correct when the battery is removed | - Lack of residual magnetism |
| | | The alternator builds up but its voltage does not reach the rated value when the battery is removed | - Check the connection of the voltage reference to the AVR |
| | | | - Faulty diodes |
| | | | - Armature short-circuit |
| | | The alternator builds up but its voltage disappears when the battery is removed | - Faulty AVR |
| | | | - Field windings open circuit (check winding) |
| | | | - Revolving field coil open circuit (check the resistance) |
| Voltage too low | Check the drive speed | Correct speed | Check the AVR connections (possible AVR failure) |
| | | | - Field windings short-circuited |
| | | | - Rotating diodes burnt out |
| | | | - Main field winding short-circuited<br>- Check the resistance |
| | | Speed too low | Increase the drive speed (do not touch the AVR voltage pot. (P2) before running at the correct speed) |
| Voltage too high | Adjust AVR voltage potentiometer | Adjustment ineffective | Faulty AVR |
| Voltage oscillations | Adjust the AVR stability potentiometer | If no effect: try normal or fast stability modes (ST2) | - Check the speed: possibility of cyclic irregularity |
| | | | - Loose connections |
| | | | - Faulty AVR |
| | | | - Speed too low when on load (or AVR LAM set too high) |
| Voltage correct at no load and too low when on load<br>(*) | Run at no load and check the voltage between E+ and E- on the AVR | AREP: Voltage between E+ and E-<br>= 6V < UDC < 10V | - Check the speed |
| | | SHUNT: Voltage between E+ and E-<br>= 10V < UDC < 15V | - Faulty rotating diodes |
| | | | - Short-circuit in the revolving field coil. Check the resistance. |
| | | | - Faulty exciter armature. Check the resistance. |
| (*) Warning: During single-phase operation, check that the sensing wires from the AVR are connected to the correct output terminals. | | | |
| Voltage disappears during operation<br>(**) | Check the AVR, the surge suppressor, the rotating diodes, and replace any defective components | The voltage does not return to the rated value | - Exciter winding open circuit |
| | | | - Faulty exciter armature |
| | | | - Faulty AVR |
| | | | - Revolving field coil open circuit or short-circuited |
| (**) Warning: The AVR internal protection may cut in (overload lost connection, short circuit). | | | |

**Checking the winding**

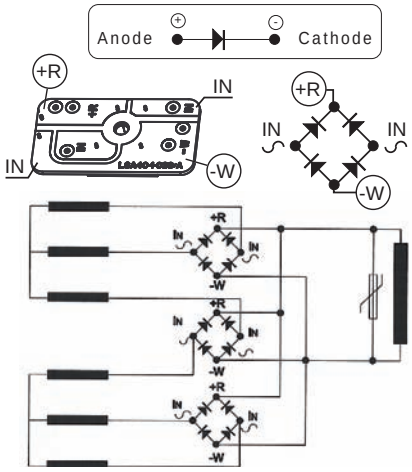
You can check the winding insulation by performing a high voltage test. In this case, you must disconnect all AVR wires.

**CAUTION**

**Damage caused to the AVR in such conditions is not covered by our warranty.**

**Checking the diode bridge**

A diode in good working order should allow the current to flow only in the anode to cathode direction.




**Checking the windings and rotating diodes using separate excitation**

**WARNING**

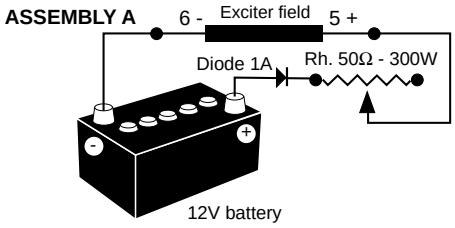
**During this procedure, make sure that the alternator is disconnected from any external load and inspect the terminal box to check that the connections are fully tightened.**

1. Stop the unit, disconnect and isolate the AVR wires.

2. There are two ways of creating an assembly with separate excitation.

**Assembly A:** Connect a 12 V battery in series with a rheostat of approximately 50 ohms - 300 W and a diode on both exciter field wires (5+) and (6-).

**Assembly A**



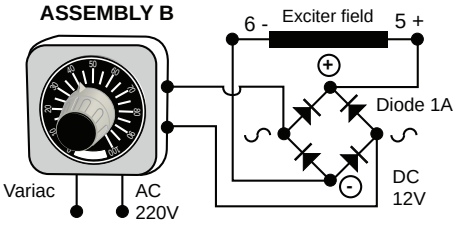

**Assembly B:** Connect a “Variac” variable power supply and a diode bridge on both exciter field wires (5+) and (6-).

Both these systems should have characteristics which are compatible with the field excitation power of the machine (see the nameplate).

3. Run the unit at its rated speed.

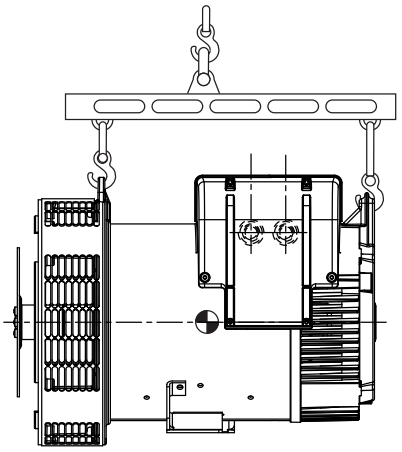
4. Gradually increase the exciter field current by adjusting the rheostat or the variac and measure the output voltages on L1 - L2 - L3, checking the excitation voltage and current at no load (see the machine nameplate or ask for the factory test report). When the output voltage is at its rated value and balanced within 1% for the rated excitation level, the machine is in good working order. The fault therefore comes from the AVR or its associated wiring (i.e. sensing, auxiliary windings).

**Assembly B**



**⚠ CAUTION**

**During the warranty period, this operation should only be carried out in an LEROY-SOMER approved workshop or in our factory, otherwise the warranty may be invalidated. Whilst being handled, the machine should remain horizontal (rotor not locked in position). Check how much the machine weighs before choosing the lifting method.**



**Tools required**

To fully dismantle the machine, we recommend using the tools listed below:

- 1 ratchet spanner + extension
- 1 torque wrench
- 1 set of flat spanners: 8 mm, 10 mm, 18 mm -1 socket set: 8, 10, 13, 16, 18, 21, 24, 30 mm
- 1 socket with male ferrule: 5 mm
- 1 puller

**Screw tightening torque**

See pages 124 and 125.

**⚠ CAUTION**

**The screws for fixing the feet on the housing and immobilising the stator must not be removed (bolt of the stator lower).**

**Access to connections and the regulation system**

The terminals and AVR are accessed directly by removing the terminal box lid (41).

AVR is accessed directly by removing the terminal box lid

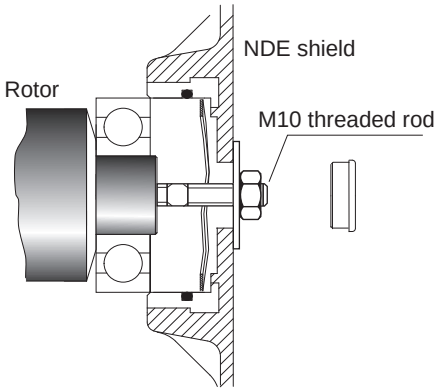
**Accessing, checking and replacing the diode bridge**

**Dismantling**

- Remove the terminal box lid [41].
- Cut the fixing clamps of the exciter cables, disconnect E+, E- from the exciter.
- Remove the 4 nuts on the tie rods.
- Remove the NDE shield [36] using a puller: e.g. U.32 - 350 (Facom).
- Unsolder the connections.
- Check the bridge using an ohmmeter or a battery lamp.

**Reassembly**

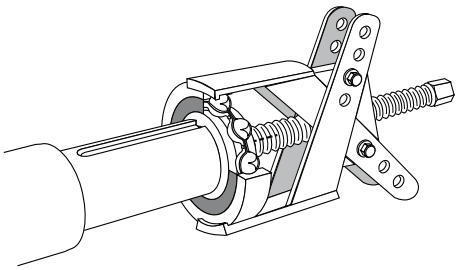
- Replace the bridges, respecting the polarity.
- Resolder the connections.
- Fit a new O ring seal in the shield.
- Refit the NDE shield and pass the bundle of wires between the top bars of the shield.
- Replace the fixing clamps on the cables.
- Replace the terminal box lid [41].



**Replacing the NDE bearing on single-bearing machines**

**Dismantling**

- Remove the NDE shield [36].
- Remove the ball bearing [70] using a screw puller.



**Reassembly**

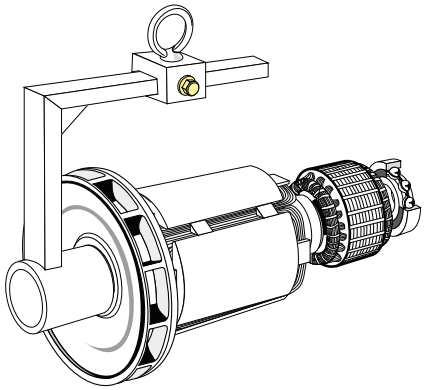
- Heat the inner slip ring of a new bearing by induction or in a drying oven at 80 °C (do not use an oil bath) and fit it to the alternator.
- Place the preloading wavy washer [79] in the flange and fit a new O ring seal [349].
- Replace the NDE bracket [36].

**Accessing the main field and stator**

**Dismantling**

Follow the procedure for dismantling bearings.

- Remove the coupling discs (single-bearing alternator) or the DE flange (two-bearing alternator) and insert a tube of the corresponding diameter on the shaft end or a support made according the following bellow.



- Rest the rotor on one of its poles, then slide it out. Use the tube as a lever arm to assist dismantling.
- After extraction, be careful with the fan. It is necessary to replace the fan in case of disassembling.
- After extracting the rotor, be careful not to damage the fan and place the revolving field on special V-blocks.

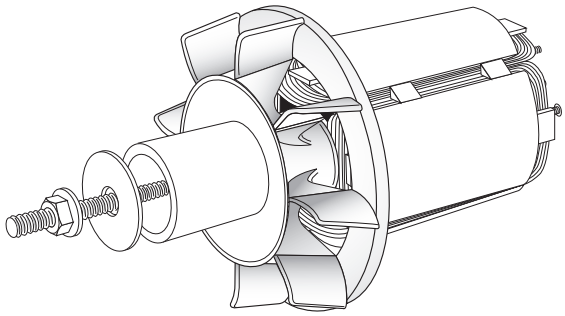
**NOTE: If intervention is required on the main field (rewinding, replacement of components), the rotor assembly must be rebalanced.**

**Reassembly**

- Follow the dismantling procedure in reverse order.

Take care not to knock the windings when refitting the rotor in the stator.

If you replace the fan, respect the assembly guide according the following bellow. Use a tube and a screw.



Follow the procedure for reassembling the bearings.

**TABLE OF CHARACTERISTICS**
**TAL 44, TAL 46**

Table of average values: Alternator - 4 pole - 50 Hz - Winding No. M/ M1 (4-wire) - no. 6S (6-wire) - no. 6 (12-wire) The voltage and current values are given for no-load operation and operation at rated load with separate field excitation. All values are given at ± 10% (for exact values, consult the test report) and are subject to change without prior warning.

**Three-phase: 4-pole, SHUNT excitation 6 and 12 wire Resistances at 20 °C (Ω)**

| Type | Stator L/N | Rotor | Exciter Field | Exciter Armature |
|---|---|---|---|---|
| **(G80) TAL44-C** | 0.050 | 2.35 | 11.65 | 0.790 |
| **(G100, G115) TAL44-E** | 0.034 | 2.89 | 12.94 | 0.920 |
| **(G135, G150) TAL44-J** | 0.029 | 3.15 | 12.94 | 0.920 |
| **(G170) TAL46-A** | 0.023 | 0.51 | 10.01 | 0.1001 |
| **(G200) TAL46-B** | 0.023 | 0.51 | 10.01 | 0.1001 |
| **(G225) TAL46-C** | 0.020 | 0.54 | 10.01 | 0.1001 |

**Field excitation current i exc (A)**
**400V - 50 Hz**

“i exc”: excitation current of the exciter field

| Type | No Load | At Rated Load |
|---|---|---|
| **(G80) TAL44-C** | 0.8 | 2.75 |
| **(G100, G115) TAL44-E** | 0.67 | 2.57 |
| **(G135, G150) TAL44-J** | 0.66 | 2.79 |
| **(G170) TAL46-A** | 0.95 | 3.40 |
| **(G200) TAL46-B** | 0.95 | 3.72 |
| **(G225) TAL46-C** | 1.01 | 3.84 |

**For 60 Hz machines, the "i exc" values are approximately 5 to 10% lower.**

**Table of weights (values given for information only)**

| Type | Total weight (kg) | Rotor (kg) |
|---|---|---|
| **(G80) TAL44-C** | 295 | 127 |
| **(G100, G115) TAL44-E** | 368 | 160 |
| **(G135, G150) TAL44-J** | 398 | 172 |
| **(G170) TAL46-A** | 569 | 243 |
| **(G200) TAL46-B** | 599 | 243 |
| **(G225) TAL46-C** | 674 | 255 |

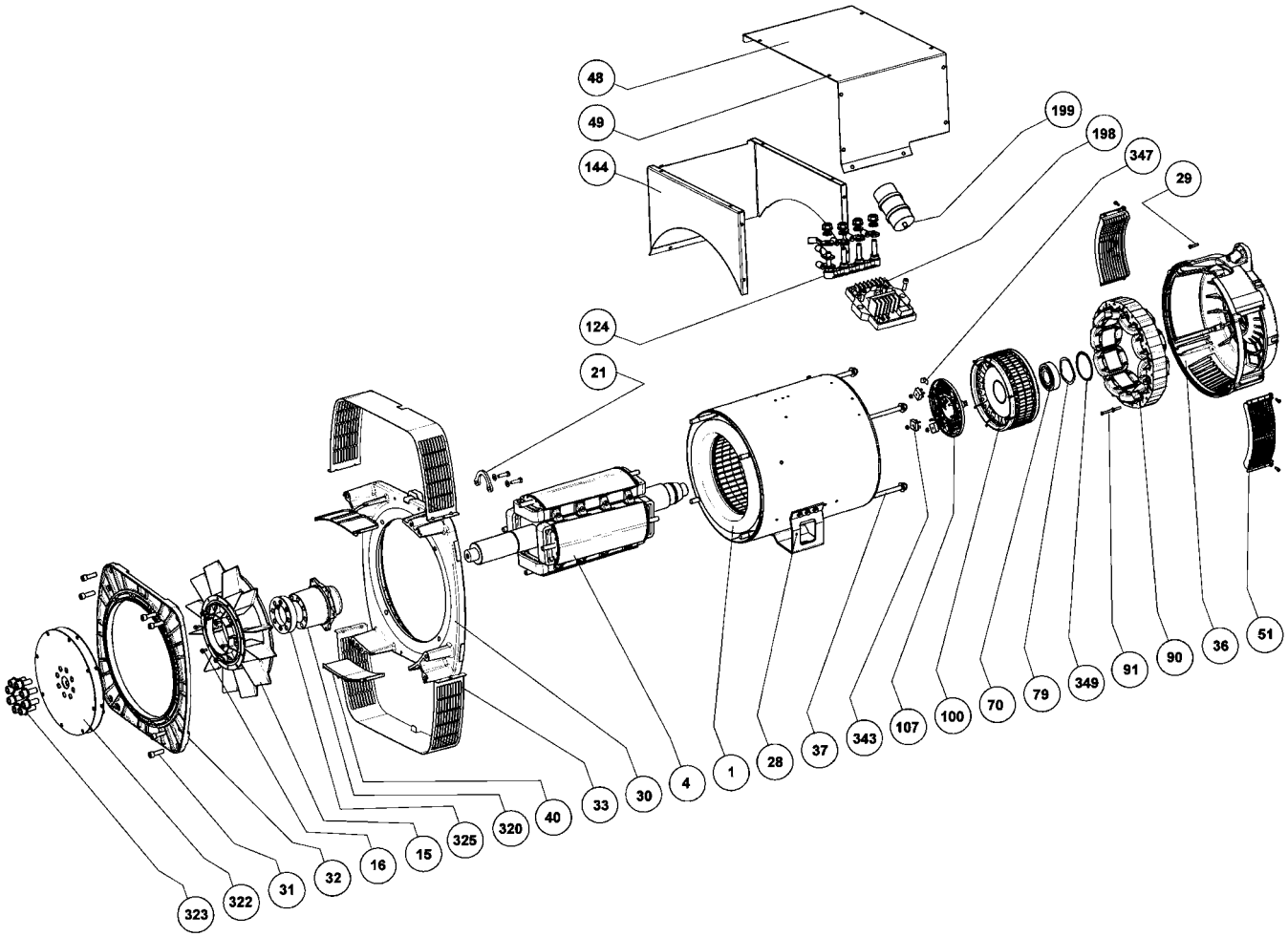

Portable Power

# ALTERNATORS COMPONENTS

**CONTENTS**

## TAL44 SINGLE (SEE  ON PAGE 124.) SHUNT

## EXPLODED VIEW, PARTS LIST AND TIGHTENING TORQUE

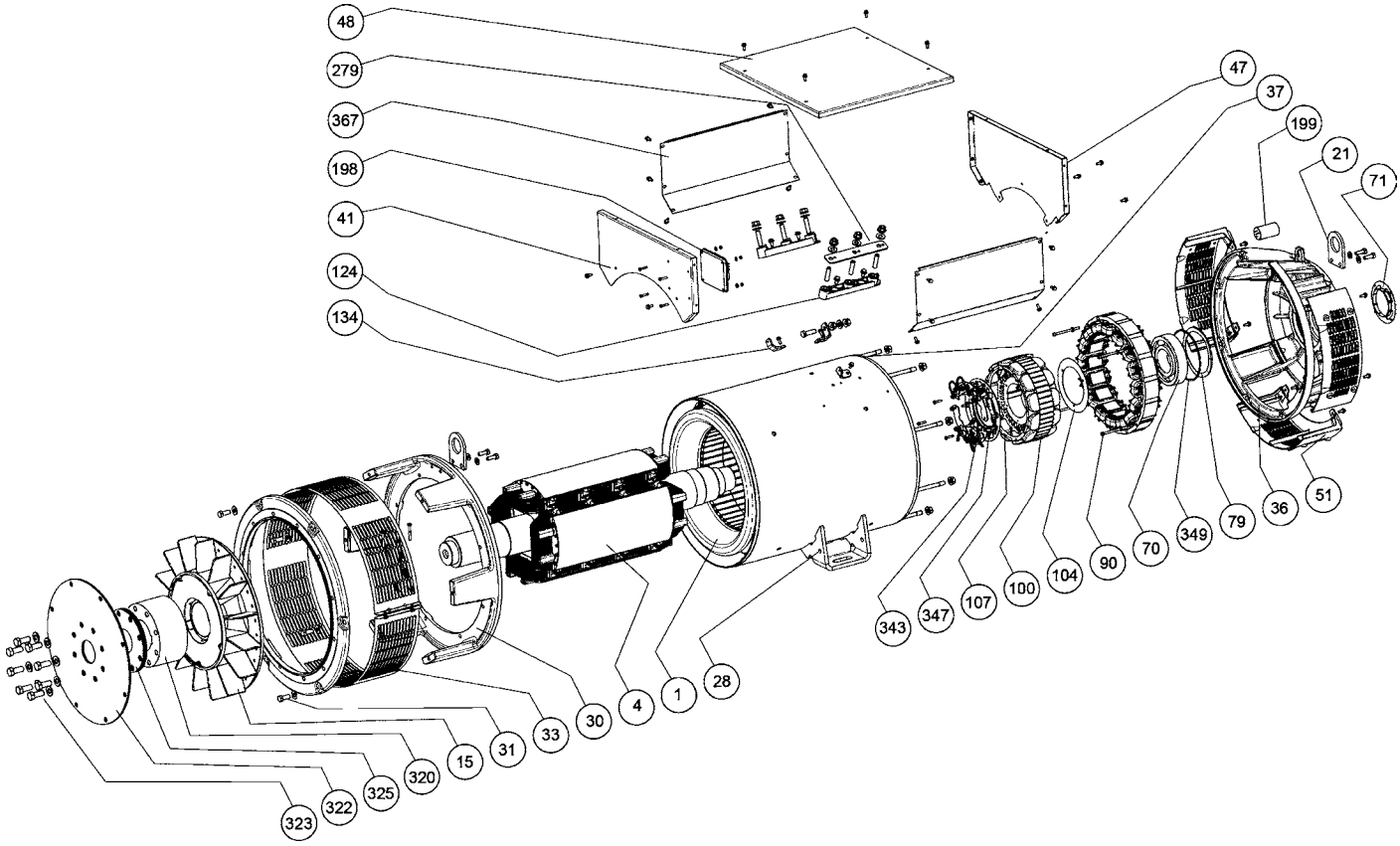



| REF. | QTY | DESCRIPTION | SCREW Ø | TORQUE N.m. | REF. | QTY | DESCRIPTION | SCREW Ø | TORQUE N.m. |
|---|---|---|---|---|---|---|---|---|---|
| **1** | 1 | Stator assembly | - | - | **70** | 1 | NDE bearing | - | - |
| **4** | 1 | Rotor assembly | - | - | **79** | 1 | Preloading (wavy) washer | - | - |
| **15** | 1 | Fan | - | - | **90** | 1 | Exciter field (stator) | - | - |
| **16** | 6 | Fixing bolts | M6 | 5 | **91** | 4 | Fixing bolts | M6 | 10 |
| **21** | 1 | Lifting eye (only with TAL 044 L and M) | M10 | 40 | **100** | 1 | Exciter armature (rotor) | - | - |
| **28** | 1 | Earth terminal | M6* | 10** | **107** | 1 | Diode support ring | M5 | 6 |
| **29** | 1 | Earth continuity bolts | M6 | 10 | **124** | | Terminal block | M6 | 6 |
| **30** | 1 | Drive end (DE) shield | - | - | **144** | 1 | Terminal box | - | - |
| **31** | 8 | Fixing bolts | M12 | 69 | **198** | 1 | Voltage regulator (AVR) | M5 | 3.6 |
| **32** | 1 | S.A.E. adaptor ring | - | - | **199** | 1 | Interference suppression module (RFI kit) | M5 | 6 |
| **33** | 2 | Protective guard | M6 | 6 | **320** | 1 | Coupling sleeve | - | - |
| **36** | 1 | Non drive end (NDE) shield | - | - | **322** | 2 | Coupling discs | - | - |
| **37** | 4 | Tie rod | M14 | 90*** | **323** | 8 | Fixing bolts | M16 | 320 |
| **40** | 2 | Plastic cover (except with TAL 044 L and M) | - | - | **325** | - | Spacer shims | - | - |
| **48** | 1 | Terminal box lid | M6 | 8 | **343** | 3 | Diode bridge assembly | M5 | 3 |
| **49** | 1 | Terminal box bolts | M6 | 8 | **347** | 1 | Surge suppressor (+ PCB) | M6 | 4 |
| **51** | 1 | Air intake guard | M6 | 3.6 | **349** | 1 | O-ring seal | - | - |

* M12 (only with TAL 044 L and M)  ** 69 N.m (only with TAL 044 L and M)  ***130 N.m (only with TAL 044 L and M)

## TAL46 SINGLE BEARING SHUNT

## EXPLODED VIEW, PARTS LIST AND TIGHTENING TORQUE




| REF. | QTY | DESCRIPTION | SCREW Ø | TORQUE N.m. | REF. | QTY | DESCRIPTION | SCREW Ø | TORQUE N.m. |
|---|---|---|---|---|---|---|---|---|---|
| **1** | 1 | Stator assembly | - | - | **90** | 1 | Exciter field (stator) | - | - |
| **4** | 1 | Rotor assembly | - | - | **100** | 1 | Exciter armature (rotor) | - | - |
| **15** | 1 | Fan | - | - | **104** | 1 | Washer | - | - |
| **21** | 1 | Lifting eye | M10 | 40 | **107** | 1 | Diode support ring | - | - |
| **28** | 1 | Earth terminal | M10 | 24 | **124** | 1 | Terminal block | M12 | 20 |
| **30** | 1 | Drive end (DE) shield | - | - | **134** | 1 | Panel fixing | M6 | 10 |
| **31** | 6 | Fixing bolts | - | - | **198** | 1 | Voltage regulator (AVR) | - | - |
| **33** | 1 | Protective guard | M6 | 6 | **199** | 1 | Interference suppression module (RFI kit) | - | - |
| **36** | 1 | Non drive end (NDE) shield | M12 | 75 | **279** | 6 / 8 | Connection bar | - | - |
| **37** | 8 | Tie rod | - | - | **320** | 1 | Coupling sleeve | - | - |
| **41** | 1 | Terminal box front panel | M6 | 8 | **322** | 3 | Coupling discs | - | - |
| **47** | 1 | NDE terminal box seal | M6 | 8 | **323** | 6 | Fixing bolts | M16 | 170 |
| **48** | 1 | Terminal box lid | M6 | 8 | **325** | - | Spacer shims | - | - |
| **51** | 1 | Air intake guard | M6 | 8 | **343** | 1 | Diode bridge assembly | M6 | 4 |
| **70** | 1 | Non drive end (NDE) shield | - | - | **347** | 1 | Surge suppressor (+ PCB) | - | - |
| **71** | 1 | Outer bearing retainer | - | - | **349** | 1 | O-ring seal | - | - |
| **79** | 1 | Preloading (wavy) washer | - | - | **367** | 2 | Terminal box side panel | M6 | 8 |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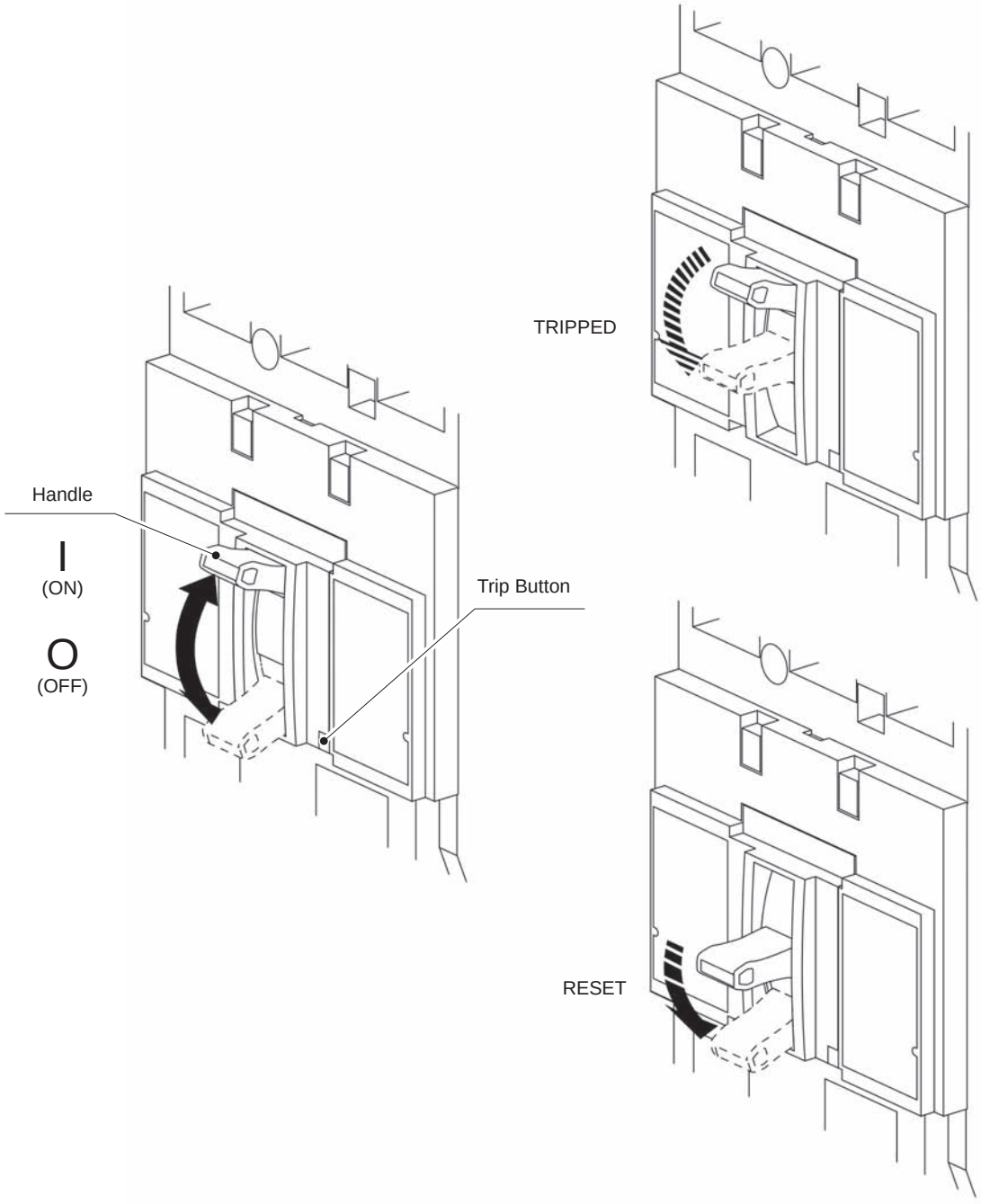
# MAIN BREAKER OPERATION

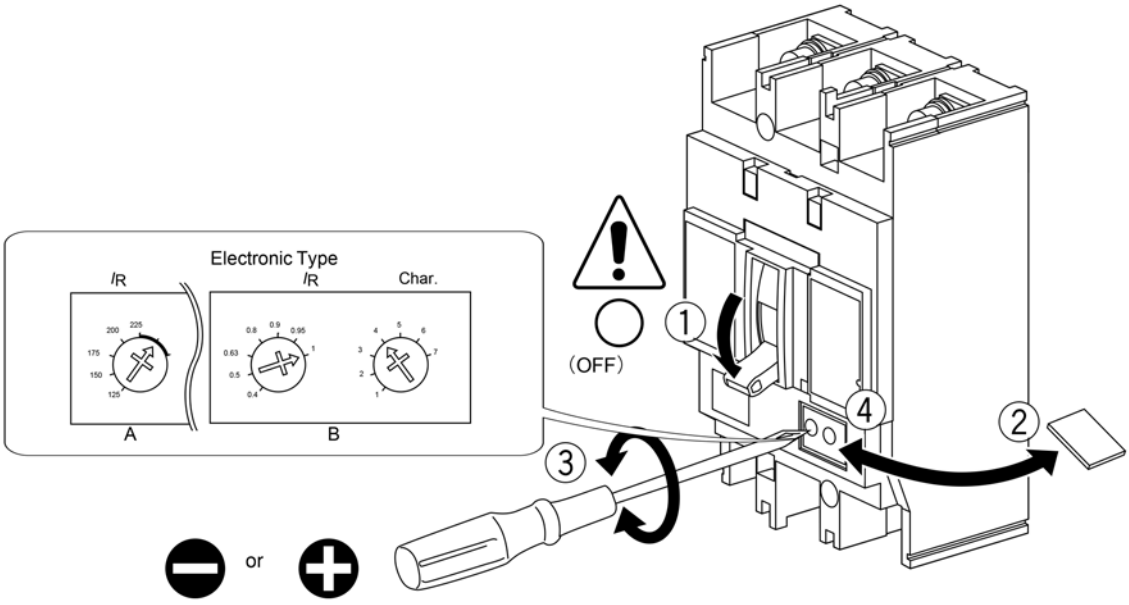
**CONTENTS**




| | Operation | Operation effort |
|---|---|---|
| S160 - S250 | ○ (OFF)⇒ \| (ON) | 22N |
| | \| (ON)⇒ ○ (OFF) | 110N |
| | TRIP⇒ ○ (OFF) | 28N |
| S400 | ○ (OFF)⇒ \| (ON) | 68N |
| | \| (ON)⇒ ○ (OFF) | 115N |
| | TRIP⇒ ○ (OFF) | 125N |

## BREAKER ADJUSTING INSTRUCTIONS

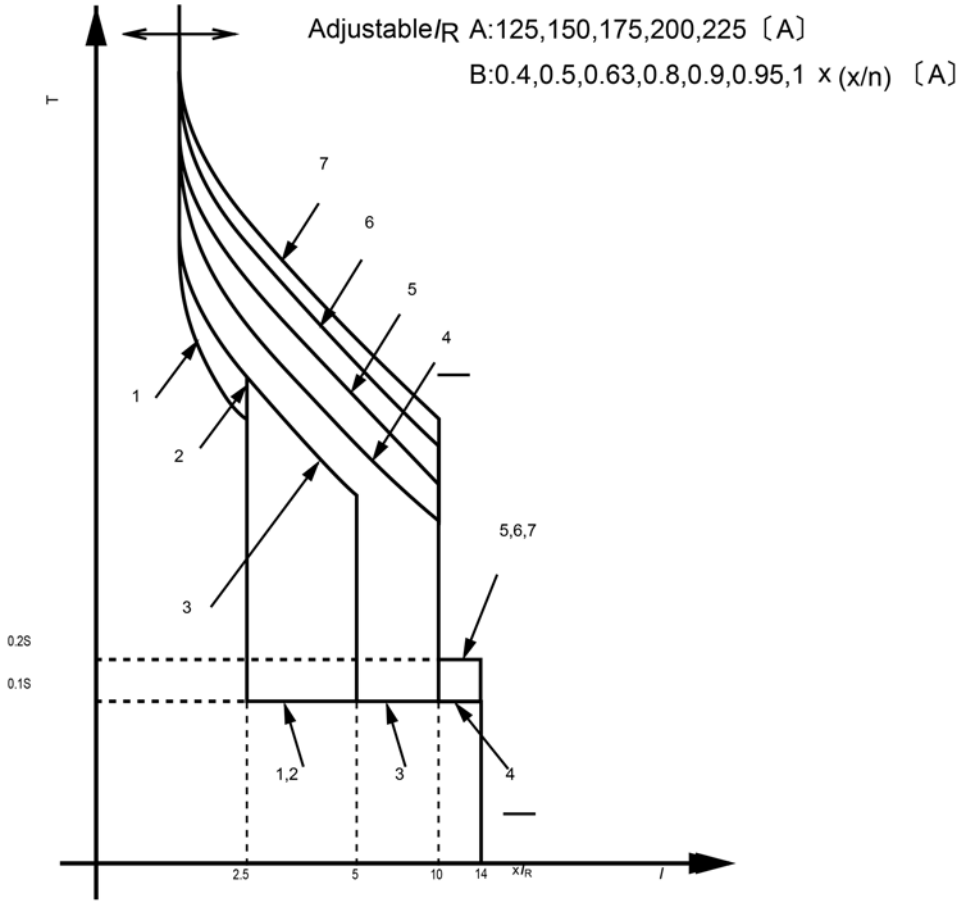
### ELECTRONIC TYPE: S150 TO S250 SERIES




### TIME / CURRENT CHARACTERISTIC CURVES

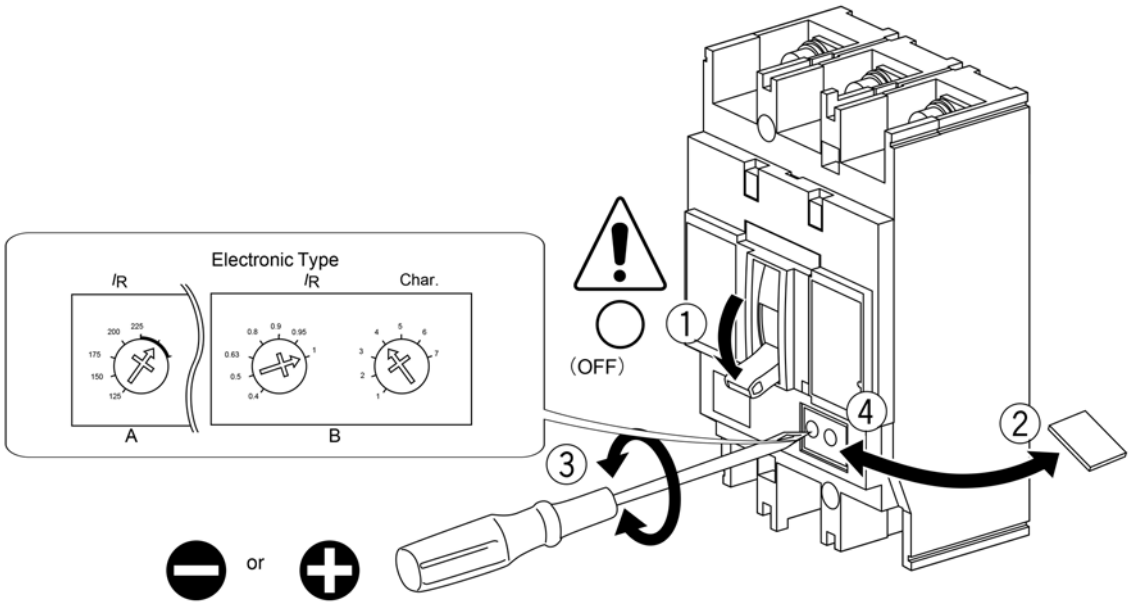
Under bar is default setting.

Electronic Type



## BREAKER ADJUSTING INSTRUCTIONS

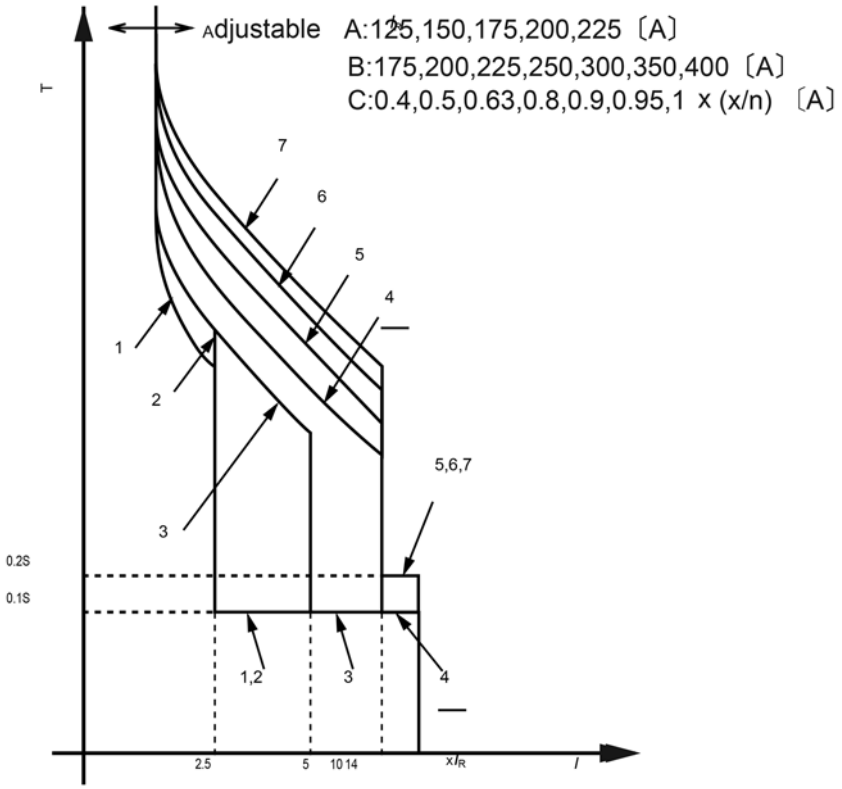
### ELECTRONIC TYPE: S400 AND S600 SERIES



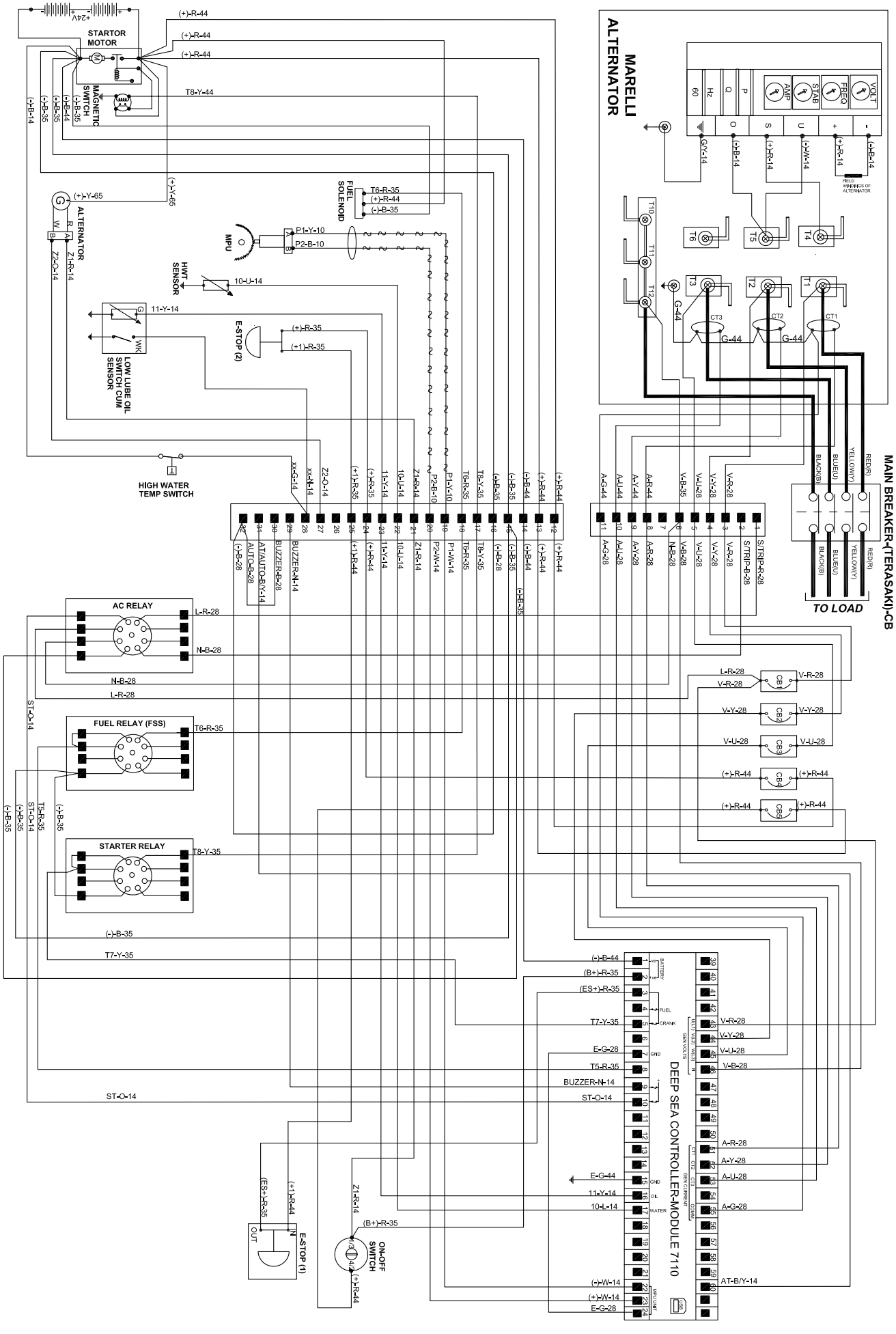

### TIME / CURRENT CHARACTERISTIC CURVES

Under bar is default setting.

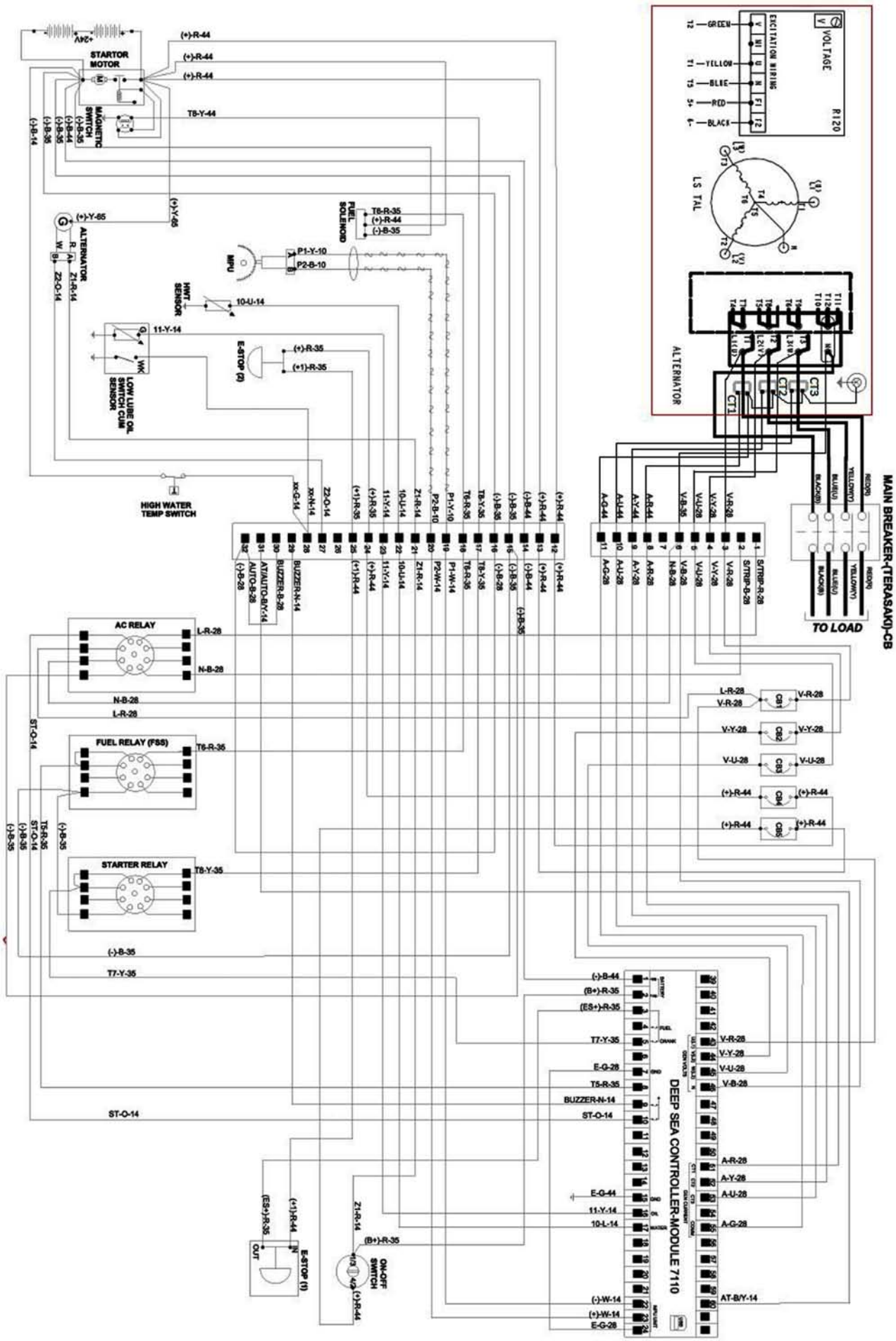
Electronic Type



# WIRING DIAGRAM - MARELLI



## WIRING DIAGRAM - LS TAL

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