Carrier TRANSICOLD

Diesel Generator Set

OPERATIONS AND SERVICE MANUAL

For

69UG15

PowerLINE® Series 24 Genset Units

PID UG2400 to 2499

T-382 Rev B

Carrier
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Safety

1.1 General Safety Notices

Installation and servicing of generator set equipment can be hazardous due to system belts, radiator fan, and electrical components. Only trained and qualified service personnel should install, repair, or service generator set equipment. When working on generator set equipment, observe all potential Danger, Warning and Caution hazards, including those shown below and on hazard labels attached to the unit.

The following general safety notices supplement specific warnings and cautions appearing elsewhere in this manual. They are recommended precautions that must be understood and applied during operation and maintenance of the equipment covered herein. The general safety notices are presented in the following three sections labeled: First Aid, Operating Precautions and Maintenance Precautions. A listing of the specific warnings and cautions appearing elsewhere in the manual follows the general safety notices.

1.2 First Aid

An injury, no matter how slight, should never go unattended. Always obtain first aid or medical attention immediately.

1.3 Operating Precautions

- Wear proper service attire when performing work. Do not wear loose clothing as they could get caught on machine components.
- Wear the proper protective equipment when working around the machine, including safety glasses and hearing protection.
- Keep hands, clothing and tools clear of the radiator fan and rotating belts.
- No work should be performed on the unit until all circuit breakers and start-stop switches are turned off and the negative battery terminal has been disconnected.
- Always work in pairs. Never work on the equipment alone.
- In case of severe vibration or unusual noise, stop the unit and investigate.

1.4 Maintenance Precautions

1.4.1 Electrical

- Do not bypass any electrical safety devices, e.g. bridging an overload, or using any sort of jumper wires. Problems with the system should be diagnosed, and any necessary repairs performed, by qualified service personnel.
- In case of an electrical fire, open the circuit switch and extinguish with CO2 (never use water).
- This unit is equipped with a lead-acid type battery. The battery normally vents small amounts of flammable hydrogen gas. Do not smoke when checking the battery. A battery explosion can cause serious physical harm and/or blindness.
- Be sure power is turned off and the negative battery cable is disconnected before working on a generator set.
- Keep the electrolyte away from your eyes, hands, and clothes. Sulfuric acid in the battery electrolyte is poisonous: it can cause blindness and is strong enough to burn your skin and clothing. If you spill electrolyte on yourself, clean yourself with water and get medical aid immediately.

1.4.2 Exhaust

- Exhaust gas and components are extremely hot during operation. Avoid skin exposure and contact with hot exhaust gas or components.
- Do not work immediately after stopping the engine. The engine, muffler, radiator, and hydraulic components are extremely hot.

1.4.3 Fluids

- The engine is equipped with a pressurized cooling system. Under normal operating conditions, the coolant in the engine and radiator is under high pressure and is very hot. Contact with hot coolant can cause severe burns. Do not remove the cap from a hot radiator. If the cap must be removed, do so very slowly in order to release the pressure without spray.
- Fuel tanks present explosion, fire, and rupture hazards even if liquid fuel has been drained. Do not attempt any repairs, especially repairs using flame, welder or torch, unless you have been properly trained and the tank has been emptied of liquid fuel and fuel vapors and the tank is properly ventilated.
- Keep fire (welding sparks, grinding sparks, cigarettes) away from the fuel.
- Wipe off the fuel when spilled.
- Keep away from high pressure fluids bursting from a hose or pipe. The fluid can penetrate your skin and cause serious injuries.
- Release residual pressure in the hydraulic circuit before removing the hydraulic components. Pay attention because the machine or attachment may move unexpectedly.
- Do not remove caps and plugs soon after stopping the engine. The temperature and pressure of the coolant, hydraulic oil, and fuel are still high.
- Protective goggles must be worn when checking for fuel discharge from the supply pump outlet, as fuel may be discharged.
- Prior to disconnecting a high pressure pipe, stop the engine and wait at least 5 minutes.

1.5 Specific Hazard Statements

To help identify the hazard labels on the unit and explain the level of awareness each one carries, explanations with appropriate consequences are provided below:

DANGER - Indicates an immediate hazard which WILL result in severe personal injury or death.

WARNING - Indicates hazards or unsafe conditions which COULD result in severe personal injury or death.

CAUTION - Indicates potential hazards or unsafe practices which COULD result in minor personal injury, product, or property damage.

The statements that follow are applicable to the generator set and appear elsewhere in this manual. These recommended precautions must be understood and applied during operation and maintenance of the equipment covered herein.

⚠ WARNING

To prevent injury, the procedures provided for installation and removal of the generator set must be followed carefully.

⚠ WARNING

Disconnect the power plug before removing the generator set.

⚠ WARNING

Beware of moving fan belt, belt driven components and hot exhaust components.

⚠ WARNING

Under no circumstances should ether or any other unauthorized starting aids be used in conjunction with the air intake heater.

⚠ WARNING

Beware of pinch points.

⚠ WARNING

Do not use gasoline to clean air cleaner parts.

⚠ WARNING

Make sure the engine is cooled down enough before removing the oil pressure switch. Be careful when removing the oil pressure switch as engine oil will flow out.

⚠ CAUTION

Prior to first use of the genset, ensure all shipping packaging and debris is removed and discarded.

⚠ CAUTION

Observe proper polarity when installing the battery or connecting a battery charger. The negative battery terminal must be grounded. Reverse polarity may damage the charging system. When charging the battery in unit, isolate the battery by disconnecting the negative battery terminal first, then the positive. Once the battery has been charged, connect the positive battery terminal first, then the negative.

⚠ CAUTION

Do not pre-fill a new replaced fuel filter prior to installation. This can damage the engine's fuel injectors.

⚠ CAUTION

Never pour cold water into a hot engine.

⚠ CAUTION

Use only ethylene glycol anti-freeze (with inhibitors) in system. Using glycol by itself will damage the cooling system.

⚠ CAUTION

Always cover the engine inlet tube while the air cleaner is being serviced.

⚠ CAUTION

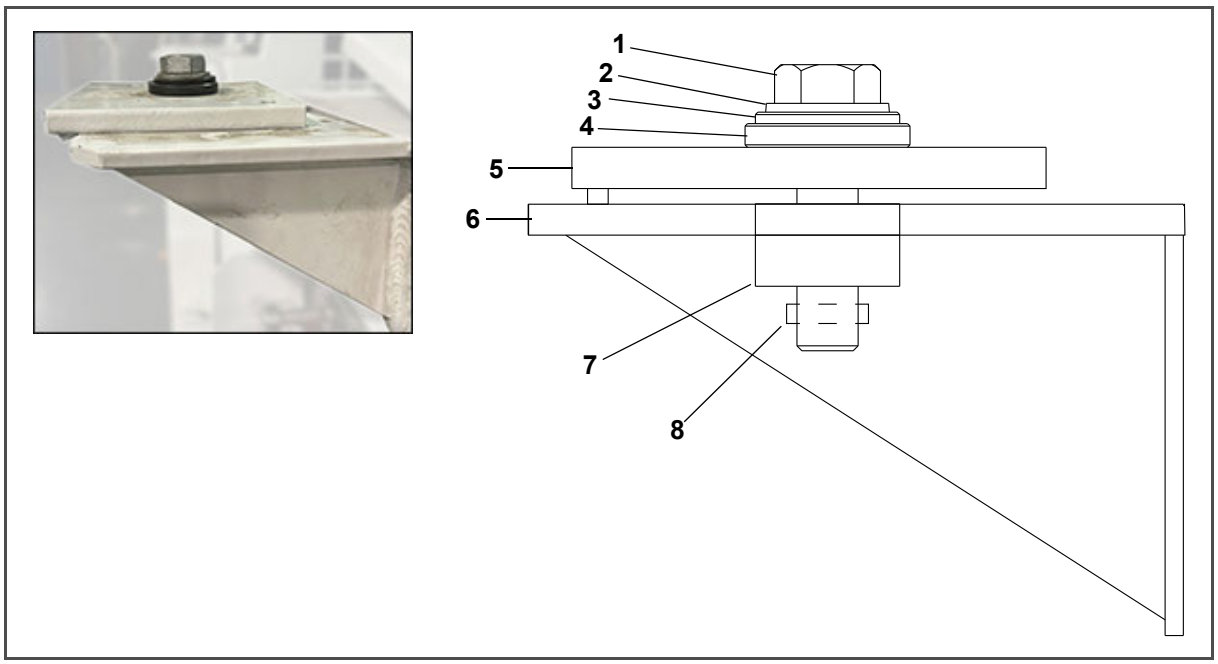
Continued operation with failed shockmounts may result in engine or generator damage. When a shockmount has been cut, split, abraded or has flared due to normal deterioration, it must be replaced. Damage to the mounts may not be visible when installed and under load from the component. To correctly inspect shockmounts, they must be removed.

Section 2
Installation and Removal

2.1 Installation

The generator set is mounted under the center of the trailer chassis and is easily handled with a fork lift truck capable of handling 3,000 pounds. The fork lift pockets provided are accessible from either side. Mounting clamps, shown in **Figure 2.1**, are designed to be attached to outside I-beam flanges only. Maximum chassis width is 38 inches on center.

Figure 2.1 Standard Mounting Clamp Hardware



1) Mounting Bolt
2) Washer, Spherical
3) Washer, Spherical, Male
4) Washer, Spherical, Female
5) Mounting Plate
6) Generator Frame
7) Tee Nut
8) Roll Pin

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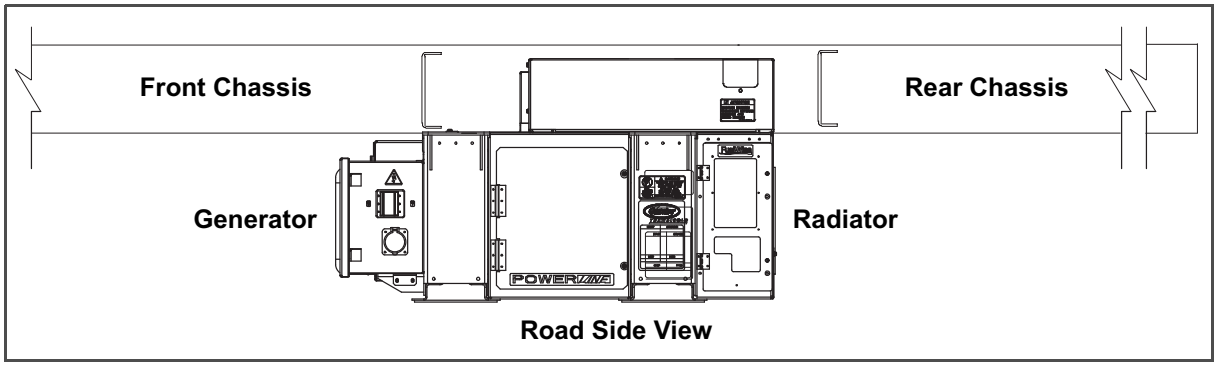
Procedure:

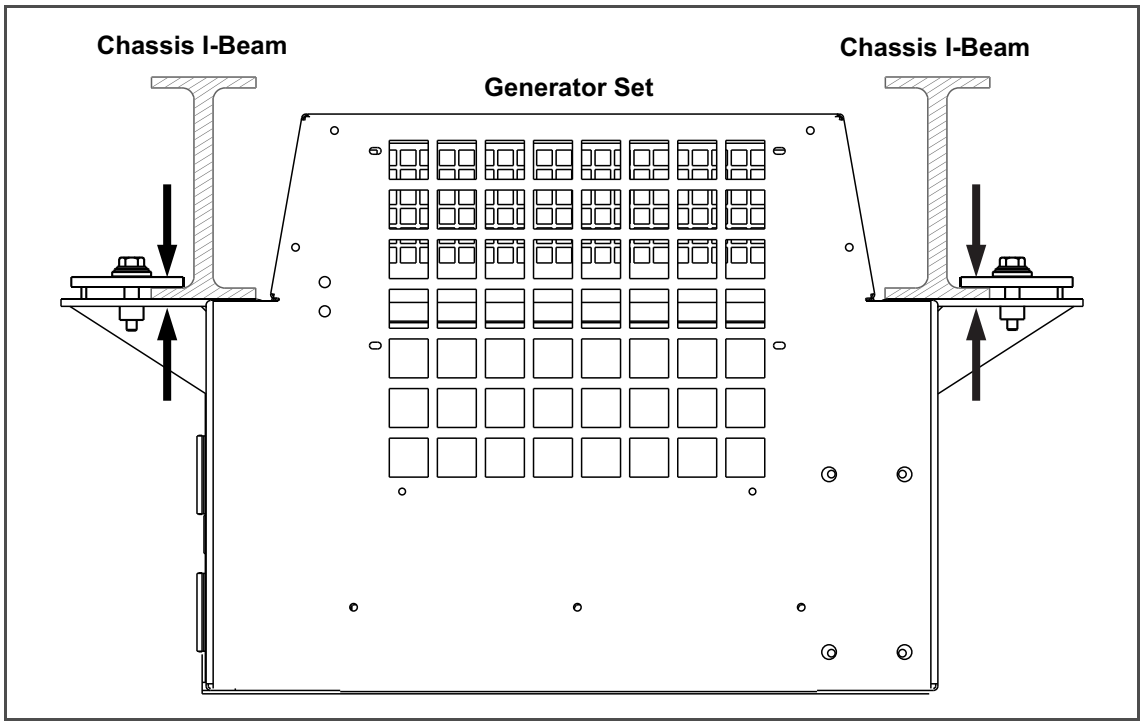
1. Inspect hardware, **Figure 2.1**, to ensure all items are not damaged and in place. It is recommended to use Carrier provided hardware.

   NOTE: Mounting bolts are Grade 5 steel with 3/4-10 UNC-2A threads.

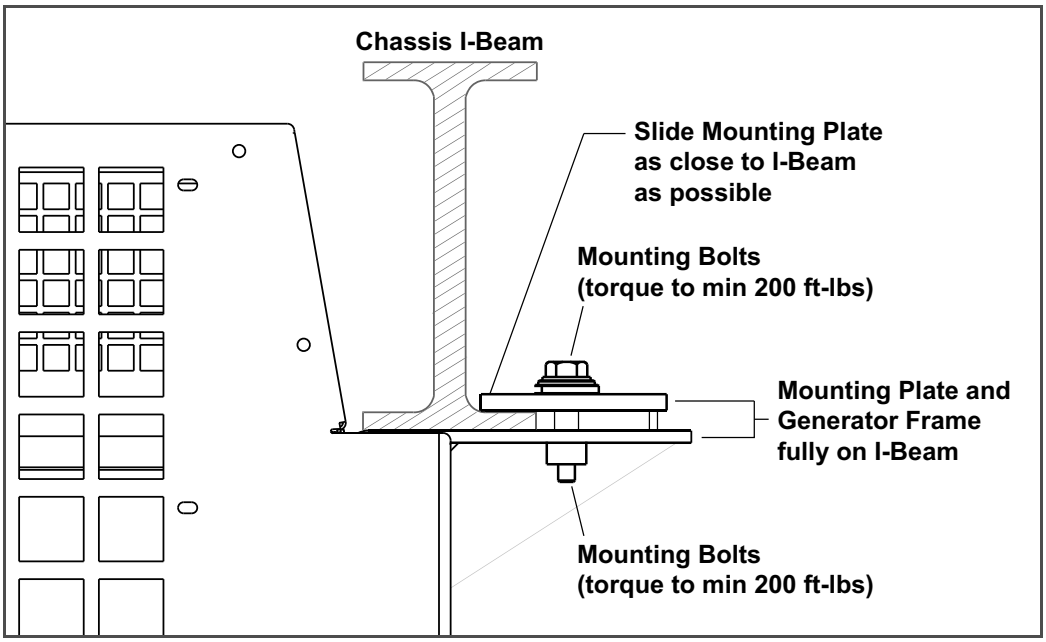
2. Loosen the mounting bolts enough to push the mounting plates to the outermost position.
3. Place forks into the fork lift pockets of the generator set.
4. Using the fork truck, center the generator set under the chassis between the rails.



5. Lift the forks up so that both sides of the generator set mounts are touching the chassis I-beam.



6. Slide the mounting plates fully onto the chassis I-beams and torque mounting bolts to a minimum of 200 ft-lbs (271 Nm), in a cross pattern. The torque range is 200 to 260 ft-lbs. (271 to 352 Nm).



⚠ WARNING

Mis-alignment with the chassis and generator set mount may result in a false torque.

⚠ WARNING

If a bolt is heavily corroded, spray the hardware with a corrosive cleaner with lubricant.

7. Back the fork truck from the unit, removing the forks from the unit.
8. Perform a torque check on all four mounting bolts with the fork truck removed. Minimum of 200 ft-lbs.

NOTE: It is important to ensure the forklift is removed when checking torque on the genset. Keeping the forklift installed can cause a false torque reading due to the forks holding the unit down, possibly resulting in the unit not being properly secured to the chassis.

If the genset is removed for PM or service, it is recommended that the hardware be sprayed with a rust inhibiting lubricant prior to re-installation. Additionally, the tool used to check torque should be periodically checked for accuracy.

2.2 Removal

1. Disconnect the power cable to the generator set (if connected).
2. With a fork lift in position and safety chain attached, slide the mounting plates back sufficiently to clear the chassis.
3. Lower and remove the generator set.

Section 3
Description

3.1 Introduction

The Carrier Transicold model 69UG15 Series 24 diesel-driven generator set provides a constant electrical power supply for all-electric refrigeration units. The 69UG15 generator set is an under-mounted unit secured to the frame rails of the container trailer chassis.

The generator set consists of a diesel engine directly connected to an alternating current generator and mounted in a structural steel frame. The engine is a vertical, in-line, four cylinder diesel manufactured by Kubota. The generator is a 15 kW, permanent, single winding, dual bearing type that supplies nominal 50/60Hz power.

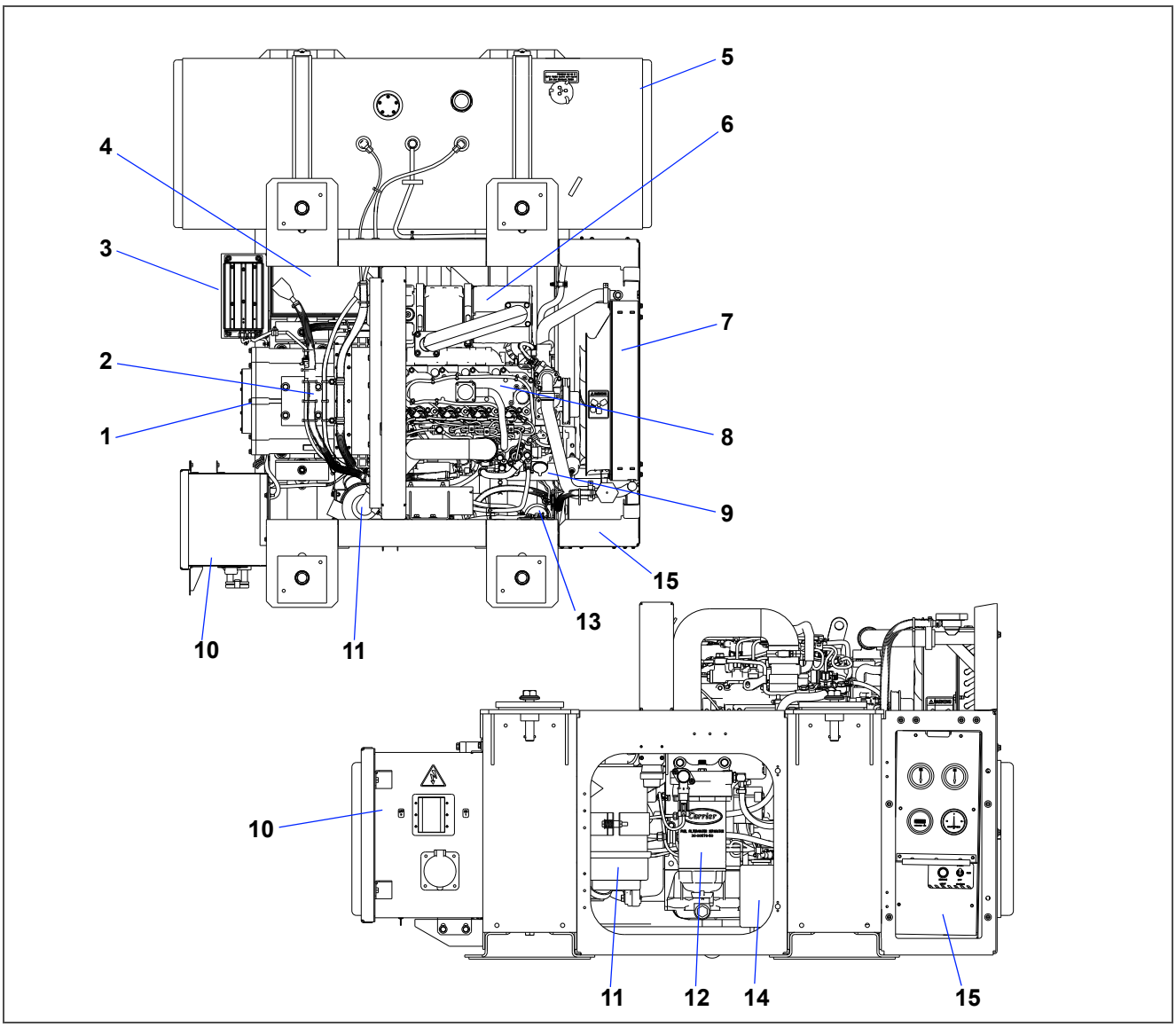
Electrical controls are mounted in a control box with operating controls and gauges mounted on a control panel, which also serves as the control box cover. The control panel components are protected by a deflector assembly and control box door.

See **Figure 3.1** and **Figure 3.2** for component locations.

Figure 3.1 Generator Set

1) Standard Mounts
2) Power Cord Receptacle Cover
3) Unit Nameplate (Model, Serial, PID)
4) Access Door
5) Control Box / Control Panel
6) Fuel Tank

Figure 3.2 Generator Set - Covers Removed



1) AC Generator
2) Voltage Controller
3) Battery Charger
4) Battery
5) Fuel Tank
6) Exhaust (DOC)
7) Radiator
8) Engine
9) Oil Filter
10) Receptacle Box
11) Engine Air Cleaner / Air Filter
12) Fuel Filter / Water Separator
13) Pre-Filter Fuel Pump
14) Coolant Recovery Bottle
15) Control Panel and Control Box

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3.2 Configuration Identification

Generator set identification information is provided on a unit nameplate located on the side of the unit. The label provides the generator set model number, serial number and parts identification number (PID). The model number identifies the overall configuration, while the PID provides information on specific optional equipment and differences in detailed parts.

Carrier TRANSICOLD

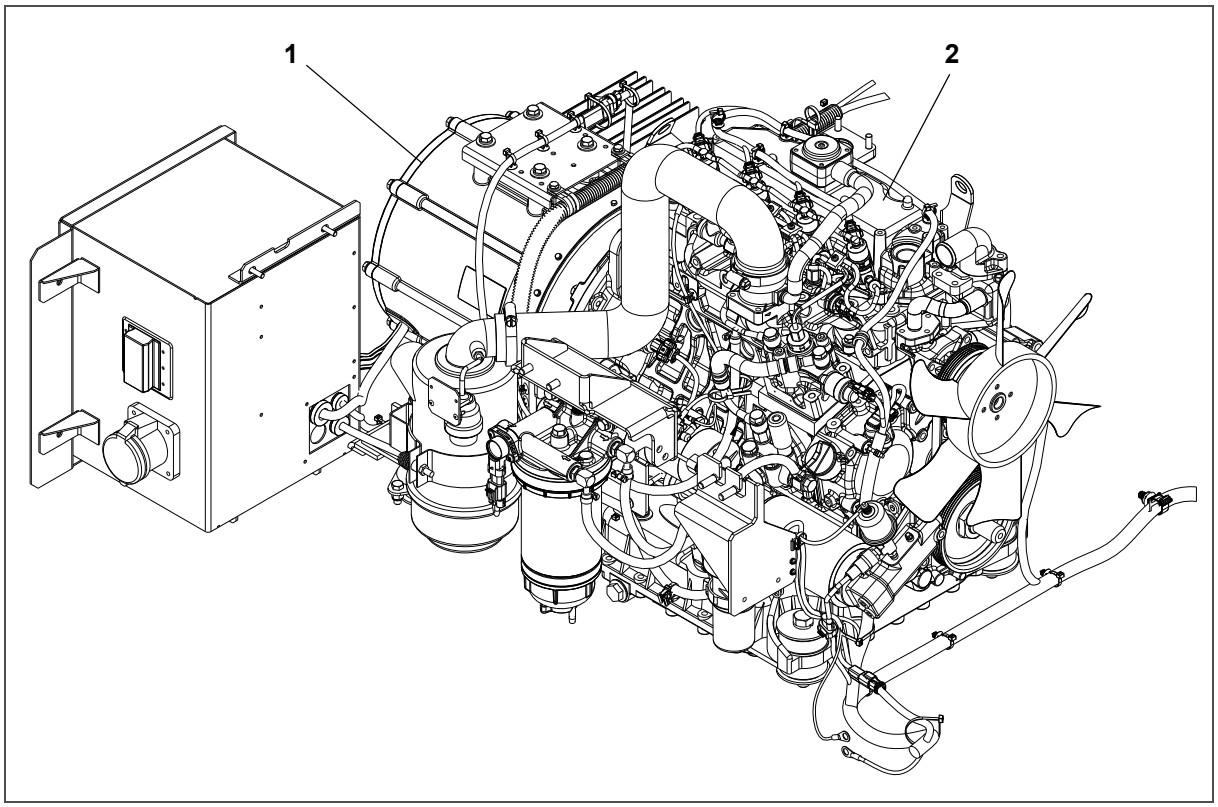
Carrier Transicold Division
Carrier Corporation
Syracuse, New York

MODEL NO.	69UG15-068S-24
PARTS ID NO.	UG2400
SERIAL NO.	7010266
DATE OF MFG.	04-2023

3.3 Alternating Current Generator

The alternating current (AC) generator, as shown in **Figure 3.3**, converts mechanical energy produced by the engine into electrical current. The AC generator bolts directly to the engine and supplies nominal 50/60Hz power based on the load requirement. Generator sets will start at 50Hz. Once the unit is running the voltage controller, as described in **Section 3.4**, reads the voltage output of the generator and adjusts accordingly to keep voltage within ISO limits. As the container becomes loaded, voltage drops and current increases, causing the generator set to adjust speed based on power demand and ambient conditions. The unit typically runs at 50Hz and varies generator output via winding selection. The speed change to 60 Hz typically occurs when the ambient temperature is high and the unit is heavily loaded.

Figure 3.3 AC Generator



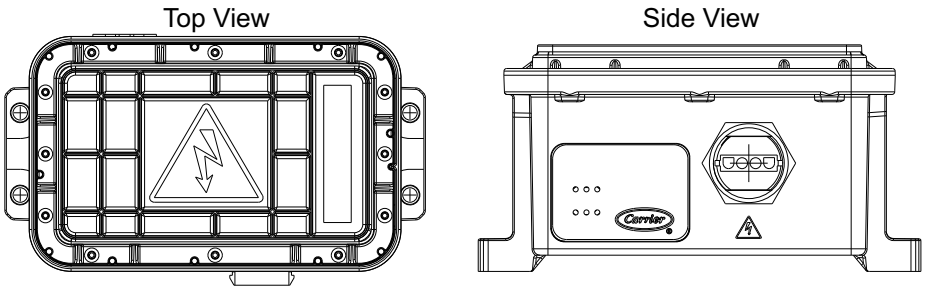
1) Generator
2) Engine

- - - - -

3.4 Voltage Controller

The voltage controller (VC), as shown in **Figure 3.4**, regulates AC generator output voltage. It is typically located inside the receptacle box but may also be mounted on the unit. The voltage controller reads AC generator voltage output while the unit is running and adjusts accordingly via two-speed and single winding control to keep the voltage within ISO limits. Generator data is summarized in **Table 3–3**. The voltage controller (VC) is protected by two fuses (VCF1, VCF2).

Figure 3.4 Voltage Controller

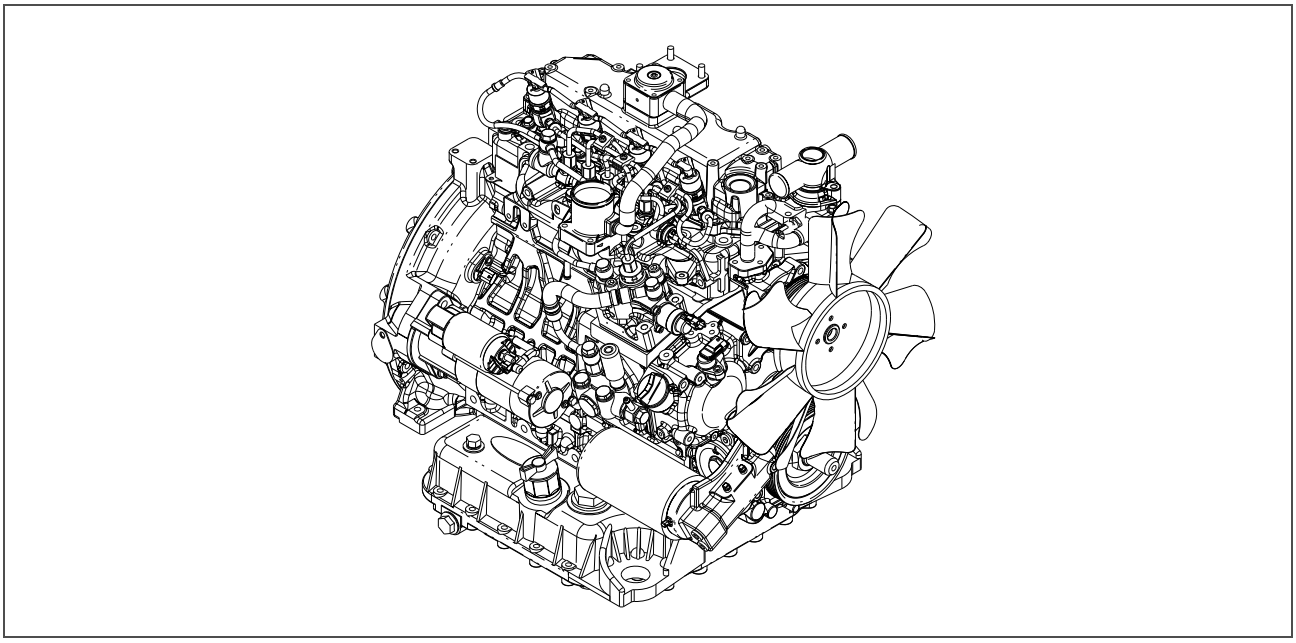


3.5 Engine

The engine, as shown in **Figure 3.5**, is a vertical, in-line four cylinder diesel engine that is directly connected to the AC generator. The engine is a Kubota V2403-CR series, model number V2403-CR-E4B-CTD-6, which uses a diesel engine fuel injection control system for the precise metering and delivery of fuel into the engine combustion chamber.

A separate manual, 62-12258 Diesel Engine Workshop for V2403-CR-E4B Engines, is available to cover information not detailed in this operations and service manual.

Figure 3.5 Engine - Front view



The engine system consists of the following major components that are described in detail in this chapter.

- Engine Body. See **Section 3.6**
- Fuel System. See **Section 3.7**
- Intake and Exhaust System. See **Section 3.8**
- Lubrication System. See **Section 3.9**
- Cooling System. See **Section 3.10**
- Electrical System. See **Section 3.11**

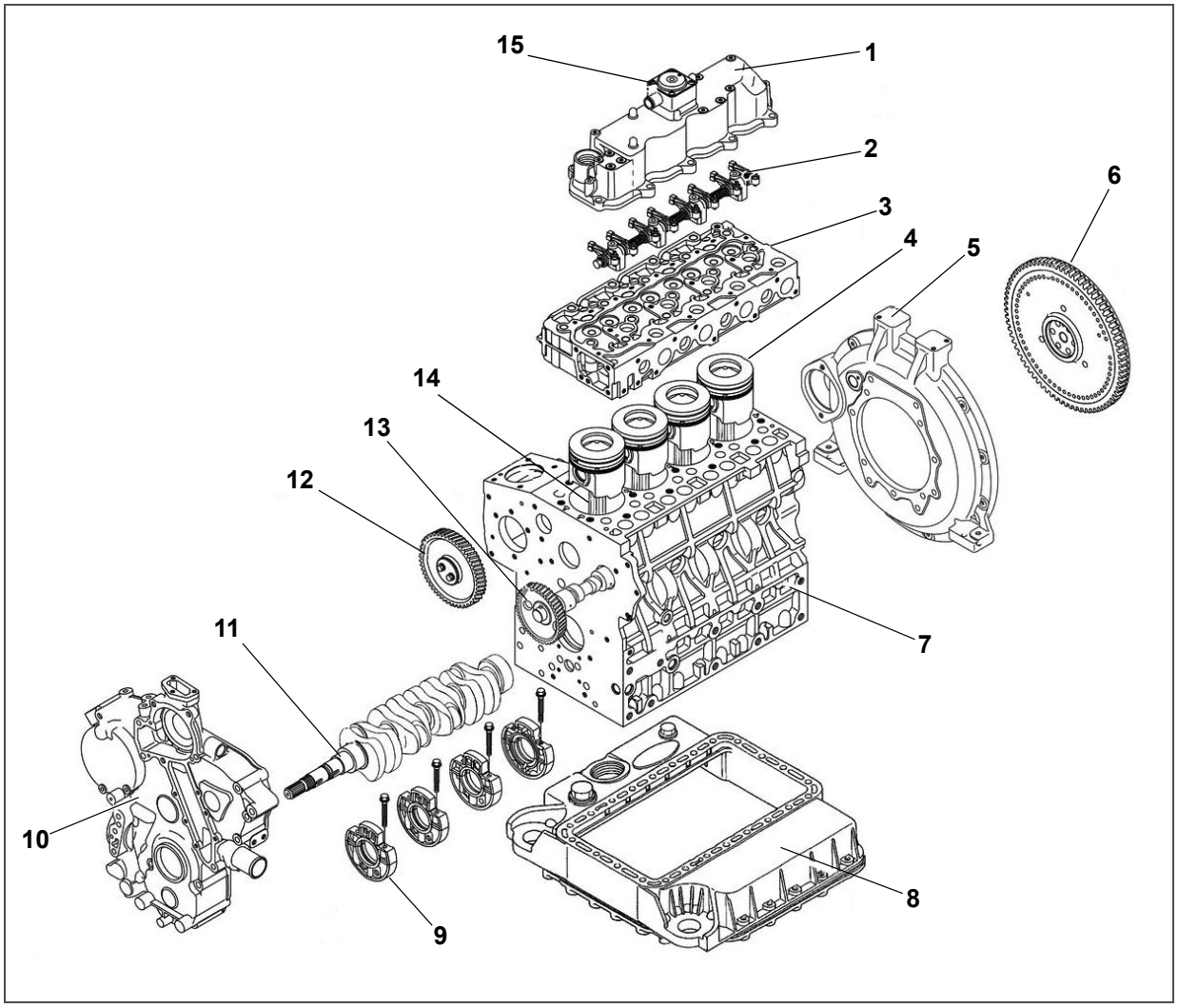
Other engine resources discussed in this manual:

- Engine Specifications. See **Section 3.15**
- Troubleshooting Engine Symptoms. See **Section 5.3**
- Servicing Engine Components. See **Section 6.3**.

3.6 Engine Body

The engine body, as shown in **Figure 3.6**, is the main part of the engine. It consists of cylinder related components, primary motion components and valve train mechanisms. Each of the parts are designed and assembled with passages for circulation of lubricating oil and coolant within the engine.

Figure 3.6 Engine Body



1) Cylinder Head Cover
2) Rocker Arm
3) Cylinder Head
4) Piston
5) Flywheel Housing
6) Flywheel
7) Crankcase
8) Oil Pan
9) Main Bearing Case
10) Gear Case
11) Crankshaft
12) Idle Gear
13) Camshaft with Cam Gear
14) Connecting Rod
15) Breather

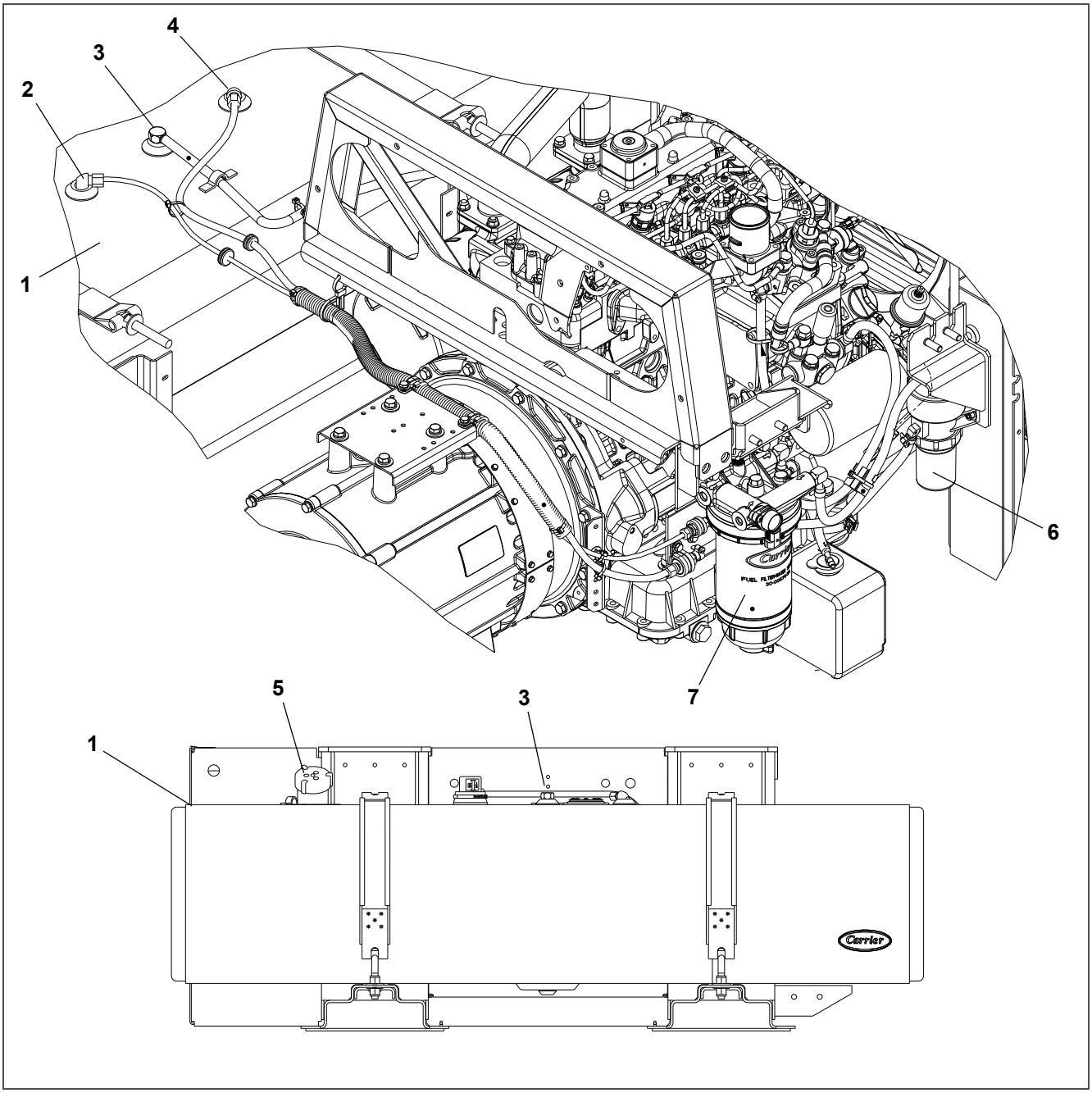
- - - - -

3.7 Engine Fuel System

The engine fuel system, as shown in **Figure 3.7** & **Figure 3.8**, is a common rail system (CRS) that injects a precise amount of atomized fuel into the engine cylinders. A CRS allows for improved efficiency and combustion, better atomization from higher fuel pressures and a reduction of emission pollutants. Fuel is pumped to the injectors for engine combustion. Surplus fuel is returned to the fuel tank after fuel injection.

Various parameters such as fuel pressure in the rail, coolant temperature, etc are transmitted from various sensors to an engine control unit (ECU). See **Section 3.7.9** for more details on the ECU.

Figure 3.7 Fuel System Components - Carrier



1) Fuel Tank
2) Fuel Supply Line
3) Fuel Tank Vent
4) Fuel Return Line
5) Fuel Fill Cap
6) Fuel Pre-Filter Pump
7) Fuel Filter / Water Separator

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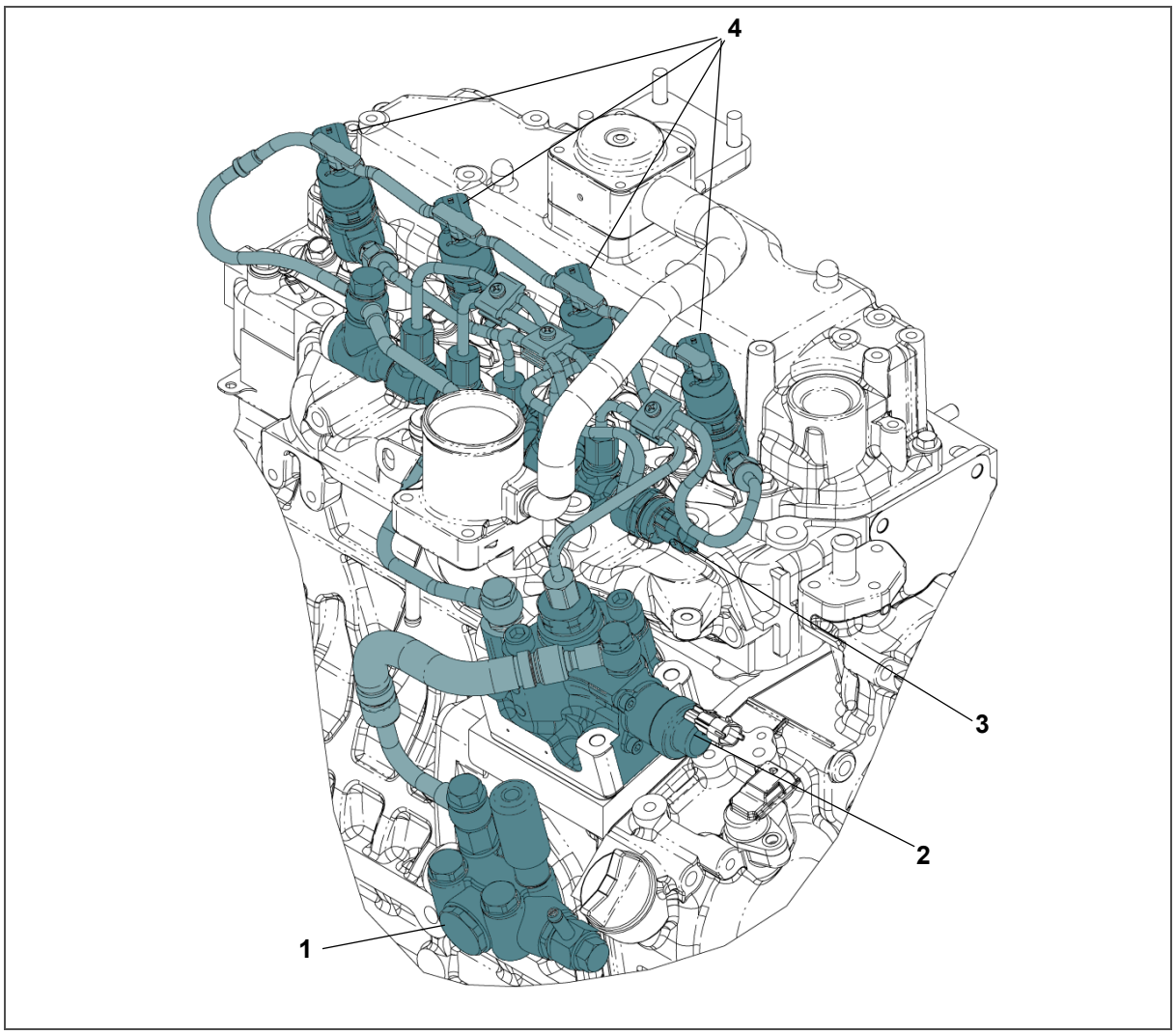
Figure 3.8 Fuel System Components - Kubota



1) Fuel Feed Pump
2) Fuel Supply Pump, High Pressure
3) Rail Assembly
4) Fuel Injectors (4)

- - - - -

3.7.1 Fuel System Flow

The fuel system diagram is shown in **Figure 3.9**.

Fuel exits the tank at low pressure and flows through the fuel shutoff valve to a pre-filter pump.

The pre-filter pump sends fuel to the fuel filter at a flow that allows for proper filter performance.

The fuel filter removes water and finer particles and includes a 12-volt fuel heater.

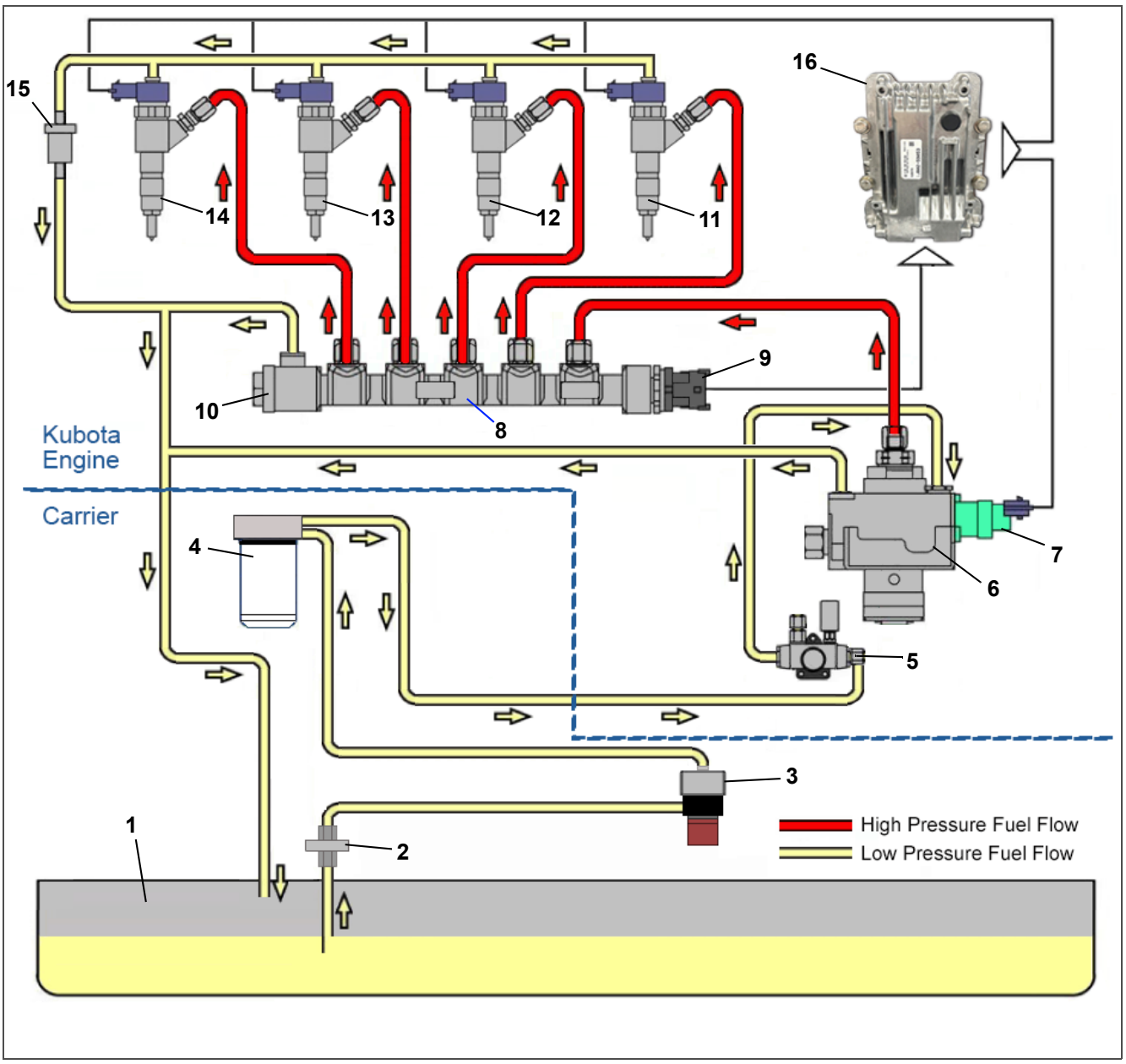
The low pressure fuel enters the fuel feed pump, where it is then sent to the high pressure supply pump.

The high pressure supply pump compresses the fuel to higher pressures, up to 1,300 bar (18,855 psi), and distributes to the rail assembly.

The rail assembly stores high pressure fuel and delivers fuel to the four injectors, 1 for each cylinder. Pressure in the rail is monitored by the rail pressure sensor (RPS). If pressure reaches dangerous limits, the pressure limiter (PL) opens to release fuel back to the tank.

The injectors perform fuel injection into the combustion chamber based on a signal received from the engine control unit (ECU).

Figure 3.9 Fuel System Diagram



1) Fuel Tank
2) Fuel Tank Shutoff Valve
3) Pre-Filter Pump
4) Fuel Filter / Water Separator
5) Feed Pump
6) High Pressure Supply Pump
7) Suction Control Valve (SCV)
8) Rail Assembly
9) Rail Pressure Sensor (RPS)
10) Pressure Limiter (PL)
11) Fuel Injector 1
12) Fuel Injector 2
13) Fuel Injector 3
14) Fuel Injector 4
15) Check Valve
16) Engine Control Unit (ECU)

- - - - -

3.7.2 Fuel Tank

The fuel tank is available in 50 or 65 gallon capacity. The tank is equipped with a fuel gauge, a fill cap and a fuel tank breathing vent valve.

3.7.3 Pre-Filter Fuel Pump

The pre-filter fuel pump, as shown in **Figure 3.10**, sends fuel to the fuel filter at a proper flow for filter performance.

Figure 3.10 Pre-Filter Pump

3.7.4 Fuel Filter / Water Separator

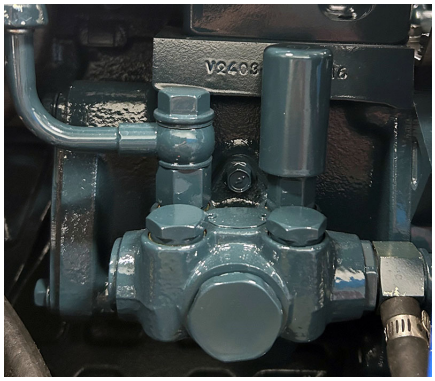
The fuel filter, as shown in **Figure 3.11**, is a fuel particle filtration system that helps prevent premature injector and pump wear by delivering cleaner fuel to the engine. The fuel filter includes integral depth coalescing water separation, water-in-fuel visual float ring, drain valve assembly, supply air bleed and a fuel heater.

Figure 3.11 Fuel Filter

3.7.5 Fuel Feed Pump

The fuel feed pump, as shown in **Figure 3.12**, supplies fuel to the high pressure supply pump mechanically. The fuel feed pump is equipped with a priming pump, which removes air through priming pump manual operation.

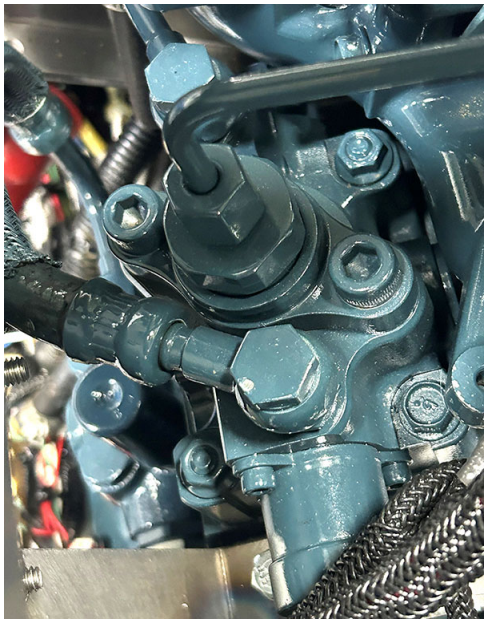
Figure 3.12 Fuel Feed Pump



3.7.6 High Pressure Supply Pump

The high pressure supply pump, as shown in **Figure 3.13**, pressurizes and supplies fuel to the rail assembly at more than twice the pressure of conventional pumps. The pump consists of a suction control valve (SCV), overflow valve, IO valve and zero delivery drain.

Figure 3.13 High Pressure Supply Pump (top view)



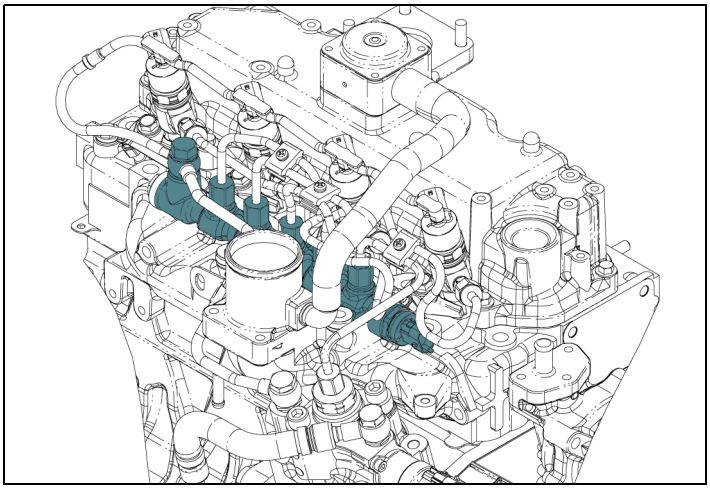
The engine side fuel camshaft rotates and during the lowering stroke a spring causes the plunger to lower. An optimal amount of fuel adjusted by the suction control valve (SCV) is suctioned through the IO valve and into the plunger chamber. During the lift stroke of the cam the plunger rises, which pressurizes the fuel and supplies it through the IO valve to the rail.

When the fuel pressure delivered from the feed pump rises above a prescribed amount, the overflow valve has a function of returning fuel to the tank. When fuel pressure increases and exceeds the force of the spring, the valve piston is pushed. The fuel then passes through the port provided in the valve body and returns to the fuel tank stabilizing the suction control valve (SCV) pressure and accurately adjusting the fuel flow.

3.7.7 Rail Assembly

The rail assembly, as shown in **Figure 3.14**, stores high pressure fuel fed from the supply pump and while retaining the pressure, delivers fuel to the injectors for each cylinder. The rail assembly consists of a rail body, rail pressure sensor and pressure limiter (PL). Pressure in the rail body is monitored by the rail pressure sensor (RPS). If pressure reaches dangerous limits, the pressure limiter (PL) opens to release fuel back to the tank.

Figure 3.14 Rail Assembly



3.7.8 Fuel Injectors

There are four fuel injectors, as shown in **Figure 3.15**, that inject high pressure fuel from the rail into the combustion chamber. Injection is performed based on a signal received from the engine control unit (ECU) indicating fuel injection timing and fuel amount. See **Section 3.7.9** for more details on the ECU.

NOTE: The injectors are referred to as ENINJ1, ENINJ2, ENINJ3, ENINJ4 on the carrier system schematic.

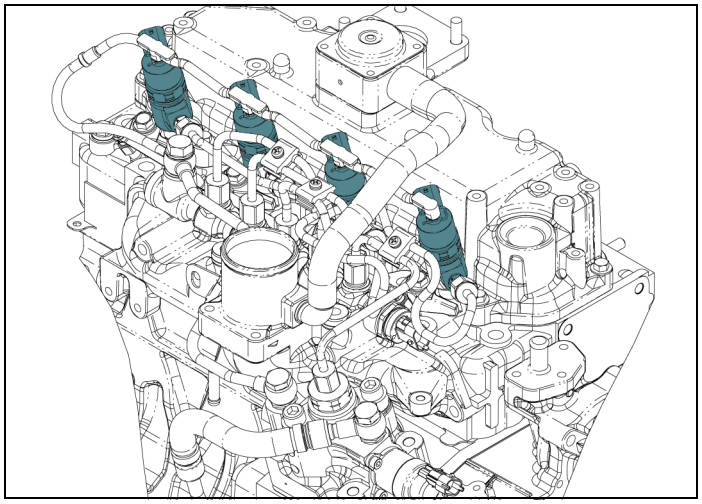
There are three injections for every one combustion cycle:

- Pre injection. A small amount is injected to reduce the effects of initial combustion and to lower nitrogen oxides and noise.
- Main injection. The highest amount of volume is injected, primarily for combustion.
- After injection. This is for combustion of unburned fuel.

In addition, a post injection is run for after treatment (not during combustion). The fuel is injected during the exhaust stroke to raise the temperature of the DOC to combust particulate matter.

A pressure limiter (PL) operates when the pressure inside the rail becomes excessively high (valve opens to return fuel back to the tank). Once the pressure drops, it acts to hold the pressure (valve closes).

Figure 3.15 Fuel Injectors

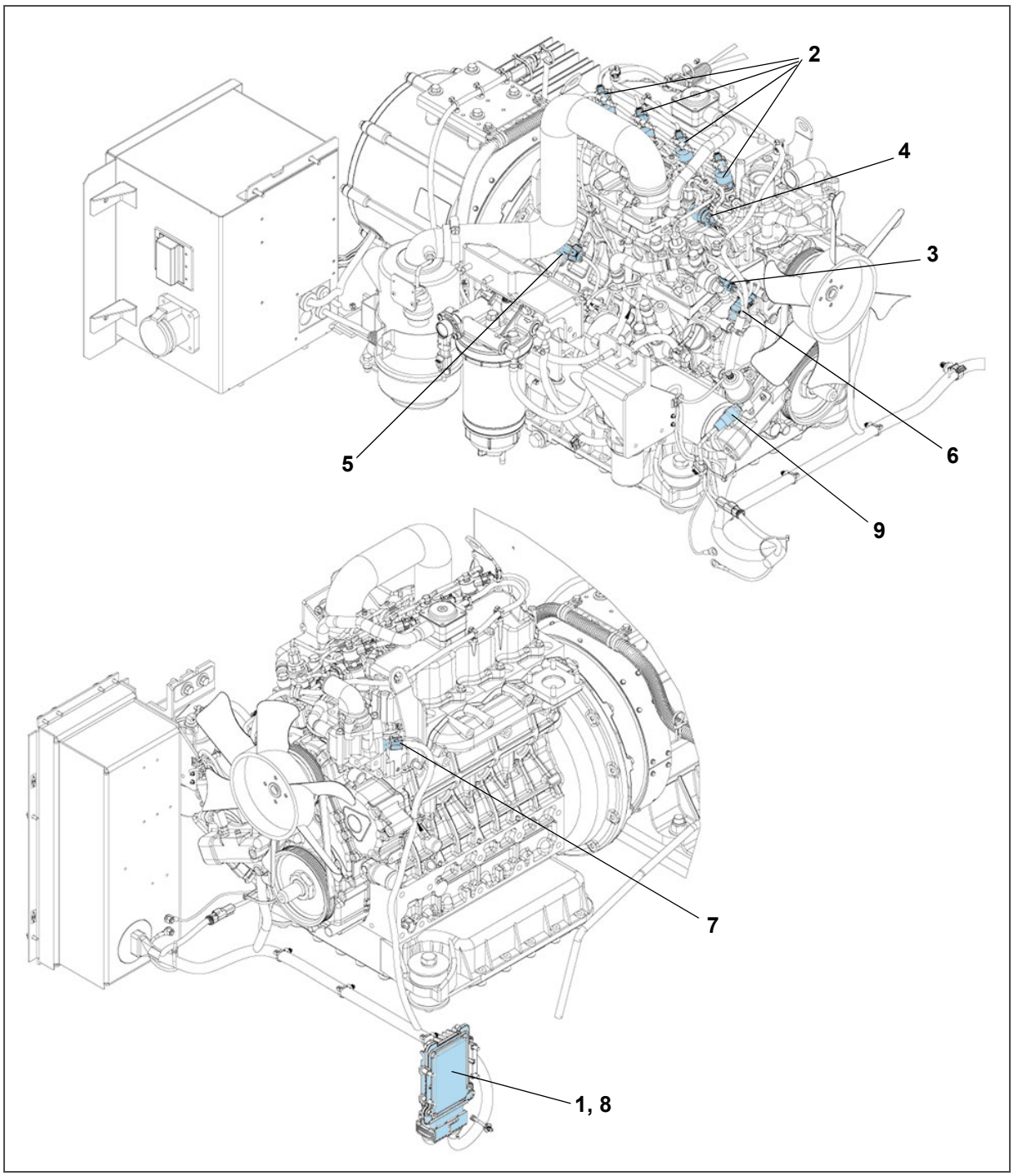


3.7.9 Engine Control Unit

The engine control unit (ECU) along with associated components is illustrated in **Figure 3.16**. The ECU controls the injection amount, timing, rate and pressure during fuel injection. The ECU consists of a case and electronics part mounting board, with operating software installed. ECU control is performed by sending instructions to each actuator (suction control valve, individual injectors) based on input signals received from each sensor.

NOTE: The ECU is listed as ENCU on the carrier system schematic.

Figure 3.16 ECU with Related Actuators and Sensors



1) Engine Control Unit (ECU)
2) Fuel Injectors
3) Suction Control Valve
4) Rail Pressure Sensor
5) Crankshaft Position Sensor
6) Camshaft Position Sensor
7) Coolant Temperature Sensor
8) Atmospheric Pressure Sensor
9) Low Oil Pressure Switch

- - - - -

The following items are controlled by the ECU as control for a common rail system (CRS) engine:

- Fuel injection quantity control. The amount of fuel injected is determined using standard injection volume calculated based on engine state and operating conditions. A calibration value is added to this information

through parameters such as coolant temperature.

- Fuel injection timing control. The ECU controls injection timing through start of energization of the injectors. First the main injection timing is determined and next other injection timing such as pilot injections are set.
- Fuel injection rate control. A pilot injection enables maintaining minimum initial fuel injection rate. This mitigates explosive initial combustion and reduces nitrogen oxides and noise.
- Fuel injection pressure control. Based on engine load (final injection volume and engine speed), the engine ECU calculates the set fuel injection pressure. Calculated data is used to control the volume supplied by the supply pump as well as the fuel pressure in the rail.

3.7.9.1 Suction Control Valve

The suction control valve (SCV) is a proportional control valve that adjusts the amount of fuel delivered from the high pressure supply pump, requested by the ECU. It is mounted on the side of the pump.

NOTE: This is referred to as the Engine Fuel Control Valve (ENFCV) on the carrier system schematic.

3.7.9.2 Rail Pressure Sensor

The rail pressure sensor detects the fuel pressure inside the rail, converts this to an electronic signal and sends it to the engine control unit (ECU) to provide optimal feedback control for the engine speed and load. This greatly improves the ability to raise the pressure at low speed and enables high-pressure injection from low speed ranges. It is mounted at the end of the rail assembly.

NOTE: This is referred to as the Engine Fuel Rail Pressure Sensor (ENFRP) on the carrier system schematic.

3.7.9.3 Crankshaft Position Sensor

The engine crankshaft position sensor senses the pulsar hole on a flywheel and detects the angular position of the crankshaft. This sensor is a magnetic resistance element type sensor, mounted on the flywheel housing.

NOTE: This is referred to as the NE sensor in Kubota literature.

NOTE: This is referred to as the Engine Speed Sensor (ENSSN) on the carrier system schematic.

3.7.9.4 Camshaft Position Sensor

The camshaft position sensor senses the teeth on a pulsar gear and detects the angular position of the camshaft. The pulsar gear has teeth at non-equal intervals. This sensor is a magnetic resistance element type sensor.

NOTE: This is referred to as the G sensor in Kubota literature.

NOTE: This is referred to as the Engine Camshaft Sensor (ENCS) on the carrier system schematic.

3.7.9.5 Coolant Temperature Sensor

The coolant temperature sensor detects the temperature of the coolant inside the engine. When the engine coolant temperature changes, the resistance of the thermistor at the tip of the sensor changes. Once the resistance changes, the sensor output voltage changes and the output voltage signal of the sensor is sent to the ECU.

NOTE: This is referred to as the Engine Coolant Temperature Sensor (ENCT) on the carrier system schematic.

3.7.9.6 Atmospheric Pressure Sensor

The atmospheric pressure sensor detects atmospheric (barometric) pressure and outputs a signal to the ECU.

NOTE: This sensor is built into the ECU and is not serviceable.

3.7.9.7 Low Oil Pressure Switch

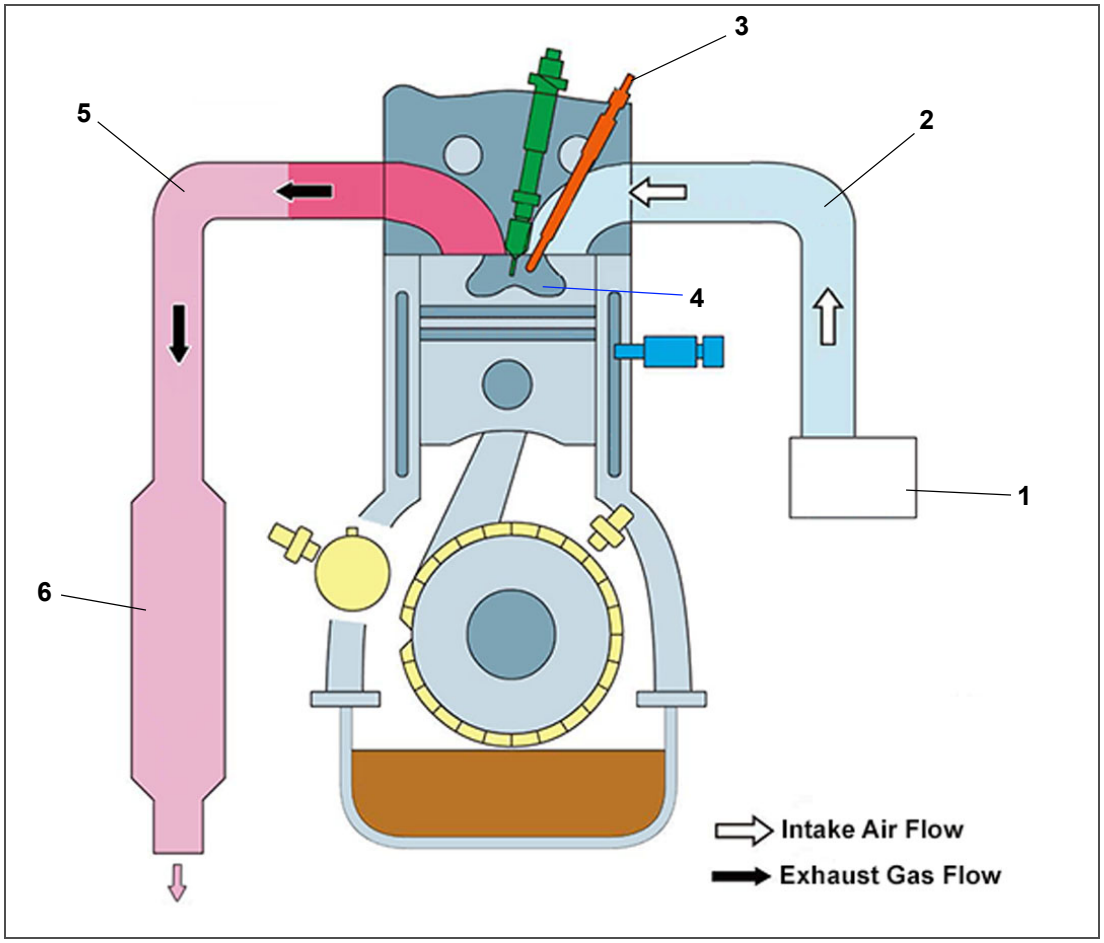
The low oil pressure sensor determines if the oil pressure is within the specified range while the engine is running.

NOTE: This is referred to as the Low Oil Pressure Switch (LOP) on the carrier system schematic.

3.8 Engine Intake and Exhaust System

The air intake and exhaust system is illustrated in **Figure 3.17**. The air intake system supplies clean air to the engine. The exhaust system collects exhaust gases after combustion and discharges them to the atmosphere once after-treatment occurs.

Figure 3.17 Intake and Exhaust Flow

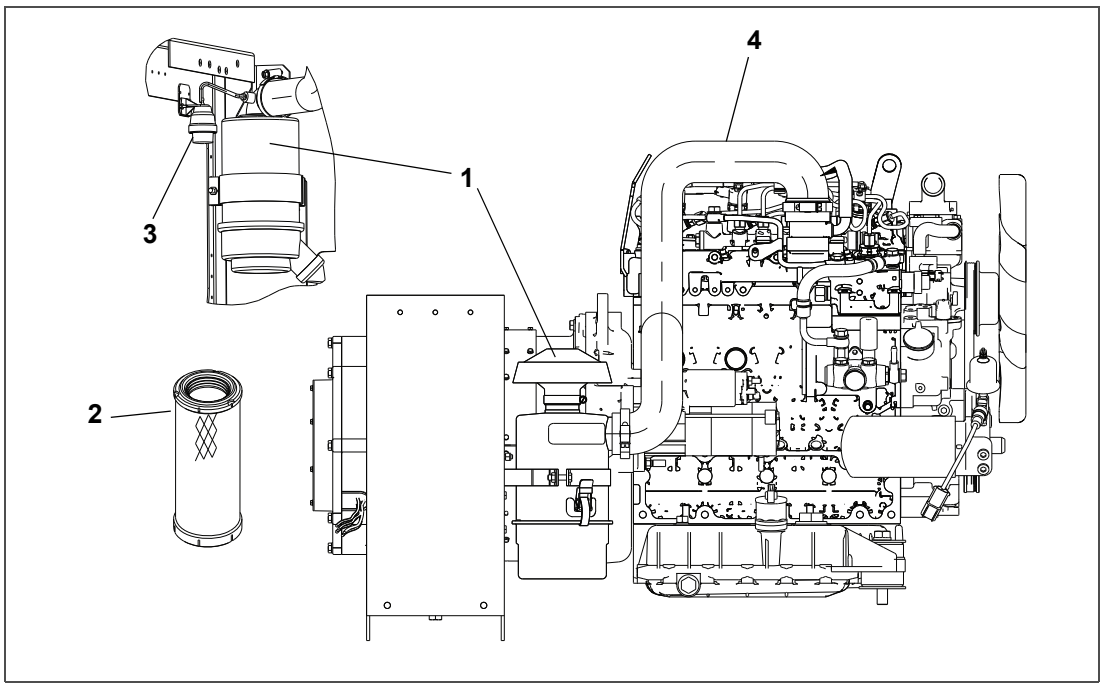


1) Air Cleaner
2) Intake Manifold
3) Glow Plug
4) Combustion Chamber
5) Exhaust Manifold
6) Diesel Oxidation Catalyst (DOC)

3.8.1 Engine Air Cleaner

The engine air cleaner system, as shown in **Figure 3.18**, utilizes a filter element to filter the engine intake air. The air cleaner effectively removes contaminants from the air stream, resulting in prolonged engine life and reduced wear on all operating engine parts. When a dry element air filter is utilized, an air filter indicator (see **Figure 3.19**) is mounted on the air filter body to indicate when the filter element needs to be replaced.

Figure 3.18 Engine Air Cleaner



1) Air Cleaner / Air Filter
2) Air Filter Element
3) Air Filter Minder / Indicator
4) Air to Intake Manifold

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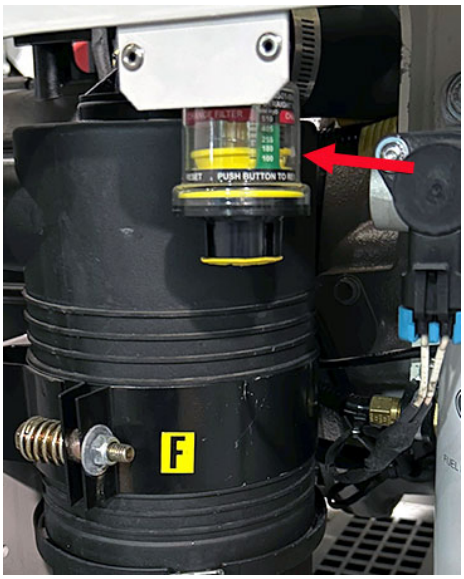
Figure 3.19 Air Filter Minder / Indicator



3.8.2 Intake Manifold

The intake manifold is mounted on the intake air side of the cylinder head. Its primary function is to distribute intake air to each cylinder. Air flows from the air cleaner filter to the intake manifold.

3.8.3 Glow Plug

The glow plug warms intake air at the combustion chamber to help with starting the engine. There are four glow plugs, one for each combustion chamber. Glow plugs are activated when coolant temperature is sensed by the ECU to be 21°C (70°F) or less. See **Section 9.4** for glow plug logic chart.

3.8.4 Exhaust Manifold

The exhaust manifold is mounted on the exhaust side of the cylinder head. The exhaust manifold is ducting that collects exhaust gases combusted in each cylinder and feeds this to the engine exhaust after-treatment system.

3.8.5 Engine Exhaust After-Treatment System

The Diesel Oxidation Catalyst (DOC) burns particulate matter, such as soot, contained in the exhaust gas. A post injection occurs in the combustion chamber (not during combustion) to raise the temperature inside the DOC to combust particulate matter. In the chemical reaction that occurs, the particulate matter is converted from carbon monoxide to carbon dioxide and water. The carbon dioxide is released to the atmosphere.

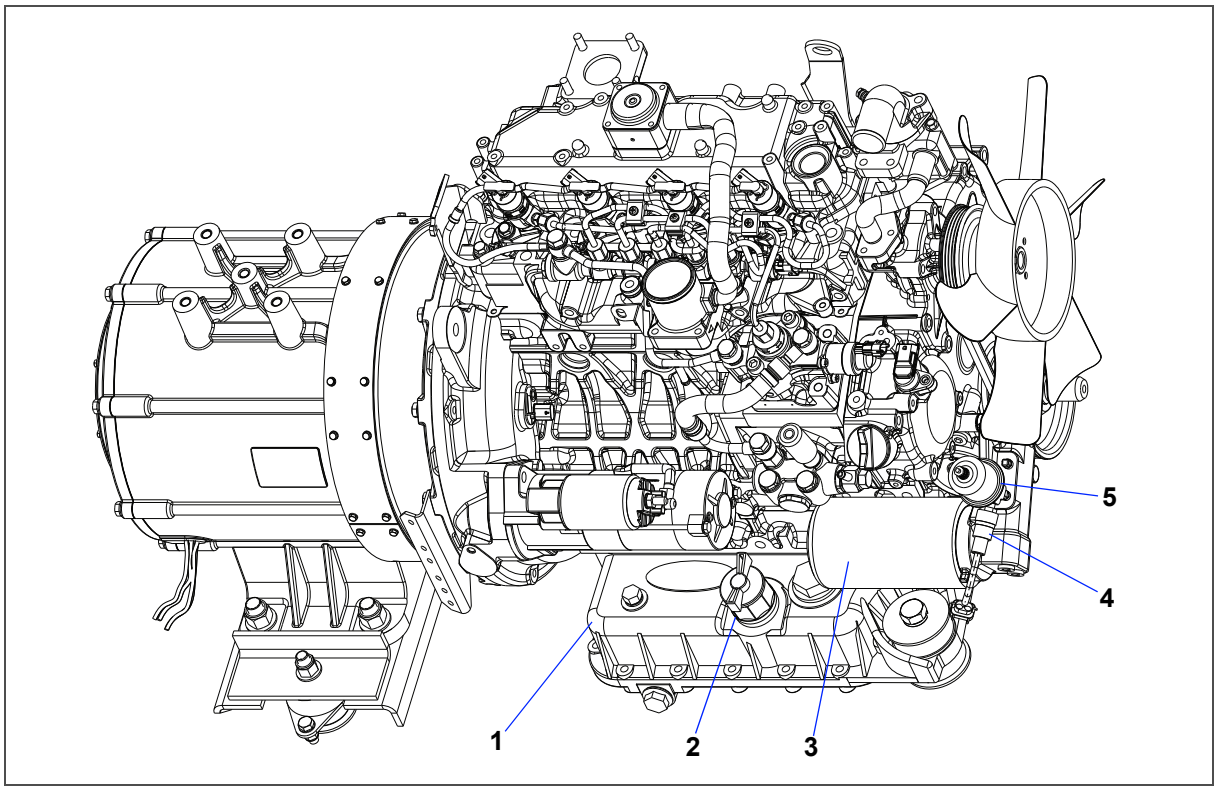
Figure 3.20 Diesel Oxidation Catalyst (DOC)

3.9 Engine Lubrication System

The engine lubrication system, as shown in **Figure 3.21**, supplies lubricating oil to the various moving parts in the engine. Its main function is to allow the formation of a film of oil between moving parts, to reduce friction and wear.

The engine lubricating oil filter is mounted in a horizontal arrangement. The oil pressure sender (OPS), located at the oil filter housing, senses lube oil pressure and transmits a signal to the oil pressure gauge (OPG) located on the control panel. See **Figure 3.24** for control panel components. The low oil pressure (LOP) switch opens when engine lubricating oil pressure is observed below 18 psig (1.27 kg/cm^2).

Figure 3.21 Engine Lubrication System



1) Oil Pan
2) Oil Dipstick / Fill Cap
3) Oil Filter
4) Low Oil Pressure (LOP) Switch
5) Oil Pressure Sender (OPS)

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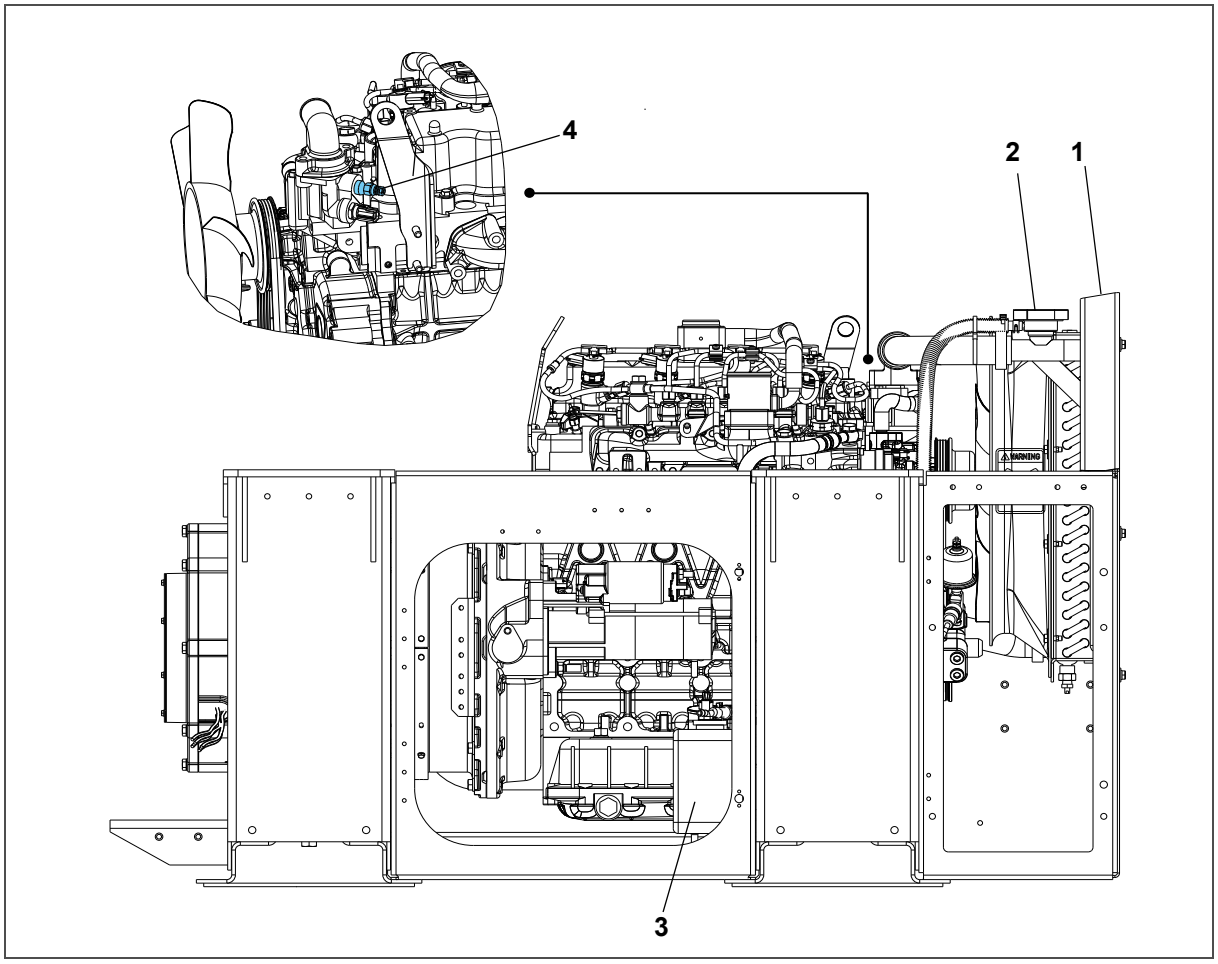
3.10 Engine Cooling System

The engine cooling system, as shown in **Figure 3.22**, uses extended life coolant and a radiator to keep the engine from overheating. The radiator transfers the heat from the engine coolant to the surrounding air. The water pump and the radiator cooling fan are belt-driven from the engine crankshaft. The water temperature sender (WTS) is an engine protection device that monitors and regulates cooling water temperature.

Figure 3.22 Engine Cooling System



1) Radiator assembly
2) Radiator fill cap
3) Coolant recovery bottle
4) Water Temperature Sender (WTS)

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3.11 Engine Electrical System

The engine electrical system refers to the engine start circuit and the charge circuit. The starting circuit starts up the starter by means of the ignition switch, as shown in **Figure 3.23**, and starts the engine by turning the flywheel. The charge circuit generates electricity in the AC generator utilizing power when the engine is running and this is then used to power the battery charger, which powers the battery.

Figure 3.23 Ignition Switch

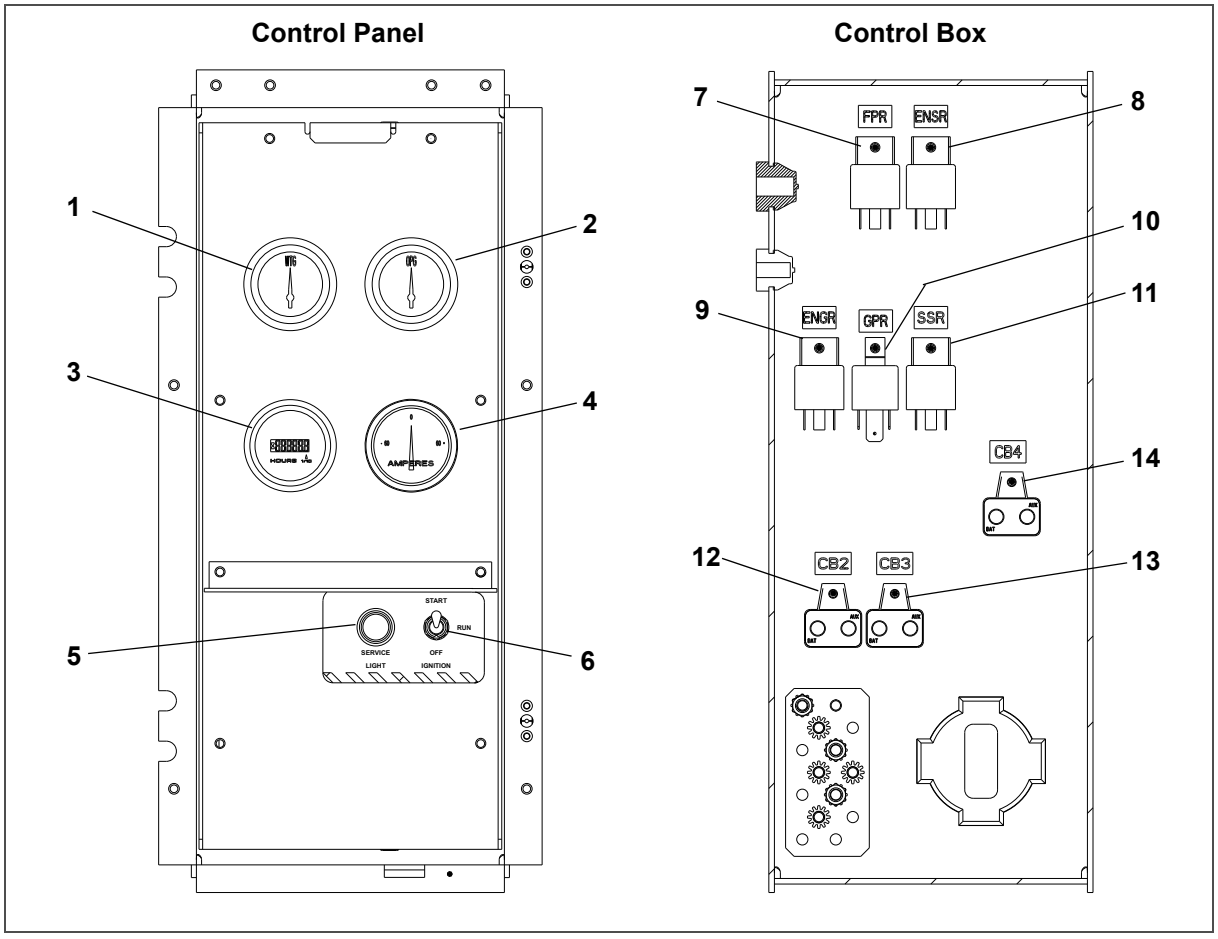
3.11.1 Battery and Battery Charger

The battery, located next to the radiator assembly, provides 12 VDC power to the starter when starting the engine. It also provides the initial voltage for the glow plug until the unit starts. The solid state battery charger is powered by the generator and is located on top of the generator. The battery charger is protected by a 5 amp fuse in the receptacle box. The battery charger produces a tapered charge (40 amps maximum) and is designed not to overcharge the battery.

3.12 Control Panel and Control Box Components

The control panel and control box, as shown in **Figure 3.24**, contain components required for monitoring and controlling the generator set unit.

Figure 3.24 Control Panel and Control Box



1) Water Temperature Gauge (WTG)
2) Oil Pressure Gauge (OPG)
3) Total Time Meter (TT)
4) Ammeter (A)
5) Engine Service Light (ESL)
6) Ignition Switch (IGN)
7) Fuel Pump Relay (FPR)
8) Engine Speed Relay (ENSR)
9) Engine Relay (ENGR)
10) Glow Plug Relay (GPR)
11) Starter Solenoid Relay (SSR)
12) Circuit Breaker (CB-2)
13) Circuit Breaker (CB-3)
14) Circuit Breaker (CB-4)

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3.12.1 Water Temperature Gauge

The water temperature gauge (WTG) displays cooling water operating temperature as reported by the water temperature sender (WTS), The WTS was previously discussed in **Section 3.10**. Once the unit has achieved normal running temperature, the coolant temperature is between 82 - 96°C.

3.12.2 Oil Pressure Gauge

The oil pressure gauge (OPG) displays normal operating engine oil pressure as reported by the oil pressure sender (OPS) on the oil filter housing. The OPS was previously discussed in **Section 3.9**. Normal oil pressure is 43 to 64 psi (3.0 to 4.5 kg/cm2).

3.12.3 Total Time Meter

The total time meter (TT) calculates the total hours the unit has been running, providing an accurate readout of accumulated engine running time. This data can be used to establish proper maintenance schedules, as shown in **Table 6–2**.

3.12.4 Ammeter

The ammeter (A) indicates the rate of charge or discharge of the battery charging system. The battery charging system is composed of the battery and the battery charger, either solid state or alternator.

3.12.5 Engine Service Light

The engine service light (ESL) is illuminated to indicate that service is needed for the engine as reported by the engine control unit (ECU).

3.12.6 Ignition Switch

The ignition switch (IGN) is a momentary switch that has OFF / RUN / START positions.

- **OFF**: In the OFF position, power supply is turned OFF and the engine is stopped.
- **RUN**: In the RUN position, all electrical equipment is operational. The engine is in operating position. Pre-heat of combustion chamber.
- **START**: When held in the START (ignition) position, the starter motor solenoid is energized, which allows the starter motor to crank the engine. The switch is released to the RUN position once the engine has started.

NOTE: The battery can drain if the engine is not running and the ignition switch is left in the RUN position.

3.12.7 Starter Solenoid Relay

The starter solenoid relay (SSR) switches on the current that activates the starter solenoid when the ignition switch is held in the START position.

3.12.8 Engine Speed Relay

The engine speed relay (ENSR) allows the engine speed to be run at either 1500 or 1800 rpm. The engine will run at 1500 rpm unless the voltage controller senses low voltage and then a signal is sent to adjust the speed to 1800 rpm.

3.12.9 Fuel Pump Relay

The fuel pump relay (FPR) powers the pre-filter fuel pump. An in-line fuse (F4) is between the relay and the pump. The FPR closes when the low oil pressure (LOP) switch closes, after which it powers the fuel pump.

3.12.10 Engine Relay

The engine relay (ENGR) or main relay helps to ensure that the engine control unit (ECU) gets the power it needs to run and function as intended. The ENGR closes when the ignition switch is placed in the RUN position. It provides power to the engine control unit (ECU) and connected sensors, the gauge cluster on the control box cover and the integrated fuel heater.

3.12.11 Glow Plug Relay

The glow plug relay (GPR) switches on the current that turns the glow plug on to help heat up the engine. Glow plugs are activated when coolant temperature is sensed by the ECU to be below 21°C (70°F). See **Section 9.4** for glow plug logic chart.

3.12.12 Circuit Breakers

CB-2 trips at 30 amps to protect the ignition and starter circuits.

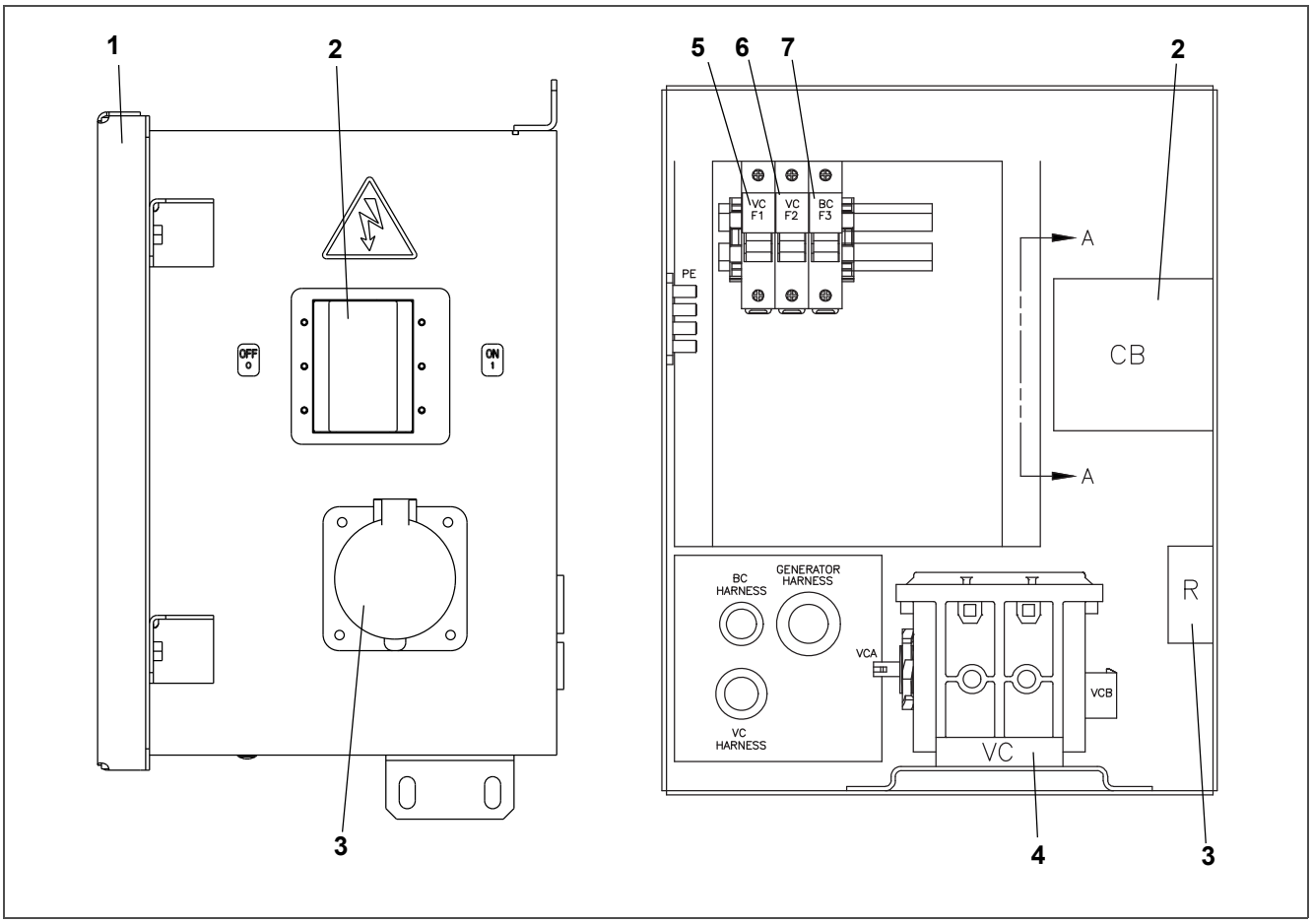
CB-3 trips at 50 amps to protect the glow plug (GP) circuit.

CB-4 trips at 30 amps to protect the 12 volt supply circuit.

3.13 Receptacle Box Components

The receptacle box, as shown in **Figure 3.25**, contains components required for monitoring and controlling the generator set unit.

Figure 3.25 Receptacle Box



1) Access Cover
2) Circuit Breaker (CB1) Genset
3) Receptacle
4) Voltage Controller (VC)
5) Voltage Controller Fuse (VCF1)
6) Voltage Controller Fuse (VCF2)
7) Battery Charger Fuse (BCF3)

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3.14 Safety Devices

Safety devices, such as circuit breakers, fuses, and safety switches, protect system components from damage.

Safety device specifications are provided in the following **Table 3–1**.

Table 3–1 Safety Devices

Engine	
Unsafe Condition:	Low engine lubricating oil pressure
Safety Switch	Low oil pressure (LOP) switch - Automatic reset
Switch Setting	Opens below 18 psig (1.27 kg/cm^2)
Unsafe Condition:	High engine cooling water temperature
Safety Switch	Engine Coolant Temperature (ENCT) sensor
Switch Setting	Opens at 120°C (248°F)

Table 3–1 Safety Devices

Unsafe Condition:	Excessive current draw by the ignition and starter circuits.
Safety Switch	Circuit breaker (CB-2) - Automatic reset
Switch Setting	Trips at 30 amps
Unsafe Condition:	Excessive current draw by the ignition switch, starter switch, total time meter (TT), water temperature gauge (WTG) and oil pressure gauge (OPG).
Safety Switch	Fuse 1, 2, 3 (replace)
Switch Setting	Trips at 5 amps
Pre-Filter Fuel Pump	
Unsafe Condition:	Excessive current draw on the pre-filter fuel pump
Safety Switch	Fuse F4
Switch Setting	Trips at 5 amps
Glow Plug	
Unsafe Condition:	Excessive current draw on the glow plug (GP) circuit
Safety Switch	Circuit breaker (CB-3) - Automatic reset
Switch Setting	Trips at 50 amps
Battery Charger	
Unsafe Condition:	Excessive current draw on 12 volt supply circuit.
Safety Switch	Circuit breaker (CB-4) - Automatic reset
Switch Setting	Trips at 30 amps
Unsafe Condition:	Excessive current draw on 460 volt feed circuit
Safety Switch	Fuse BCF3
Switch Setting	Trips at 5 amps
Generator	
Unsafe Condition:	Excessive current draw by load
Safety Switch	Circuit breaker (CB-1, 460 volt) - Manual reset
Switch Setting	Trips at 26 amps (460 VAC)
Voltage Controller	
Unsafe Condition:	Excessive current draw on 460 volt feed circuit
Safety Switch	Fuses VCF1, VCF2
Switch Setting	Trips at 5 amps
Diesel Oxidation Catalyst (DOC)	
Unsafe Condition:	Excessive surface temperature of DOC
Safety Switch	DOC thermal switches (DOCS1 / DOCS2), normally closed
Switch Setting	Opens at 260°C (500°F)

3.15 Unit Specifications

Table 3–2 Fuel Tank

Capacity:	Nominal tank size: 120 gallon
	Fill capacity: 120 gallon
	Draw capacity: 119 gallon (Allows for DOT required 5% vapor space)
Unit Weight:	Engine (Dry) without accessories: 1875 lb (851 kg) approximate

Table 3–3 Generator

Output:	15 KW, 18.75 KVA, 0.8 pf KW
Output Voltage:	400-500 VAC @ 60 Hz; 360-460 VAC @ 50 Hz
Speed:	1800 RPM @ 60 Hz; 1500 RPM @ 50 Hz
Weight:	267 lb (121 kg)
Part Number:	54-00378-20

Table 3–4 Engine Data

Model	V2403-CR-E4B-CTD-6
Cylinders (Number):	Four
Engine Type	Vertical, water-cooled, 4-cycle diesel
Bore x Stroke:	87 x 102.4 mm (3.43 x 4.031 in.)
Total Displacement:	2.434 liters (148.5 cubic in.)
Direction of Rotation	Counter-clockwise (viewed from flywheel side)
Firing Order:	1-3-4-2
Compression Ratio:	18.1 to 1
Starting System	Electric starting with starter
Starter Motor	12V, 2.0 kW
Starting Support	Glow plug in combustion chamber Glow plug amperage: Approximately 12 amps at 12 VDC Glow plug resistance (cold): Approximately 1 ohms
Weight (Dry):	487 lb (221 kg) Included ATU, excluded cooling fan
Oil Pressure	Oil pressure at idle speed: • Service specification: More than 14 psi (1.0 kg/cm2) • Service limit: 7 psi (0.5 kg/cm2) Oil pressure at rated speed: • Service specification: 43 to 64 psi (3.0 to 4.5 kg/cm2) • Service limit: 36 psi (2.5 kg/cm2)
Oil Pressure Switch	Working pressure: 7 psi (0.5 kg/cm2)
Oil Sump Volume	15.0 US quarts (14.2 L)

Table 3–4 Engine Data (Continued)

Oil Level Indicator	Dipstick in oil pan or fill cap **NOTE**: To check oil level on engines with the dipstick mounted in the fill cap, remove the cap and wipe the dipstick clean. Insert the cap back onto the oil fill tube, then remove to check level. It is not necessary to screw the cap back into the fill tube when checking level. DO NOT add oil if level is within the “safe” range. If needed, add oil to bring level within the “safe” range. Screw cap fully into fill tube after checking level.
Lube Oil Specification	Use a heavy duty lubricating oil conforming to American Petroleum Institute (API) Service Classification CK-4 or better.
Lube Oil Viscosity	For outdoor temperatures -18° to 7°C (0 to 45°F): SAE: 5W30 For outdoor temperatures above 7°C (45°F): SAE: 10W30 or 15W40
Fuel Specifications	Since KUBOTA diesel engines of less than 56 kW (75 hp) utilize EPA Tier 4 and Interim Tier 4 standards, the use of ultra low sulfur fuel is mandatory for these engines, when operated in US EPA regulated areas. Therefore, use Ultra Low Sulfur Diesel (ULSD) or diesel with $\leq$ B5 (5% biodiesel)
Fuel Heater Thermostat (FHT)	Thermostat On Temperature: ≤ 3 ± 5°C (37.4 ± 9°F) Thermostat On Temperature: ≥ 21 ± 7°C (69.8 ± 12.6°F) FH Power Consumption: 225 W 10%-20% at 20 °C (-4°F) at 12VDC
Fuel Pump, Pre-Filter	Shut off pressure: 9 to 11.5 psig (0.63 to 0.81 kg/cm2) Maximum operating fuel temperature: 76°C (170°F) @ 14 VDC, 6 psi back pressure, 82°C (180°F) ambient.
Fuel Pump. Feed	Maximum discharge pressure: 72.5 psig (5.10 kg/cm2)
Fuel Pump, High Pressure Supply	Rail pressure (at idling): 25 to 30 mPa; 260 to 300 kgf/cm2; 3700 to 4300 psi Rail pressure (at rated speed, no load): 60 to 65 MPa; 620 to 660 kgf/cm2; 8700 to 9400 psi
Fuel Pressure Limiter	Valve opening pressure: Approximately 200 MPa; 2039 kgf/cm2; 29000 psi Valve closing pressure: Approximately 50 MPa; 510 kgf/cm2; 7260 psi
Fuel Injector	Operating voltage: 110 V Operating pressure range: 30 to 160 MPa; 306 to 1630 kgf/cm2; 4360 to 23200 psi
Crankshaft Position Sensor	Operating voltage: 5V Number of pulsar holes at flywheel: 56
Camshaft Position Sensor	Operating voltage: 5V Number of pulsar gear teeth: 3
Cooling System:	Capacity: 6 us quarts (5.68 liters)
	Anti-Freeze: Extended Life 50/50 mix of Ethylene Glycol & Water

Section 4
Operation

4.1 Pre-Start Inspection

⚠ CAUTION

Prior to first use of the genset, ensure all shipping packaging and debris is removed and discarded.

1. Check engine lubrication and fuel filters, oil lines, and connections for leaks. If required, tighten connections and / or replace gaskets.
2. Check the engine lubricating oil level. Refer to lube oil specifications as detailed in **Table 3–4**.
3. Check the fan belt for fraying or cracks and proper tension. See **Section 6.4.4.3** for procedure.
4. Check the radiator hoses for leaks and check radiator coolant level. Refer to coolant specifications as detailed in **Table 3–4**.
5. Check the radiator coil and generator air intake screen for cleanliness. If required, clean using compressed air, reversing the normal air flow.
6. Check the air cleaner for cleanliness and clean if necessary. See **Section 6.4.2** for procedure.
7. Drain water from the fuel filter bowl.
8. Fill the fuel tank with diesel fuel. Refer to fuel specifications as detailed in **Table 3–4**.
9. Check the glow plug (GP) amperage. Refer to glow plug specifications as detailed in **Table 3–4**.
10. Check the battery terminals for cleanliness and secureness. If required, clean, then coat with a battery terminal sealant.
11. Check and if required, tighten all electrical connections.
12. Check and if required, tighten all hardware, brackets, etc.
13. Ensure that the main generator set circuit breaker (CB-1) is in the OFF position.
14. Connect the power cable to the refrigeration unit. Then, proceed to **Section 4.2** for starting instructions.

4.2 Starting Instructions

Before start up, both the generator set circuit breaker (CB-1) and the refrigerated unit should be OFF. After start up, the generator set should be run for at least two minutes to allow the power source to stabilize before supplying power to the refrigerated unit. This will eliminate the potential of any cold start transient spikes from reaching the refrigerated unit. Cold start transient spikes can potentially cause nuisance over voltage alarms on refrigerated units that are sensitive to electrical spikes or transients.

⚠ WARNING

Beware of moving fan belt, belt driven components and hot exhaust components.

⚠ WARNING

Under no circumstances should ether or any other unauthorized starting aids be used in conjunction with the glow plug (GP).

NOTE: Piston rings in engines that have operated less than 100 hours may not be fully seated. This may lead to the possibility of oil seepage from the exhaust pipe. To properly seat the rings, operate the engine under full load for a period of 24 hours. If the condition persists, check valve clearance when the engine is cold.

Procedure:

1. Make sure that circuit breaker CB-1 is in the OFF position.
2. Hook up the 460 volt cable from the refrigerated unit to the generator set receptacle.
3. Turn the ignition switch to the RUN position.
4. Leave the generator set in the RUN position for 15 seconds. Then, turn the ignition switch to the START position. After the engine has started, the ignition switch returns to the RUN position.

   NOTE: At warmer temperatures, the START switch can be activated in less time. Refer to the table below for reference.

Ambient Temp (F)	Ambient Temp (C)	Time (seconds)
68	20	4.5
50	10	8.5
32	0	9.5
-22 (or lower)	-30 (or lower)	15

NOTE: The battery can drain if the engine is not running and the ignition switch is left in the RUN position.

4.3 Post-Start Inspection

1. Allow the generator set unit to run for at least 2 minutes.
2. Turn on circuit breaker CB-1.
3. Check generator output with a volt meter. Voltage output at start up with no load at 50Hz operation should be 1500 RPM, 360-460 VAC. Voltage output may vary and fall with ISO specifications based on ambient. Refer to output values as detailed in **Table 3–3**.
4. Start the refrigeration unit.
5. Run the engine for 10 minutes and check total time meter operation.
6. Listen for abnormal bearing noise from the AC generator.
7. Check the fuel lines, lube oil lines, and filters for leaks.
8. Check the exhaust system for leaks.

4.4 Stopping Instructions

1. Place circuit breaker CB-1 in the OFF position.
2. Turn the ignition switch to the OFF position.

4.5 Sequence of Operation

1. When the ignition switch is turned to the START position, current flows from the battery to the starter motor (SM).
2. The starter motor rotates and a pinion gear engages and starts to rotate.
3. The pinion gear meshes with the flywheel and causes the flywheel to rotate.
4. The flywheel rotates the crankshaft, which then starts piston movement.
5. Fuel is pumped to the engine cylinders and ignited by heat of compression; thus starting the engine.
6. When the START switch is released, the starter is disengaged. The switch returns to the RUN position.
7. With the engine running, power from the crankshaft turns the fan drive pulley.
8. The fan belt transfers power to the AC generator, which converts mechanical energy to electricity.

Section 5
Troubleshooting

NOTE: Read the **Safety** chapter carefully prior to troubleshooting the engine or generator set.

5.1 Engine Pre-Work Checklist

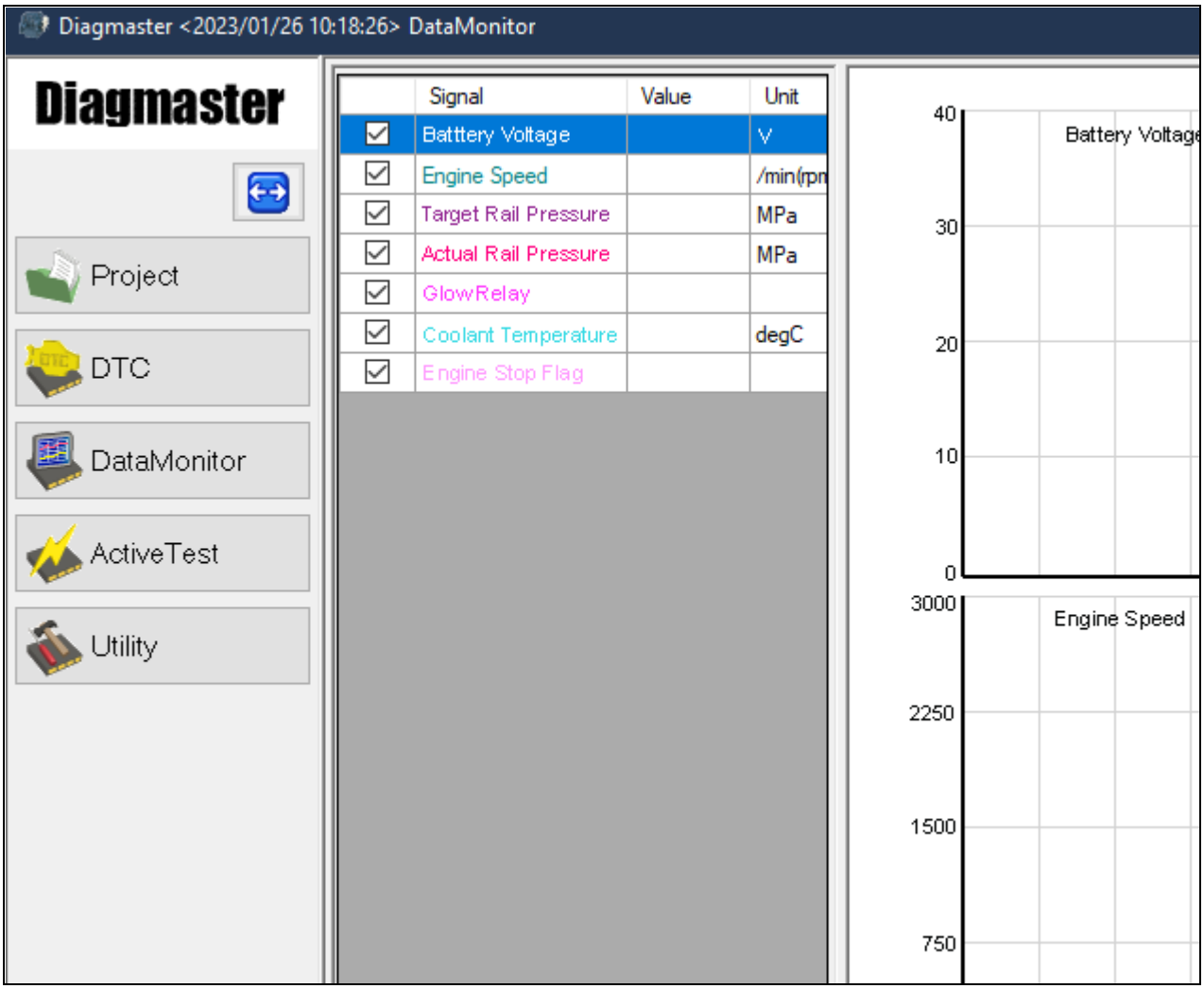
Prior to performing any failure diagnosis work, it is recommended to check and record the content of the **Engine Pre-Work Checklist** in order to check the engine's state of use.

5.2 Kubota Engine Support

The Kubota Engine Park (KEP) website provides access to additional resources for operating, servicing and troubleshooting Kubota engines. From here, a user can download Diagmaster diagnosis software, application manuals, and service manuals. Contact a Carrier service engineer to request login credentials.

KEP can be accessed by visiting https://ba.engine.kubota.com/web/guest/home

The engine diagnosis procedures in this section involve connecting a computer to the engine ECU and using Diagmaster software to check engine conditions and measurements. Refer to the **Diagmaster** chapter for detailed installation and operating procedures.



5.3 Symptom - Engine is Starting Poorly

The following symptoms may indicate an engine starting poorly:

- Engine can not start cranking
- Engine cranks, but fails to start
- Engine takes time to start

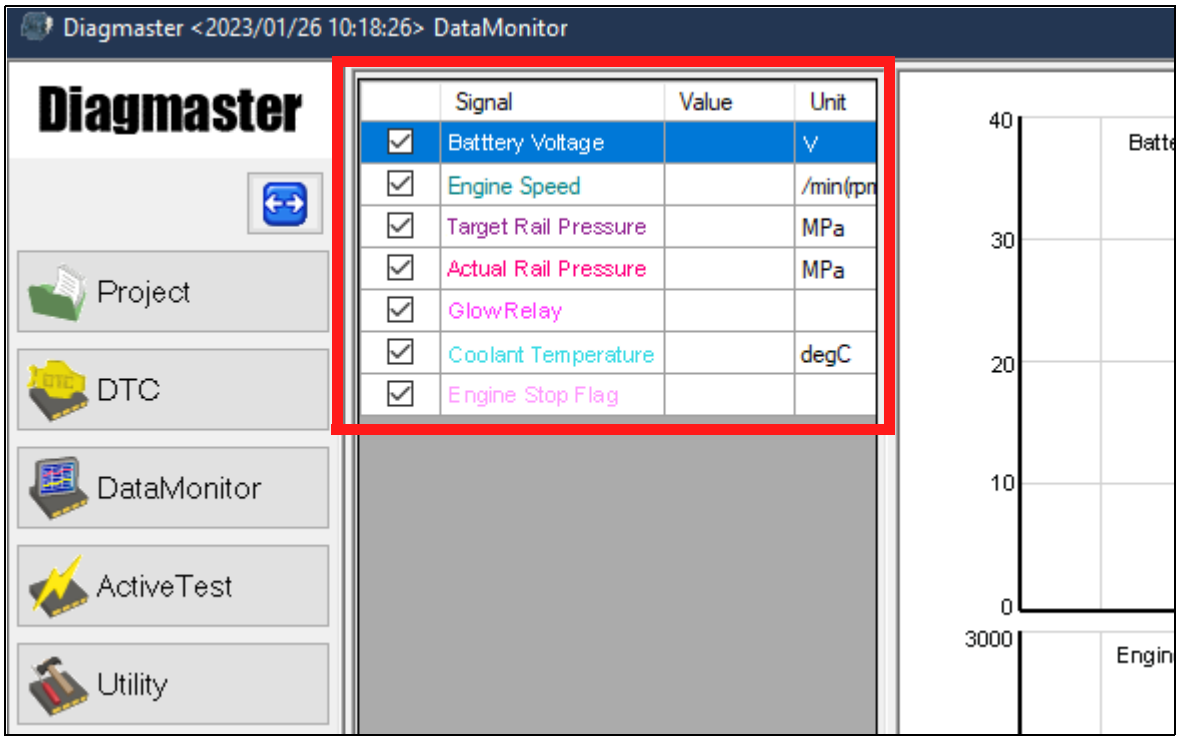
Table 5–1 Engine is Starting Poorly - Causes and Actions

Electrical System
Cause / Action: 1. Power supply is poor. Check the battery. 2. Power supply circuit malfunction. Check the ignition switch or main relay. 3. Starting circuit malfunction. Check the starter, starter relay or ignition switch. 4. Preheating circuit malfunction. Check the glow relay or glow plug.
Engine Body
Cause / Action: 1. Engine is seizing. Check the crankshaft, piston or connecting rod. 2. Compression is insufficient. Check the cylinder, piston ring, valve, cylinder head, timing gear, or valve clearance.
Fuel System
Cause / Action: 1. Fuel supply is poor. Check the fuel tank, fuel feed pumps, fuel filter or fuel hoses. 2. Fuel high pressure supply is poor. Check the supply pump, suction control valve (SCV) or rail. 3. Fuel injection is poor. Check the injector or overflow pipe. 4. Sensor signal problem. Check the crankshaft position sensor, camshaft position sensor or pulsar gear. 5. Fuel is poor. Check the fuel quality.
Intake / Exhaust System
Cause / Action: 1. Intake is poor. Check the air cleaner. 2. Exhaust is poor. Check the DOC.
Other
Cause / Action: 1. Operating environment problem. Check for cold outside temperatures. 2. Problem on vehicle side. Check the engine drag or start conditions. 3. ECU stop instruction. Check the ECU or engine stop switch.

5.3.1 Diagnosing an Engine that is Starting Poorly

1. Inspect the following items (from the pre-work checklist, **Section 6.2**) to verify the following criteria:
   - Fuel quantity meets the specified amount; Fuel quality meets the fuel standard
   - Air cleaner element is not clogged
2. Connect a computer to the ECU and open Diagmaster software.
3. Place the ignition switch (IGN) in the START position to start the engine.
4. If the engine starts, then continue to the next step. If the engine does not start, check the following:
   - The battery is causing a power supply problem.
   - The ignition switch or main relay is causing a malfunction in the power supply circuit.

5. Go to the Data Monitor screen and bring up the following data monitor settings on the screen.
   - Battery Voltage, Engine Speed, Target Rail Pressure and Actual Rail Pressure, Glow Relay, Coolant Temperature, Engine Stop Flag



6. Click the Play button (green) to start data measurement and Stop button (gray) to finish. During a measurement, observe the data on screen when the engine is stopped (ignition RUN) and also when the engine cranking (ignition START). Check the measurements for each of the settings active in the screen and compare to the reference values given in the tables below.

   If the problem can not be solved after observing the measurements, check the compression pressure measurement. If compression is insufficient: check the cylinder, piston ring, valve, cylinder head, timing gear or valve clearance.

Battery Voltage	
Reference:	When engine stopped (ignition RUN): around 12V When engine cranking: 10 to 12V
Symptom:	Voltage is too low when ignition is in RUN or while cranking.
Cause / Action:	Power supply is poor. Check the battery.
Engine Speed	
Reference:	When engine stopped (ignition RUN): 0 rpm When engine cranking: 200 rpm
Symptom:	No rotation
Cause / Action:	Starting circuit malfunction. Check the starter, starter relay, or ignition switch
Symptom:	Slow rotation
Cause / Action:	Engine seizing. Check the crankshaft, piston, or connecting rod
Target Rail Pressure vs Actual Rail Pressure	
Reference:	When engine stopped (ignition RUN): Target __ MPa, Actual 0 MPa When engine cranking: Equivalent to target
Symptom:	Actual rail pressure is higher than the target
Cause / Action:	Fuel injection is poor. Check the injector or overflow pipe

Symptom:	Actual pressure is lower than the target
Cause / Action:	Fuel high pressure supply is poor. Check the high pressure supply pump, suction control valve (SCV), rail, or injector.
Cause / Action:	Fuel supply is poor. Check the fuel tank, fuel feed pumps, fuel filter, or fuel hoses.
Glow Relay | Coolant Temperature	
Reference:	OFF: Coolant temperature 21°C or higher ON: Coolant temperature below 21°C.
Symptom:	Somewhat hotter than the glow relay operating temperature
Cause / Action:	Operating environment problem. Check for cold outside temperatures.
Symptom:	ON (operating)
Cause / Action:	Preheating circuit problem. Check the glow relay or glow plug.
Engine Stop Flag	
Reference:	When engine stopped (ignition RUN): ON When engine cranking: OFF
Symptom:	Stays ON even after cranking
Cause / Action:	ECU stop instruction. Check the engine stop switch or ECU.

Other Related Procedures:

- Check the Fuel System. See **Section 6.4.1**.
- Check the Intake Air System. See **Section 6.4.2**.
- Check the Electrical System.

5.4 Symptom - Engine is Operating Poorly

The following symptoms may indicate an engine operating poorly:

- Engine idle is unstable
- Engine response is slow or no response
- Engine stalls

Table 5–2 Engine is Operating Poorly - Causes and Actions

Engine Body
Cause / Action: 1. Compression is insufficient. Check the cylinder, piston ring, valve, cylinder head, timing gear, or valve clearance.
Fuel System
Cause / Action: 1. Fuel supply is poor. Check the fuel tank, fuel feed pumps, fuel filter or fuel hoses. 2. Fuel high pressure supply is poor. Check the high pressure supply pump, suction control valve (SCV) or rail. 3. Fuel injection is poor. Check the injector. 4. Sensor signal problem. Check the crankshaft position sensor, camshaft position sensor, pulsar gear, rail pressure sensor, coolant temperature sensor, or CAN communications. 5. Fuel is poor. Check the fuel quality.
Intake / Exhaust System
Cause / Action: 1. Intake is poor. Check the air cleaner or intake air hose. 2. Exhaust is poor. Check the DOC.

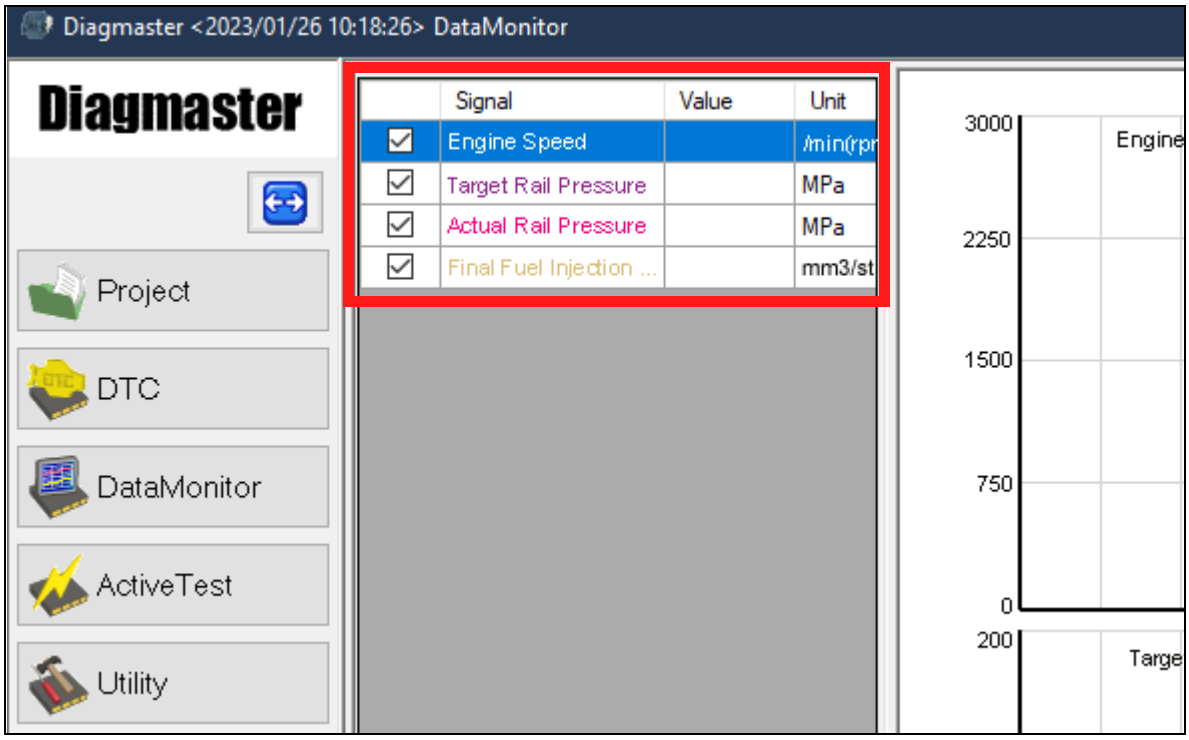
Table 5–2 Engine is Operating Poorly - Causes and Actions

Other
Cause / Action: 1. Problem on vehicle side. Check for overload or CAN communication content. 2. Calibration or correction after maintenance was not completed. Check that an injector correction or injection timing correction was performed.

5.4.1 Diagnosing an Engine that is Operating Poorly

1. Inspect the following items (from the pre-work checklist, **Section 6.2**) to verify the following criteria:
   - Engine oil quantity meets the specified amount; Engine oil quality meets the oil standard
   - Fuel quantity meets the specified amount; Fuel quality meets the fuel standard
   - Coolant quantity meets the specified amount
   - Air cleaner element is not clogged.
2. Connect a computer to the ECU and open Diagmaster software.
3. Place the ignition switch (IGN) in the START position to start the engine.
4. Check that any of the procedures listed below were completed recently:
   - Injector correction to an injector, or the engine ECU
   - Injector timing correction to the flywheel housing, flywheel, or crankshaft

   If so, verify that an Injector Compensation was performed on the Utility screen. This is necessary to re-register the injectors to the engine ECU. See **Section 7.3.9** for related information.
5. Go to the Data Monitor screen and bring up the following data monitor settings on the screen.
   - Engine Speed, Target Rail Pressure and Actual Rail Pressure, Final Fuel Injection Quality



6. Click the Play button (green) to start data measurement and Stop button (gray) to finish. During a measurement, observe the data on screen when the engine is stopped (ignition RUN) and also when the engine cranking (ignition START). Check the measurements for each of the settings active in the screen and compare to the reference values given in the tables below.

   If the problem can not be solved after observing the measurements, check the compression pressure measurement. If compression is insufficient: check the cylinder, piston ring, valve, cylinder head, timing gear or valve clearance.

Engine Speed:	
Reference:	1500 rpm (at no-load maximum speed)
Symptom:	Engine reaches the specified rpm
Cause / Action:	Problem on generator side. Check for overload condition.
Target Rail Pressure & Actual Rail Pressure:	
Reference:	Equivalent to target (at no-load maximum speed)
Symptom:	Actual pressure equivalent to target pressure; Actual pressure follows the target pressure; Actual pressure is stable
Cause / Action:	Fuel pressure supply is poor. Check the supply pump, suction control valve (SCV), rail, or injector
Cause / Action:	Fuel supply is poor. Check the fuel tank, fuel feed pumps, fuel filter or fuel hoses.
Cause / Action:	Pressure sensor signal. Check the rail pressure sensor.
Final Fuel Injection Quantity:	
Reference:	About 90 MPa (at no-load maximum speed)
Symptom:	Quantity is too much
Cause / Action:	Fuel injection is poor. Check the injector.

Other Related Procedures:

- Stop Injection of the Injector. See **Section 7.3.8**.
- Check the Fuel System. See **Section 6.4.1**.
- Check the Intake Air System. See **Section 6.4.2**.
- Check the Electrical System.
- Check the Coolant System. See **Section 6.4.4**.

5.5 Symptom - Engine Output is Insufficient

The following symptoms may indicate an engine with insufficient output:

- Poor power
- Huge drop in RPM when under load

Table 5–3 Engine Output is Insufficient - Causes and Actions

Engine Body
Cause / Action: 1. Compression is insufficient. Check the cylinder, piston ring, valve, cylinder head, timing gear, or valve clearance.

Table 5–3 Engine Output is Insufficient - Causes and Actions

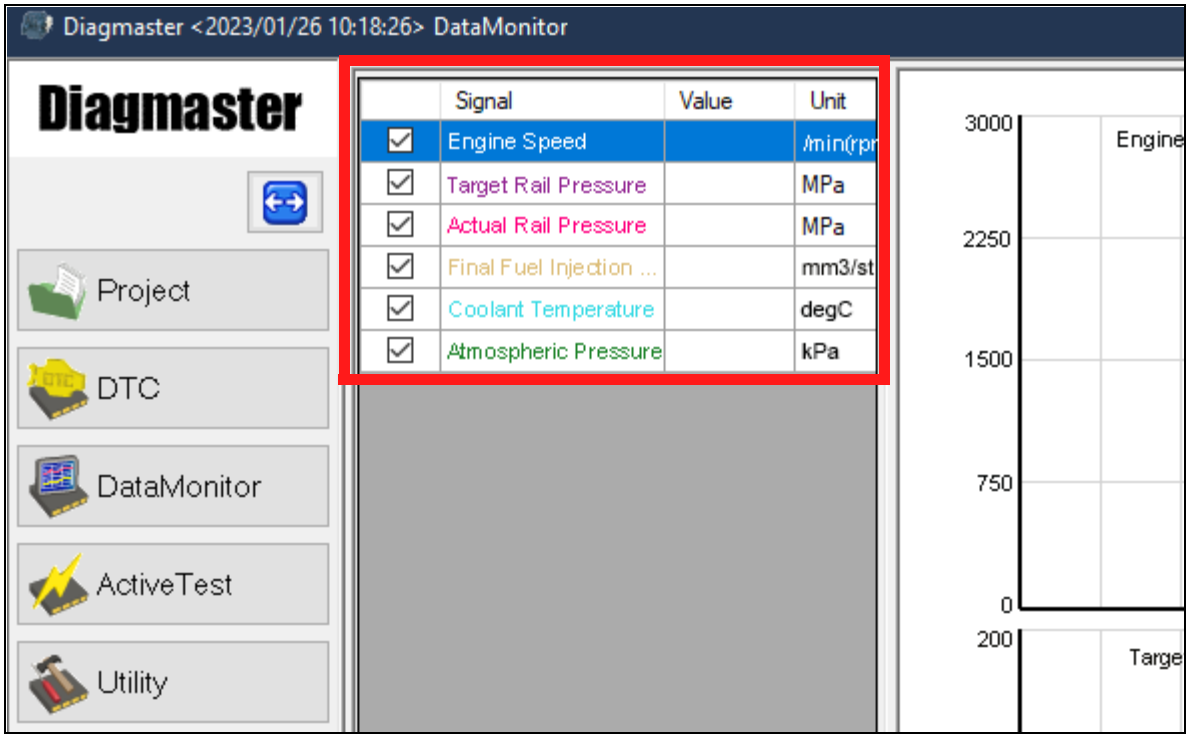
Fuel System
Cause / Action: 1. Fuel supply is poor. Check the fuel tank, fuel feed pumps, fuel filter or fuel hose. 2. Fuel high pressure supply is poor. Check the high pressure supply pump, suction control valve (SCV) or rail. 3. Fuel injection is poor. Check the injector. 4. Sensor signal problem. Check the crankshaft position sensor, camshaft position sensor, pulsar gear, rail pressure sensor, coolant temperature sensor, or CAN communications. 5. Fuel is poor. Check the fuel quality.
Intake / Exhaust System
Cause / Action: 1. Intake is poor. Check the air cleaner or intake air hose. 2. Exhaust is poor. Check the DOC.
Lubrication System
Cause / Action: 1. Oil viscosity is improper. Check the engine oil. 2. Oil quantity is excessive. Check the engine oil.
Cooling System
Cause / Action: 1. Coolant temperature rise is insufficient. Check the thermostat, coolant temperature sensor. 2. Overheating. Check the radiator, radiator cap, fan belt, fan drive, thermostat, water hose or coolant.
Other
Cause / Action: 1. Problem on vehicle side. Check for an overload or CAN communication error. 2. Calibration or correction after maintenance was not completed. Check that an injector correction or injection timing compensation was performed. 3. Operating environment problem. Check for hot or cold outside air or condition due to high altitude.

5.5.1 Diagnosing an Engine with Insufficient Output

1. Inspect the following items (from the pre-work checklist, **Section 6.2**) to verify the following criteria:
   - Engine oil quantity meets the specified amount; Engine oil quality meets the oil standard
   - Fuel quantity meets the specified amount; Fuel quality meets the fuel standard
   - Fuel filter not clogged
   - Coolant quantity meets the specified amount
   - Air cleaner element is not clogged.
   - Intake air hoses are not disconnected, have cracks or deformation
2. Connect a computer to the ECU and open Diagmaster software.
3. Place the ignition switch (IGN) in the START position to start the engine.
4. Check that any of the procedures listed below were completed recently:
   - Injector correction to an injector, or the engine ECU
   - Injector timing correction to the flywheel housing, flywheel, or crankshaft

   If so, verify that an Injector Compensation was performed on the Utility screen. This is necessary to re-register the injectors to the engine ECU. See **Section 7.3.9** for related information.

5. Go to the Data Monitor screen and bring up the following data monitor settings on the screen.
   - Engine Speed, Target Rail Pressure & Actual Rail Pressure, Final Fuel Injection Quantity, Coolant Temperature, Atmospheric Pressure



6. Click the Play button (green) to start data measurement and Stop button (gray) to finish. During a measurement, observe the data on screen when the engine is stopped (ignition RUN) and also when the engine cranking (ignition START). Check the measurements for each of the settings active in the screen and compare to the reference values given in the tables below.

   If the problem can not be solved after observing the measurements, check the compression pressure measurement. If compression is insufficient: check the cylinder, piston ring, valve, cylinder head, timing gear or valve clearance.

Engine Speed:	
Reference:	1500 rpm (at no-load maximum speed)
Symptom:	It reaches the specified rpm.
Cause / Action:	Problem on vehicle side. Check for an overload condition.
Target Rail Pressure & Actual Rail Pressure:	
Reference:	Equivalent to target (at no-load maximum speed)
Symptom:	Actual pressure equivalent to target pressure; Actual pressure follows the target pressure; Actual pressure is stable
Cause / Action:	Fuel pressure supply is poor. Check the supply pump, suction control valve (SCV), rail, or injector.
	Fuel supply is poor. Check the fuel tank, fuel feed pumps, fuel filter, or fuel hoses.
	Pressure sensor signal. Check the rail pressure sensor
Final Fuel Injection Quantity:	
Reference:	About 90 MPa (at no-load maximum speed)
Symptom:	Quantity is too much
Cause / Action:	Fuel injection is poor. Check the injector.

Coolant Temperature:	
Reference:	After warmup, 80.5 to 95°C (At no-load maximum speed)
Symptom:	Temperature is too low
Cause / Action:	Coolant temperature rise is insufficient. Check the thermostat.
	Sensor signal error. Check the coolant temperature sensor.
	Operating environment problem. Check for cold outside air.
Symptom:	Temperature is too high
Cause / Action:	Overheating. Check the radiator, radiator cap, fan belt, fan drive or thermostat.
	Pressure sensor signal. Check the coolant temperature sensor.
Atmospheric Pressure:	
Reference:	About 100 kPa (At no-load maximum speed)
Symptom	Pressure is too low
Cause / Action:	Operating environment problem. Check for high altitude condition.

Other Related Procedures:

- Stop Injection of the Injector. See **Section 7.3.8**.
- Check the Fuel System. See **Section 6.4.1** for procedures.
- Check the Intake Air System. See **Section 6.4.2** for procedures.
- Check the Electrical System.
- Check the Coolant System. See **Section 6.4.4** for procedure.

5.6 Symptom - Engine Noise is Abnormal

The following symptoms may indicate an engine with abnormal noise:

- Knocking
- Noise

Table 5–4 Engine Noise is Abnormal - Causes and Actions

Engine Body
Cause / Action: 1. Compression leakage. Check the cylinder, piston ring, valve, cylinder head, timing gear, or valve clearance.
Fuel System
Cause / Action: 1. Fuel high pressure supply is poor. Check the high pressure supply pump, suction control valve (SCV) or rail. 2. Fuel injection is poor. Check the injector. 3. Sensor signal problem. Check the crankshaft position sensor, camshaft position sensor, pulsar gear or rail pressure sensor. 4. Fuel is poor. Check the fuel quality.
Intake / Exhaust System
Cause / Action: 1. Intake is poor. Check the air cleaner or intake air hose.
Cooling System
Cause / Action: 1. Overheating. Check the radiator, radiator cap, fan belt, fan drive, thermostat, water hose or coolant

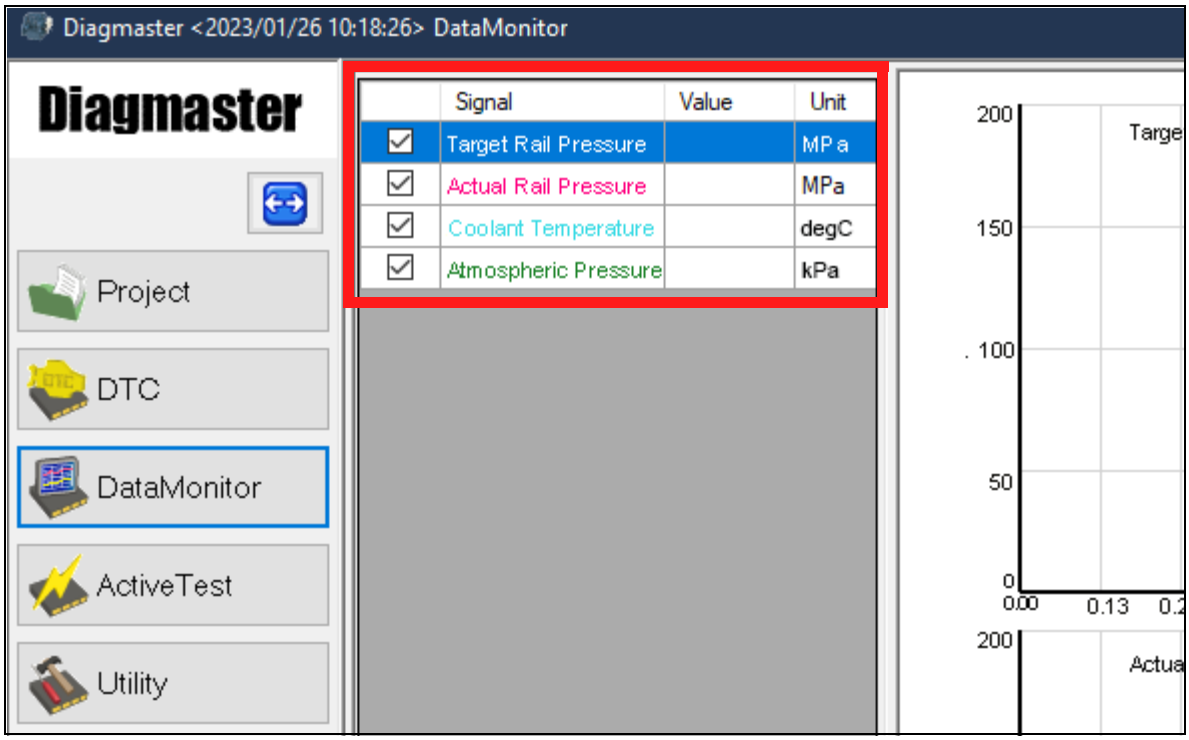
Table 5–4 Engine Noise is Abnormal - Causes and Actions

Other
Cause / Action: 1. Engine drag. Check the power transmission parts on the vehicle side. 2. Calibration or correction after maintenance was not completed. Check that an injector correction or injection timing compensation was performed. 3. Loose parts. Check each clamp and mounting screw.

5.6.1 Diagnosing an Engine with Abnormal Noise

1. Inspect the following items (from the pre-work checklist, **Section 6.2**) to verify the following criteria:
   - Engine oil quantity meets the specified amount; Engine oil quality meets the oil standard
   - Fuel quantity meets the specified amount; Fuel quality meets the fuel standard
   - Coolant quantity meets the specified amount
   - Air cleaner element is not clogged.
2. Connect a computer to the ECU and open Diagmaster software.
3. Place the ignition switch (IGN) in the START position to start the engine.
4. Check that any of the procedures listed below were completed recently:
   - Injector correction to an injector, or the engine ECU
   - Injector timing correction to the flywheel housing, flywheel, or crankshaft

   If so, verify that an Injector Compensation was performed on the Utility screen. This is necessary to re-register the injectors to the engine ECU. See **Section 7.3.9** for related information.
5. Go to the Data Monitor screen and bring up the following data monitor settings on the screen:
   - Target Rail Pressure & Actual Rail Pressure, Coolant Temperature, Atmospheric Pressure



6. Click the Play button (green) to start data measurement and Stop button (gray) to finish. During a measurement, observe the data on screen when the engine is stopped (ignition RUN) and also when the engine cranking (ignition START). Check the measurements for each of the settings active in the screen and compare to the reference values given in the tables below.

   If the problem can not be solved after observing the measurements, check the compression pressure measurement. If compression is insufficient: check the cylinder, piston ring, valve, cylinder head, timing gear or valve clearance.

.

Target Rail Pressure & Actual Rail Pressure:	
Reference:	Equivalent to target (at no-load maximum speed)
Symptom:	Actual pressure equivalent to target pressure; Actual pressure follows the target pressure; Actual pressure is stable
Cause / Action:	Fuel delivery / injection is abnormal. Check the supply pump, suction control valve (SCV), rail or injector.
	Fuel supply is unstable. Check the fuel tank, fuel feed pumps, fuel filter or fuel hose.
	Sensor error. Check the rail pressure sensor.
Coolant Temperature:	
Reference:	After warmup, 80.5 to 95°C (At no-load maximum speed)
Symptom	Temperature is too low
Cause / Action:	Coolant temperature rise is insufficient. Check the thermostat.
	Sensor signal error. Check the coolant temperature sensor.
	Operating environment problem. Check for cold outside air.
Symptom:	Temperature is too high
Cause / Action:	Overheating. Check the radiator, radiator cap, fan belt, fan drive or thermostat.
	Pressure sensor signal. Check the coolant temperature sensor.
	Operating environment problem. Check for hot outside air.
Atmospheric Pressure:	
Reference:	About 100 kPa (At no-load maximum speed)
Symptom:	Pressure is too low
Cause / Action:	Operating environment problem. Check for high altitude condition.

Other Related Procedures:

- Stop Injection of the Injector. See **Section 7.3.8**.
- Check the Fuel System. See **Section 6.4.1**.
- Check the Intake Air System. See **Section 6.4.2**.
- Check the Electrical System.
- Check the Coolant System. See **Section 6.4.4**.

5.7 Symptom - Engine Emission Deterioration

The following symptoms may indicate an engine with emission deterioration:

- Black smoke
- White smoke

Table 5–5 Engine Emission Deterioration - Causes and Actions

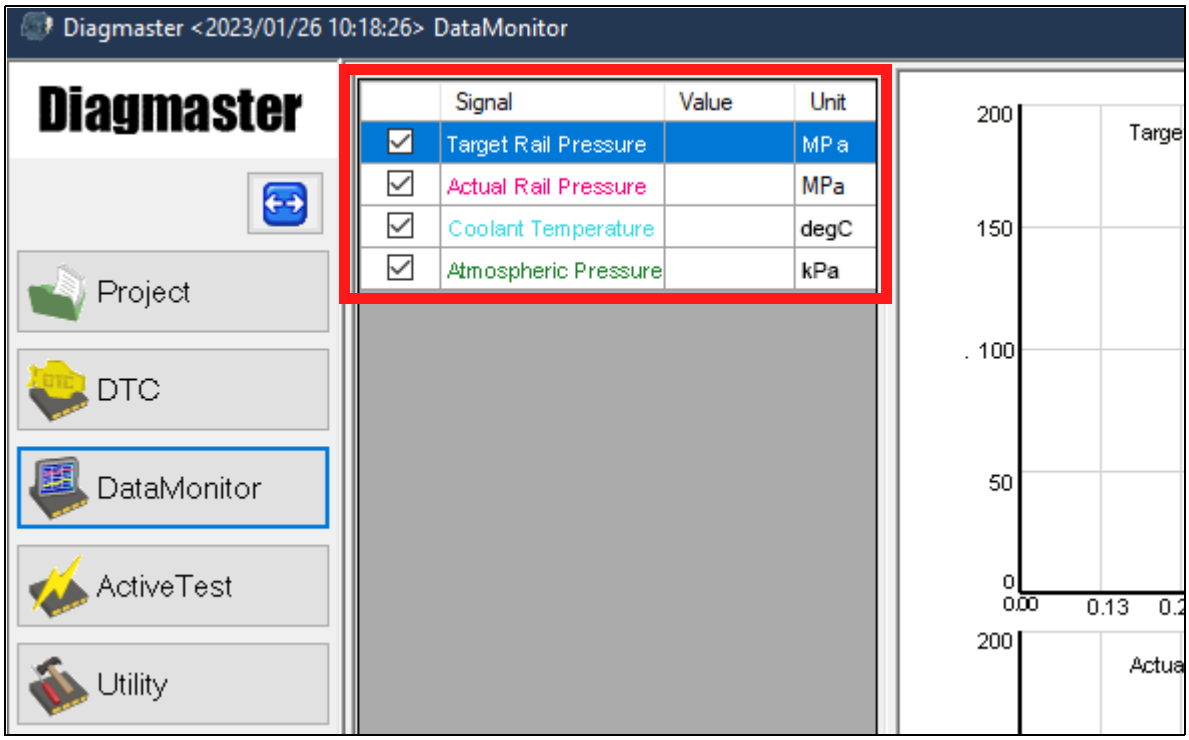
Engine Body
Cause / Action: 1. Compression leakage. Check the cylinder, piston ring, valve, cylinder head, timing gear, or valve clearance. 2. Oil rise. Check the cylinder or piston ring. 3. Oil drop. Check the valve, valve stem seal or cylinder head.
Fuel System
Cause / Action: 1. Fuel high pressure supply or injection is poor. Check the high pressure supply pump, suction control valve (SCV), rail or injector. 2. Sensor signal problem. Check the crankshaft position sensor, camshaft position sensor, pulsar gear, rail pressure sensor, atmospheric pressure sensor, coolant temperature sensor. 3. Fuel is poor. Check the fuel quality.
Intake / Exhaust System
Cause / Action: 1. Intake is poor. Check the air cleaner or intake air hose. 2. Exhaust is poor. Check the DOC.
Lubrication System
Cause / Action: 1. Oil quantity excessive. Check the engine oil.
Cooling System
Cause / Action: 1. Coolant temperature rise is insufficient. Check the thermostat, coolant temperature sensor, or low ambient temperature. 2. Overheating. Check the radiator, radiator cap, fan belt, fan drive, thermostat, water hose or coolant,
Other
Cause / Action: 1. Operating environment problem. Check the atmospheric pressure sensor, coolant temperature sensor.

5.7.1 Diagnosing an Engine with Emission Deterioration

1. Inspect the following items (from the pre-work checklist, **Section 6.2**) to verify the following criteria:
   - Engine oil quantity meets the specified amount; Engine oil quality meets the oil standard
   - Engine oil amount is decreasing short term and increasing in long term
   - Fuel quantity meets the specified amount; Fuel quality meets the fuel standard.
   - Coolant quantity meets the specified amount
   - Air cleaner element is not clogged.
2. Connect a computer to the ECU and open Diagmaster software.
3. Place the ignition switch (IGN) in the START position to start the engine.
4. Check that any of the procedures listed below were completed recently:
   - Injector correction to an injector, or the engine ECU
   - Injector timing correction to the flywheel housing, flywheel, or crankshaft

   If so, verify that an Injector Compensation was performed on the Utility screen. This is necessary to re-register the injectors to the engine ECU. See **Section 7.3.9** for related information.

5. Go to the Data Monitor screen and bring up the following data monitor settings on the screen:
   - Target Rail Pressure & Actual Rail Pressure, Coolant Temperature, Atmospheric Pressure



6. Click the Play button (green) to start data measurement and Stop button (gray) to finish. During a measurement, observe the data on screen when the engine is stopped (ignition RUN) and also when the engine cranking (ignition START). Check the measurements for each of the settings active in the screen and compare to the reference values given in the tables below.

   If the problem can not be solved after observing the measurements, check the following items:

   Check the compression pressure measurement. If compression is insufficient: check the cylinder, piston ring, valve, cylinder head, timing gear or valve clearance.

   Check the cylinder wear and piston ring gap. If oil rise is observed: check the cylinder or piston ring.

   Check the valve stems and cylinder head. If oil drop is observed: check the valve, valve stem seal or cylinder head.

Target Rail Pressure & Actual Rail Pressure:	
Reference:	Equivalent to target (at no-load maximum speed)
Symptom:	Actual pressure equivalent to target pressure; Actual pressure follows the target pressure; Actual pressure is stable
Cause / Action:	Fuel delivery / injection is abnormal. Check the supply pump, suction control valve (SCV), rail or injector.
	Fuel supply is unstable. Check the fuel tank, pre-filter fuel pump, fuel filter, fuel feed pump or fuel hose.
	Sensor error. Check the rail pressure sensor
Coolant Temperature:	
Reference:	After warmup, 80.5 to 95°C (At no-load maximum speed)
Symptom:	Temperature is too low
Cause / Action:	Coolant temperature rise is insufficient. Check the fan drive.
	Sensor signal error. Check the coolant temperature sensor.
	Operating environment problem. Check for cold outside air condition.

Symptom	Temperature is too high
Cause / Action:	Overheating. Check the radiator, radiator cap, fan belt, fan drive or thermostat.
	Pressure sensor signal. Check the coolant temperature sensor.
	Operating environment problem. Check for hot outside air condition.
Atmospheric Pressure:	
Reference:	About 100 kPa (At no-load maximum speed)
Symptom:	Temperature is too low
Cause / Action:	Operating environment problem. Check for a high altitude condition.

Other Related Procedures:

- Stop Injection of the Injector. See **Section 7.3.8**.
- Check the Fuel System. See **Section 6.4.1**.
- Check the Intake Air System. See **Section 6.4.2**.
- Check the Electrical System.
- Check the Coolant System. See **Section 6.4.4**.

5.8 Battery Charger Troubleshooting

Table 5–6 Battery Charger - Causes and Actions

Condition: CB4 trips when charger is turned on.
Cause / Action: 1. Short in 12-volt wiring causing overload of charger. Locate and remove short or replace the charger.
Condition: Circuit breaker trips repeatedly, even when not connected.
Cause / Action: 1. Internal short. Replace the charger.
Condition: Charger does not taper back after charging for a few minutes.
Cause / Action: 1. Bad cell in battery. Test battery for defect according to battery manufacturer's instructions. 2. Charger is bad. Replace the charger.
Condition: Charger does not charge.
Cause / Action: 1. Fuse BCF3 is open. Replace the fuse. 2. Charger is not receiving AC input. Use voltmeter to confirm charger is receiving 360-500 VAC. If not, check input connections / fuses. 3. Charger output is not connected to 12 volt battery. Check output wiring connections to battery. 4. Charger is bad. Replace the charger.
Condition: Low output voltage measured across charger output.
Cause / Action: 1. Battery is not connected to the charger. It is normal to measure 12 volts or less across charger output with no battery connected. Check charging leads from the charger to the battery.
Condition: Reverse polarity connection to battery has caused charger to stop charging.
Cause / Action: 1. Internal DC fuse is blown and possible damage to current carrying components. Replace.

5.9 Alternating Current (AC) Generator Troubleshooting

Table 5–7 Alternating Current Generator - Causes and Actions

Condition: No voltage.
Cause / Action: 1. Rotor magnetism is lost. Replace. 2. Circuit breaker is tripped. Check CB1. 3. Open in stator windings. Replace. 4. Short circuited. Replace. 5. Worn drive gear is stripped. Check / Replace. 6. Contactor is not engaged. Replace.
Condition: Low voltage
Cause / Action: 1. Engine speed is low. Refer to the Engine workshop manual. 2. High resistance connections, connections are warm or hot. Tighten. 3. Rotor magnetism is lost. Replace.
Condition: Fluctuating voltage (May be indicated by flickering lights)
Cause / Action: 1. Speed fluctuating. 2. Engine speed is irregular. Refer to the Engine workshop manual. 3. Terminal or load connections are loose. Tighten. 4. Bad bearing is causing uneven air gap. Replace.
Condition: High Voltage
Cause / Action: 1. Engine speed is excessive
Condition: Overheating
Cause / Action: 1. Generator is overloaded. Check. 2. Vents / baffles are clogged. Check / clean. 3. High temperature surrounding generator. 4. Air circulation or recirculation is insufficient. Check / clean. 5. Load is unbalanced. 6. Bearing is dry. Replace.
Condition: Mechanical Noise
Cause / Action: 1. Bearing is bad. Replace. 2. Rotor is rubbing on stator. Replace. 3. Laminations are loose. Replace. 4. Coupling is loose or misaligned. Check drive gear.
Condition: Generator frame produces shock when touched.
Cause / Action: 1. Static charge. Check ground to frame.

5.10 Voltage Controller Troubleshooting

The voltage controller has one green indicator light and one yellow indicator light. When the green light is illuminated, it means that the voltage controller is receiving power. The yellow light only illuminates (flashes) to indicate that there is a problem.

Table 5–8 Voltage Controller - Causes and Actions

Condition: Green LED is not illuminated.
Cause / Action: 1. No power to the voltage controller (VC). Contactor failed. Or, check line side power on contactors.
Condition: Yellow LED flash code: one long and three short
Cause / Action: 1. Over voltage error. Check engine speed.
Condition: Yellow LED flash code: one long and four short
Cause / Action: 1. Under voltage error. Check engine speed.

5.11 High Voltage Circuit, Electrical Troubleshooting

⚠ WARNING

Before proceeding with troubleshooting, make sure to follow your company's standard safety procedures for working with electrical components

Table 5–9 High Voltage Circuit Troubleshooting

Item: Receptacle (R)
Checks / Cause / Action: 1. Check output voltage at Receptacle R (L1-L2, L2-L3, L1-L3) (50Hz: 360 - 460 VAC and 60Hz: 400 - 500 VAC). Problem could be a faulty receptacle. Replace.
Item: High Voltage Wires (from Circuit Breaker to Receptacle)
Checks / Cause / Action: 1. Check if wires / terminals are connected. Check continuity for each leg. Problem could be loose connections. Tighten as required.
Item: Circuit Breaker (CB)
Checks / Cause / Action: 1. Test the output power from circuit breaker CB (21-22, 22-23, 21-23). Problem could be a faulty circuit breaker. Replace. 2. Verify circuit breaker (CB) is in the ON position. 3. Test the input power to the circuit breaker CB (11-12, 12-13, 11-13).
Item: Voltage Controller (VC) and Fuses
Checks / Cause / Action: 1. Verify VCF1 fuse is not blown. Check continuity for each leg across fuse, outside of circuit; inside of circuit if not running. Replace fuse if required. 2. Verify VCF2 fuse is not blown. Check continuity for each leg across fuse, outside of circuit; inside of circuit if not running. Replace fuse if required. 3. Verify voltage controller has power (powered by high voltage). Verify green light is illuminated. Problem could be a faulty voltage controller, loose connections or a faulty generator.

Table 5–9 High Voltage Circuit Troubleshooting

Item: Voltage Controller (VC) and Fuses
4. Verify voltage controller has green light illuminated and yellow light flashing at 1 Hz. Yellow light flashing sequence other than at 1 Hz indicates a fault condition. • One Long / Two Short = voltage controller fault. This indicates a failed voltage controller. Replace. • One Long / Three Short = over voltage error. Check engine speed. • One Long / Four Short = under voltage error. Check engine speed. • One Long / Five Short = hot start error. Reset power to the unit. • One Long / Six Short = voltage controller fault. This indicates a failed voltage controller. Replace. • One Long / Seven Short = voltage controller fault. This indicates a failed voltage controller. Replace 5. Verify that the connectors to the Voltage Controller are secured; snapped in place and do not easily pull out. Check if the connectors are pushed in all the way. Remove connectors and inspect terminal pin insertion depth. Very depth is the same. Check to see if wires / terminals are connected.

5.12 DTC Codes

When an error occurs in the engine control unit (ECU), the engine service light on the generator set control panel illuminates to signal that a DTC code is present.

Figure 5.1 Engine Service Light (ESL)

DTC codes can be monitored by connecting a computer to the ECU and using Diagmaster software. Diagmaster has a DTC screen that allows for managing of DTC codes, including saving code information and clearing codes. Refer to the **Section 7.2** for Diagmaster installation and operation procedures.

Figure 5.2 Diagmaster DTC Screen

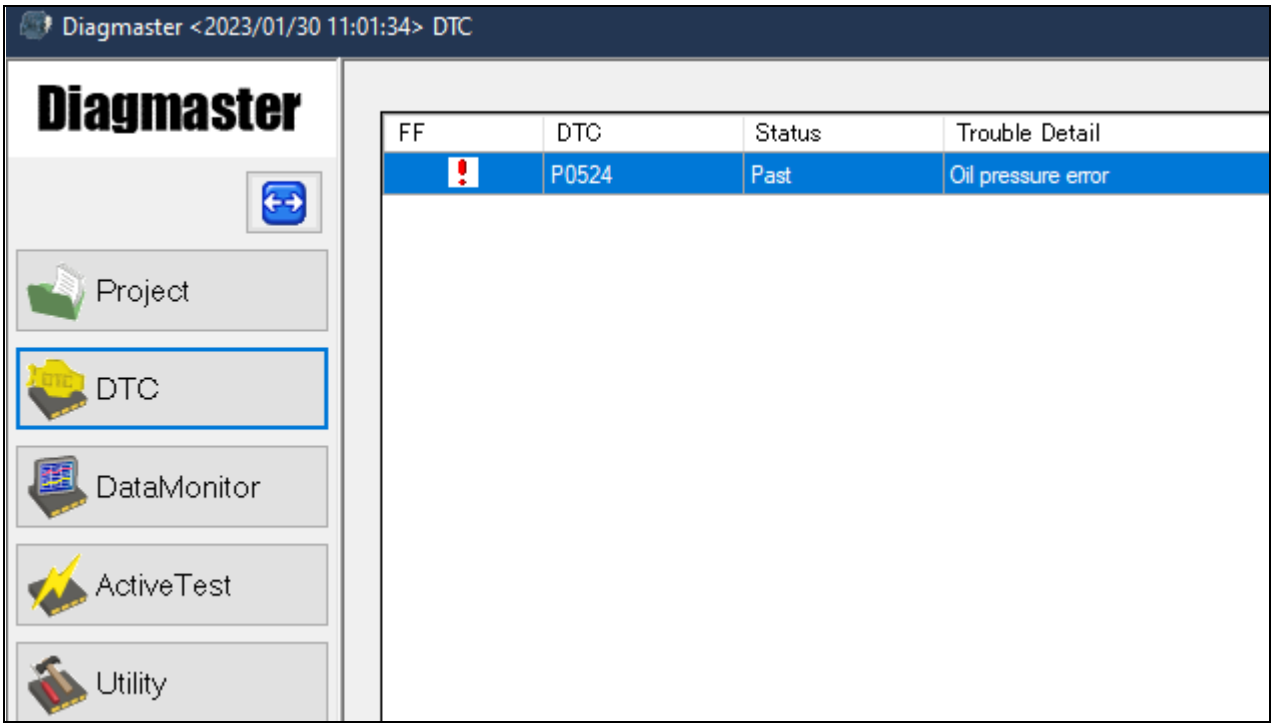


Table 5–10 DTC Codes - Summary

Code	Description
P0016	NE-G phase shift (636-7)
P0087	Pressure limiter emergency open (633-7)
P0088	High rail pressure (157-0)
P0089	SCV stuck (1347-7)
P0093	Fuel leak high pressure fuel system (1239-1)
P0117	Coolant temperature sensor: low (110-4)
P0118	Coolant temperature sensor: high (110-3)
P0192	Rail pressure sensor: low (157-4)
P0193	Rail pressure sensor: high (157-3)
P0200	Injector charge voltage: high (523535-0)
P0201	Open circuit of harness or coil in 1st cylinder injector (651-3)
P0202	Open circuit of harness or coil in 3rd cylinder injector (653-3)
P0203	Open circuit of harness or coil in 4th cylinder injector (654-3)
P0204	Open circuit of harness or coil in 2nd cylinder injector (652-3)
P0217	Engine overheat (110-0)
P0219	Engine overrun (190-0)
P0335	No pulse from crankshaft position sensor (NE sensor) (636-8)
P0336	Crankshaft position sensor (NE sensor) pulse number error (636-2)
P0340	No pulse from camshaft position sensor (G sensor) (723-8)
P0341	Camshaft position sensor (G sensor) pulse number error (723-2)
P0380	Glow relay abnormality open circuit (676-5)
P0380	Glow relay abnormality +B short (523544-3)
P0380	Glow relay abnormality ground short (523544-4)
P0381	Glow relay driving circuit overheat (676-0)
P0524	Engine oil pressure low error (100-1)
P0562	Battery voltage: low (168-4)
P0563	Battery voltage: high (168-3)
P0602	QR data error (data write error) (523538-2)
P0602	QR data error (data write error) (523538-7)
P0605	ECU flash ROM error (682-2)
P0606	ECU CPU error (Main IC error) (1077-2)
P0606	ECU CPU error (Monitoring IC) (523527-2)
P0611	Injector charge voltage: low (523525-1)
P0627	SCV drive system abnormality open circuit (1347-5)
P0628	SCV drive system abnormality ground short (1347-4)
P0629	SCV drive system abnormality B + short (1347-3)
P062B	Internal injector drive circuit abnormality open circuit (1077-12)
P062D	Internal injector drive circuit abnormality short circuit (523605-6)
P0643	Sensor supply voltage 1 abnormality (3509-3)

Table 5–10 DTC Codes - Summary

Code	Description
P0653	Sensor supply voltage 2 abnormality (3510-3)
P0663	Sensor supply voltage 3 abnormality (3511-3)
P0687	Main relay is locked in closed position (1485-2)
P081A	Ground short of starter (677-4)
P1990	EEPROM checksum error (523700-13)
P2148	All injectors +B short or ground short (523523-3)
P2228	Atmospheric pressure sensor low (108-4)
P2229	Atmospheric pressure sensor high (108-3)
P2293	Pressure limiter abnormality (679-9)
P2293	Pressure limiter failure after pressure relief valve (679-16)
P2294	Pressure limiter error (number of times) (679-15)
P2294	Pressure limiter error (amount of time) (679-10)
P3014	Water in water separator failure (97-31)
P3025	Overheat pre-caution (523603-15)
U0075	CAN2 bus off error (523547-2)
U0077	CAN1 bus off error (523604-2)

5.12.1 P0016 NE-G phase shift (636-7)

SPN Name:	Engine Position Sensor
Cause:	A large phase shift occurs between NE pulse and G pulse. NE refers to the crankshaft position sensor (Engine speed sensor) G refers to the camshaft position sensor
DTC set preconditions:	• Ignition switch is ON • Battery voltage is normal • Sensor supply voltage VCC# is normal • NE sensor signal is normal • G sensor signal is normal • Engine speed is 350 rpm or higher • Coolant temperature is 10°C (50°F) or higher
DTC set parameter:	The phase difference between NE pulse and G pulse is approximately within +30 and -20 degrees.
Time to action / number of error detections:	2 times or more
Limp home action:	There is an output limitation of approximately 75% of normal condition.
Behavior during malfunction:	The engine hesitates at start-up due to an invalid G sensor signal.
Error recovery conditions:	Diagnostic counter = 0 or turn ignition switch OFF
Delay time for recovery:	Delay time varies with engine speed in proportional relation: 30 seconds at 800 rpm, 15 seconds at 1600 rpm.
Components to check:	• Pulsar gear of the camshaft position sensor • Flywheel • Cam gear • Crank gear • Camshaft • Crankshaft • Wire harness

Related Reference Material

- Description and location of engine position sensors (NE and G). See **Section 3.7.9**.
- Inspect around the pulsar hole on flywheel. See **Section 5.13.1**.
- Inspect around the camshaft position pulsar gear. See **Section 5.13.2**.

5.12.2 P0087 Pressure limiter emergency open (633-7)

SPN Name:	Engine Fuel Actuator 1 Control Command
Cause:	Pressure limiter emergency is open
DTC set preconditions:	Sensor supply voltage VCC# is normal
DTC set parameter:	• Pressure limiter emergency is open • Engine speed is more than 10 rpm
Time to action / number of error detections:	One time or more
Limp home action:	There is an output limitation of approximately 50% of normal condition.
Behavior during malfunction:	• Output is insufficient • Exhaust gas emissions will worsen
Error recovery conditions:	Turn ignition switch OFF.
Delay time for recovery:	None
Components to check:	• Fuel • Fuel hose • SCV • Supply pump • Rail (rail pressure sensor) • Injector
Remarks	This code is to minimize PM emission. Engine speed may go down due to lack of fuel pressure, regardless limp home action.

Related Reference Material

- Description of fuel system. See **Section 3.7**.
- Diagnosing fuel pressure (low / high) or a stuck SCV. See **Section 5.13.3**.

5.12.3 P0088 High rail pressure (157-0)

SPN Name:	Engine Injector Metering Rail 1 Pressure
Cause:	Actual pressure exceeds the command pressure
DTC set preconditions:	• Rail pressure sensor is normal • Sensor supply voltage VCC# is normal
DTC set parameter:	Actual pressure is more than 179 MPa (1830 kg/cm^2, 26000 psi)
Time to action / number of error detections:	3 seconds or more
Limp home action:	There is an output limitation of approximately 50% of normal condition.
Behavior during malfunction:	• Output is insufficient • Exhaust gas emissions will worsen
Error recovery conditions:	Turn ignition switch OFF.
Delay time for recovery:	None
Components to check:	• Fuel • Fuel hose • SCV • Supply pump • Rail (rail pressure sensor) • Injector
Remarks	This code is to minimize PM emission.

Related Reference Material

- Description of fuel system. See **Section 3.7**.
- Location of rail pressure sensor. See **Section 3.7.9**.
- Diagnosing fuel pressure (low / high) or a stuck SCV. See **Section 5.13.3**.

5.12.4 P0089 SCV stuck (1347-7)

SPN Name:	Engine Fuel Pump Pressurizing Assembly #1
Cause:	Suction control valve (SCV) is stuck at the open position. Actual rail pressure continuously exceeds the command rail pressure.
DTC set preconditions:	• Engine is running (Q: 3 mm^3/st or more) • Injector is normal • Battery voltage is normal • Sensor supply voltage VCC# is normal • Rail pressure sensor is normal
DTC set parameter:	Discharge request of supply pump goes -1800 mm^3/st or less and the actual rail pressure is 20 MPa (200 kgf/cm^2, 2900 psi) higher than command pressure.
Time to action / number of error detections:	5 seconds or more
Limp home action:	There is an output limitation of approximately 50% of normal condition.
Behavior during malfunction:	• Output is insufficient • Exhaust gas emissions will worsen • Engine stops in some cases
Error recovery conditions:	Turn ignition switch OFF.
Delay time for recovery:	None
Components to check:	• Fuel • Fuel hose • SCV • Supply pump • Rail (rail pressure sensor) • Injector
Remarks	This code is to minimize PM emission.

Related Reference Material

- Description of fuel system. See **Section 3.7**.
- Location of SCV. See **Section 3.7.9**.
- Diagnosing fuel pressure (low / high) or a stuck SCV. See **Section 5.13.3**.

5.12.5 P0093 Fuel leak high pressure fuel system (1239-1)

SPN Name:	Engine Fuel Leakage 1
Cause:	Fuel leak from the high pressure fuel system. Fuel consumption is calculated from the difference of fuel pressure before and after the injection. And the error will be detected when excess fuel consumption is found.
DTC set preconditions:	• Battery voltage is normal • Sensor supply voltage VCC# is normal • Rail pressure sensor is normal • Suction control valve (SCV) is normal • Injector and injector drive circuit are normal • Crankshaft position sensor (NE) signal is active. Engine is operating at 700 rpm or more. • No DTC of P0087, P0088, P0089
DTC set parameter:	• Pump supplies fuel fully • The deviation between actual rail pressure and desired one is more than 20 MPa (200 kg/cm^2, 2900 psi)
Time to action / number of error detections:	60 seconds or more
Limp home action:	There is an output limitation of approximately 50% of normal condition.
Behavior during malfunction:	• Output is insufficient • Exhaust gas emissions will worsen • Engine stops in some cases
Error recovery conditions:	Turn ignition switch OFF.
Delay time for recovery:	None
Components to check:	• Fuel • Fuel system-related parts
Remarks	This code is to minimize PM emission

Related Reference Material

- Description of fuel system. See **Section 3.7**.
- Diagnosing low fuel pressure in the high pressure system. See **Section 5.13.4**.

5.12.6 P0117 Coolant temperature sensor: low (110-4)

SPN Name:	Engine Coolant Temperature
Cause:	Ground short circuit of the coolant temperature sensor or harness.
DTC set preconditions:	Battery voltage is normal
DTC set parameter:	Voltage of the coolant temperature sensor is 0.176 V or less.
Time to action / number of error detections:	3 seconds or more
Limp home action:	• During start-up = -25°C (-13°F) [default value] • Under other conditions = 80°C (176°F) [default value] • There is an output limitation of approximately 75% of normal condition.
Behavior during malfunction:	• Increase in amount of white smoke at low temperature • Output is insufficient • Exhaust gas emissions will worsen
Error recovery conditions:	Turn ignition switch OFF.
Delay time for recovery:	None
Components to check:	• Coolant temperature sensor • Wire harness • ECU

Related Reference Material

- Description of coolant system. See **Section 3.10**.
- Location of coolant temperature sensor. See **Section 3.7.9**
- Checking coolant temperature sensor, wire harness, ECU connectors. See **Section 5.13.5**.

5.12.7 P0118 Coolant temperature sensor: high (110-3)

SPN Name:	Engine Coolant Temperature
Cause:	Open circuit or +B short circuit of the coolant temperature sensor or harness.
DTC set preconditions:	Battery voltage is normal
DTC set parameter:	Voltage of the coolant temperature sensor is 4.87 V or more.
Time to action / number of error detections:	3 seconds or more
Limp home action:	• During start-up = -25°C (-13°F). This is the default value. • Under other conditions = 80°C (176°F). This is the default value. • There is an output limitation of approximately 75% of normal condition.
Behavior during malfunction:	• White smoke increases at low temperature • Output is insufficient • Exhaust gas emissions will worsen
Error recovery conditions:	Turn ignition switch OFF.
Delay time for recovery:	None
Components to check:	• Coolant temperature sensor • Wire harness • ECU

Related Reference Material

- Description of coolant system. See **Section 3.10**.
- Location of coolant temperature sensor. See **Section 3.7.9**.
- Checking coolant temperature sensor, wire harness, ECU connectors. See **Section 5.13.6**.

5.12.8 P0192 Rail pressure sensor: low (157-4)

SPN Name:	Engine Injector Metering Rail 1 Pressure
Cause:	Ground short circuit of the rail pressure sensor or harness. Or, the rail pressure sensor has failed.
DTC set preconditions:	• Battery voltage is normal • Sensor supply voltage VCC# is normal
DTC set parameter:	Voltage of the rail pressure sensor is 0.065 V or less.
Time to action / number of error detections:	Transient
Limp home action:	There is an output limitation of approximately 50% of normal condition. And the engine is forcibly stopped 60 seconds later.
Behavior during malfunction:	• Output is insufficient • Exhaust gas emissions will worsen • Noise will worsen • White smoke increases • Engine stops
Error recovery conditions:	Turn ignition switch OFF.
Delay time for recovery:	None
Components to check:	• Rail pressure sensor (rail) • Wire harness • ECU
Remarks	This code is to minimize PM emission

Related Reference Material

- Description of fuel system. See **Section 3.7**.
- Location of rail pressure sensor. See **Section 3.7.9**.
- Measuring output voltage of the ECU connector - rail pressure sensor. See **Section 5.13.10**.
- Measuring output voltage - rail pressure sensor. See **Section 5.13.11**.
- Measuring power supply voltage - rail pressure sensor. See **Section 5.13.12**.
- Measuring power supply voltage of the ECU connectors - rail pressure sensor. See **Section 5.13.13**.
- Checking ECU connectors. See **Section 5.13.47**.

5.12.9 P0193 Rail pressure sensor: high (157-3)

SPN Name:	Engine Injector Metering Rail 1 Pressure
Cause:	• Open circuit or +B short circuit of the rail pressure sensor or harness. Or, the rail pressure sensor has failed.
DTC set preconditions:	• Battery voltage is normal • Sensor supply voltage VCC# is normal
DTC set parameter:	Voltage of rail pressure sensor is 3.235 V or more.
Time to action / number of error detections:	Transient
Limp home action:	There is an output limitation of approximately 50% of normal condition. And the engine is forcibly stopped 60 seconds later.
Behavior during malfunction:	• Output is insufficient • Exhaust gas emissions will worsen • Noise will worsen • White smoke increases • Engine stops
Error recovery conditions:	Turn ignition switch OFF.
Delay time for recovery:	None
Components to check:	• Rail pressure sensor (rail) • Wire harness • ECU
Remarks	This code is to minimize PM emission

Related Reference Material

- Description of fuel system. See **Section 3.7**.
- Location of rail pressure sensor. See **Section 3.7.9**.
- Measuring output voltage of the ECU connector - rail pressure sensor. See **Section 5.13.10**.
- Measuring output voltage - rail pressure sensor. See **Section 5.13.11**.
- Measuring power supply voltage - rail pressure sensor. See **Section 5.13.12**.
- Measuring power supply voltage of the ECU connectors - rail pressure sensor. See **Section 5.13.13**.
- Checking ECU connectors. See **Section 5.13.47**.
- Checking injector driving circuit. See **Section 5.13.14**.
- Checking injectors. See **Section 5.13.15**.

5.12.10 P0200 Injector charge voltage: high (523535-0)

SPN Name:	proprietary
Cause:	Injector charge voltage is high.
DTC set preconditions:	• Battery voltage is normal • CPU is normal
DTC set parameter:	Injector charge voltage: High
Time to action / number of error detections:	Transient
Limp home action:	There is an output limitation of approximately 75% of normal condition. And the engine is forcibly stopped 60 seconds later.
Behavior during malfunction:	• Output is insufficient • Exhaust gas emissions will worsen • Engine stops
Error recovery conditions:	Turn ignition switch OFF.
Delay time for recovery:	None
Components to check:	• Injector • ECU

Related Reference Material

- Checking injector driving circuit. See **Section 5.13.14**.
- Checking injectors. See **Section 5.13.15**.

5.12.11 P0201 Open circuit of harness or coil in 1st cylinder injector (651-3)

SPN Name:	Engine Injector Cylinder #01
Cause:	Open circuit of either the harness or the injector coil.
DTC set preconditions:	• Engine is operating • Battery voltage is normal • Occurs during injection • CPU is normal
DTC set parameter:	Open circuit of either the harness or injector coil.
Time to action / number of error detections:	3 times or more
Limp home action:	There is an output limitation of approximately 75% of normal condition.
Behavior during malfunction:	• Output is insufficient • Exhaust gas emissions will worsen • Vibration increases
Error recovery conditions:	Turn ignition switch OFF.
Delay time for recovery:	None
Components to check:	• Injector • Wire harness • ECU
Remarks	This code is to minimize PM emission. Injectors which have no error continue to operate.

Related Reference Material

- Location of injectors. See **Section 3.7.9**.
- Checking injectors. See **Section 5.13.16**.
- Checking wire harness for disconnection. See **Section 5.13.17**.
- Checking ECU connectors. See **Section 5.13.47**.

5.12.12 P0202 Open circuit of harness or coil in 3rd cylinder injector (653-3)

SPN Name:	Engine Injector Cylinder #03
Cause:	Open circuit of either the harness or injector coil.
DTC set preconditions:	• Engine is operating • Battery voltage is normal • Occurs during injection • CPU is normal
DTC set parameter:	Open circuit of either the harness or injector coil.
Time to action / number of error detections:	3 times or more
Limp home action:	There is an output limitation of approximately 75% of normal condition.
Behavior during malfunction:	• Output is insufficient • Exhaust gas emissions will worsen • Vibration increases
Error recovery conditions:	Turn ignition switch OFF.
Delay time for recovery:	None
Components to check:	• Injector • Wire harness • ECU
Remarks	This code is to minimize PM emission. Injectors which have no error continue to operate.

Related Reference Material

- Location of injectors. See **Section 3.7.9**.
- Checking injectors. See **Section 5.13.16**.
- Checking wire harness for disconnection. See **Section 5.13.17**.
- Checking ECU connectors. See **Section 5.13.47**.

5.12.13 P0203 Open circuit of harness or coil in 4th cylinder injector (654-3)

SPN Name:	Engine Injector Cylinder #04
Cause:	Open circuit of either the harness or the injector coil.
DTC set preconditions:	• Engine is operating • Battery voltage is normal • Occurs during injection • CPU is normal
DTC set parameter:	Open circuit of either the harness or the injector coil.
Time to action / number of error detections:	3 times or more
Limp home action:	There is an output limitation of approximately 75% of normal condition.
Behavior during malfunction:	• Output is insufficient • Exhaust gas emissions will worsen • Vibration increases
Error recovery conditions:	Turn ignition switch OFF.
Delay time for recovery:	None
Components to check:	• Injector • Wire harness • ECU
Remarks	This code is to minimize PM emission. Injectors which have no error continue to operate.

Related Reference Material

- Location of injectors. See **Section 3.7.9**.
- Checking injectors. See **Section 5.13.16**.
- Checking wire harness for disconnection. See **Section 5.13.17**.
- Checking ECU connectors. See **Section 5.13.47**.

5.12.14 P0204 Open circuit of harness or coil in 2nd cylinder injector (652-3)

SPN Name:	Engine Injector Cylinder #02
Cause:	Open circuit of either the harness or the injector coil.
DTC set preconditions:	• Engine is operating • Battery voltage is normal • Occurs during injection • CPU is normal
DTC set parameter:	Open circuit of either the harness or the injector coil.
Time to action / number of error detections:	3 times or more
Limp home action:	There is an output limitation of approximately 75% of normal condition.
Behavior during malfunction:	• Output is insufficient • Exhaust gas emissions will worsen • Vibration increases
Error recovery conditions:	Turn ignition switch OFF.
Delay time for recovery:	None
Components to check:	• Injector • Wire harness • ECU
Remarks	This code is to minimize PM emission. Injectors which have no error continue to operate.

Related Reference Material

- Location of injectors. See **Section 3.7.9**.
- Checking injectors. See **Section 5.13.16**.
- Checking wire harness for disconnection. See **Section 5.13.17**.
- Checking ECU connectors. See **Section 5.13.47**.

5.12.15 P0217 Engine overheat (110-0)

SPN Name:	Engine Coolant Temperature
Cause:	Overheat of engine coolant temperature.
DTC set preconditions:	Coolant temperature sensor is normal.
DTC set parameter:	Engine coolant temperature is 120°C (248°F) or more.
Time to action / number of error detections:	5 seconds or more
Limp home action:	There is an output limitation of approximately 75% of normal condition.
Behavior during malfunction:	• Output is insufficient • Overheating
Error recovery conditions:	Diagnostic counter = 0 or turn ignition switch OFF.
Delay time for recovery:	30 seconds
Components to check:	• Coolant • Coolant temperature sensor • Coolant equipment-related parts

Related Reference Material

- Procedure for diagnosing overheating. See **Section 5.13.22**.

5.12.16 P0219 Engine overrun (190-0)

SPN Name:	Engine Speed
Cause:	Engine speed exceeds the threshold speed.
DTC set preconditions:	Ignition switch is ON.
DTC set parameter:	Engine speed is 3500 rpm or more.
Time to action / number of error detections:	3 revolutions or more
Limp home action:	Stop injection (Q = 0 mm^3/st)
Behavior during malfunction:	Engine overrun
Error recovery conditions:	Diagnostic counter = 0 or turn ignition switch OFF.
Delay time for recovery:	Immediately
Components to check:	Generator-side issue

5.12.17 P0335 No pulse from crankshaft position sensor (NE sensor) (636-8)

SPN Name:	Engine Position Sensor
Cause:	Open circuit or short circuit of the crankshaft position sensor (NE) or harness. Or, the sensor has failed.
DTC set preconditions:	• Battery voltage is normal • Sensor supply voltage VCC# is normal • Engine is not stalled
DTC set parameter:	No recognition of the crankshaft position sensor (NE) pulse.
Time to action / number of error detections:	10 times or more
Limp home action:	There is an output limitation of approximately 75% of normal condition.
Behavior during malfunction:	• Starting is poor • Vibration increases slightly • Output is insufficient • Driven only by the camshaft position sensor (G)
Error recovery conditions:	Turn ignition switch OFF.
Delay time for recovery:	None
Components to check:	• Crankshaft position sensor • Flywheel • Wire harness • ECU

Related Reference Material

- Location of crankshaft position sensor. See **Section 3.7.9**.
- Checking crankshaft position sensor power supply voltage. See **Section 5.13.23**.
- Checking wire harness for disconnection. See **Section 5.13.24**.
- Checking power supply voltage of the ECU connectors. See **Section 5.13.25**.
- Checking ECU connectors. See **Section 5.13.47**.
- Checking around the crankshaft position sensor. See **Section 5.13.26**.

5.12.18 P0336 Crankshaft position sensor (NE sensor) pulse number error (636-2)

SPN Name:	Engine Position Sensor
Cause:	Open circuit or short circuit of the crankshaft position sensor (NE) or harness. Or, the sensor has failed.
DTC set preconditions:	• Battery voltage is normal • Sensor supply voltage VCC# is normal • Engine speed is 350 min^{-1} (rpm) or higher
DTC set parameter:	Pulse count per rotation is not 58 teeth.
Time to action / number of error detections:	10 times or more
Limp home action:	There is an output limitation of approximately 75% of normal condition.
Behavior during malfunction:	• Starting is poor • Vibration increases slightly • Output is insufficient • Driven only by the camshaft position sensor (G)
Error recovery conditions:	Turn ignition switch OFF.
Delay time for recovery:	None
Components to check:	• Crankshaft position sensor • Pulsar gear • Wire harness • ECU

Related Reference Material

- Location of crankshaft position sensor. See **Section 3.7.9**.
- Checking crankshaft position sensor power supply voltage. See **Section 5.13.23**.
- Checking wire harness for disconnection. See **Section 5.13.24**.
- Checking power supply voltage of the ECU connectors. See **Section 5.13.25**.
- Checking ECU connectors. See **Section 5.13.47**.
- Checking around the crankshaft position sensor. See **Section 5.13.26**.

5.12.19 P0340 No pulse from camshaft position sensor (G sensor) (723-8)

SPN Name:	Engine Speed 2
Cause:	Open circuit or short circuit of the camshaft position sensor (G) or harness. Or, the sensor has failed.
DTC set preconditions:	• Battery voltage is normal • Sensor supply voltage VCC# is normal • Engine is not stalled
DTC set parameter:	No recognition of the camshaft position sensor (G) pulse.
Time to action / number of error detections:	4.4 rotations of the CRANK sensor pulse.
Limp home action:	None
Behavior during malfunction:	The engine hesitates at start-up due to an invalid G sensor signal.
Error recovery conditions:	Diagnostic counter = 0 or turn ignition switch OFF.
Delay time for recovery:	1.1 rotations of CRANK sensor pulse
Components to check:	• Camshaft position sensor • Pulsar gear • Wire harness • ECU
Remarks	The engine cannot start if both the crankshaft position sensor and camshaft position sensors are damaged.

Related Reference Material

- Location of camshaft position sensor. See **Section 3.7.9**.
- Checking camshaft position sensor power supply voltage. See **Section 5.13.27**.
- Checking wire harness for disconnection. See **Section 5.13.28**.
- Checking power supply voltage of the ECU connectors. See **Section 5.13.29**.
- Checking ECU connectors. See **Section 5.13.47**.
- Checking around the camshaft position sensor. See **Section 5.13.30**.

5.12.20 P0341 Camshaft position sensor (G sensor) pulse number error (723-2)

SPN Name:	Engine Speed 2
Cause:	Open circuit or short circuit of the camshaft position sensor (G) or harness. Or, the sensor has failed.
DTC set preconditions:	• Battery voltage is normal • Sensor supply voltage VCC# is normal • Engine speed is 350 min^{-1} (rpm) or higher
DTC set parameter:	Pulse count per rotation is not 3 teeth.
Time to action / number of error detections:	4.4 rotations of the CRANK sensor pulse.
Limp home action:	None
Behavior during malfunction:	The engine hesitates at start-up due to an invalid G sensor signal.
Error recovery conditions:	Diagnostic counter = 0 or turn ignition switch OFF.
Delay time for recovery:	1.1 rotations of the CAM sensor pulse.
Components to check:	• Camshaft position sensor • Pulsar gear • Wire harness • ECU

Related Reference Material

- Location of camshaft position sensor. See **Section 3.7.9**.
- Checking camshaft position sensor power supply voltage. See **Section 5.13.27**.
- Checking wire harness for disconnection. See **Section 5.13.28**.
- Checking power supply voltage of the ECU connectors. See **Section 5.13.29**.
- Checking ECU connectors. See **Section 5.13.47**.
- Checking around the camshaft position sensor. See **Section 5.13.30**.

5.12.21 P0380 Glow relay abnormality open circuit (676-5)

SPN Name:	Engine Glow Plug Relay
Cause:	Open circuit of the air glow relay.
DTC set preconditions:	• Battery voltage is normal • Glow relay is being energized
DTC set parameter:	Open circuit of either the harness or the relay coil.
Time to action / number of error detections:	3 seconds or more
Limp home action:	None
Behavior during malfunction:	• Starting is faulty at low temperature • White smoke increases
Error recovery conditions:	Turn ignition switch OFF.
Delay time for recovery:	None
Components to check:	• Glow relay • Wire harness • ECU

Related Reference Material

- Checking wire harnesses. See **Section 5.13.31**.
- Checking glow relays. See **Section 5.13.32**.
- Checking ECU connectors. See **Section 5.13.47**.

5.12.22 P0380 Glow relay abnormality +B short (523544-3)

SPN Name:	proprietary
Cause:	+B short of the glow relay driving circuit.
DTC set preconditions:	• Battery voltage is normal • Glow relay is being energized
DTC set parameter:	+B short circuit of the harness.
Time to action / number of error detections:	3 seconds or more
Limp home action:	None
Behavior during malfunction:	• Starting is faulty at low temperature • White smoke increases at low temperatures
Error recovery conditions:	Turn ignition switch OFF.
Delay time for recovery:	None
Components to check:	• Glow relay • Wire harness • ECU

Related Reference Material

- Checking wire harnesses. See **Section 5.13.31**.
- Checking glow relays. See **Section 5.13.32**.
- Checking ECU connectors. See **Section 5.13.47**.

5.12.23 P0380 Glow relay abnormality ground short (523544-4)

SPN Name:	proprietary
Cause:	Ground short of glow relay driving circuit
DTC set preconditions:	• Battery voltage is normal • Glow relay is being energized
DTC set parameter:	Ground short circuit of the harness
Time to action / number of error detections:	3 seconds or more
Limp home action:	None
Behavior during malfunction:	• Starting is faulty at low temperature • White smoke increases at low temperatures
Error recovery conditions:	Turn ignition switch OFF.
Delay time for recovery:	None
Components to check:	• Glow relay • Wire harness • ECU

Related Reference Material

- Checking wire harnesses. See **Section 5.13.31**.
- Checking glow relays. See **Section 5.13.32**.
- Checking ECU connectors. See **Section 5.13.47**.

5.12.24 P0381 Glow relay driving circuit overheat (676-0)

SPN Name:	Engine Glow Plug Relay
Cause: (s)	Overheat of the glow plug driving circuit.
DTC set preconditions:	• Ignition switch is ON • Battery voltage is normal • Glow relay is being energized
DTC set parameter:	Starting aid relay coil resistance or load is too high for the specified value of the ECU.
Time to action / number of error detections:	3 seconds or more
Limp home action:	None
Behavior during malfunction:	None
Error recovery conditions:	Turn ignition switch OFF.
Delay time for recovery:	None
Components to check:	• Wire harness • ECU

Related Reference Material

- Checking wire harnesses. See **Section 5.13.31**.
- Checking glow relays. See **Section 5.13.32**.
- Checking ECU connectors. See **Section 5.13.47**.

5.12.25 P0524 Engine oil pressure low error (100-1)

SPN Name:	Engine Oil Pressure
Cause:	Low oil pressure (LOP) switch
DTC set preconditions:	• Battery voltage is normal • Ignition switch turn ON • Starter switch signal is not activated • 10 seconds or more after engine start (engine speed is 700 rpm or higher)
DTC set parameter:	Oil pressure switch ON condition continues for one second or more.
Time to action / number of error detections:	Transient
Limp home action:	Engine stop
Behavior during malfunction:	Engine stop
Error recovery conditions:	Turn ignition switch OFF.
Delay time for recovery:	None
Components to check:	• Low oil pressure (LOP) switch • Wire harness • Lube oil equipment-related parts

Related Reference Material

- Location of oil pressure switch. See **Section 3.9**.
- Simple check of oil pressure switch. See **Section 5.13.33**.
- Checking wire harnesses. See **Section 5.13.34**.
- Checking engine oil pressure. See **Section 6.4.4.2**

5.12.26 P0562 Battery voltage: low (168-4)

SPN Name:	Battery Potential / Power Input 1
Cause:	Open circuit, short circuit or damage of the wire harness. Or, a battery fault is present.
DTC set preconditions:	• Ignition switch is ON • Starter switch signal is not activated
DTC set parameter:	• ECU recognition of battery voltage is 8 V or less. • Not monitored during cranking.
Time to action / number of error detections:	1 second or more
Limp home action:	There is an output limitation of approximately 75% of normal condition.
Behavior during malfunction:	• Faulty starting • Output is insufficient • Exhaust gas emissions will worsen • Engine stops in some cases
Error recovery conditions:	Diagnostic counter = 0 or turn ignition switch OFF.
Delay time for recovery:	30 seconds
Components to check:	• Battery • Relay • Wire harness • ECU

Related Reference Material

- Checking ECU terminal voltage. See **Section 5.13.37**.
- Checking ECU connectors. See **Section 5.13.47**.

5.12.27 P0563 Battery voltage: high (168-3)

SPN Name:	Battery Potential / Power Input 1
Cause:	Open circuit, short circuit or damage of the wire harness. Or, a battery fault is present.
DTC set preconditions:	• Ignition switch is ON • Starter switch signal is not activated
DTC set parameter:	ECU recognition of battery voltage is 16 V or more.
Time to action / number of error detections:	1 second or more
Limp home action:	There is an output limitation of approximately 75% of normal condition.
Behavior during malfunction:	• Faulty starting • Output is insufficient • Exhaust gas emissions will worsen
Error recovery conditions:	Turn ignition switch OFF.
Delay time for recovery:	None
Components to check:	• Battery • Relay • Wire harness • ECU

Related Reference Material

- Checking ECU terminal voltage. See **Section 5.13.37**.
- Checking ECU connectors. See **Section 5.13.47**.

5.12.28 P0602 QR data error (data write error) (523538-2)

SPN Name:	Proprietary
Cause:	QR data read error has occurred. An electromagnetic interference (EMI) may have caused the temporary malfunction.
DTC set preconditions:	Ignition switch is ON
DTC set parameter:	QR data read error from EEPROM
Time to action / number of error detections:	Transient
Limp home action:	There is an output limitation of approximately 75% of normal condition. And injector calibration is not executed.
Behavior during malfunction:	Output is insufficient
Error recovery conditions:	Diagnostic counter = 0 or turn ignition switch OFF.
Delay time for recovery:	Immediately
Components to check:	ECU
Remarks	To cover each injector dispersion.

Related Reference Material

- Recheck injector correction and DTC. See **Section 5.13.18**.

5.12.29 P0602 QR data error (data write error) (523538-7)

SPN Name:	Proprietary
Cause:	QR data is unwritten. An electromagnetic interference (EMI) may have caused the temporary malfunction.
DTC set preconditions:	Ignition switch is ON
DTC set parameter:	Area of QR data on EEPROM is vacant
Time to action / number of error detections:	Transient
Limp home action:	There is an output limitation of approximately 75% of normal condition. And the injector nozzle correction factor = 0 [default value]
Behavior during malfunction:	Insufficient output
Error recovery conditions:	Diagnostic counter = 0 or turn ignition switch OFF
Delay time for recovery:	Immediately
Components to check:	ECU

Related Reference Material

- Recheck injector correction and DTC. See **Section 5.13.18**.

5.12.30 P0605 ECU flash ROM error (682-2)

SPN Name:	Program Memory
Cause:	FLASH ROM error has occurred. An electromagnetic interference (EMI) may have caused the temporary malfunction.
DTC set preconditions:	Ignition switch is ON
DTC set parameter:	• Check-sum error • Erase error • Write error • Read error
Time to action / number of error detections:	1 time or more
Limp home action:	Engine stops
Behavior during malfunction:	Engine stops
Error recovery conditions:	Turn ignition switch OFF.
Delay time for recovery:	None
Components to check:	ECU

Related Reference Material

- In Diagmaster, clear the DTC. If the same DTC is detected and can not be cleared, replace the ECU.

5.12.31 P0606 ECU CPU error (Main IC error) (1077-2)

SPN Name:	Engine Fuel Injection Pump Controller
Cause:	Failure of CPU and / or IC. An electromagnetic interference (EMI) may have caused the temporary malfunction.
DTC set preconditions:	• Ignition switch is ON • Battery voltage is 10V or more • Starter switch signal is not activated
DTC set parameter:	CPU and / or IC fatal error
Time to action / number of error detections:	1 time or more
Limp home action:	Engine stops
Behavior during malfunction:	Engine stops
Error recovery conditions:	Turn ignition switch OFF.
Delay time for recovery:	None
Components to check:	ECU

Related Reference Material

- n Diagmaster, clear the DTC. If the same DTC is detected and can not be cleared, replace the ECU.

5.12.32 P0606 ECU CPU error (Monitoring IC) (523527-2)

SPN Name:	proprietary
Cause:	Failure of monitoring IC of CPU. An electromagnetic interference (EMI) may have caused the temporary malfunction.
DTC set preconditions:	• Ignition switch is ON • Battery voltage is 10V or more • Starter switch signal is not activated
DTC set parameter:	Failure of monitoring IC of CPU
Time to action / number of error detections:	1 time or more
Limp home action:	Engine stops
Behavior during malfunction:	Engine stops
Error recovery conditions:	Turn ignition switch OFF.
Delay time for recovery:	None
Components to check:	ECU

Related Reference Material

- n Diagmaster, clear the DTC. If the same DTC is detected and can not be cleared, replace the ECU.

5.12.33 P0611 Injector charge voltage: low (523525-1)

SPN Name:	proprietary
Cause:	Injector charge voltage is low. Or, the charge circuit of the ECU has failed.
DTC set preconditions:	• Battery voltage is normal • CPU is normal
DTC set parameter:	Injector charge voltage is low. Or, the charge circuit of the ECU has failed.
Time to action / number of error detections:	Transient
Limp home action:	There is an output limitation of approximately 75% of normal condition.
Behavior during malfunction:	• Output is insufficient • Exhaust gas emissions will worsen • Engine stops
Error recovery conditions:	Turn ignition switch OFF.
Delay time for recovery:	None
Components to check:	• Injector • Wire harness • ECU

Related Reference Material

- Checking injector driving circuit. See **Section 5.13.14**.
- Checking injectors. See **Section 5.13.14**.

5.12.34 P0627 SCV drive system abnormality open circuit (1347-5)

SPN Name:	Engine Fuel Pump Pressurizing Assembly #1
Cause:	Open circuit of the suction control valve (SCV)
DTC set preconditions:	• Battery voltage is normal • Ignition switch is ON • Starter switch signal is not activated
DTC set parameter:	Open circuit of the suction control valve (SCV)
Time to action / number of error detections:	Transient
Limp home action:	There is an output limitation of approximately 50% of normal condition. The engine is forcibly stopped 60 seconds later.
Behavior during malfunction:	• Output is insufficient • Exhaust gas emissions will worsen • Engine stops
Error recovery conditions:	Turn ignition switch OFF.
Delay time for recovery:	None
Components to check:	Inhibit

Related Reference Material

- Location of suction control valve. See **Section 3.7.9**.
- Checking resistance of SCV. See **Section 5.13.35**.
- Checking SCV. See **Section 5.13.36**.
- Checking ECU connectors. See **Section 5.13.47**.

5.12.35 P0628 SCV drive system abnormality ground short (1347-4)

SPN Name:	Engine Fuel Pump Pressurizing Assembly #1
Cause:	Ground short circuit of the suction control valve (SCV).
DTC set preconditions:	• Battery voltage is normal • Ignition switch is ON • Starter switch signal is not activated
DTC set parameter:	• Ground short circuit of the suction control valve (SCV).
Time to action / number of error detections:	Transient
Limp home action:	Engine stops.
Behavior during malfunction:	• Output is insufficient • Exhaust gas emissions will worsen • Engine stops
Error recovery conditions:	Turn ignition switch OFF.
Delay time for recovery:	None
Components to check:	• SCV • Wire harness • ECU

Related Reference Material

- Location of suction control valve. See **Section 3.7.9**.
- Checking resistance of SCV. See **Section 5.13.35**.
- Checking SCV. See **Section 5.13.36**.
- Checking ECU connectors. See **Section 5.13.47**.

5.12.36 P0629 SCV drive system abnormality B + short (1347-3)

SPN Name:	Engine Fuel Pump Pressurizing Assembly #1
Cause:	+B short circuit of the suction control valve (SCV).
DTC set preconditions:	• Battery voltage is normal • Starter switch is ON • Starter switch signal is not activated
DTC set parameter:	Open circuit of the suction control valve (SCV).
Time to action / number of error detections:	Transient
Limp home action:	There is an output limitation of approximately 50% of normal condition. The engine is forcibly stopped 60 seconds later.
Behavior during malfunction:	• Output is insufficient • Exhaust gas emissions will worsen • Engine stops
Error recovery conditions:	Turn ignition switch OFF.
Delay time for recovery:	None
Components to check:	• SCV • Wire harness • ECU

Related Reference Material

- Location of suction control valve. See **Section 3.7.9**.
- Checking resistance of SCV. See **Section 5.13.35**.
- Checking SCV. See **Section 5.13.36**.
- Checking ECU connectors. See **Section 5.13.47**.

5.12.37 P062B Internal injector drive circuit abnormality open circuit (1077-12)

SPN Name:	Engine Fuel Injection Pump Controller
Cause:	Injector drive IC error or open circuit of cylinder injector #1, 2, 3 or 4.
DTC set preconditions:	• Ignition switch is *"ON"* • Battery voltage is 10 V or more • Starter switch signal is not activated
DTC set parameter:	Injector drive IC error or open circuit of cylinder injector #1, 2, 3 or 4.
Time to action / number of error detections:	1 time or more
Limp home action:	Engine stops
Behavior during malfunction:	Engine stops
Error recovery conditions:	Turn ignition switch OFF.
Delay time for recovery:	None
Components to check:	• Injector • Wire harness

Related Reference Material

- Checking injectors. See **Section 5.13.16**.
- Checking wire harnesses for disconnection. See **Section 5.13.17**.
- Checking ECU connectors. See **Section 5.13.47**.

5.12.38 P062D Internal injector drive circuit abnormality short circuit (523605-6)

SPN Name:	Proprietary
Cause:	Short circuit in injector driver IC.
DTC set preconditions:	• Battery voltage is normal • Ignition switch is ON
DTC set parameter:	Injector IC report the error
Time to action / number of error detections:	3 times or more
Limp home action:	There is an output limitation of approximately 75% of normal condition. The injectors which have the error stop injection.
Behavior during malfunction:	• Output is insufficient • Exhaust gas emissions will worsen • Engine vibration increases • Engine stops in some cases
Error recovery conditions:	Turn ignition switch OFF.
Delay time for recovery:	None
Components to check:	• Injector • Wire harness

Related Reference Material

- Checking for ground short inside injector. See **Section 5.13.19**.
- Checking wire harnesses for ground short circuit. See **Section 5.13.20**.
- Checking wire harnesses for +B short circuit. See **Section 5.13.21**.
- Checking ECU connectors. See **Section 5.13.47**.

5.12.39 P0643 Sensor supply voltage 1 abnormality (3509-3)

SPN Name:	Sensor supply voltage 1
Cause:	Sensor supply voltage 1 error or recognition error.
DTC set preconditions:	• Battery voltage is normal • Ignition switch turn ON
DTC set parameter:	Voltage to sensor is 4.75 V or less or voltage to sensor is 5.25 V or more
Time to action / number of error detections:	Transient
Limp home action:	Engine stops
Behavior during malfunction:	• Faulty starting • Output is insufficient • Exhaust gas emissions will worsen • Engine stops
Error recovery conditions:	Turn ignition switch OFF.
Delay time for recovery:	None
Components to check:	• Rail pressure sensor • Crankshaft position sensor (NE sensor) • Camshaft position sensor (G sensor) • Wire harness • ECU
Remarks	Emission related

Related Reference Material

- Checking ECU connectors. See **Section 5.13.47**.

5.12.40 P0653 Sensor supply voltage 2 abnormality (3510-3)

SPN Name:	Sensor supply voltage 2
Cause:	Sensor supply voltage 2 error or recognition error.
DTC set preconditions:	• Battery voltage is normal • Ignition switch ON
DTC set parameter:	Voltage to sensor is 4.75 V or less or voltage to sensor is 5.25 V or more.
Time to action / number of error detections:	Transient
Limp home action:	There is an output limitation of approximately 75% of normal condition.
Behavior during malfunction:	• Faulty starting • Output is insufficient • Exhaust gas emissions will worsen
Error recovery conditions:	Turn ignition switch OFF.
Delay time for recovery:	None
Components to check:	• Wire harness • ECU
Remarks	Emission related

Related Reference Material

- Checking ECU connectors. See **Section 5.13.47**.

5.12.41 P0663 Sensor supply voltage 3 abnormality (3511-3)

SPN Name:	Sensor supply voltage 3
Cause:	Sensor supply voltage 3 error or recognition error.
DTC set preconditions:	• Battery voltage is normal • Ignition switch ON
DTC set parameter:	Voltage to sensor is 4.75 V or less or voltage to sensor is 5.25 V or more.
Time to action / number of error detections:	Transient
Limp home action:	There is an output limitation of approximately 75% of normal condition.
Behavior during malfunction:	Poor starting
Error recovery conditions:	Turn ignition switch OFF.
Delay time for recovery:	None
Components to check:	ECU
Remarks	Emission related

Related Reference Material

- Checking ECU connectors. See **Section 5.13.47**.

5.12.42 P0687 Main relay is locked in closed position (1485-2)

NOTE: The engine warning light will not turn ON when this error code is active.

SPN Name:	ECM Main Relay
Cause:	Main relay has failed.
DTC set preconditions:	• Ignition switch OFF • Engine stops
DTC set parameter:	Main relay stays active longer than 1 second without command.
Time to action / number of error detections:	1 time or more
Limp home action:	None
Behavior during malfunction:	Dead battery
Error recovery conditions:	Turn ignition switch OFF.
Delay time for recovery:	None
Components to check:	• ECU • Main relay • Ignition switch • Wire harness

Related Reference Material

- Checking relays. See **Section 5.13.38**.
- Checking input / output voltage of ECU side relays. See **Section 5.13.39**.

5.12.43 P081A Ground short of starter (677-4)

SPN Name:	Engine Starter Motor Relay
Cause:	Ground short of starter relay driving circuit.
DTC set preconditions:	• Ignition switch is ON • Battery voltage is normal
DTC set parameter:	Ground short circuit of harness.
Time to action / number of error detections:	3 seconds or more
Limp home action:	None
Behavior during malfunction:	Faulty starting
Error recovery conditions:	Turn ignition switch OFF.
Delay time for recovery:	None
Components to check:	Inhibit

Related Reference Material

- Checking wire harnesses. See **Section 5.13.40**.
- Checking relays. See **Section 5.13.41**.
- Checking ECU connectors. See **Section 5.13.47**.

5.12.44 P1990 EEPROM checksum error (523700-13)

SPN Name:	Proprietary
Cause:	KBT-EEPROM checksum error.
DTC set preconditions:	Battery voltage is normal
DTC set parameter:	EEPROM checksum error
Time to action / number of error detections:	Immediate
Limp home action:	None
Behavior during malfunction:	None
Error recovery conditions:	Turn ignition switch OFF.
Delay time for recovery:	None
Components to check:	• ECU • Trim data write error

Related Reference Material

- Checking DTCs and Writing Trim Data. See **Section 5.13.42**.

5.12.45 P2148 All injectors +B short or ground short (523523-3)

SPN Name:	Proprietary
Cause:	Wire harness short to +B or wire harness short to ground
DTC set preconditions:	• Engine is operating • Battery voltage is normal
DTC set parameter:	Wire harness short to +B or wire harness short to ground
Time to action / number of error detections:	3 times or more
Limp home action:	All injectors stop injection
Behavior during malfunction:	Engine stops
Error recovery conditions:	Turn ignition switch OFF
Delay time for recovery:	None
Components to check:	• Injector • Wire harness • ECU

Related Reference Material

- Checking for ground short inside injector. See **Section 5.13.19**.
- Checking wire harnesses for ground short circuit. See **Section 5.13.20**.
- Checking wire harnesses for +B short circuit. See **Section 5.13.21**.
- Checking ECU connectors. See **Section 5.13.47**.

5.12.46 P2228 Atmospheric pressure sensor low (108-4)

SPN Name:	Barometric Pressure
Cause:	Sensor or ECU internal circuit short to ground.
DTC set preconditions:	Battery voltage is normal.
DTC set parameter:	Barometric pressure sensor voltage is 0.2 V or less.
Time to action / number of error detections:	3 seconds or more
Limp home action:	65 kPa (0.663 kgf/cm^2, 9.43 psi). This is the default value.
Behavior during malfunction:	Output is insufficient.
Error recovery conditions:	Diagnostic counter = zero or turn ignition switch OFF.
Delay time for recovery:	Immediately
Components to check:	ECU
Remarks	Default value is set in consideration with high altitude usage.

Related Reference Material

- Checking DTCs. See **Section 5.13.43**.

5.12.47 P2229 Atmospheric pressure sensor high (108-3)

SPN Name:	Barometric Pressure
Cause:	Sensor or ECU internal circuit short to +B
DTC set preconditions:	Battery voltage is normal
DTC set parameter:	Barometric pressure sensor voltage is 4.85 V or more.
Time to action / number of error detections:	3 seconds or more
Limp home action:	65 kPa (0.663 kgf/cm^2, 9.43 psi) [default value]
Behavior during malfunction:	Output is insufficient.
Error recovery conditions:	Diagnostic counter = zero or turn ignition switch OFF.
Delay time for recovery:	Immediately
Components to check:	ECU
Remarks	Default value is set in consideration with high altitude usage

Related Reference Material

- Checking DTCs. See **Section 5.13.43**.

5.12.48 P2293 Pressure limiter abnormality (679-9)

SPN Name:	Pressure relief valve
Cause:	Rail pressure value is too high or low despite the existence of response that the pressure limiter opened.
DTC set preconditions:	• Battery voltage is normal • Ignition switch is in RUN • After DTC P0088, P0089
DTC set parameter:	After fault opening pressure limiter, rail pressure is 160 MPa (1630 kg/cm^2, 23200 psi) or more.
Time to action / number of error detections:	20 seconds or more
Limp home action:	Engine stops
Behavior during malfunction:	Engine stops
Error recovery conditions:	Turn ignition switch OFF.
Delay time for recovery:	None
Components to check:	• Fuel • Fuel hose • Supply pump • Rail (rail pressure sensor) • Injector

Related Reference Material

- Diagnosing high fuel pressure. See **Section 5.13.3**.

5.12.49 P2293 Pressure limiter failure after pressure relief valve (679-16)

SPN Name:	Pressure relief valve
Cause:	Rail pressure value is too high or low despite the existence of response that the pressure limiter opened.
DTC set preconditions:	• Battery voltage is normal • Ignition switch is ON
DTC set parameter:	• Pressure limiter open (the opening response is detected) • Rail pressure value is not within 50 MPa (510 kgf/cm^2, 7250 psi) and 120 MPa (1220 kgf/cm^2, 17400 psi)
Time to action / number of error detections:	Transient
Limp home action:	Engine stops
Behavior during malfunction:	Engine stops
Error recovery conditions:	Turn ignition switch OFF.
Delay time for recovery:	None
Components to check:	ECU

Related Reference Material

- Checking DTCs. See **Section 5.13.44**.

5.12.50 P2294 Pressure limiter error (number of times) (679-15)

SPN Name:	Pressure relief valve
Cause:	Pressure limiter opened many times.
DTC set preconditions:	• Battery voltage is normal • Ignition switch is ON
DTC set parameter:	Pressure limiter opened more than 50 times.
Time to action / number of error detections:	Transient
Limp home action:	There is an output limitation of approximately 75% of normal condition. The engine forcibly stopped 60 seconds later.
Behavior during malfunction:	Engine stops
Error recovery conditions:	Reset with the service tool.
Delay time for recovery:	None

5.12.51 P2294 Pressure limiter error (amount of time) (679-10)

SPN Name:	Pressure relief valve
Cause:	Pressure limiter opened many times.
DTC set preconditions:	• Battery voltage is normal • Ignition switch is ON
DTC set parameter:	Pressure limiter opened more than 300 minutes.
Time to action / number of error detections:	Transient
Limp home action:	There is an output limitation of approximately 75% of normal condition. The engine forcibly stopped 60 seconds later.
Behavior during malfunction:	Engine stops
Error recovery conditions:	Reset with the service tool.
Delay time for recovery:	None

5.12.52 P3014 Water in water separator failure (97-31)

SPN Name:	Water in Fuel Indicator
Cause:	Water level in the fuel filter.
DTC set preconditions:	• Battery voltage is normal • Ignition switch is ON • Starter switch signal is not activated
DTC set parameter:	Sedimenter switch ON
Time to action / number of error detections:	Transient
Limp home action:	None
Behavior during malfunction:	• Output is insufficient • Engine stops
Error recovery conditions:	Diagnostic counter = zero or turn ignition switch OFF
Delay time for recovery:	None
Components to check:	• Water separator • ECU

5.12.53 P3025 Overheat pre-caution (523603-15)

SPN Name:	proprietary
Cause:	Coolant temperature
DTC set preconditions:	Coolant temperature sensor is normal
DTC set parameter:	Engine coolant temperature is 110°C (230°F) or more
Time to action / number of error detections:	Transient
Limp home action:	None
Behavior during malfunction:	Worsening exhaust gas emissions (NOx)
Error recovery conditions:	Diagnostic counter = zero or turn ignition switch OFF
Delay time for recovery:	Immediately
Components to check:	• Coolant • Coolant temperature sensor • Coolant equipment-related parts

Related Reference Material

- Procedure for diagnosing overheating. See **Section 5.13.22**.

5.12.54 U0075 CAN2 bus off error (523547-2)

SPN Name:	proprietary
Cause:	CAN2 +B or ground short circuit or high traffic error.
DTC set preconditions:	• Battery voltage is normal • Ignition switch is in RUN
DTC set parameter:	CAN2 bus off
Time to action / number of error detections:	2 seconds or more
Limp home action:	Forced idle. Accelerator limitation: 0%
Behavior during malfunction:	• Output is insufficient • Transmitted CAN data invalid
Error recovery conditions:	Turn ignition switch OFF.
Delay time for recovery:	None
Components to check:	• Wire harness • ECU

Related Reference Material

- Checking DTCs. and CAN2 related wiring. See **Section 5.13.45**.

5.12.55 U0077 CAN1 bus off error (523604-2)

SPN Name:	proprietary
Cause:	CAN1 +B or ground short circuit or high traffic error.
DTC set preconditions:	• Battery voltage is normal • Ignition switch is in RUN
DTC set parameter:	CAN1 bus off
Time to action / number of error detections:	2 seconds or more
Limp home action:	There is an output limitation of approximately 75% of normal condition.
Behavior during malfunction:	• Output is insufficient • Transmitted CAN data invalid
Error recovery conditions:	Turn ignition switch OFF.
Delay time for recovery:	None
Components to check:	• Wire harness • ECU

Related Reference Material

- Checking DTCs and CAN1 related wiring. See **Section 5.13.46**.

5.13 Related Procedures

5.13.1 Inspecting Around the Pulsar Hole on the Flywheel

This procedure is related to DTC code P0016.

1. Inspect the flywheel (pulsar hole on the flywheel) for the following:
   - Installation not misaligned
   - No foreign matter adhering
2. Inspect the crank gear to make sure it is not out of position.
3. Inspect the crankshaft to make sure side clearance is within service specifications.

5.13.2 Inspecting Around the Camshaft Position Pulsar Gear

This procedure is related to DTC code P0016.

1. Inspect the cam/camshaft position pulsar gear for the following:
   - Not out of position
   - No foreign matter adhering
   - Side clearance is within service specifications
2. Inspect the camshaft to make sure side clearance within service specifications.

5.13.3 Diagnosing Fuel Pressure or a Stuck Suction Control Valve (SCV)

This procedure is related to DTC codes P0087, P0088 and P0089.

1. Check the Pre-work checklist, shown in **Section 6.2**. Make sure fuel tank is at least half full and fuel quality meets the standard.
2. Turn the ignition switch to RUN.
3. Connect a computer to the ECU and launch Diagmaster software. See **Section 7.2.4** for procedure.
4. Check that any of the procedures listed below were completed recently:
   - Injector correction to an injector, or the engine ECU
   - Injector timing correction to the flywheel housing, flywheel, or crankshaft

   If so, verify that an Injector Compensation was performed on the Utility screen. This is necessary to re-register the injectors to the engine ECU. See **Section 7.3.9** for related information.
5. Bring up the Data Monitor screen, select the following signals for monitoring and then record the measurement:
   - Target Rail Pressure
   - Actual Rail Pressure
   - Target Suction Control Valve (SCV) Current
   - Actual Suction Control Valve (SCV) Current

   See **Section 7.3.7** for instructions on setting up measurements from the Data Monitor screen.
6. Turn the ignition switch to START to start the engine.
7. Observe the Data Monitor signals and troubleshoot accordingly.
   - Problem areas (for low fuel pressure) could be the fuel line, rail pressure sensor or SCV.
   - Problem areas (for high fuel pressure) could be the fuel line of SCV.
8. Bring up the Active Test screen and perform an Injector Stop. See **Section 7.3.8** for procedure. Troubleshoot accordingly. Problem areas could be the ECU or injector.

5.13.4 Diagnosing Low Fuel Pressure in a High Pressure System

This procedure is for diagnosing a potential fuel leak in the high pressure fuel system. This procedure is related to DTC code P0093.

1. Check the Pre-work checklist (**Section 6.2**). Make sure fuel tank is at least half full and fuel quality meets the standard. Make sure fuel tank is at least half full and fuel quality meets the standard.
2. Turn the ignition switch to RUN.
3. Connect a computer to the ECU and launch Diagmaster software. See **Section 7.2.4**.
4. Check that any of the procedures listed below were completed recently:
   - Injector correction to an injector, or the engine ECU
   - Injector timing correction to the flywheel housing, flywheel, or crankshaft

   If so, verify that an Injector Compensation was performed on the Utility screen. This is necessary to re-register the injectors to the engine ECU. See **Section 7.3.9** for related information.
5. Bring up the Data Monitor screen, select the following signals for monitoring and then record the measurement:
   - Target Rail Pressure
   - Actual Rail Pressure

   See **Section 7.3.7** for instructions on setting up measurements from the Data Monitor screen.
6. Turn the ignition switch to START to start the engine.
7. Observe the Data Monitor signals and troubleshoot accordingly. Problem areas (could be the fuel line, rail pressure sensor, high pressure pipe or a failure with the fuel system in general.

5.13.5 Checking the Coolant Temperature Sensor (low temperature)

This procedure is to service a coolant temperature sensor low error condition by checking for a ground short circuit of the sensor or harness. This procedure is related to DTC code P0117.

NOTE: Before diagnosing the problem, use Diagmaster to try to reproduce it based on any DTC information. Check the coolant temperature related signals on the Data Monitor screen.

1. Disconnect the coolant temperature sensor connector.
2. Measure the resistance between the coolant temperature sensor terminals.

Temperature	Resistance
20°C (68°F)	Approximately 2.5 KΩ
40°C (104°F)	Approximately 1.2 KΩ
60°C (140°F)	Approximately 0.58 KΩ
80°C (176°F)	Approximately 0.32 KΩ
100°C (212°F)	Approximately 0.18 KΩ

   - If resistance is not within specification, replace the coolant temperature sensor.
   - If resistance is within specification, continue to check the wire harness for a ground short.
3. Check the wire harness for a ground short. See **Section 5.13.7** for procedure.
   - If resistance is abnormal, repair or replace the wire harness (including connectors).
   - If resistance is normal, continue to check the ECU connectors.
4. Check the state of the ECU connectors. See **Section 5.13.47** for procedure.
   - If state of the ECU connector is abnormal, repair or replace as necessary.
   - If state of the ECU connector is normal, replace the ECU.

5.13.6 Checking the Coolant Temperature Sensor (high temperature)

This procedure is to service a coolant temperature sensor high error by checking for an open circuit or a +B short circuit of the sensor or harness. This procedure is related to DTC code P0118.

1. Disconnect the coolant temperature sensor connector.
2. Measure the resistance between the coolant temperature sensor terminals.

Temperature	Resistance
20°C (68°F)	Approximately 2.5 KΩ
40°C (104°F)	Approximately 1.2 KΩ
60°C (140°F)	Approximately 0.58 KΩ
80°C (176°F)	Approximately 0.32 KΩ
100°C (212°F)	Approximately 0.18 KΩ

   - If resistance is not within specification, replace the coolant temperature sensor.
   - If resistance is within specification, continue to check the wire harness for disconnection.
3. Check the wire harness for disconnection. See **Section 5.13.8** for procedure.
   - If resistance is abnormal, repair or replace the wire harness (including connectors).
   - If resistance is normal, continue to check the wire harness for +B short.
4. Check the wire harness for +B short. See **Section 5.13.9** for procedure.

5.13.7 Checking a Wire Harness for Ground Short - Coolant Temperature Sensor

This procedure is related to DTC code P0117.

1. Disconnect the ECU connector from the ECU.
2. Measure the resistance between the ECU connector at the harness side (terminals 33, 11) and body earth.
   - If resistance is normal, check the ECU connectors. See **Section 5.13.47** for procedure.
   - If resistance is abnormal, repair or replace the wire harness (including connectors).

5.13.8 Checking a Wire Harness for Disconnection - Coolant Temperature Sensor

This procedure is related to DTC code P0118.

1. Disconnect the ECU connector from the ECU and connect the coolant temperature sensor connector.
2. Measure the resistance between the coolant temperature sensor connector at the harness side and ECU connector at the harness side. Terminals to measure:
   - Sensor terminal 1 and ECU terminal 33
   - Sensor terminal 2 and ECU terminal 11
3. Check that resistance is several Ω or more.
   - If resistance is normal, check the wire harness for +B short. See **Section 5.13.9** for procedure.
   - If resistance is abnormal, repair or replace the wire harness (including connectors).

5.13.9 Checking a Wire Harness for +B Short - Coolant Temperature Sensor

This procedure is related to DTC code P0118.

1. Connect the ECU connector to the ECU.
2. Turn the ignition switch to “RUN” and measure the voltage between terminal of the coolant temperature sensor connector at the harness side. Voltage should be approximately 5V.
   - If voltage is abnormal, repair or replace the wire harness (including connectors).
   - If voltage is normal, check the ECU connectors. See **Section 5.13.47** for procedure.

5.13.10 Measuring Output Voltage of the ECU Connectors - Rail Pressure Sensor

This procedure is related to DTC code P0192 and P0193.

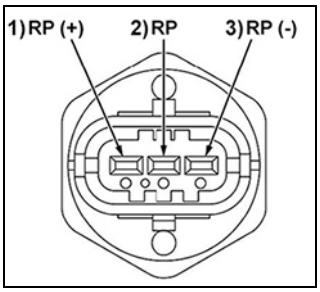
NOTE: Before diagnosing the problem, use Diagmaster to try to reproduce it based on any DTC information. Check the related signals on the Data Monitor screen. Diagnose whether it is the ECU (including connectors) or something else.

1. Set up the conditions and measure the voltage between the ECU terminals 54 (Tester +) and 76 (Tester -). Voltage specification varies based on rotation speed, load (after warm-up). With ignition switch in RUN (engine stopped) voltage should be approximately 0.3V. During no-load maximum speed, voltage is approximately 1.5V.
   - If voltage is normal, check the ECU connectors. See **Section 5.13.47** for procedure.
   - If voltage is abnormal, measure the rail pressure sensor output voltage. See **Section 5.13.11** for procedure.

5.13.11 Measuring Output Voltage - Rail Pressure Sensor

This procedure is to diagnose whether the problem is with the wire harness output voltage line (including connectors) or something else. This procedure is related to DTC code P0192 and P0193.

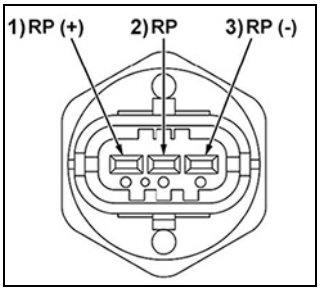
1. Measure the voltage between the rail pressure sensor terminals (2 and 3). Voltage specification varies based on rotation speed, load (after warm-up). With ignition switch in RUN (engine stopped) voltage should be approximately 0.3V. During no-load maximum speed, voltage is approximately 1.5V.
   - If voltage is normal, repair or replace the wire harness (including connectors).
   - If voltage is abnormal, measure the rail pressure sensor power supply voltage. See **Section 5.13.12** for procedure.



5.13.12 Measuring Power Supply Voltage - Rail Pressure Sensor

This procedure is to diagnose whether the sensor is damaged. This procedure is related to DTC code P0192 and P0193.

1. Remove the connector of the rail pressure sensor.
2. Turn the ignition switch to “RUN” and measure the voltage between the connector terminals (2 and 3) on the rail pressure sensor wire harness side. Voltage should be approximately 5V.
   - If voltage is normal, the rail pressure sensor is damaged. Replace the rail.
   - If voltage is abnormal, measure the power supply voltage of the ECU connectors. See **Section 5.13.47** for procedure.



5.13.13 Measuring Power Supply Voltage of ECU Connectors - Rail Pressure Sensor

This procedure is to diagnose whether the problem is the wire harness power supply voltage line (including connectors) or the ECU. This procedure is related to DTC code P0192 and P0193.

1. Turn the ignition switch to “RUN” and measure the voltage between terminals 32 (Tester +) and 76 (Tester -) of the ECU. Voltage should be approximately 5V.
   - If voltage is normal, repair or replace the wire harness (including connectors).
   - If voltage is abnormal, check the ECU connectors. See **Section 5.13.47** for procedure.

5.13.14 Checking Injector Driving Circuit

This procedure is related to DTC codes P0193 and P0200.

1. Disconnect the injector connector.
2. Measure the voltage between the injector connector at the harness side. Voltage should be approximately 12V.
   - If voltage is normal, check the injectors. See **Section 5.13.15** for procedure.
   - If voltage is abnormal, replace the ECU.

5.13.15 Checking Injectors

This procedure is related to DTC codes P0193 and P0200

NOTE: Before diagnosing the problem, use Diagmaster to try to reproduce it based on any DTC information. Check the injector related signals on the Data Monitor screen.

1. Measure the resistance between injector terminals 1 (-) and 2 (+). Resistance should be approximately 0.22 to 0.30 Ω.
   - If resistance is normal, then no action to take. If the DTC continues to appear, then replace the ECU.
   - If resistance is abnormal, replace the injector.

5.13.16 Checking Injectors (Open Circuit of Harness)

This procedure is related to DTC codes P0201, P0202, P0203 and P0204.

NOTE: Before diagnosing the problem, use Diagmaster to try to reproduce it based on any DTC information. Check the injector related signals on the Data Monitor screen.

1. Disconnect the injector connector
2. Measure the resistance between injector terminals of the cylinder indicating a DTC. Resistance should be approximately 0.22 to 0.30 Ω.
   - If resistance is normal, then check the wire harness. See **Section 5.13.17** for procedure.
   - If resistance is abnormal, replace the injector.

5.13.17 Checking a Wire Harness for Disconnection - Injectors

This procedure is related to DTC codes P0201, P0202, P0203 and P0204.

1. Disconnect the injector and the ECU from the connector.
2. Measure the resistance between the injector connector at the harness side and the ECU connector at the harness side. Terminals to measure:
   - Injector #1: injector terminal 1 (-) and ECU terminal 3; injector terminal 2 (+) and ECU terminal 73
   - Injector #2: injector terminal 1 (-) and ECU terminal 5; injector terminal 2 (+) and ECU terminal 51
   - Injector #3: injector terminal 1 (-) and ECU terminal 5; injector terminal 2 (+) and ECU terminal 29
   - Injector #4: injector terminal 1 (-) and ECU terminal 3; injector terminal 2 (+) and ECU terminal 7
3. Check that resistance is about 0.4 Ω.
   - If resistance is normal, repair or replace the wire harness (connectors).

- If resistance is abnormal, check the ECU connectors. See **Section 5.13.47** for procedure.

5.13.18 Check DTCs and Verify Injector Correction

This procedure is related to DTC code P0602.

Refer to the Diagmaster section for detailed operating procedures for using Diagmaster.

1. Turn the ignition switch to RUN position.
2. Connect a computer to the ECU and open Diagmaster software.
3. Bring up the DTC screen and clear the DTC(s).
4. Bring up the Utility screen and perform an injector compensation on all injectors.
5. Turn the ignition switch OFF and then back to RUN.
6. Turn the ignition switch to START to start the engine.
7. Check whether or not the same DTC is detected. An electromagnetic interference (EMI) may have caused the temporary malfunction.
   - If the DTC is not detected, then the system has recovered.
   - If the DTC is detected again, then replace the ECU.

5.13.19 Checking for a Ground Short - Injectors

This procedure is related to DTC codes P062D, P0643 and P2148.

1. Disconnect the injector connectors.
2. Check for ground short circuits inside the injectors by testing the continuity between body ground and the terminals of each injector (1, 2).
   - If continuity is normal, check the wire harness for a ground short circuit. See **Section 5.13.20**.
   - If continuity is abnormal, replace the injector.

5.13.20 Checking a Wire Harness for Ground Short Circuit - Injectors

This procedure is related to DTC codes P062D, P0643 and P2148.

1. Disconnect the injectors and ECU from their connectors.
2. Check for ground short circuits in the wire harness by testing the continuity between body ground and the terminals. Terminals to measure:
   - Injector #1: ECU terminals 3 and 73
   - Injector #2: ECU terminals 5 and 51
   - Injector #3: ECU terminals 5 and 29
   - Injector #4: ECU terminals 3 and 7
   - If continuity is normal, check the wire harness for +B short. See **Section 5.13.21**.
   - If continuity is abnormal, repair or replace the wire harness.

5.13.21 Checking a Wire Harness for +B Short Circuit - Injectors

This procedure is to diagnose whether the wire harness power supply is short circuited. This procedure is related to DTC codes P062D, P0643 and P2148.

1. Disconnect the injectors and ECU from their connectors.
2. Check whether the wire harness power supply is short circuited and check each terminal and the power supply for continuity. Refer to table below:

Terminals to Measure	Power Supply Points to Measure

Injector connector harness side terminals	Positive terminal, negative terminal	Feed pump Each switch Each lamp
ECU connector harness side terminals	3, 5, 7, 29, 51, 73	

3. Check that there are no short circuits.
   - If normal, check the ECU connectors. See **Section 5.13.47**.
   - If abnormal, repair or replace the wire harness.

5.13.22 Diagnosing an Overheating Condition or Improper Rise in Temperature

This diagnostic procedure is to systematically check the components suspected of causing an overheating condition. This procedure is related to DTC code P0217.

1. Inspect items from the pre-work checklist, **Section 6.2**, to make sure the criteria regarding the coolant system are met. Make sure coolant quantity and quality are meeting the proper standards.
2. Check the condition of the fan belt. See **Section 6.4.4.4** for procedure.
3. Turn the ignition switch to START to start the engine.
4. Check the coolant level in the radiator after a warm up.
   - If the level does not rise, check the water pump, thermostat or fan drive.
   - If the level rises, check the radiator cap, radiator or coolant concentration.
5. Connect a computer to the ECU and launch Diagmaster software. See **Section 7.2.4**.
6. Bring up the Data Monitor screen, select the following coolant temperature signals for monitoring and then record the measurement.
   - Coolant Temperature
   - Coolant Temperature Sensor Output Voltage

   See **Section 7.3.7** for instructions on setting up measurements from the Data Monitor screen.
7. Observe the data on screen when the engine is running.
   - If temperature does not change or fails to rise more than a certain amount, then check the coolant temperature sensor.
   - If temperature rises slowly, then check the thermostat.
8. Repair or replace any abnormal areas.

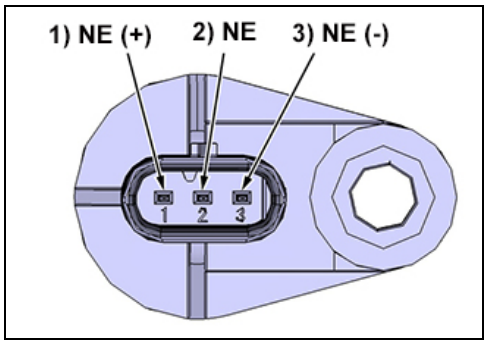
5.13.23 Checking Power Supply Voltage - Crankshaft Position Sensor

This procedure is related to DTC codes P0335 and P0336.

NOTE: Before diagnosing the problem, use Diagmaster to try to reproduce it based on any DTC information. Check the related signals on the Data Monitor screen. Diagnose whether it is the ECU (including connectors) or something else.

1. Disconnect the connector of the crankshaft position sensor.
2. Turn the ignition switch to “RUN” and measure the voltage between connector terminals 1 and 3 on the crankshaft position sensor wire harness side. Voltage should be approximately 5V.
   - If voltage is normal, check around the crankshaft position sensor. See **Section 5.13.26** for procedure.

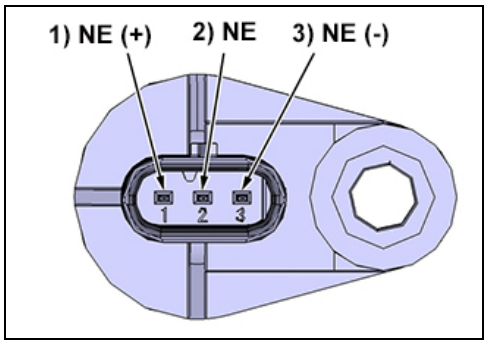
- If voltage is abnormal, check the wire harness for disconnection. See **Section 5.13.24** for procedure.



5.13.24 Checking a Wire Harness for Disconnection - Crankshaft Position Sensor

This procedure is related to DTC codes P0335 and P0336.

1. Disconnect the connector of the crankshaft position sensor and the connector of the ECU.
2. Measure the resistance between connector terminals on the crankshaft position sensor wire harness side and ECU connector at the harness side. Terminals to measure:
   - Sensor terminal 1 and ECU terminal 39
   - Sensor terminal 2 and ECU terminal 75
   - Sensor terminal 3 and ECU terminal 8.
3. Check that resistance is several Ω and more.
   - If resistance is normal, measure the power supply voltage of the ECU connectors. See **Section 5.13.25** for procedure.
   - If resistance is abnormal, repair or replace the wire harness (connectors).



5.13.25 Checking Power Supply Voltage of ECU Connectors - Crankshaft Position Sensor

This procedure is related to DTC codes P0335 and P0336.

1. Turn the ignition switch to RUN and measure the voltage between terminals 39 (+) and 8 (-) of the ECU. Voltage should be approximately 5V.
   - If voltage is normal, then there is no abnormality, this is a temporary error.
   - If voltage is abnormal, check the ECU connectors. See **Section 5.13.47** for procedure.

5.13.26 Checking Around the Crankshaft Position Sensor

This procedure is related to DTC codes P0335 and P0336.

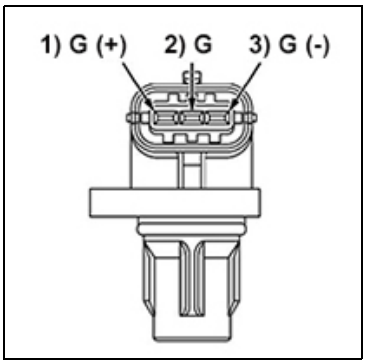
1. Inspect the flywheel for the following:
   - Installation not misaligned
   - No foreign matter adhering
2. Inspect the crankshaft position sensor to make sure no foreign matter is stuck to the sensor surface.

5.13.27 Checking Power Supply Voltage - Camshaft Position Sensor

This procedure is related to DTC codes P0340 and P0341.

NOTE: Before diagnosing the problem, use Diagmaster to try to reproduce it based on any DTC information. Check the related signals on the Data Monitor screen. Diagnose whether it is the ECU (including connectors) or something else.

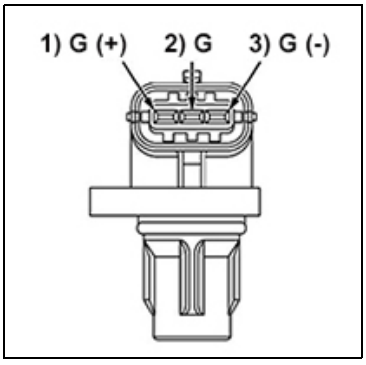
1. Disconnect the connector of the camshaft position sensor.
2. Turn the ignition switch to “RUN” and measure the voltage between connector terminals 1 and 2 on the camshaft position sensor wire harness side. Voltage should be approximately 5V.
   - If voltage is normal, check around the camshaft position sensor. See **Section 5.13.30**.
   - If voltage is abnormal, check the wire harness for disconnection. See **Section 5.13.28**.



5.13.28 Checking a Wire Harness for Disconnection - Camshaft Position Sensor

This procedure is related to DTC codes P0340 and P0341.

1. Disconnect the connector of the camshaft position sensor and the connector of the ECU.
2. Measure the resistance between connector terminals on the camshaft position sensor wire harness side and ECU connector at the harness side. Terminals to measure:
   - Sensor terminal 1 and ECU terminal 45
   - Sensor terminal 2 and ECU terminal 46
   - Sensor terminal 3 and ECU terminal 44.



3. Check that resistance is several Ω and more.
   - If resistance is normal, measure the power supply voltage of the ECU connectors. See **Section 5.13.29** for procedure.
   - If resistance is abnormal, repair or replace the wire harness (connectors).

5.13.29 Checking Power Supply Voltage of ECU Connectors - Camshaft Position Sensor

This procedure is related to DTC codes P0340 and P0341.

1. Turn the ignition switch to “RUN” and measure the voltage between terminals 45 (+) and 44 (-) of the ECU. Voltage should be approximately 5V.

- If voltage is normal, then there is no abnormality, this is a temporary error.
- If voltage is abnormal, check the ECU connectors. See **Section 5.13.47** for procedure.

5.13.30 Checking Around the Camshaft Position Sensor

This procedure is related to DTC codes P0340 and P0341.

1. Inspect the camshaft position pulsar gear for the following:
   - Installation not mis-aligned
   - No foreign matter adhering
   - Teeth not worn
2. Inspect the camshaft position sensor for the following:
   - No foreign mater stuck to sensor surface
   - No trace of interference with cam position pulsar gear

5.13.31 Checking a Wire Harness - Glow Relay

This procedure is related to DTC codes P0380 and P0381.

NOTE: Before diagnosing the problem, use Diagmaster to try to reproduce it based on any DTC information. Check the related signals on the Data Monitor screen. Diagnose whether the wire harness (including connectors) is damaged or something else is.

NOTE: The glow relay turns OFF at coolant temperatures above 21°C (70°F).

1. Disconnect the connector from the ECU.
2. Disconnect the glow relay from the connector.
3. Check the conduction of the wire harness at glow relay terminal 4 and ECU terminal 70. Check for continuity.
   - If continuity is normal, check the glow relay.
   - If continuity is abnormal, repair or replace the wire harness (connectors).

5.13.32 Checking the Operation of a Relay - Glow Relay

This procedure is for checking the relay separately and deciding whether the relay is the problem. This involves 3 tests: measuring voltage, checking continuity, and measuring resistance. Relay specifications vary with the engine. This procedure is related to DTC codes P0380 and P0381.

1. **Measure voltage**. Remove the connector of the coolant temperature sensor and connect a dummy resistor.

NOTE: The dummy resistor: 15 to 25 kΩ [comparable to approximately -30 to -20°C (-22 to -5°F). The glow relay comes on when the coolant temperature is below 10°C (50°F).

2. Turn the ignition switch to RUN and measure the voltage of the glow relay between relay terminals 3 and 4.
3. The voltage should be equivalent to the generator set battery voltage value.
   - If voltage is normal, check the ECU connectors. See **Section 5.13.47**.
   - If voltage is abnormal, replace the glow relay.
4. **Check continuity**. Remove the connector of the coolant temperature sensor and connect a dummy resistor.

NOTE: The dummy resistor: 15 to 25 kΩ [comparable to approximately -30 to -20°C (-22 to -5°F). The glow relay comes on when the coolant temperature is below 21°C (70°F).

5. Turn the ignition switch to “RUN” and check continuity between the glow plug relay terminals 1 and 2. There must be continuity.
   - If continuity is normal, check the ECU connectors. See **Section 5.13.47**.
   - If continuity is abnormal, replace the glow plug relay.
6. **Measure resistance**. Disconnect the glow relay from the connector.
7. Measure the resistance between the glow relay terminals 3 and 4.

8. Verify the resistance is within specification.
   - If resistance is normal, check the ECU connectors. See **Section 5.13.47**.
   - If resistance is abnormal, replace the glow plug relay.

5.13.33 Checking the Operation of the Low Oil Pressure Switch

This procedure is related to DTC code P0524.

⚠ CAUTION

When checking the low oil pressure (LOP) switch, if the engine oil level is low then the engine may be damaged. So, limit the time the amount of time that the engine is started.

1. Connect a computer to the ECU and open Diagmaster. See **Section 7.2.4** for procedure.
2. Launch Diagmaster software. See **Section 7.3.1** for procedure.
3. Turn the ignition switch to START to start or RUN for diagnosis purposes.
4. Go to the Data Monitor screen and bring up the Oil Pressure SW setting.
5. Observe the data on the screen to diagnose the ON/OFF state of the low oil pressure (LOP) switch signal.
   - When the ignition switch is in START (engine running), the LOP switch status should be ON.
   - When the ignition switch is in RUN (engine stopped), the LOP status should be OFF.
6. For further diagnosis, disconnect the LOP connector.
7. Set up the conditions and check for continuity between the LOP switch terminal and body ground. Continuity should be present with ignition switch in RUN (engine stopped). Continuity should not be present when the engine is running.
   - If continuity is normal, check the wire harness. See **Section 5.13.34**.
   - If continuity is abnormal, replace the LOP switch. See **Section 6.4.3.2**.

5.13.34 Checking a Wire Harness - Low Oil Pressure Switch

This procedure is to diagnose whether the problem is the wire harness (including connectors) or something else. This procedure is related to DTC code P0524.

1. Disconnect the sensors and the ECU from the connector.
2. Check the continuity of the harness at the oil pressure switch terminal and ECU terminal 47.
   - If continuity is normal, check the engine oil pressure.
   - If continuity is abnormal, repair or replace the wire harness (connectors).
3. Check for short circuits between the terminals of the oil pressure switch and those of the ECU by testing continuity between body ground and each terminal.
   - If there are no short circuits, check the engine oil pressure. See **Section 6.4.4.2**.
   - If short circuits are found, repair or replace the wire harness (connectors).

5.13.35 Checking Resistance - Suction Control Valve (SCV)

This procedure is to diagnose whether the problem is the ECU (including the connectors) or something else. This procedure is related to DTC codes P0627, 0628 and 0629.

1. Disconnect the ECU connector from the ECU.
2. Measure the resistance on the ECU connector side at terminals 4 and 89. Resistance specification is: Temperature: 20°C (68°F); Resistance: 2.6 to 3.5 Ω; Insulation resistance (between terminal and body): 100 MΩ or higher.
   - If resistance is normal, check the ECU connectors. See **Section 5.13.47**.
   - If resistance is abnormal, check the SCV sensor wire harness. See **Section 5.13.36**.

5.13.36 Checking a Wire Harness - Suction Control Valve (SCV)

This procedure is to diagnose whether the problem is the SCV sensor wire harness (including connectors). This procedure is related to DTC codes P0627, 0628 and 0629.

1. Disconnect the SCV connector.
2. Measure the resistance between the terminals on the SCV sensor. Resistance specification is: Temperature: 20°C (68°F); Resistance: 2.6 to 3.5 Ω; Insulation resistance (between terminal and body): 100 MΩ or higher.
   - If resistance is normal, repair or replace the wire harness (including connectors).
   - If resistance is abnormal, replace the SCV or supply pump unit.

5.13.37 Checking ECU Terminal Voltage

This procedure is related to DTC codes P0562 and P0563.

1. Set up the conditions and measure the voltage between ECU terminals. Terminals to measure:
   - Terminal 4 battery (+) and terminals 1,2 power ground (-).
   - Terminal 6 battery (-) and terminals 1,2 power ground (-).
2. Voltage with engine operating should be 8 to 16V.
   - If voltage is normal, check the ECU connectors. See Section.
   - If voltage is abnormal, continue with the next step of this procedure.
3. Set up the conditions and measure the voltage between body earth and ECU terminals 1,2 power ground.
4. Voltage with engine operating should be 0.5 V or lower.
   - If voltage is normal, check the charging system, the battery itself, the wire harness and cables.
   - If voltage is abnormal, check the wire harness between the ECU terminals and body ground terminals.

5.13.38 Checking the Operation of a Relay - Main Relay / Engine Relay

This procedure is a general relay checking procedure. This procedure is related to DTC code P0687.

1. Disconnect the relay.
2. Turn the ignition switch to RUN and measure the voltage between terminals 1 and 3 on the relay connector side. Voltage should be equivalent to the battery voltage value.
   - If voltage is normal, check the relay.
   - If voltage is abnormal, check for open circuits in the harness between terminals of the relay and the battery and repair or replace as needed.
3. Check for continuity between terminals 3 and 4 of the relay.
   - If continuity is normal, check for continuity between terminals 1 and 2 of the relay. There is resistance in the relay coil, so it should be 0 Ω. Check for an open circuit
   - If continuity is abnormal, replace the relay.
4. Check for continuity between terminals 1 and 2 of the individual relay when the relay is ON. Apply a battery voltage to relay terminals 3 and 4 to turn it ON. Check for continuity between terminals 1 and 2 and check whether the contacts of the relay are normal or not.
   - If continuity is normal, check the input/output voltage of the ECU-side relays.
   - If continuity is abnormal, replace the relay.

5.13.39 Checking Input / Output Voltage of ECU Side Relays

This procedure is related to DTC code P0687.

1. Turn the ignition switch to RUN and check the voltage of the input terminal 4 and 6 on the ECU side of the main relay. Voltage should be equivalent to the battery voltage value.
   - If voltage is normal, replace the ECU.

- If voltage is abnormal, check the wire harness and connectors between the relays and ECU. If there are no open or short circuits, check the voltage of the output terminals 50 of the ECU side of the main relay.

2. Turn ignition switch to OFF and then RUN. Measure the voltage of the output terminals 50 on the ECU side of the main relay. There should be no change in voltage.
   - If voltage is normal, check for open circuits in the harness between the relay and the ECU. Repair and replace.
   - If voltage is abnormal, replace the ECU.

5.13.40 Checking a Wire Harness - Starter Relay

This procedure is related to DTC code P081A.

NOTE: Before diagnosing the problem, use Diagmaster to try to reproduce it based on any DTC information. Check the related signals on the Data Monitor screen. Diagnose whether the wire harness (including connectors) is damaged or something else is.

1. Disconnect the connector from the ECU.
2. Disconnect the starter relay from the connector.
3. Check the conduction of the wire harness at starter relay terminal 3 and ECU terminal 68. Check that there is continuity.
   - If continuity is normal, check the starter relay. See **Section 5.13.41**.
   - If continuity is abnormal, repair or replace the wire harness (connectors).

5.13.41 Checking the Operation of a Relay - Starter Relay

This procedure is for checking the relay separately and deciding whether the relay is the problem. This involves 3 tests: measuring voltage, checking continuity, and measuring resistance. Relay specifications vary with the engine; this procedure is a general failure diagnosis of a starter relay. This procedure is related to DTC code P081A.

1. **Measure voltage**. Turn the ignition switch to RUN and measure the voltage of the glow relay between relay terminals 3 and 4. The voltage should be equivalent to the generator set battery voltage value.
   - If voltage is normal, check the ECU connectors. See **Section 5.13.47**.
   - If voltage is abnormal, replace the starter relay.
2. **Check continuity**. Remove the connector of the coolant temperature sensor and connect a dummy resistor.

NOTE: The dummy resistor: 15 to 25 kΩ [comparable to approximately -30 to -20°C (-22 to -5°F). The glow relay comes on when the coolant temperature is below 21°C (70°F).

3. Turn the ignition switch to RUN and check continuity between the starter relay terminals 1 and 2. There must be continuity.
   - If continuity is normal, check the ECU connectors. See **Section 5.13.47** for procedure.
   - If continuity is abnormal, replace the starter relay.
4. **Measure resistance**. Disconnect the starter relay from the connector.
5. Measure the resistance between the starter relay terminals 3 and 4. Verify the resistance is within specification.
   - If resistance is normal, check the ECU connectors. See **Section 5.13.47** for procedure.
   - If resistance is abnormal, replace the starter relay.

5.13.42 Checking DTCs and Rewriting Trim Data

If trim data is written, such as when the ECU is replaced, it may fail. If so, retry doing it. This procedure is related to DTC code P1990.

Refer to the **Diagmaster** chapter for detailed operating procedures for using Diagmaster.

1. Turn the ignition switch to RUN position.
2. Connect a computer to the ECU and open Diagmaster software.

3. Bring up the DTC screen and clear the DTC(s).
4. Check whether or not the same DTC is detected. An electromagnetic interference (EMI) may have caused the temporary malfunction.
   - If the DTC is not detected, then the system has recovered.
   - If the DTC is detected again, then continue to next step of this procedure.
5. .Write trim data correctly to the ECU.
6. Clear the DTC
7. Turn the ignition switch OFF and then back to RUN.
8. Check whether or not the same DTC is detected. If same DTC is detected and can not be cleared, replace the ECU.

5.13.43 Checking DTCs and the Atmospheric Pressure Sensor

The atmospheric pressure sensor is built into the ECU, so a simple check can not be performed. Check the DTC to determine whether it is damaged. This procedure is related to DTC codes P2228 and P2229.

Refer to the **Diagmaster** chapter for detailed operating procedures for using Diagmaster.

1. Turn the ignition switch to RUN position.
2. Connect a computer to the ECU and open Diagmaster software.
3. Bring up the DTC screen and clear the DTC(s).
4. Check whether or not the same DTC is detected. An electromagnetic interference (EMI) may have caused the temporary malfunction.
   - If the DTC is not detected, then the system has recovered.
   - If the DTC is detected again, then the atmospheric pressure sensor is damaged. Replace the ECU.

5.13.44 Checking DTCs after a Pressure Limiter Failure

This procedure is related to DTC code P2293.

Refer to the **Diagmaster** chapter for detailed operating procedures for using Diagmaster.

1. Turn the ignition switch to RUN position.
2. Connect a computer to the ECU and open Diagmaster software.
3. Bring up the DTC screen and clear the DTC(s).
4. Turn the ignition OFF and then back to RUN.
5. Turn the ignition to START to start the engine.
6. Check whether or not the same DTC is detected. An electromagnetic interference (EMI) may have caused the temporary malfunction.
   - If the DTC is not detected, then the system has recovered.
   - If the DTC is detected again, then replace the ECU

5.13.45 Checking DTCs and CAN2 Related Wiring

This procedure is related to DTC code U0075.

Refer to the **Diagmaster** chapter for detailed operating procedures for using Diagmaster.

1. Turn the ignition switch to RUN position.
2. Connect a computer to the ECU and open Diagmaster software.
3. Bring up the DTC screen and clear the DTC(s).
4. Check whether or not the same DTC is detected. An electromagnetic interference (EMI) may have caused the temporary malfunction.

- If the DTC is not detected, then the system has recovered.
- If the DTC is detected again, then continue to the next step of this procedure.

5. Disconnect the CAN2 connector and the ECU from the connector.

NOTE: The position and shape of the CAN2 connector varies with specifications.

6. Check the continuity of the harness between the CAN2 connector terminal and ECU terminal 62, 63. All harnesses must have continuity.
   - If continuity is normal, replace the ECU.
   - If continuity is abnormal., repair or replace any abnormal areas.
7. Check for short circuits between the terminals of CAN2 connector and those of the ECU by testing the continuity between body ground and each terminal 62, 63.
   - If no shorts are present, replace the ECU.
   - If shorts are present, repair or replace any abnormal areas.

5.13.46 Checking DTCs and CAN1 Related Wiring

This procedure is related to DTC code U0077.

Refer to the Diagmaster section for detailed operating procedures for using Diagmaster.

1. Turn the ignition switch to RUN position.
2. Connect a computer to the ECU and open Diagmaster software.
3. Bring up the DTC screen and clear the DTC(s).
4. Check whether or not the same DTC is detected. An electromagnetic interference (EMI) may have caused the temporary malfunction.
   - If the DTC is not detected, then the system has recovered.
   - If the DTC is detected again, then continue to the next step of this procedure.
5. Disconnect the CAN1 connector and the ECU from the connector.

NOTE: The position and shape of the CAN1 connector varies with specifications.

6. Check the continuity of the harness between the CAN1 connector terminal and ECU terminal 65, 66. All harnesses must have continuity.
   - If continuity is normal, replace the ECU.
   - If continuity is abnormal., repair or replace any abnormal areas.
7. Check for short circuits between the terminals of CAN1 connector and those of the ECU by testing the continuity between body ground and each terminal 65, 66.
   - If no shorts are present, replace the ECU.
   - If shorts are present, repair or replace any abnormal areas.

5.13.47 Checking the ECU Connectors

This procedure is to diagnose whether the ECU or connectors on the ECU harness side has a malfunction.

1. Inspect the state of the ECU connector pins for the following items:
   - No breakage or bending
   - No foreign matter adhering
2. Inspect the state of the ECU connector at the harness side for the following items:
   - ECU connector pins must fit together securely
   - No foreign matter adhering
3. If no abnormalities are noticed, then replace the ECU.

Section 6
Service and Preventative Maintenance

NOTE: Read the **Safety** chapter carefully prior to troubleshooting the engine or generator set.

6.1 Kubota Engine Support

The Kubota Engine Park (KEP) website provides access to additional resources for operating, servicing and troubleshooting Kubota engines. From here, a user can download Diagmaster diagnosis software, application manuals, and service manuals. Contact a Carrier service engineer to request login credentials.

KEP can be accessed by visiting https://ba.engine.kubota.com/web/guest/home

6.2 Engine Pre-Work Checklist

Prior to performing any failure diagnosis work, check and record the content of the engine pre-work checklist in order to check the engine's state of use.

Table 6–1 Engine Pre-Work Checklist

Oil		Quantity	High	Suitable	Low
		Contamination	None	Has ( )	
		Smell	None	Has ( )	
		Leakage	None	Has ( )	
		Grade	Suitable	Not suitable ( )	
		Storage state	Suitable	Not suitable ( )	
Fuel		Quantity	Full	Middle	Low
		Contamination	None	Has ( )	
		Smell	None	Has ( )	
		Leakage	None	Has ( )	
		Quality	Suitable	Not suitable ( )	
		Storage state	Suitable	Not suitable ( )	
Coolant	Radiator	Quantity	High	Suitable	Low
		Contamination	None	Has ( )	
		Smell	None	Has ( )	
		Leakage	None	Has ( )	
	Reserve tank	Quantity	High	Suitable	Low
		Contamination	None	Has ( )	
		Smell	None	Has ( )	
		Leakage	None	Has ( )	

Table 6–1 Engine Pre-Work Checklist

Wiring (connector)		Contamination	None	Has ( )
		Broken	None	Has ( )
		Damaged	None	Has ( )
Air cleaner		Contamination	None	Has ( )
		Clogging	None	Has ( )
		Broken	None	Has ( )
Water separator		Water mixed in	None	Has ( )
		Contamination	None	Has ( )
Fuel filter		Genuine parts	Yes	No ( )
Oil filter		Genuine parts	Yes	No ( )
Modification		Fuel system	None	Has ( )
		Electrical system	None	Has ( )

6.3 Generator Set and Engine Maintenance Schedule

A tabular listing of the recommended preventative maintenance activities and schedule is provided in **Table 6–2**.

Table 6–2 Preventative Maintenance Actions and Schedule

Inspection Item	Reference	Daily or Pre-Trip[1]	1 Yr[2]	2 Yr[3]	4 Yr[4]
Engine					
Check (in place) engine shockmounts visually for cracks, cuts, abrasions.	**Section 6.7.2**	x	x	x	
Replace engine shockmounts	**Section 6.7.2**				x
Tighten engine mounting bolts.	**Section 6.7.2**		x	x	x
Check valve clearance.	Engine Manual			x	x
Check crankcase breather.	none			x	x
Check for historical DTC codes.	**Section 7.3.6**			x	x
Engine - Fuel System					
Check fuel lines, filters, clamp bands and connections for leaks.	none	x	x	x	x
Check tank fuel level, refuel as needed. Check fuel gauge operation.	**Section 3.15**	x	x	x	x
Replace the fuel filter element.	**Section 6.4.1.4**		x	x	x
Drain water from the fuel filter bowl. If the bowl has water, drain water from the fuel tank sump.	none	x	x	x	x

Table 6–2 Preventative Maintenance Actions and Schedule (Continued)

Inspection Item	Reference	Daily or Pre-Trip[1]	1 Yr[2]	2 Yr[3]	4 Yr[4]
Engine - Lubrication System					
Check lubrication filters and seals for leaks.	none	x	x	x	x
Check lubrication oil level, add as required.	**Section 3.15**	x			
Change lubrication oil and oil filter (See NOTES).	**Section 6.4.3**		x	x	x
Engine - Coolant System					
Check coolant system lines, clamp bands and connections for leaks.	none	x	x	x	x
Check radiator coil for cleanliness.	**Section 6.4.4**	x	x	x	x
Check coolant level. Add 50/50 mix as required.	**Section 3.15**	x	x	x	
Clean and flush the coolant system.	**Section 6.4.4**				x
Check fan belt for fraying or cracking. Replace as required.	**Section 6.4.4.3**	x	x	x	x
Engine - Intake and Exhaust System					
Check the air cleaner element, air filter minder (indicator) and air intake line. Clean / replace filter as needed.	**Section 6.4.2**	x			
Replace Air filter if over 250 hours since last replacement.	**Section 6.4.2**		x	x	x
Check exhaust system for leaks.	none	x	x	x	x
Electrical System					
Check battery terminals for tightness and cleanliness.	none	x	x	x	x
Clean and coat battery terminals with sealant.	none		x	x	x
Check for dirty or loose electrical connections, frayed cables, cracked insulation.	none	x	x	x	x
Tighten all electrical connections in the control box.	none		x	x	x
Check the starter.	none	x			
Generator					
Check (in place) generator shockmounts visually for cracks, cuts, abrasions.	**Section 6.7.2**	x	x	x	
Replace generator shockmounts.	**Section 6.7.2**				x
Tighten generator mounting bolts.	**Section 6.7.2**		x	x	x
Check generator output with a voltmeter.	none	x	x	x	x
General					
Inspect unit for debris within the drive assembly interior and discard.	none	x	x	x	x
Check and tighten as required all hardware, brackets, etc.	none	x	x	x	x
Check total time meter operation (allow engine to run 10 minutes).	none	x	x	x	x
Listen for abnormal noises.	none	x	x	x	x
Check generator 50 hz / 1500 rpm at no load.	none	x	x	x	x
Verify operation of safety devices.	**Section 3.14**		x	x	x

NOTES ON LUBRICATING OIL AND FILTERS:

- Units have mineral oil installed from the factory. Change lubricating oil and filters after the first 2000 hours of service or at the end of the first year, whichever comes first.
- Oil changes after the first 2000 hour service, or 1 year:
  - If using mineral oil, oil changes should continue every 2000 hours of service or every 1 year, whichever comes first.
  - If using specified synthetic lubricating oil and OEM extended life oil filter, oil changes should be completed every 4000 hours of service, or every two years, whichever comes first.

[1] Pre-trip maintenance checks should be carried out prior to any use of the unit (1-15 and 31-36).

[2] One year maintenance checks should be carried out annually or every 2000 hours, whichever comes first.

[3] Two year maintenance checks should be carried out every two years or every 4000 hours, whichever comes first.

[4] Four year maintenance checks should be carried out every four years or every 8000 hours, whichever comes first.

6.4 Engine Component Service

Engine service procedures are included in this section. Any procedures not included can be referenced from one of the Kubota reference manuals.

A separate manual, 62-12258 Diesel Engine Workshop for V2403-CR-E4B Engines, is available to cover information not detailed in this operations and service manual.

6.4.1 Fuel System Service

The engine fuel system, as described in **Section 3.7**, is a common rail system (CRS) that injects a precise amount of atomized fuel into the engine cylinders.

NOTE: The generator set approved fuel is Ultra Low Sulfur Diesel (ULSD) or diesel with ≤ B5 (5% biodiesel).

NOTE: Prior to performing any diagnosis work on the fuel system, refer to the pre-work checklist located in **Section 6.2**, to make sure all criteria are met.

NOTE: Be sure to read and understand all safety precautions, located in**Section 1.4**, related to fluids and the fuel system prior to performing work.

NOTE: Make sure fuel quality meets the fuel standard, fuel quantity is at the specified amount and there are no leaks. Fuel specifications are described in **Section 3.15**.

NOTE: Be sure to use a strainer when filling the fuel to prevent dirt or debris from entering the tank.

NOTE: Do not operate the fuel tank level too low or completely out of fuel. This may cause improper engine operation and/or a DTC error code may be recorded in the ECU.

6.4.1.1 Checking the Fuel Tank

1. Check inside the fuel tank. Inspect for contaminants, water separation, and rust.
2. If the fuel tank has been modified or expanded, check the following items:
   - Tank material: resin
   - Inside tank: contaminants, water separation, rust
   - Fuel inlet/outlet: position and piping
   - Fuel pipe inside tank: inlet/outlet position (below empty position)
   - Fuel pipe inside tank: inlet clogged, pipe bent or deformed (crushed)
   - Fuel pipe inside tank: pipe connection crushed
3. If a problem is not found, clean or replace the fuel tank.

6.4.1.2 Checking the Fuel Lines and Pipes

1. Check the fuel line hoses for the following: deterioration, disconnection, perforation, cracking, or being pinched, crushed or excessively bent by other parts.

2. Check the fuel line clamps for looseness, crushing, or excessive bending.
3. Check for any traces of leaked fuel.
4. For high pressure pipes, check visually for leaks outside the engine. And also inside the head cover check for an increase in engine oil amount.
5. Repair or replace any problem areas or components.

6.4.1.3 Bleeding the Fuel System

The fuel system is a closed circuit which will require bleeding if changing a fuel filter, opening fuel lines for any reason or if the system has been emptied of fuel.

1. Make sure the fuel tank has adequate fuel.
2. Check the tightness of all fuel and filter connections.
3. Operate the hand primer pump until pressure increases.
4. Start the engine.

6.4.1.4 Replacing the Fuel Filter

⚠ CAUTION

Do not pre-fill a new replaced fuel filter prior to installation. This can damage the engine's fuel injectors.

1. To replace the fuel filter, loosen and remove the filter housing.
2. Lightly oil new gasket with lube oil
3. Replace the filter.

NOTE: If the generator set is equipped with the fuel filter bowl assembly, when replacing the fuel filter, a new fuel filter O-ring should be oiled and replaced. The clear bowl is then tightened to 18 ft-lbs (24.4 Nm).

6.4.2 Engine Air Cleaner Service

The engine air cleaner, as described in **Section 3.8.1**, uses a dry element filter to clean the engine intake air.

The engine air cleaner should be inspected regularly for leaks or clogging. A damaged air cleaner or hose can seriously affect the performance and life of the engine. The air cleaner is designed to effectively remove contaminants from the air stream entering the engine. An excessive accumulation of contaminants in the air cleaner will impair its operation. Therefore, a service schedule must be set up and followed.

The air cleaner element should be replaced after six cleanings.

⚠ CAUTION

Always cover the engine inlet tube while the air cleaner is being serviced.

1. Check all connections for mechanical tightness. Be sure the air cleaner outlet pipe is not fractured.
2. In case of leakage, if adjustment does not correct the problem, replace necessary parts or gaskets. Swollen or distorted gaskets must always be replaced.

6.4.2.1 Air Filter Indicator

The air filter indicator, see **Figure 3.19**, is mounted on the air filter body. Its function is to indicate when the air cleaner dry element needs to be replaced. In operation, when a plugged air cleaner decreases intake manifold pressure to 500mm (20") WG, the indicator moves to the red line. The air cleaner element should be replaced and the indicator reset by pressing the reset button.

6.4.2.2 Air Cleaner Dry Element Service

1. Stop the engine and open the cap clamps to remove the air cleaner bottom cap.
2. Remove the air filter element from the air cleaner body.

3. Install the new element, and secure the bottom cap with the cap clamps.

6.4.2.3 Air Cleaner Body Service

If there is any sign of contaminant buildup or plugging, the air cleaner body should be removed and back flushed. At least once a year, or at regular engine service intervals, remove the entire air cleaner and perform the following cleaning procedure:

⚠ WARNING

Do not use gasoline to clean air cleaner parts.

1. Check and clean the center tube.
2. Pump solvent through the air outlet with sufficient force and volume to produce a hard, even stream out of the bottom of the body assembly. Reverse flush until all foreign material is removed.

6.4.2.4 Air Cleaner Intake Air Line

Check whether there is an air leak in the intake air path. Observe the following inspection locations:

- Looseness, misalignment or air cleaner sensor installation.
- Loose or missing suction pipe, hose or clamp.
- Hole or crack in suction pipe or hose.
- Deformed routing of the air intake lines.

6.4.3 Lubrication System Service

The engine lubrication system, as described in **Section 3.9**, supplies lubricating oil to the various moving parts in the engine.

6.4.3.1 Replacing the Lube Oil Filter

1. After warming up the engine, stop the engine, remove the drain plug from the oil reservoir and drain the oil.
2. Replace the filters. Lightly oil the gasket on the filter before installing.
3. Add lube oil as detailed in **Table 3–4**.
4. Warm up the engine and check for leaks.

6.4.3.2 Servicing the Low Oil Pressure Switch

⚠ WARNING

Make sure the engine is cooled down enough before removing the oil pressure switch. Be careful when removing the oil pressure switch as engine oil will flow out.

1. Remove harness connection from the low oil pressure (LOP) switch.
2. Remove the low oil pressure (LOP) switch from the engine.
3. Apply Teflon thread sealer to all threads of new the new switch.
4. Install the new switch.
5. Reconnect the harness connection to the new switch.

6.4.4 Cooling System Service

The engine cooling system, as described in **Section 3.10**, uses extended life coolant and a radiator to keep the engine from overheating.

6.4.4.1 Cleaning the Cooling System

To ensure adequate cooling, the radiator must be clean, externally and internally. To service the cooling system, do the following:

1. Remove all foreign material from the radiator coil by reversing the normal air flow. Compressed air or water may be used as a cleaning agent. It may be necessary to use warm water mixed with any good commercial dishwasher detergent. Rinse coil(s) with fresh water if a detergent is used.
2. Drain coolant completely by opening the drain-cock and removing the radiator cap.

⚠ CAUTION

Never pour cold water into a hot engine.

3. Close the drain cock and fill the system with clean, untreated water to which between 3% and 5% of an alkaline base radiator cleaner should be added; 170 grams dry = 151 grams to 3.8 liters of water.
4. Run the engine 6 to 12 hours and drain the system while warm. Rinse the system three times after it has cooled down. Refill the system with water.

⚠ CAUTION

Use only ethylene glycol anti-freeze (with inhibitors) in system. Use of glycol by itself will damage the cooling system.

5. Run the engine to operating temperature. Drain the system again and fill with treated water / anti-freeze. See the above Caution statement.

6.4.4.2 Checking Engine Oil Pressure

⚠ WARNING

Make sure the engine is cooled down enough before removing the oil pressure switch. Be careful when removing the oil pressure switch as engine oil will flow out.

1. Check the amount of engine oil.
2. Remove harness connection from the low oil pressure (LOP) switch.
3. Remove the low oil pressure (LOP) switch from the engine.
4. Install an oil pressure tester.
5. Start the engine and let it warm up.
6. Set up the conditions and measure the engine oil pressure. Oil pressure specifications are detailed in **Table 3–4**. If pressure is not within specifications, inspect the oil, oil filter, relief valve, oil pump and oil clearances.

6.4.4.3 Servicing the Fan Belt

⚠ WARNING

Beware of moving fan belt, belt driven components and hot exhaust components.

⚠ WARNING

Beware of pinch points.

NOTE: A frayed, cracked or worn fan belt must be replaced. After installing a new belt, check the adjustment after running the unit for three or four hours. This will allow for the initial stretch, which is common on new belts. Once this initial stretch has taken place, the belt should be checked at regular intervals.

The fan belt is a poly V-belt that is driven by a sheave on the engine crankshaft. Its two functions are: (1) to drive the radiator fan and (2) to drive the water pump.

6.4.4.4 Checking the Fan Belt

1. Check the belt for wear by looking for fraying or cracking. Observe whether the belt is sunken into the pulley groove.
2. Check fan belt tension. Push the belt half way between the fan drive pulley and alternator pulley at specified force to measure deflection.

6.4.4.5 Replacing the Fan Belt

1. Using the proper size socket, slowly rotate the crank on the crank pulley nut. At the same time, use a flat, blunt object to guide the belt off the crank pulley towards the radiator. Be careful not to damage grooves on the pulley.
2. Replace the belt by positioning the belt on the water pump pulley, and while rotating the engine (as in step 1.), use a flat, blunt object to guide the belt onto the crank pulley. Be careful not to damage grooves on the pulley or belt.

⚠ CAUTION

Observe proper polarity when installing the battery or connecting a battery charger. The negative battery terminal must be grounded. Reverse polarity may damage the charging system. When charging the battery in unit, isolate the battery by disconnecting the negative battery terminal first, then the positive. Once the battery has been charged, connect the positive battery terminal first, then the negative.

6.5 Exhaust System

6.5.1 Removing and Replacing the DOC

⚠ WARNING

Before servicing the unit, make sure the unit is OFF and the negative battery terminal is disconnected. Follow your regional lockout tagout procedure.

⚠ WARNING

Beware of moving poly V-belt, belt driven components and hot exhaust components.

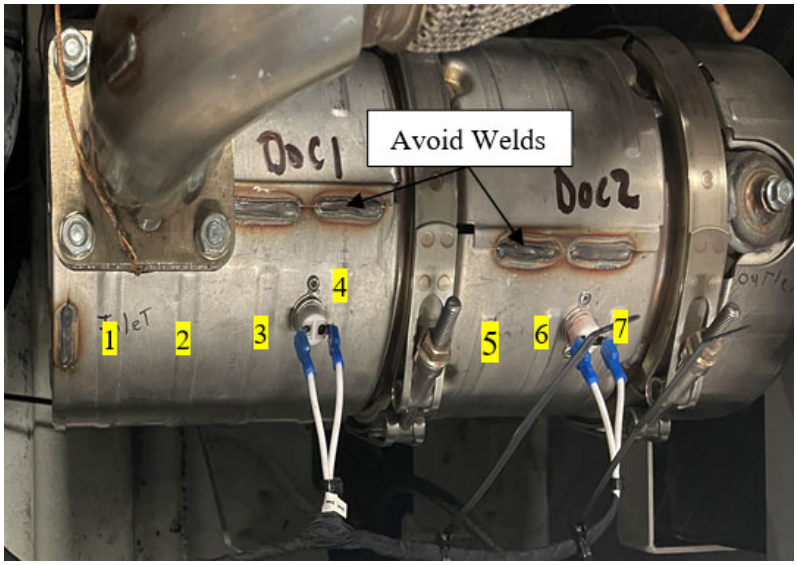
⚠ WARNING

Beware of pinch points.

1. Remove the genset cover and disconnect the battery. Follow local lockout / tagout procedures.
2. Electrically disconnect and remove the 2 thermal switches from the DOC that needs to be replaced. Set aside the switches to save for re-installation.
3. Remove the DOC from the genset and set the new DOC in place and secure.

4. Using the switches, mark and punch locations for drilling in the replacement DOC. Position so the switches are against the body of the DOC. Align between ribs 3 and 4 and between ribs 6 and 7, counting from the inlet side of the DOC. Make sure to avoid areas with welds.

   Ensure the bracket goes along radius of the DOC. The switch brackets are positioned forward to sit above the battery charger at the 2 o'clock position when viewed from the outlet of the DOC.

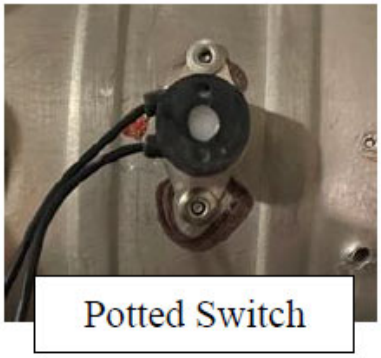


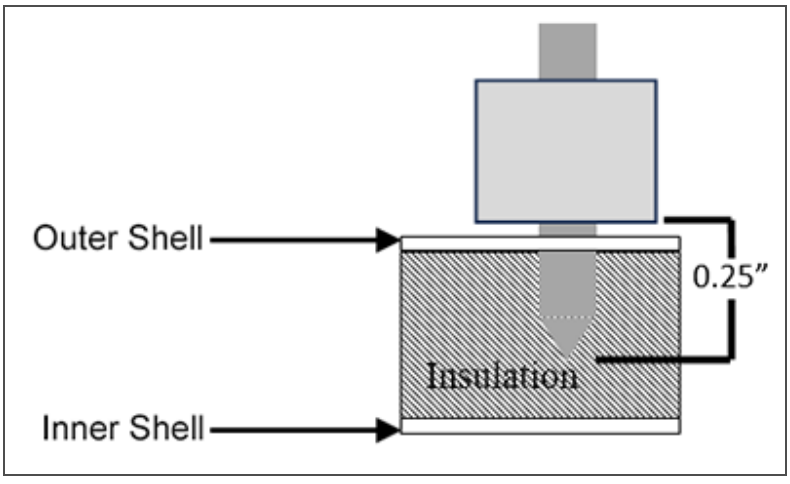
5. Drill holes through the outer shell of the DOC with a 0.129 to 0.133” drill bit and drill stop at 0.25” at the punched holes.

   For non-potted switches, drill holes (2 per switch) through the outer shell of the DOC with a 0.129 to 0.133” drill bit and drill stop at 0.25” at the punched holes.

   For potted switches, drill holes (2 per switch) through the outer shell of the DOC with a 0.160 to 0.164” drill bit and drill stop at 0.25” at the punched holes.


Non-potted Switch


Potted Switch



6. For non-potted switches, apply silicone (Permatex Ultra Red 81630 / 81624) to the rim of the switch to help seal it. Ensure the contact area remains clean.

7. Position the switch over the holes with the rim flat to the body of the DOC.

8. Attach the switches to the DOC using 4 stainless steel rivets and a powered rivet tool to ensure tightness of installation. Ensure the bracket is flat against the switch head.

   NOTE: Use a pneumatic or electronic rivet tool to ensure tightness of installation.

   For non-potted switches, use small rivets (part # 34-00928-01).

   For potted switches, use larger rivets (part # 34-00928-07).

9. Re-apply Permatex as needed to cover switch terminals for non-potted switches.

6.5.2 Removing and Replacing the DOC Thermal Switches

⚠ WARNING

Before servicing the unit, make sure the unit is OFF and the negative battery terminal is disconnected. Follow your regional lockout tagout procedure.

⚠ WARNING

Beware of moving poly V-belt, belt driven components and hot exhaust components.

⚠ WARNING

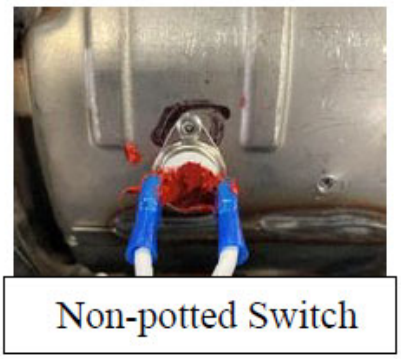
Beware of pinch points.

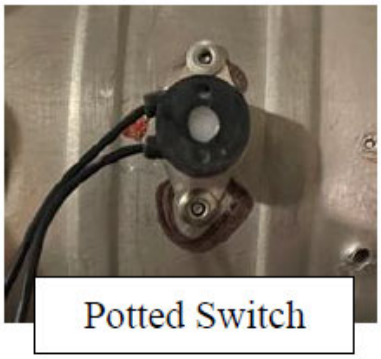
1. Remove the genset cover and disconnect the battery. Follow local lockout tagout procedures.
2. Electrically disconnect and remove the 2 thermal switches from the DOC.

3. All replacement switches are potted switches.

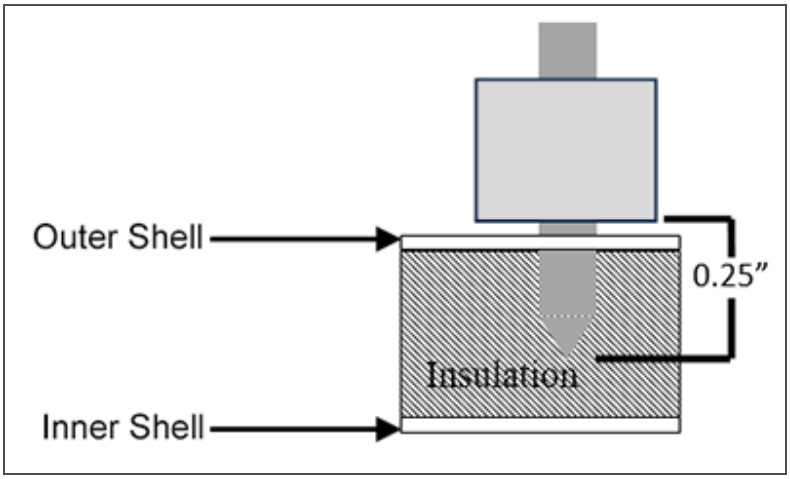
   If the removed switch was potted, then the existing holes in the DOC can be used.

   If the removed switch was non-potted, continue to the next step for hole drilling instructions.


Non-potted Switch


Potted Switch

4. Drill holes (2 per switch) through the outer shell of the DOC with a 0.160 to 0.164” drill bit and drill stop at 0.25” at the punched holes.



5. Attach the switches to the DOC using 4 stainless steel rivets (part # 34-00928-07) and a powered rivet tool to ensure tightness of installation. Ensure the bracket is flat against the switch head.

   NOTE: Use a pneumatic or electronic rivet tool to ensure tightness of installation

6.6 Electrical System

6.6.1 Battery Service

When replacing the battery, note if the unit was supplied with a mat in the battery tray. If so equipped, the mat must also be replaced. When installing cables to battery, ensure the cables are not touching anything, and are floating in free air.

6.7 General Generator Set Maintenance

The alternating current (AC) generator, as described in **Section 3.3**, converts mechanical energy produced by the engine into electrical current.

6.7.1 Removing and Replacing the AC Generator

The only serviceable parts on the generator are the torsional dampener, key, fan, and fan cover. If there is a problem with the generator, it should be replaced using the following procedure.

Unidrive torque requirements are detailed in **Section 6.7.3**.

⚠ WARNING

Before servicing the unit, make sure the unit is OFF and the negative battery terminal is disconnected. Follow your regional lockout tagout procedure.

⚠ WARNING

Beware of moving poly V-belt, belt driven components and hot exhaust components.

⚠ WARNING

Beware of pinch points.

1. Remove the unit top and side panels in order to access the generator.
2. Disconnect the battery.
3. Remove the truss assembly center nuts and nut plate.
4. Remove the truss side bolts / washers and spacers (2), and remove the truss.
5. Remove the 3/8” bolt / washer that secures the wire harnesses and fuel lines to the top of the generator. Move the wire harnesses and fuel lines out of the way.
6. Remove the 1/4” bolts / washers (4) that secure the battery charger bracket to the unit frame. This will allow you to access the cables on the bottom of the battery charger.
7. Mark and disconnect the cables on the battery charger and remove the battery charger assembly from the unit.
8. Remove the bolts / washers (6) that secure the receptacle box to the unit. Wire-tie the receptacle box to the side of the unit so that the receptacle box is not hanging by the cables.
9. Remove the tape on the wire harness and cut the wires (5) that connect the receptacle box to the generator. Make sure to cut the wires on the receptacle box side of the current butt splices.
10. Remove the bolts / washers (2) that secure the generator support plate to the two generator shockmounts.
11. Remove the bolts / washers (3) that secure the lower radiator access panel (on the other side of the unit) in order to access the engine shockmounts.
12. Back off about 1 inch (25mm), but do not remove the engine shockmount bolts. This will allow the engine / generator to be slightly lifted off of the unit frame.

NOTE: The generator / engine must be slightly lifted off of the unit frame in order to provide enough clearance for the generator support plate to slide away from the unit frame.

13. Using the lifting lugs on the top of the generator, lift the generator / engine several inches so that the generator support plate will clear the unit frame allowing the entire generator assembly to be removed.
14. Place several support beams under the engine and then lower the generator / engine onto the beams. Make sure that the generator support plate is lifted high enough to allow for the removal of the generator assembly, but not so high that the fan hits the radiator coil.
15. Starting with the lower bolts, remove the 3/8”-16 bolts / washers (12) that secure the generator to the engine.

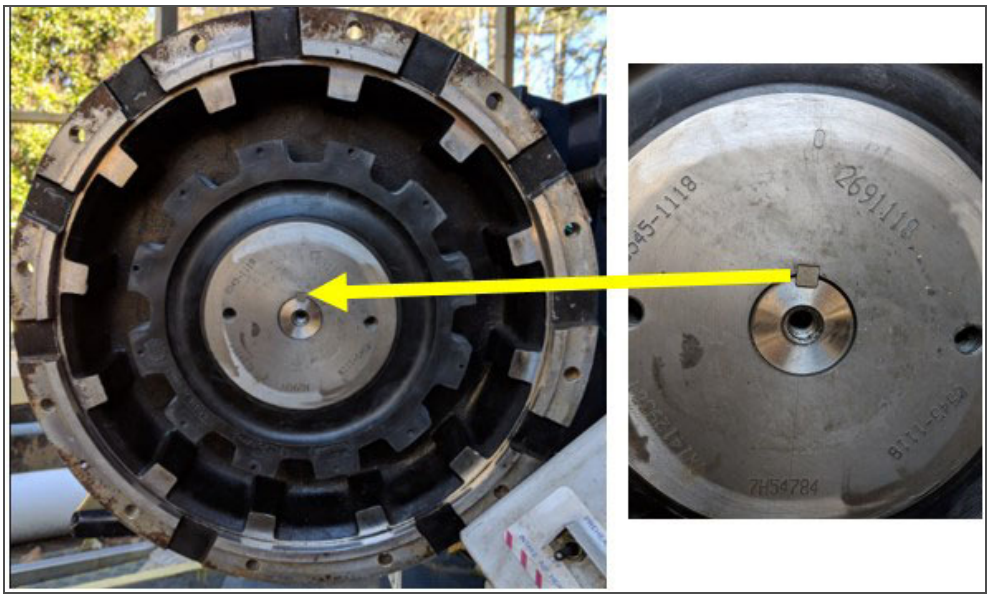
NOTE: Although the generator torsional dampener and flywheel adapter plate will normally keep the generator coupled to the engine, even without the bolts, it is safest to remove the lower generator bolts first, in case the generator shifts and falls during bolt removal.

16. Lift the generator assembly (generator & support plate) off the unit frame and lower onto a stable work surface.

NOTE: Inspect the generator torsional dampener, bolt, and key as they are removed from the old generator and installed onto the new generator. Replace any components that are worn or damaged.

17. Remove the generator torsional coupler bolt / washer and pull off the torsional dampener.
18. Place the torsional dampener on the new generator shaft.
19. Insert the key into the keyway of the generator shaft. See **Figure 6.1**.

Figure 6.1 Generator Shaft Keyway



20. Apply Loctite 262 to the generator coupler bolt. Install with washer and torque to 28 ft-lbs (38 Nm). See **Figure 6.2**.

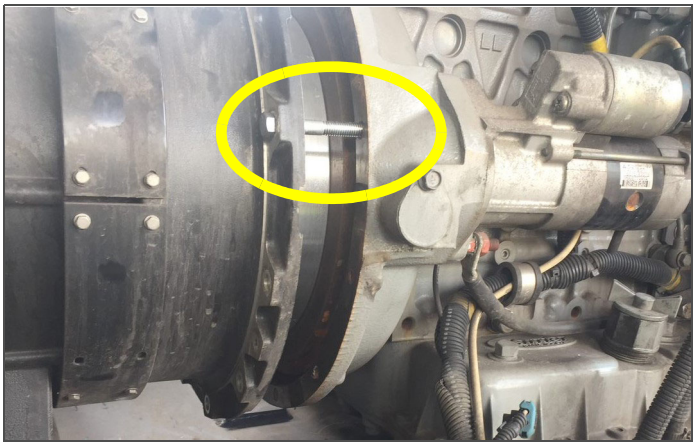
Figure 6.2 Generator Coupler Bolt

NOTE: In order to torque generator torsional dampener gear bolt, use a strap wrench or similar device to secure the dampener while torquing the bolt.

21. Remove the generator support plate from the old generator and install it onto the new generator.
22. With the torsional dampener and support plate installed on the new generator, lift and position the generator so that the generator mounting holes (12) are lined up with the engine mounting holes.
23. Insert two generator alignment bolts (2 1/2") to temporarily align / secure the generator to the engine. Tighten the bolts enough so that the torsional dampener on the generator is touching the aluminum housing on the engine. Do not over tighten the alignment bolts, as they will bottom out on the engine bell housing. See **Figure 6.3**.

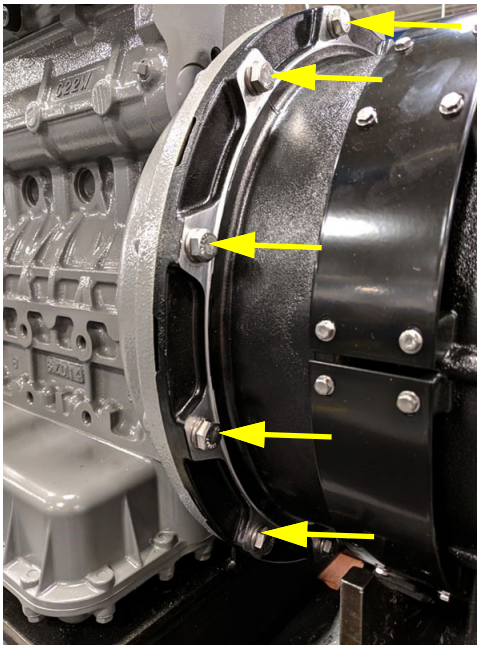
NOTE: Align the torsional dampener and aluminum housing by rotating either one to seat correctly.

Figure 6.3 Generator Alignment Bolt



24. Once aligned, push the generator to fully seat the torsional dampener into the aluminum housing of the flywheel adaptor plate.
25. With the torsional dampener seated into the aluminum housing, the alignment bolts (2) can be removed, and the generator mounting bolts (12) can be reinstalled. Torque to 25 ft-lb (34 Nm). Install several mounting bolts to secure the generator before removing the alignment bolts. See **Figure 6.4**.

Figure 6.4 Generator Mounting Bolts



NOTE: Although the torsional dampener and mating surface of the generator will generally keep the generator coupled to the engine, even with all of the bolts removed, it is safest to start installation of the top generator bolts first, just in case the generator shifts.

26. With all of the generator mounting bolts secured, use the lift to raise the generator / engine in order to remove the support blocks under the engine.
27. Place the generator support plate mounting bolts (2) down into the generator support plate in order to line up the mounting bolt holes with the shockmounts.
28. Ensure that the large washers placed on the shockmounts and slowly lower the generator / engine so that the generator support plate holes line up with the shockmount holes.
29. Remove the generator support plate bolts and install the bolts / large washers from the bottom of the shockmounts through the generator support plate. Secure the bolts (2) with nuts, torque to 75 ft-lb (102 Nm).
30. Tighten the engine shockmount bolts, torque to 90 ft-lb (122 Nm).
31. Replace the lower radiator access panel and secure with bolts / washers (3).

32. Secure the battery charger cables to the bottom of the battery charger.

⚠ CAUTION

Observe proper polarity when installing the battery or connecting a battery charger, the negative battery terminal must be grounded. Reverse polarity may damage the charging system. When charging the battery in unit, isolate the battery by disconnecting the negative battery terminal first, then the positive. Once the battery has been charged, connect the positive battery terminal first, then the negative.

33. Secure the battery charger assembly to the unit frame.
34. Cut the wire-tie supporting the receptacle box to the unit frame and re-secure the receptacle box to the unit frame using bolts and washers (6). Make sure the receptacle wires are pulled through the access port in the frame and ensure that they will be accessible to splice with the generator wires.
35. Place two pieces of heat shrink tubing (1 large, 1 small) over each receptacle box wire.
36. Connect and butt splice the receptacle box harness wires with the new generator wires.
37. For each of the other five wires, heat shrink the small tubing first, and then the large tubing to ensure a watertight seal.
38. Neatly tape all wires together.
39. Replace and secure the wire harnesses onto the top of the generator, secure with the bolt.
40. Replace the truss and the truss brackets, secure the sides with the mounting bolts (2). See **Figure 6.7**.

NOTE: Installing the two back truss bolts first allows the truss assembly to be pulled forward slightly, making it easier to install the two front truss bolts.

41. Secure the center of the truss to the isolator by installing the nuts (2) and nut plate (1).
42. Connect the battery.
43. Re-install the top and side panel covers.

6.7.2 Checking and Replacing Shockmounts

When a shockmount has been cut, split, abraded or has flared due to normal deterioration, it must be replaced. Damage to the mounts may not be visible when installed and under load from the component. To correctly inspect shockmounts, they must be removed.

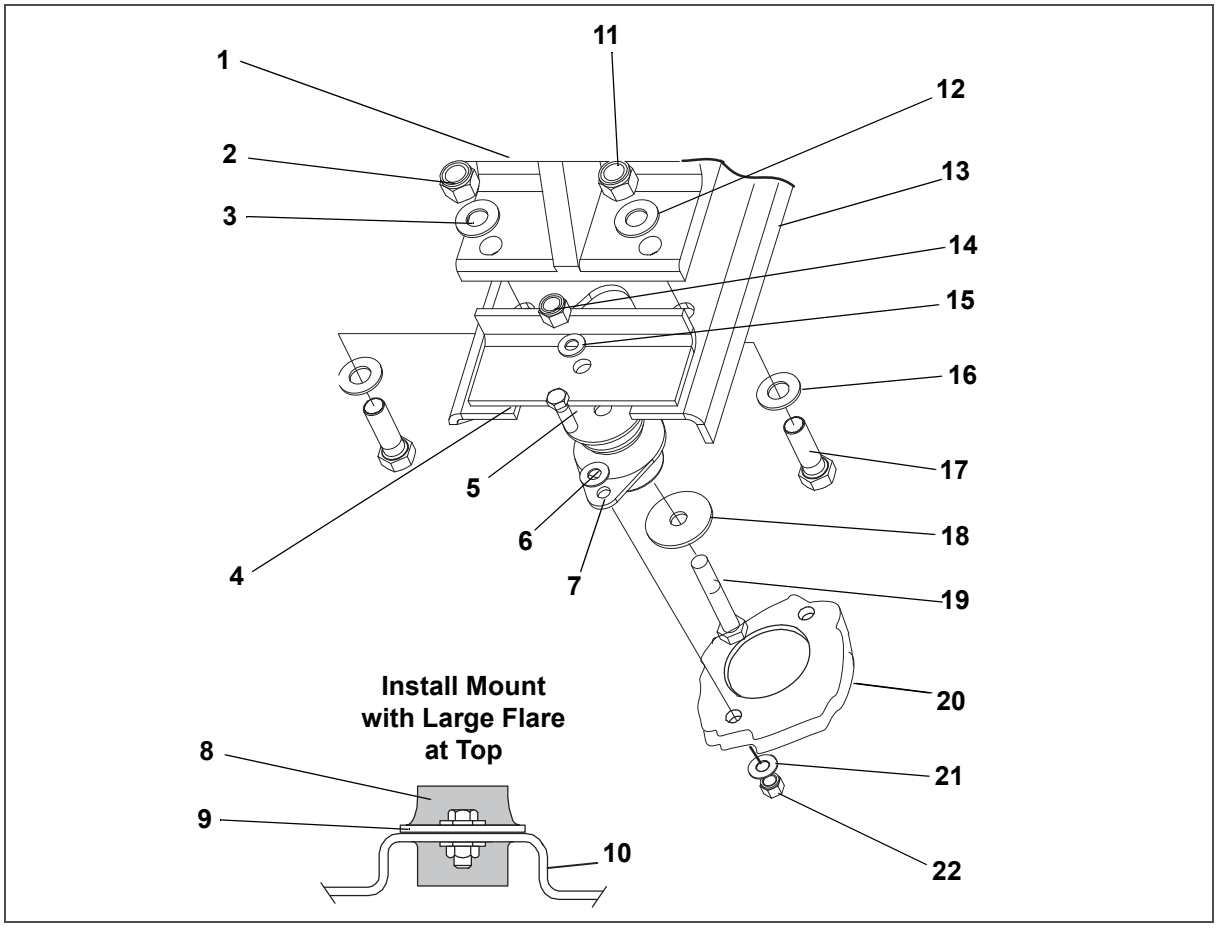
⚠ CAUTION

Continued operation with failed shockmounts may result in engine or generator damage. When a shockmount has been cut, split, abraded or has flared due to normal deterioration, it must be replaced. Damage to the mounts may not be visible when installed and under load from the component. To correctly inspect shockmounts, they must be removed

6.7.2.1 Generator Shockmount Replacement

1. Use the two lift eyes to lift and support the engine.
2. Remove shockmount hardware. See **Figure 6.5**.
3. Raise the generator just enough to remove the shockmounts.
4. Install new shockmounts.
5. Lower the engine enough to assemble hardware as shown and torque. See **Section 6.7.3** for values.
6. Remove chains from the lift eyes.

Figure 6.5 Generator Shockmounts



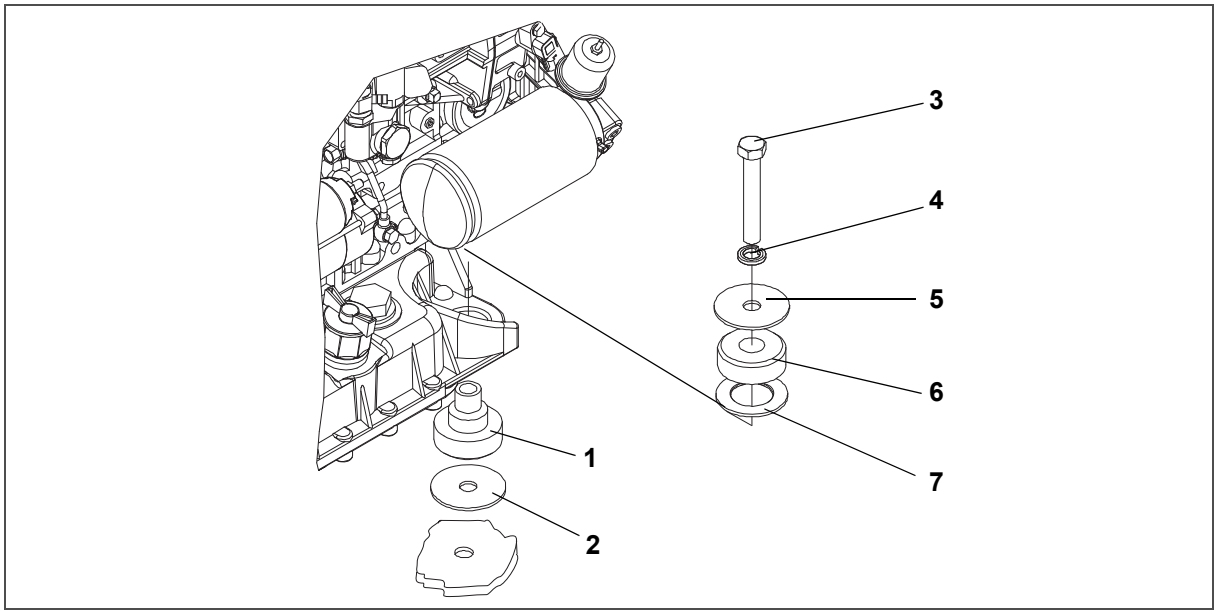
1) Generator
2) Lock-nut (5/8)
3) Flat Washer (5/8)
4) Support Plate
5) Screw (3/8)
6) Flat Washer (3/8)
7) Shockmount
8) Shockmount
9) Support Plate
10) Frame
11) Locknut (5/8)
12) Flat Washer (5/8)
13) Mounting Base
14) Lockout (1/2)
15) Flat Washer (1/2)
16) Flat Washer (5/8)
17) Screw (5/8)
18) Snubbing Washer
19) Screw (1/2)
20) Frame
21) Flat Washer (3/8)
22) Locknut (3/8)

- - - - -

6.7.2.2 Engine Isolator / Shockmount Replacement

1. Use the two lift eyes to lift and support the engine.
2. Remove truss, unidrive isolator and all hardware. See **Figure 6.7**.
3. Remove all hardware. See **Figure 6.6**.
4. Raise the engine just enough to remove the shockmounts.
5. Inspect shockmounts and replace if required.
6. Lower the engine enough to assemble hardware as shown and torque as detailed in **Section 6.7.3**.
7. Remove chains from the lift eyes.

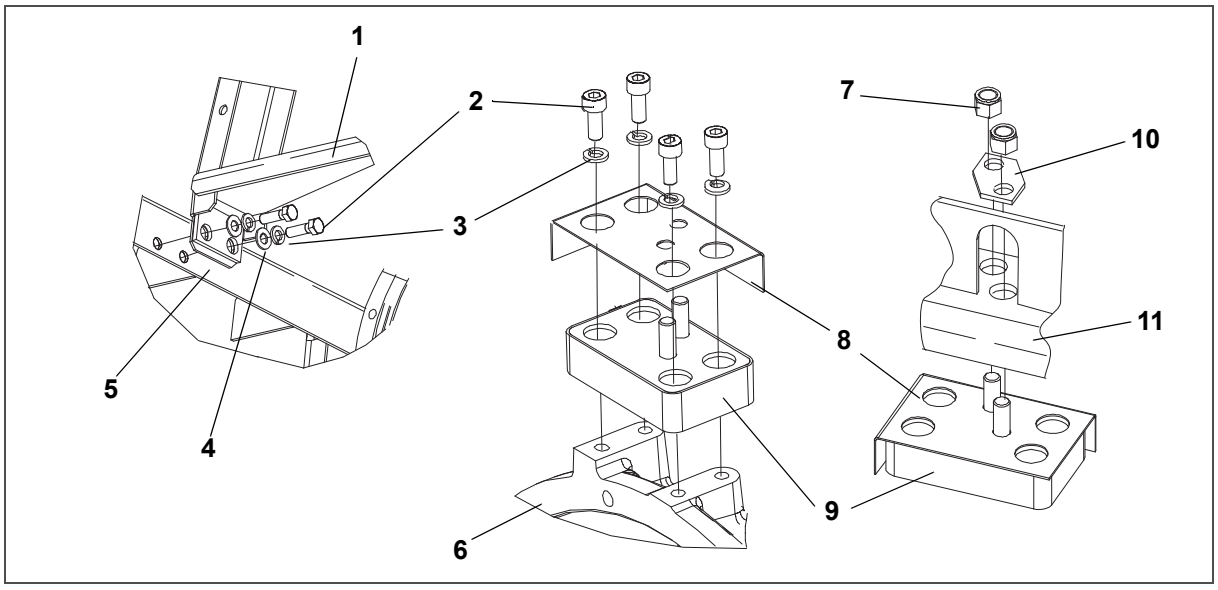
Figure 6.6 Engine Shockmounts



1) Shockmount
2) Snubbing Washer
3) Bolt
4) Lock Washer
5) Snubbing Washer
6) Shockmount
7) Flat Washer

- - - - -

Figure 6.7 Truss and Isolator



1) Truss
2) Bolt
3) Lock Washer
4) Flat Washer
5) Frame
6) Unidrive
7) Locknut
8) Heat Shield
9) Isolator
10) Nutplate
11) Truss

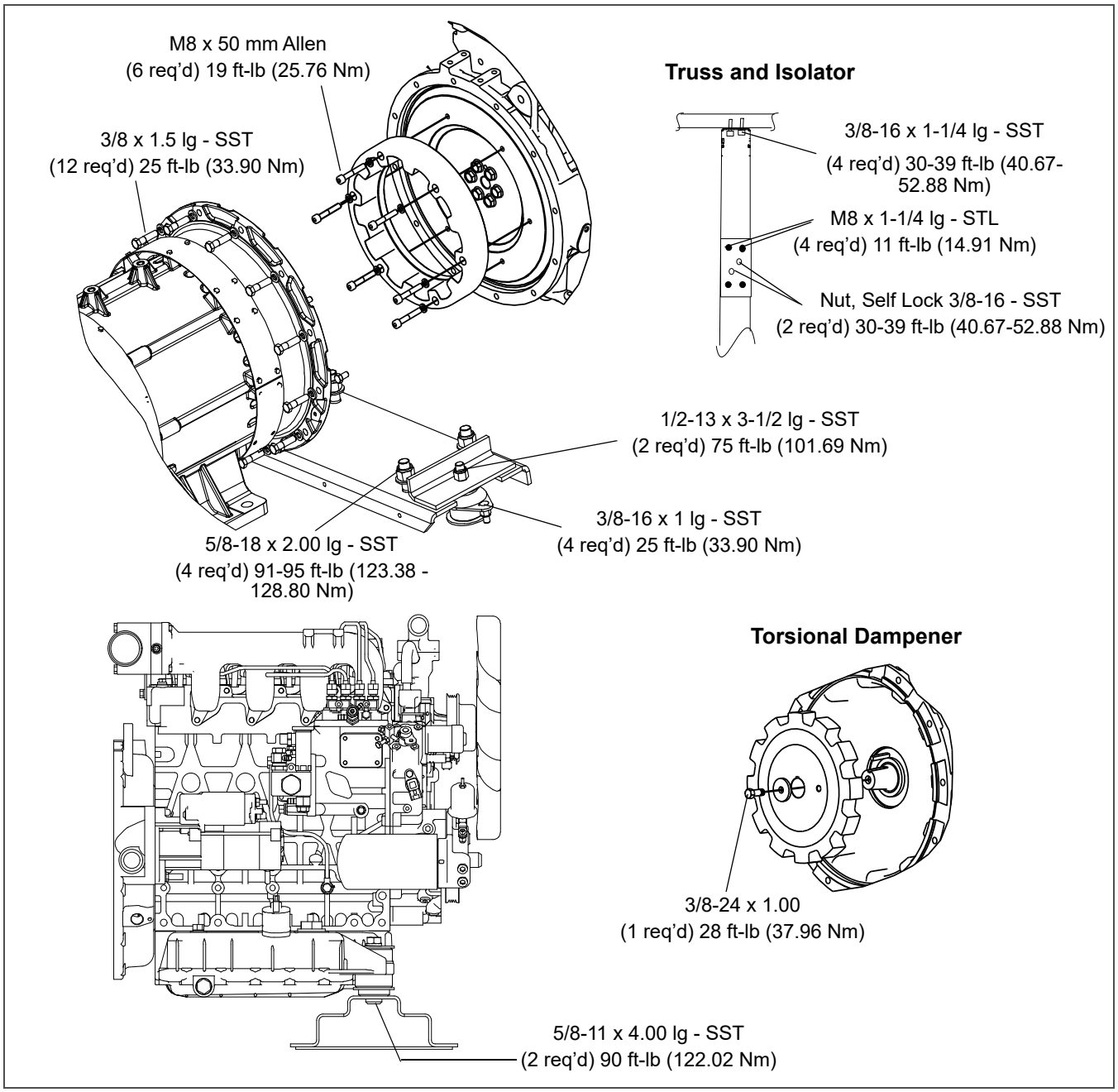
- - - - -

6.7.3 Unidrive Torque Requirements

Extensive damage may occur if the proper hardware is not used and/or proper procedures are not followed when working with the unidrive assembly. Periodic inspection of hardware and bolt torque is recommended to ensure the integrity of the unidrive. Torque value and hardware requirements for unidrive assembly are detailed in **Figure 6.8**.

NOTE: SST is an abbreviation for 300 Series Corrosion Resistant Steel. Loctite #242 or an equivalent product should be used on ALL hardware as detailed in **Figure 6.8**.

Figure 6.8 Unidrive Torque Requirements



6.7.4 Maintenance of Painted Surfaces

The unit is protected against the corrosive atmosphere in which it normally operates by a special paint system. However, should the paint system be damaged, the base metal can corrode. If the paint system is scratched or damaged, do the following:

1. Clean area to bare metal using a wire brush, emery paper or equivalent cleaning method.
2. Immediately following cleaning, spray or brush on a zinc rich primer.
3. After the primer has dried, spray or brush on finish coat of paint to match original unit color.

Section 7
Diagmaster

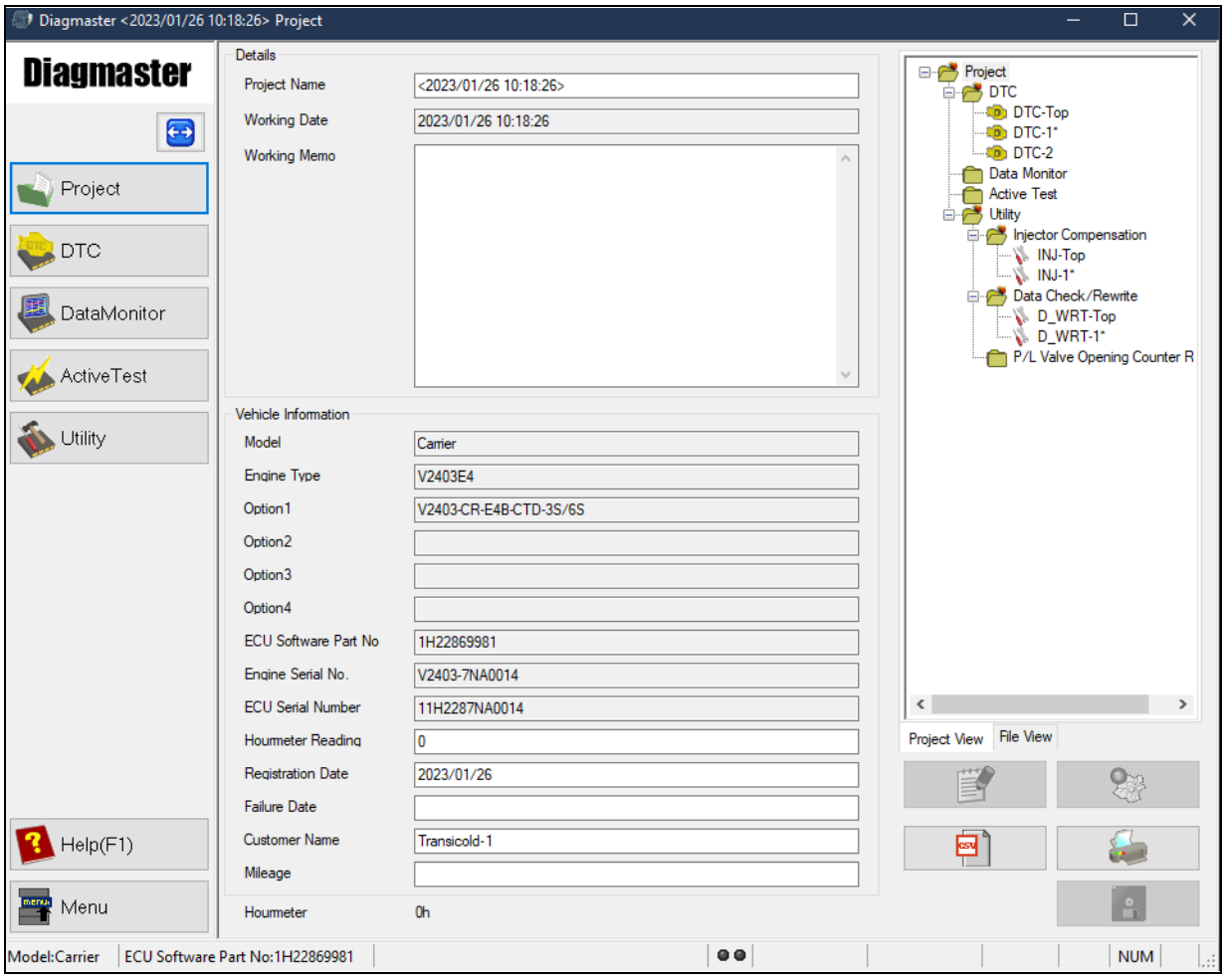
7.1 Introduction

A technician can connect to the Kubota diesel engine by using Diagmaster software. Diagmaster communicates with the Engine Control Unit (ECU) to observe and diagnose engine conditions and display this information in a user interface.

Diagmaster is equipped with the following functions:

- Managing projects
- Reading and deleting DTC codes
- Monitoring the value and information in the ECU collected from sensors and actuators
- Forcibly driving actuators such as an injector
- Utility functions such as injector compensation and injection quantity correction

Figure 7.1 Diagmaster



7.2 Setup and Installation

7.2.1 User Registration

In order to use Diagmaster to diagnose a Kubota engine, a user must be granted access through the Kubota Engine Park (KEP) website. A user must register on the KEP site for a username and password to Diagmaster.

Contact a Carrier service engineer for information on how to create a KEP account.

7.2.2 PC Requirements

CPU	1GHz or more recommended
OS	Windows 7 (32bit / 64bit versions);
	Windows 8/8.1 (32bit / 64bit versions)
	Windows 10 (32bit / 64bit versions)
Memory	2 GB or more recommended
Storage	20GB or more recommended
Monitor	1024 x 768 pixels, 256 colors or more recommended
USB	USB 1.1 / 2.0 at least 1 port

7.2.3 Software Installation Procedure

The installation files for Diagmaster are located on the Kubota Engine Park (KEP) website.

1. Login to KEP.
2. On the left hand menu, click on CRS Engine Technology and Service Information and select Diag Master update file.
3. Download the following three files from the Installer file column.
   - Diagmaster Program
   - Diagmaster Database
   - DST-i Communication Interface Driver
4. Change all three downloaded file extensions from .z_p to .zip.
5. Extract all three zip files to a folder location.
6. Install each software package, one at a time. Install in the following order:
   a. SetUp_Diagmaster_VerXX.XX.XX.exe
   b. Diagmaster_Database_XX.XX.XX.XX_for_Carrier.exe
   c. Setup_DST-i_KUBOTA_V400
7. The Diagmaster Launcher icon should now be on your desktop.

7.2.4 Connecting a Computer to the ECU

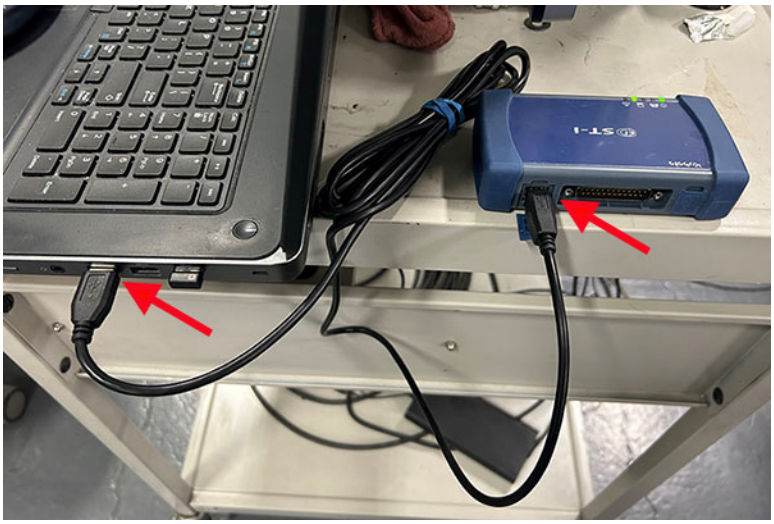
The Diagmaster Assembly Kit (Carrier PN 07-60198-00) contains all of the hardware necessary to connect a computer to the ECU, see **Figure 7.2**.

- DST-i device
- Data link cable
- USB cable: USB-B (male) to USB-A (male)

Figure 7.2 Diagmaster Assembly Kit

Procedure:

1. Connect the USB cable between the laptop and the DST-i device.



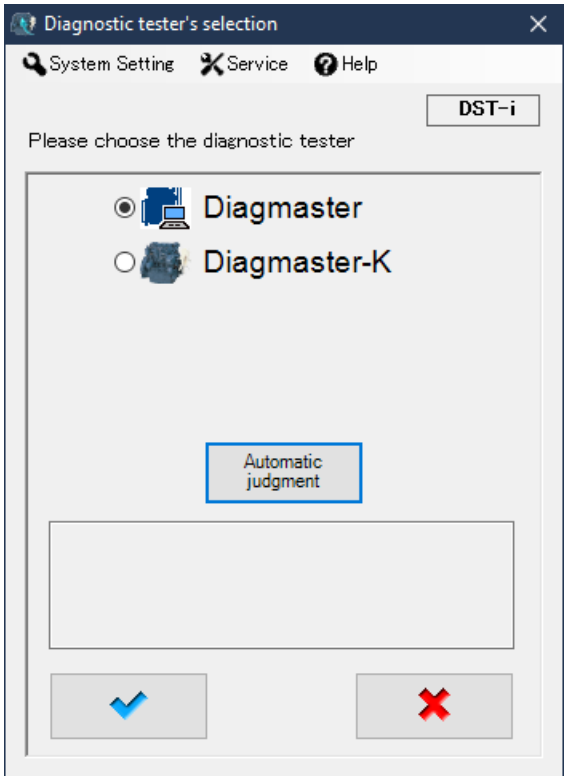
2. Connect one end of the data link cable to the DST-i device.

3. Locate the Kubota Service Port (KSP) on the unit. Remove the dust cap.
4. Connect the data link cable to the KSP.
5. Make sure the Engine START/RUN/OFF switch is in the RUN position. If diagnosis is required while the engine is running, turn the switch to the START position to start the engine. The engine can be started after connecting if needed.

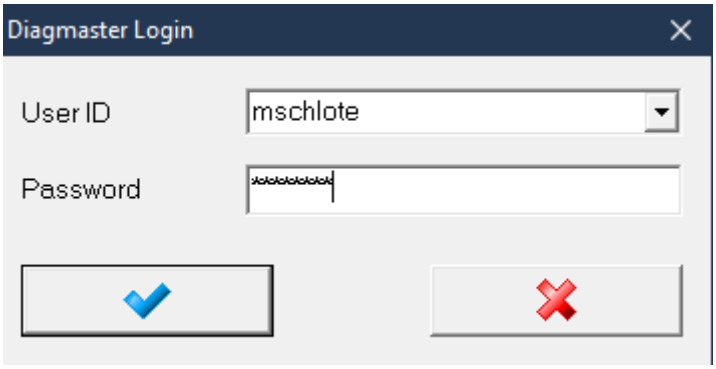
7.3 Diagmaster Operation

7.3.1 Launching Diagmaster

1. To launch Diagmaster, select Diagmaster from the Windows start menu or click on the icon from the desktop.
2. If launching Diagmaster while not connected to a unit or the unit is off, the Diagnostic tester's selection screen will appear. Otherwise, you may be directed to the login screen.

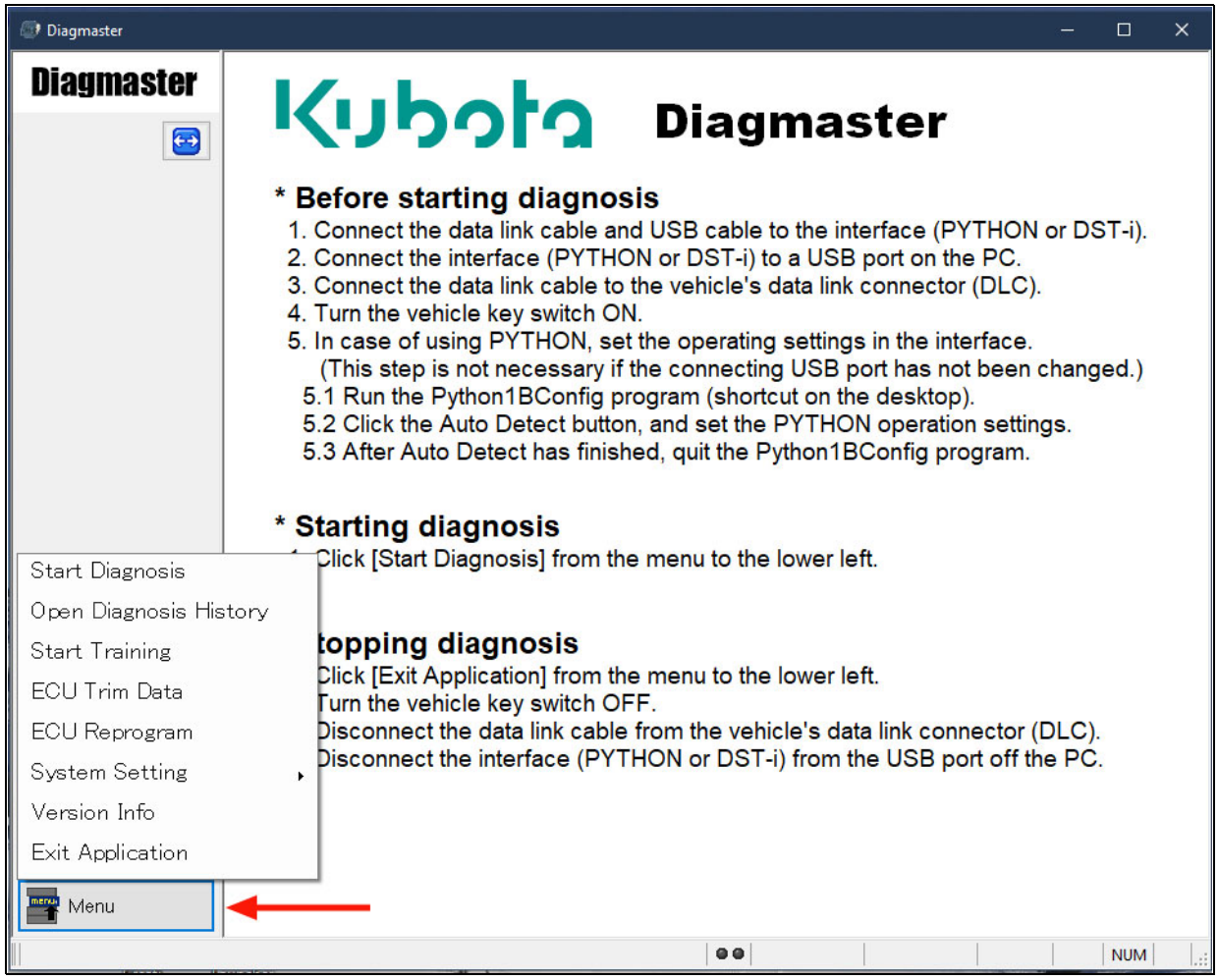


3. If user registration has not been completed, do that now:
   a. Click on System Setting and select User registration from the drop down.
   b. Fill in the user name, password and registration code fields. Refer to the email that was sent when registering for Diagmaster access on the KEP website.
4. Next, click on Automatic judgment. This will select the proper Diagmaster database to connect to. If an error message occurs after clicking the button, check the connections to the ECU.
5. At the Login screen, enter a User ID and Password and click the blue checkmark button.



7.3.2 Top Screen

After logging into Diagmaster, the Top screen appears. From here the user click on the Menu button to choose the selected path.

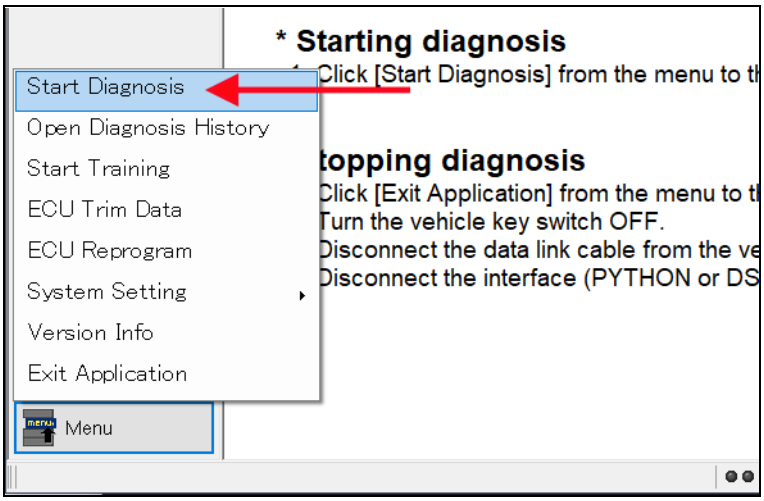


Menu Item	Description
Start Diagnosis / Finish Diagnosis	When connected to a generator set, will start fault diagnosis. Or, if a diagnosis is already in progress, this will complete diagnosis.
Open Diagnosis History / Close Diagnosis History	Displays the past history of diagnoses. Or, closes the diagnosis history item currently replayed.
Start Training / Finish Training	Operates the software in training mode, without the vehicle connected. Or, stops the training mode and returns to normal mode.
ECU Trim Data	Not used
ECU Reprogram	Not used
System Setting	Selects the display language, specifies the communication interface and changes the password.
Version Info	Displays the Diagmaster version number.
Exit Application	Exits Diagmaster.

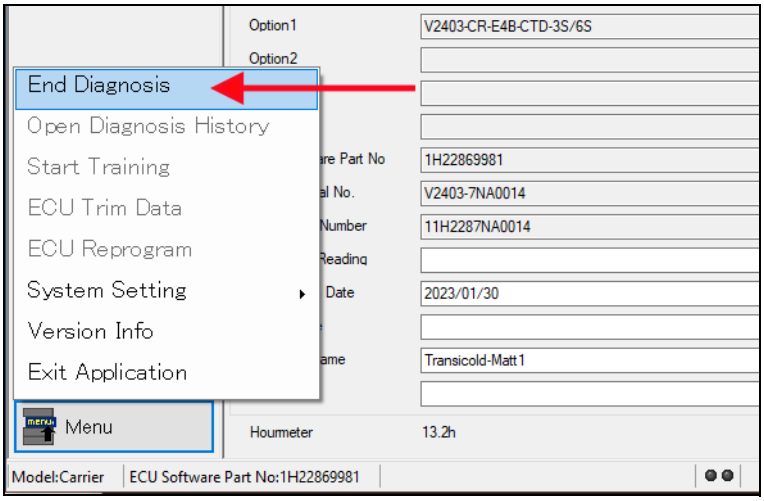
7.3.3 Starting a Diagnosis

A diagnosis is started to establish communication with the engine for diagnosis of fault conditions or performance.

1. Click on Menu and select Start Diagnosis.



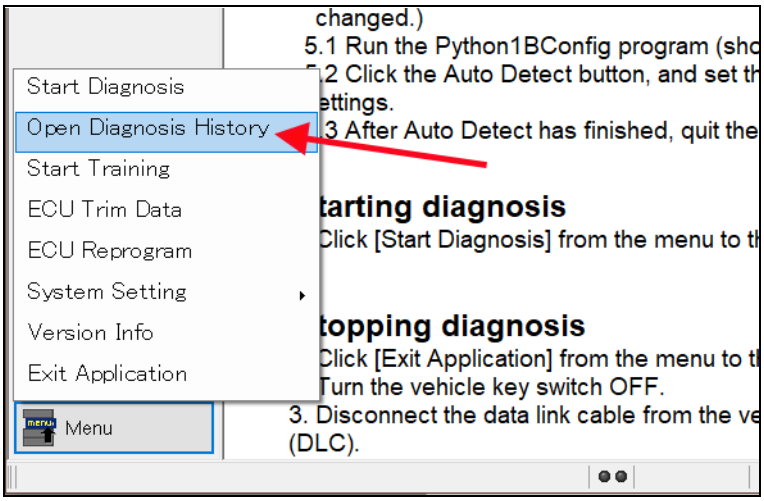
2. A screen will appear as a reminder to make sure preparations are completed. Click the blue checkmark to confirm.
3. Next, the Select Customer Info screen appears. Any diagnosis history is displayed on this screen.
   - To continue a previous diagnosis, select the history item in the row, then click the Open Folder icon. This will resume that diagnosis.
   - To start a new diagnosis, click on the New Project icon. A screen will appear to select the Vehicle Engine Type. The drop down fields may be grayed out to prevent any selections. The Customer Name field can be edited. Click the blue checkmark to confirm.
4. After communication with the ECU is established, the Project screen appears. Once the Diagnosis is started, the user can navigate between all of the various screens and perform actions, save data, etc until it is decided to end the diagnosis. See **Section 7.3.5** for Project screen description
5. To end the diagnosis, click on Menu and select End Diagnosis. This can be done from any screen.



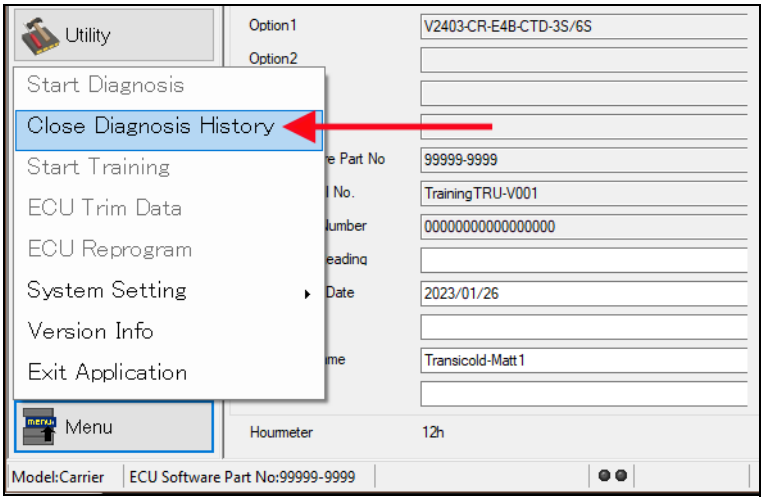
7.3.4 Opening a Diagnosis

After diagnosis has been recorded, these events can be re-opened later to examine the results.

1. Click on Menu and select Open Diagnosis History.

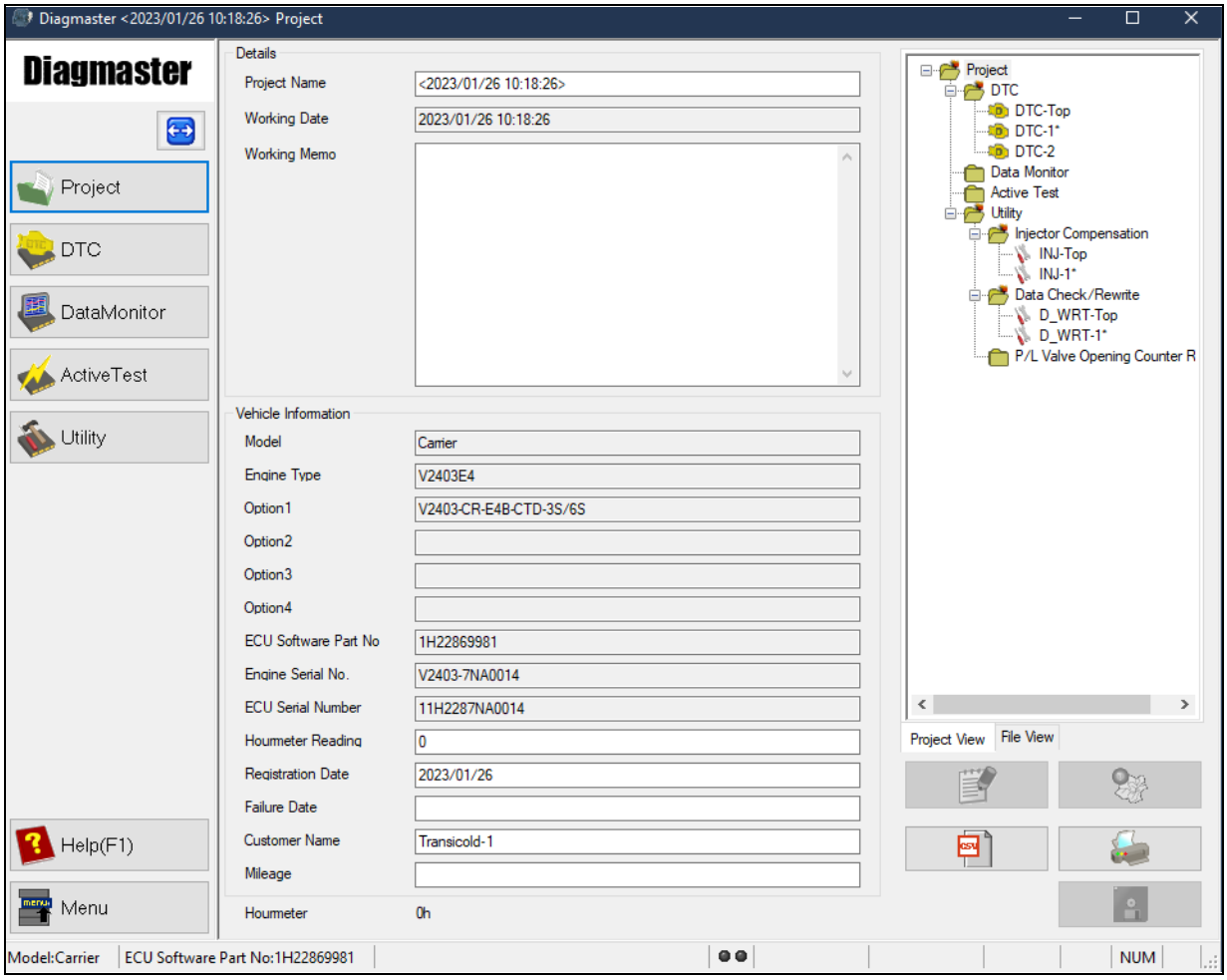


2. The Select Customer Info screen appears. Any diagnosis history is displayed on this screen. Select the history item in the row, then click the Open Folder icon. Or, double-click an item to open.
3. The Project screen opens with the details of the diagnosis history that was chosen. See **Section 7.3.5** for Project screen description.
4. When finished with viewing the chosen diagnosis history, click on Menu and select Close Diagnosis History.

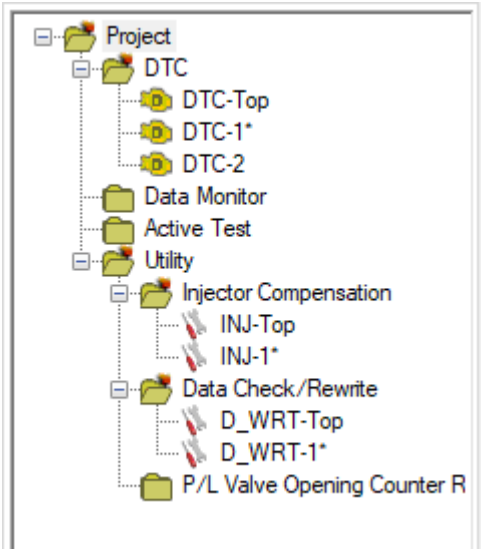


7.3.5 Project Screen

The Project screen appears initially after a Diagnosis is started or opened. From the Project screen, the fields that are not grayed out can be edited and saved. You can change the information entered in the Project screen at any time during diagnosis, but the Save button must be clicked to save changes.



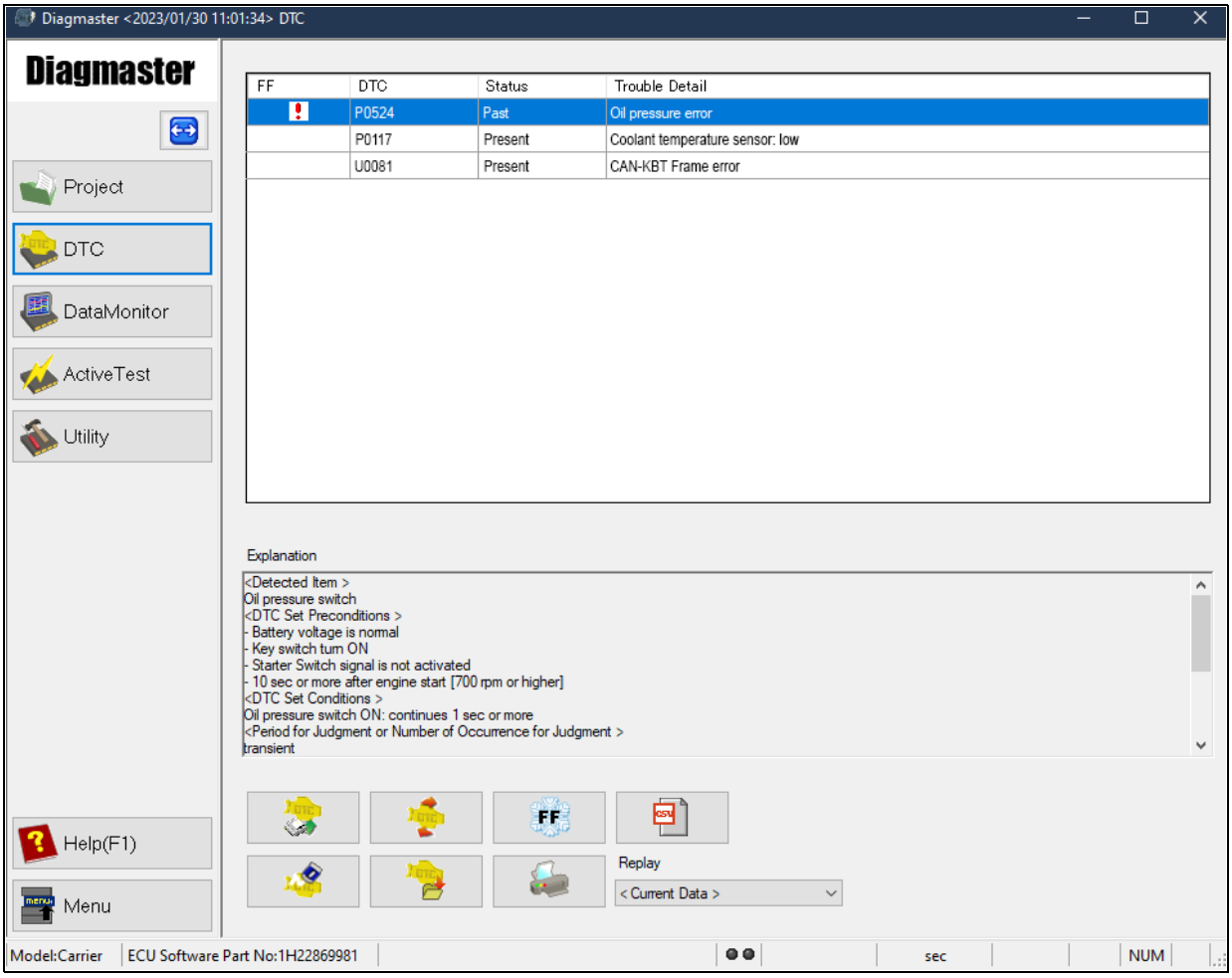
The Project Info List is displayed on the right of the Project screen.



- Items in the project can be deleted by right-clicking on the item.
- Items with filename “****-TOP” can not be deleted. This is data when starting a new diagnosis.
- Items with a filename that ends with an asterisk (*) specify initial data obtained after a diagnosis restart, it may not be saved.
- Items in the project list can have memos viewed and edited by right-clicking on the item.
- The **DTC** folder displays DTC error code and freeze frame data that is saved from the DTC screen during a diagnosis.
- The **Data Monitor** folder displays monitored data saved from the Data Monitor screen.
- The **Active Test** folder displays monitored data saved from the Active Test screen.
- The **Utility** folder displays data saved from the Utility screen.

7.3.6 DTC Screen

The DTC screen displays the DTC error codes that are past and present in the ECU. The DTC codes are listed individually in the **Section 5.12** of the Troubleshooting chapter of this manual with a description, causes and recommended actions.



- The **FF** column will have an exclamation mark if freeze frame data is saved for that DTC. Freeze frame data is a vehicle control dataset including engine speed and coolant temperature saved in the ECU memory at the moment a DTC is detected.
- The **DTC** column is the 5 digit code for the DTC code.
- The **Status** column shows whether the DTC is a current or past failure.
- The **Trouble Detail** column is a summary of the possible cause of that DTC.

FF	DTC	Status	Trouble Detail
!	P0524	Past	Oil pressure error
	P0117	Present	Coolant temperature sensor: low
	U0081	Present	CAN-KBT Frame error

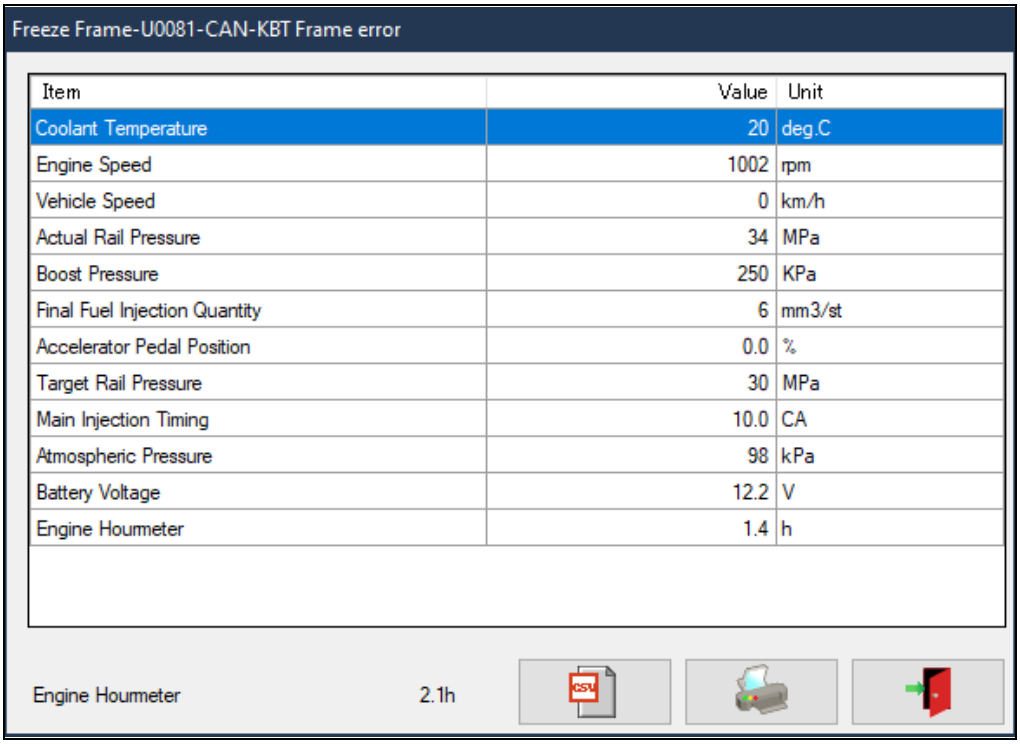
At the bottom of the screen are the following buttons starting from top row, reading left to right:

- Read DTC
- Read DTC successively
- Display Freeze Frame data
- Save data in CSV format
- Clear DTC
- Save DTC
- Print DTC list
- Replay the history of DTC saved in the same diagnosis

7.3.6.1 Displaying Freeze Frame Data

1. If a DTC code has freeze frame data available, it will have the red exclamation mark. Highlight the code and click on the Freeze Frame button.

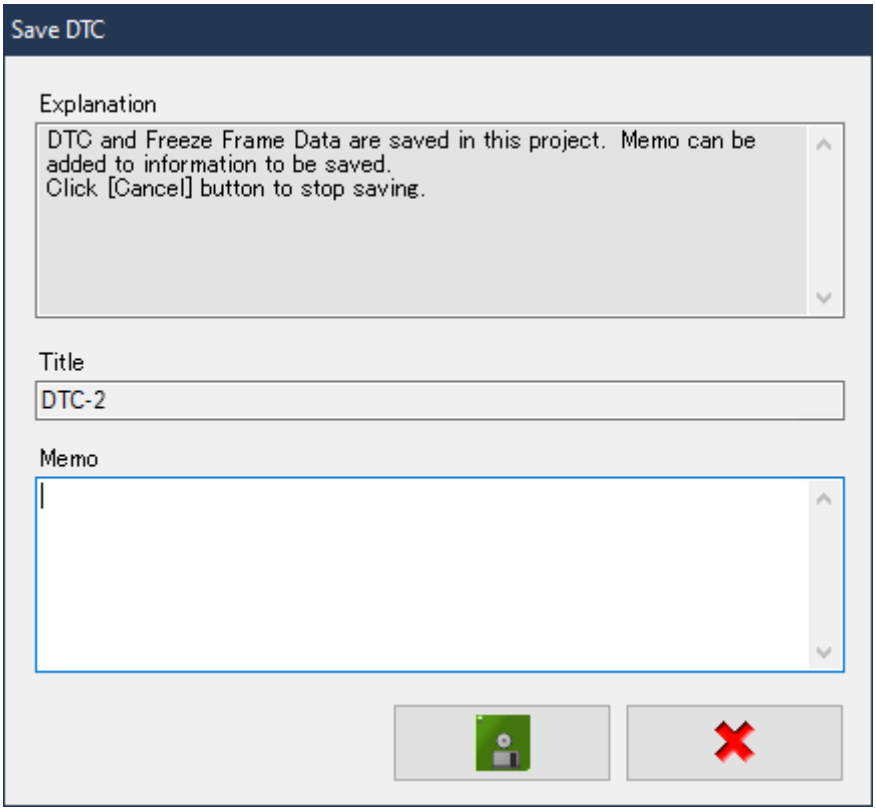
2. A pop up screen will appear to display the data. From the pop up screen, the freeze frame data can be saved as a CSV file or printed.



7.3.6.2 Saving DTC

1. Click on the Save button to save DTC and Freeze Frame information.

2. A pop up screen appears. A memo can be added prior to saving. The file name for the saved data is automatically chosen. Click the Save button to complete the save.



3. The DTC and freeze frame data saved in the project can be viewed with the Replay drop down box.

7.3.6.3 Clearing DTC

Clearing a DTS removes it from the DTC screen. Once it is removed it can not be restored. A DTC can only be cleared when it has a status of “Past” and when the same DTC does not exist as “Present” status. A “Present” DTC can not be cleared since the trouble has not been resolved yet.

NOTE: Be sure to clear a DTC with the vehicle’s engine stopped and the ignition switch ON. Deletion during engine rotation may cause a communication error.

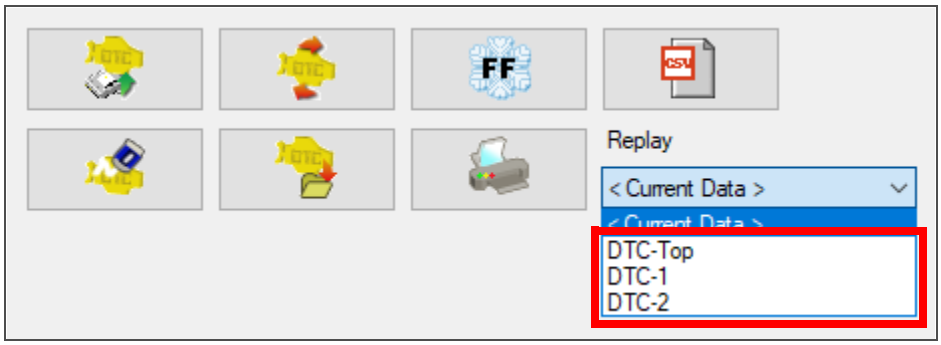
1. Highlight the DTC and click on the Clear DTC button.

2. A pop up screen appears. A memo can be added prior to saving. The file name for the saved data is automatically chosen. Click the Clear button to delete.
3. If a DTC is cleared, the DTC immediately before the cleared data and the freeze frame data are saved in the project information.

7.3.6.4 Replaying DTC

This is the procedure for displaying and reviewing a DTC previously saved in the project information.

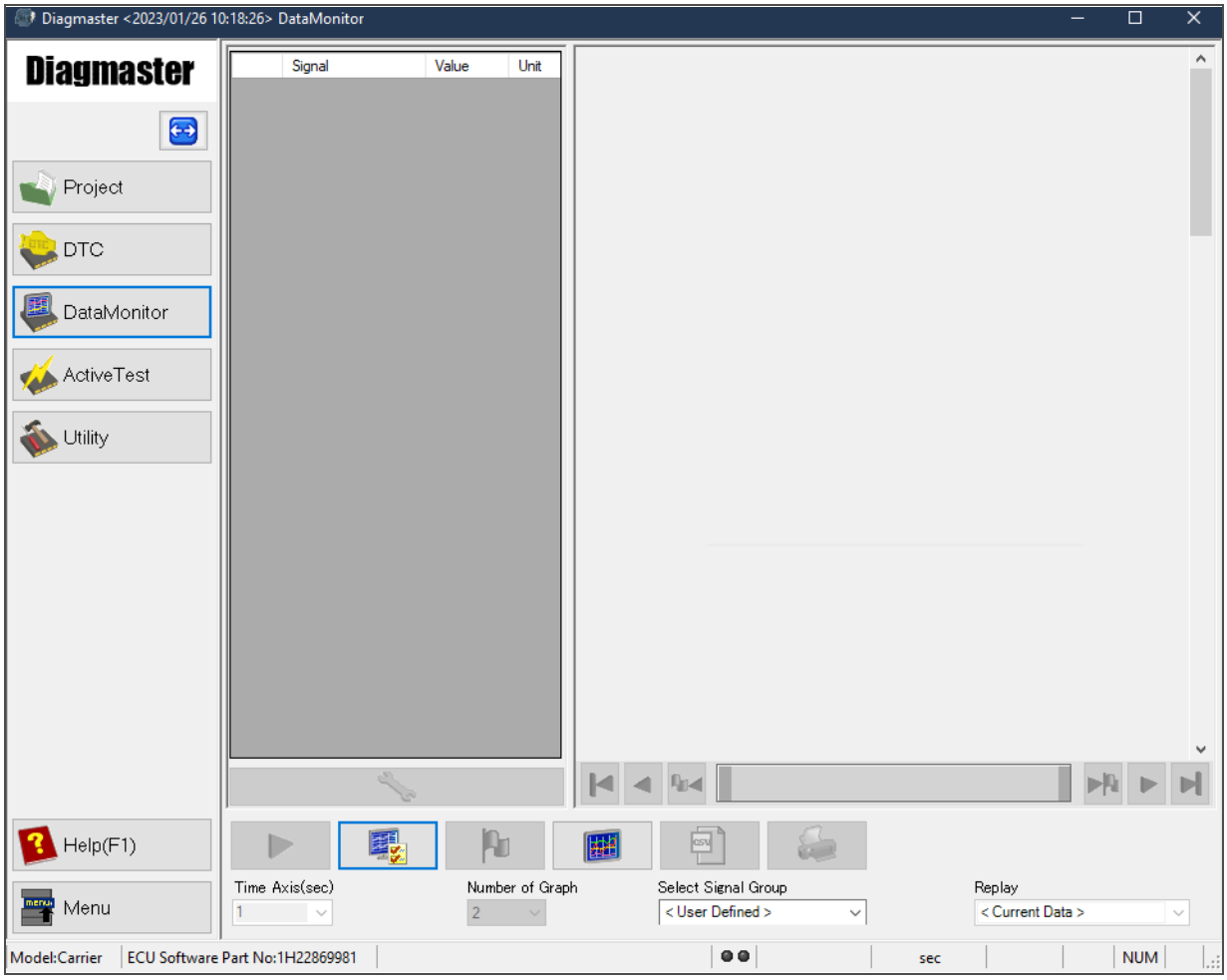
1. Click on the Replay drop down box. Select one of the saved files from the list. The content of the selected file is displayed in the DTC display at the upper part of the screen.



2. To cancel replay, select Current Data in the Replay drop down box.

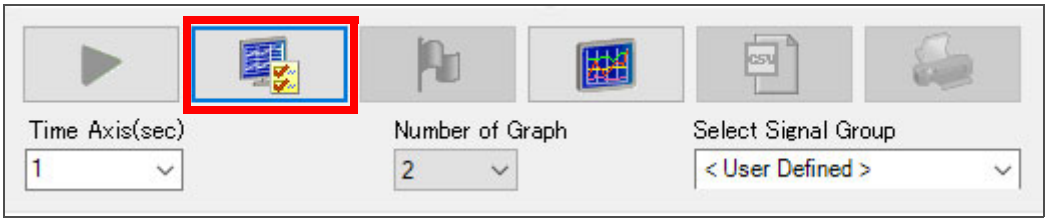
7.3.7 Data Monitor Screen

The Data Monitor screen consists of the list area, graph area and operation area. Specific data is chosen to be monitored from this screen and displayed in the graph area.

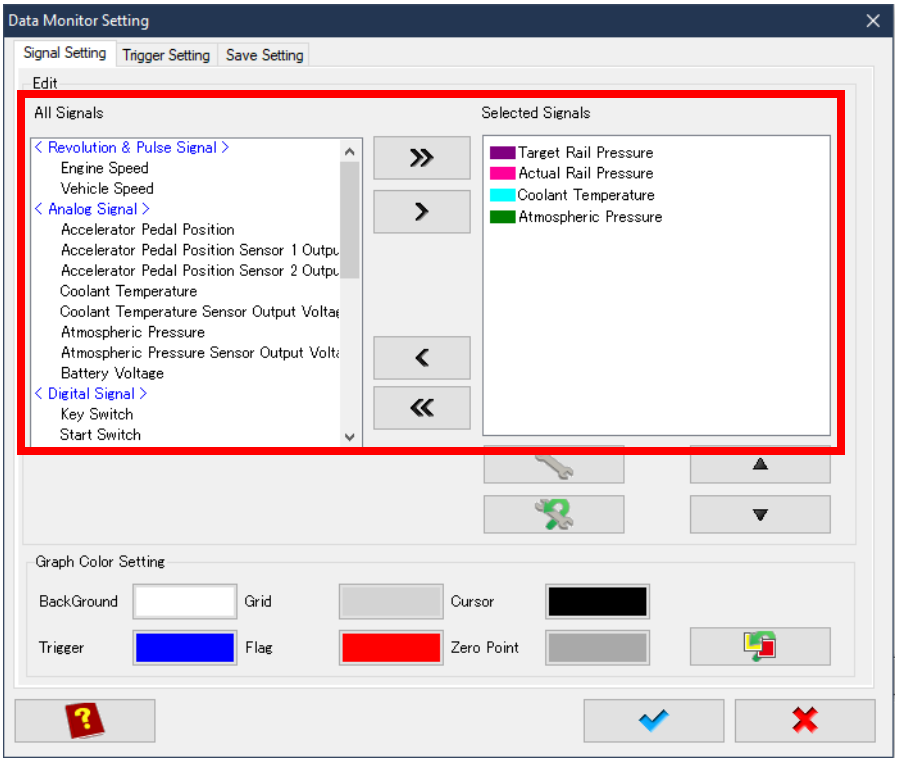


7.3.7.1 Recording Data from the Data Monitor Screen

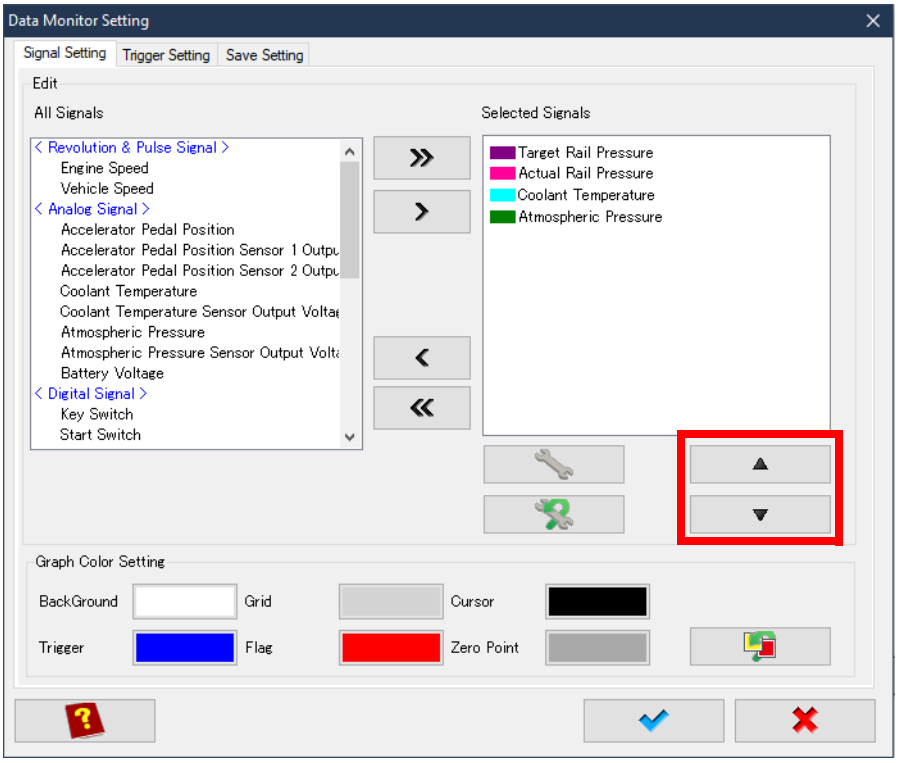
1. Click the Settings button to open the Data Monitor Setting window.



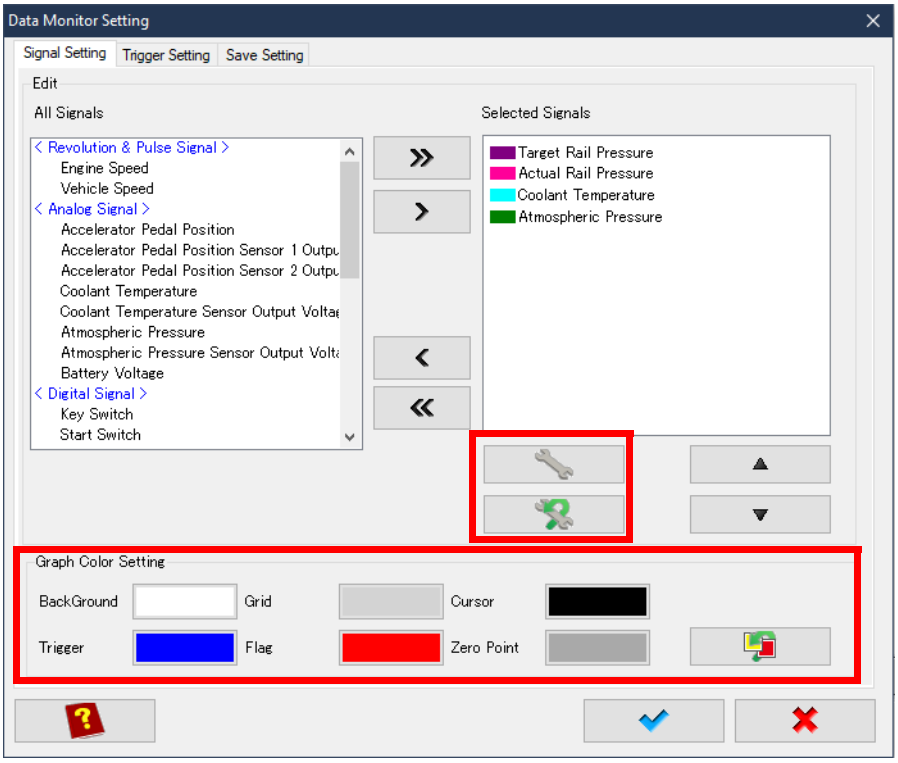
2. The Data Monitor Setting window contains a list of signals that can be measured. Use the right / left arrows to move desired signals between the All Signals and Selected Signals column. The single headed arrows move one signal and the double headed arrows move all signals. Refer to **Section 9.3** for Signal descriptions.



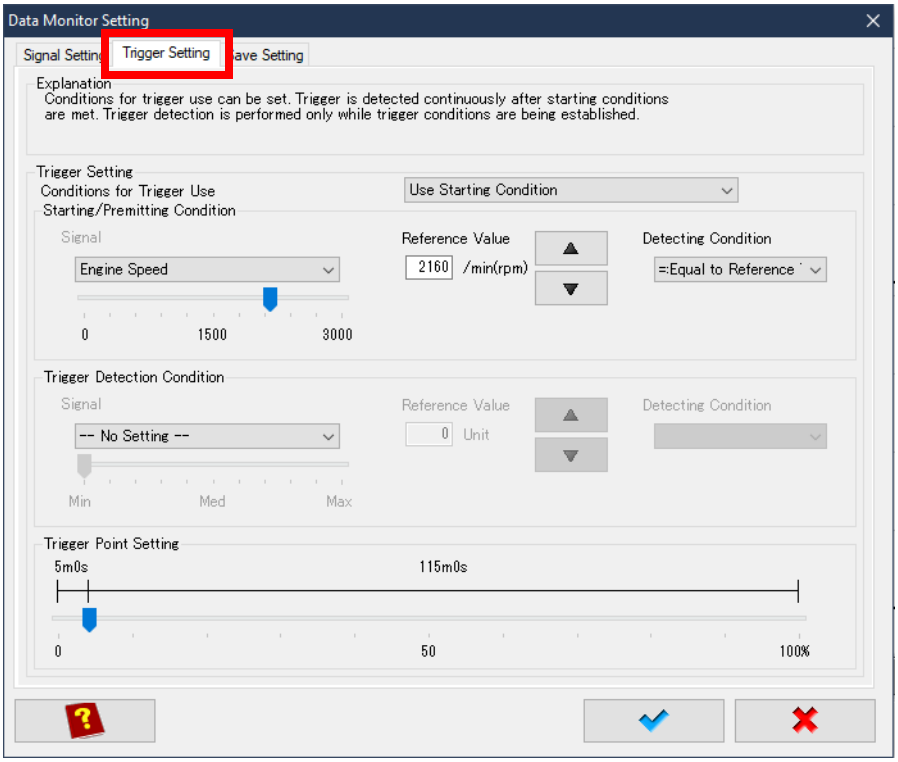
3. Use the up and down arrows to change the order of the Selected Signals column. This will set the display order of the graphs.



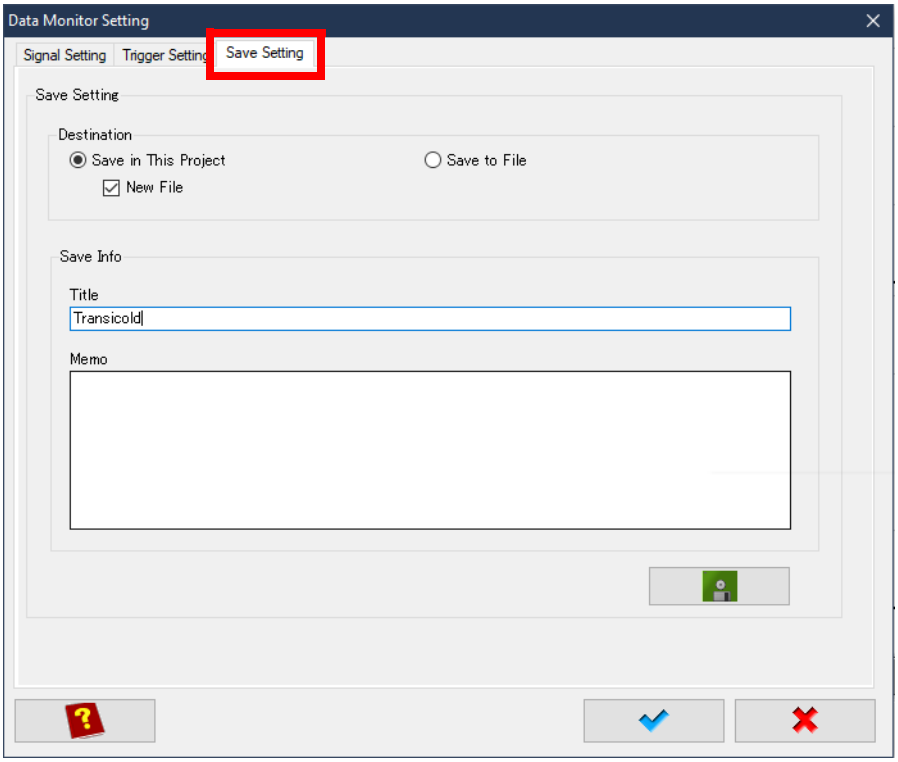
4. The remainder of the selections on this screen are for setting up the appearance of the graph. The two buttons with a wrench icon (top to bottom) are to 1) specify the line color and the range of the Y-axis for each signal and 2) reset the display settings to the default. The bottom row buttons are for setting colors on the graph.



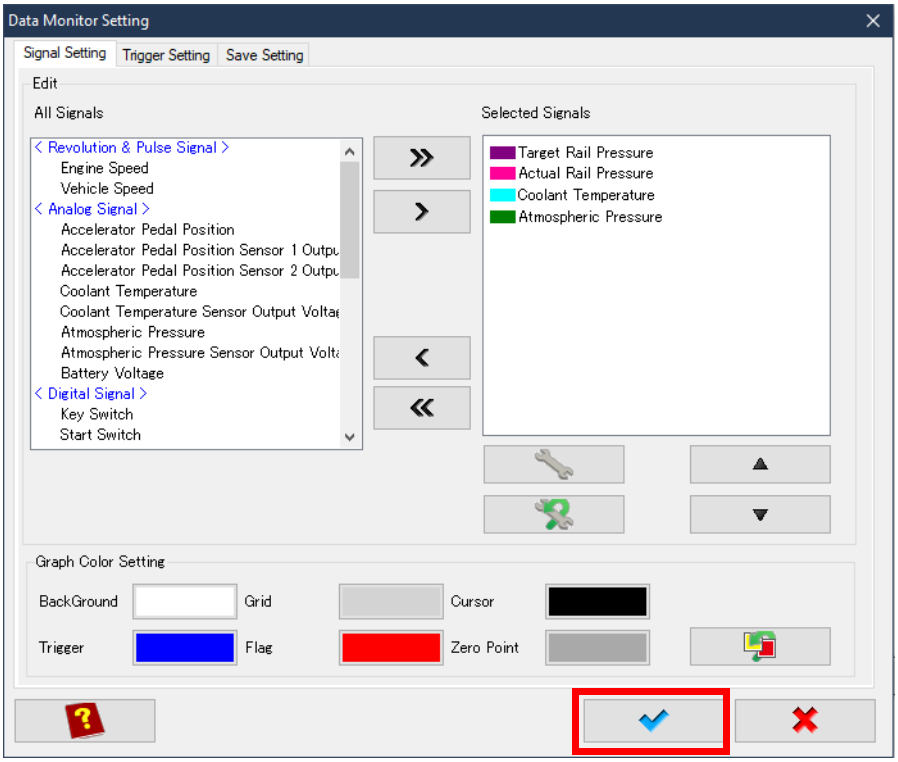
5. Click on the Trigger Setting tab. Make any desired changes.



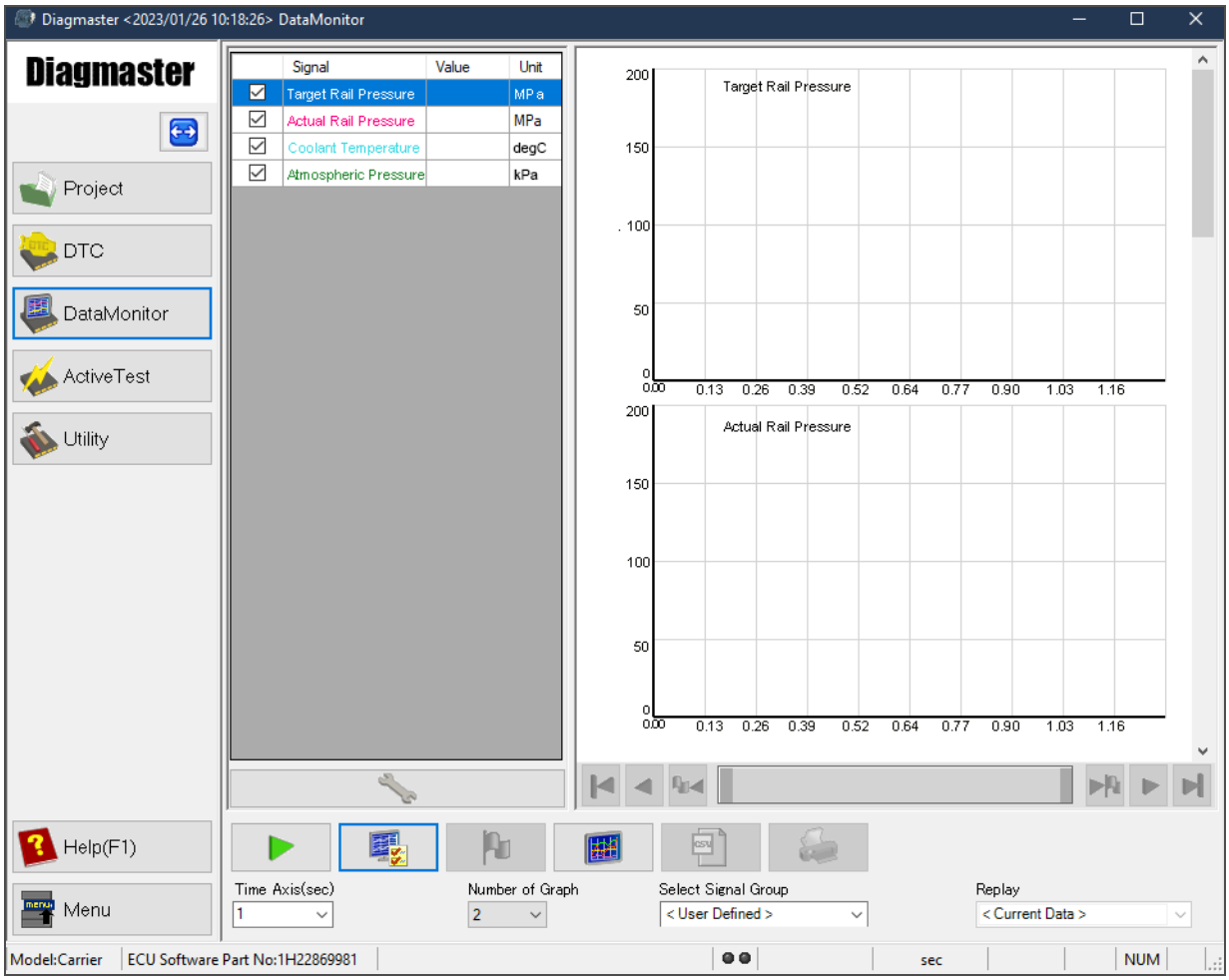
6. Click on the Save Setting tab. To create a new file, enter the title. To overwrite an existing file, select the title of a previously saved file. Choose the desired settings, enter a memo and click the save button below the Memo field. To save the settings in a file, specify the folder name and file name in the common dialog box.



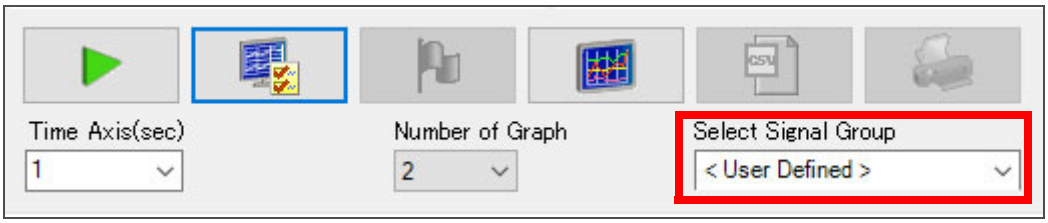
7. When finished with all data monitor settings, click the blue checkmark to complete and close the window.



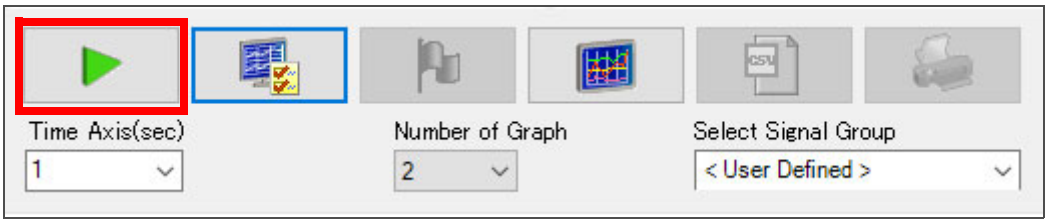
8. The selected signals appear in the list on the left while the graph representations are on the right.



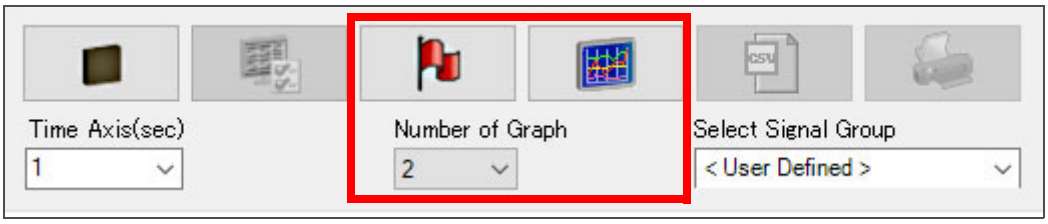
9. Signal settings that have been previously saved are stored in the Select Signal Group drop down box and can offer a way to store favorite settings for quick access.



10. Once the Signals are chosen, click the green play button to start the measurement.

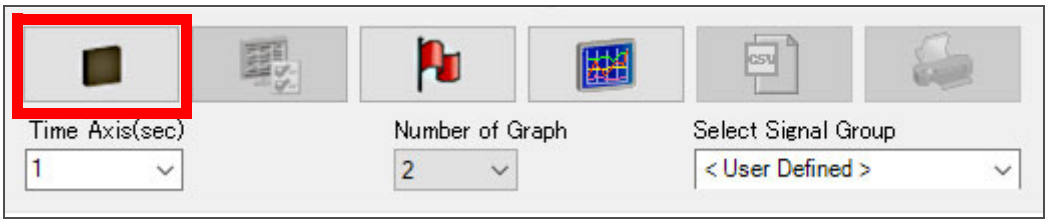


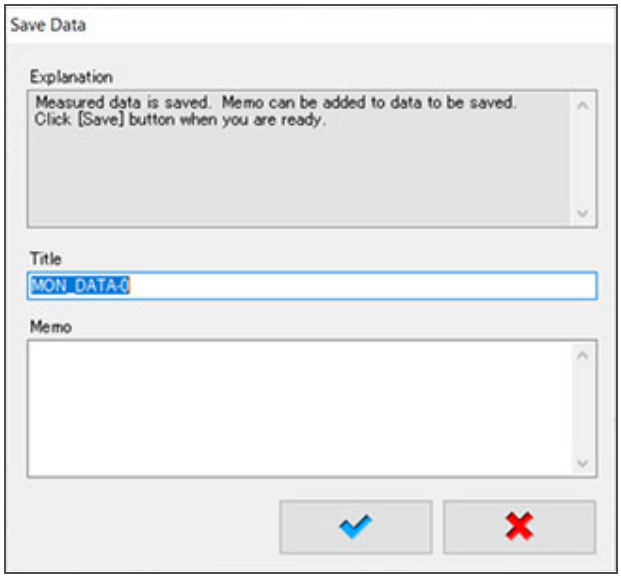
11. The following operations are available during monitoring:
    - Adding flags while monitoring data
    - Switching the graph display mode between one graph and separate graphs
    - Selecting number of graphs (2-5) to display on the screen when separate graphs chosen.



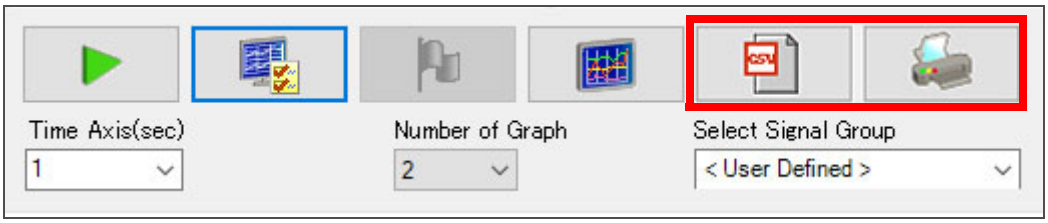
NOTE: Measured data will be recorded in the memory (on the PC) that can store approximately 2 hours of data. During measurement, the status of memory consumption is displayed in the status bar. When 2 hours of data memory is full, the old data will be overwritten by the new data.

12. Click the stop button to finish the measurement recording. The Save Data popup appears to save the data into the project information. Click the blue checkmark to save to the project.





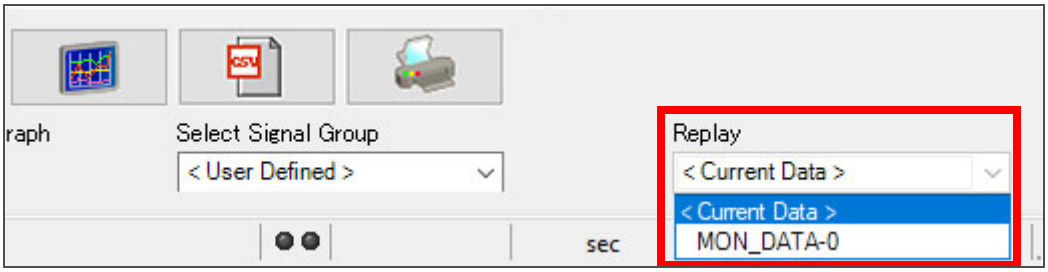
13. After monitoring, the recorded measurement can be saved as a CSV button or printed.



7.3.7.2 Replaying Monitored Data

Data that was previously recorded can be replayed from the Data Monitor screen.

1. In the bottom right corner of the Data Monitor screen, click on the Replay drop down box. When current data is monitored, it will display Current Data. All saved recordings will be listed and can be selected. To cancel replaying, select Current Data from the list.

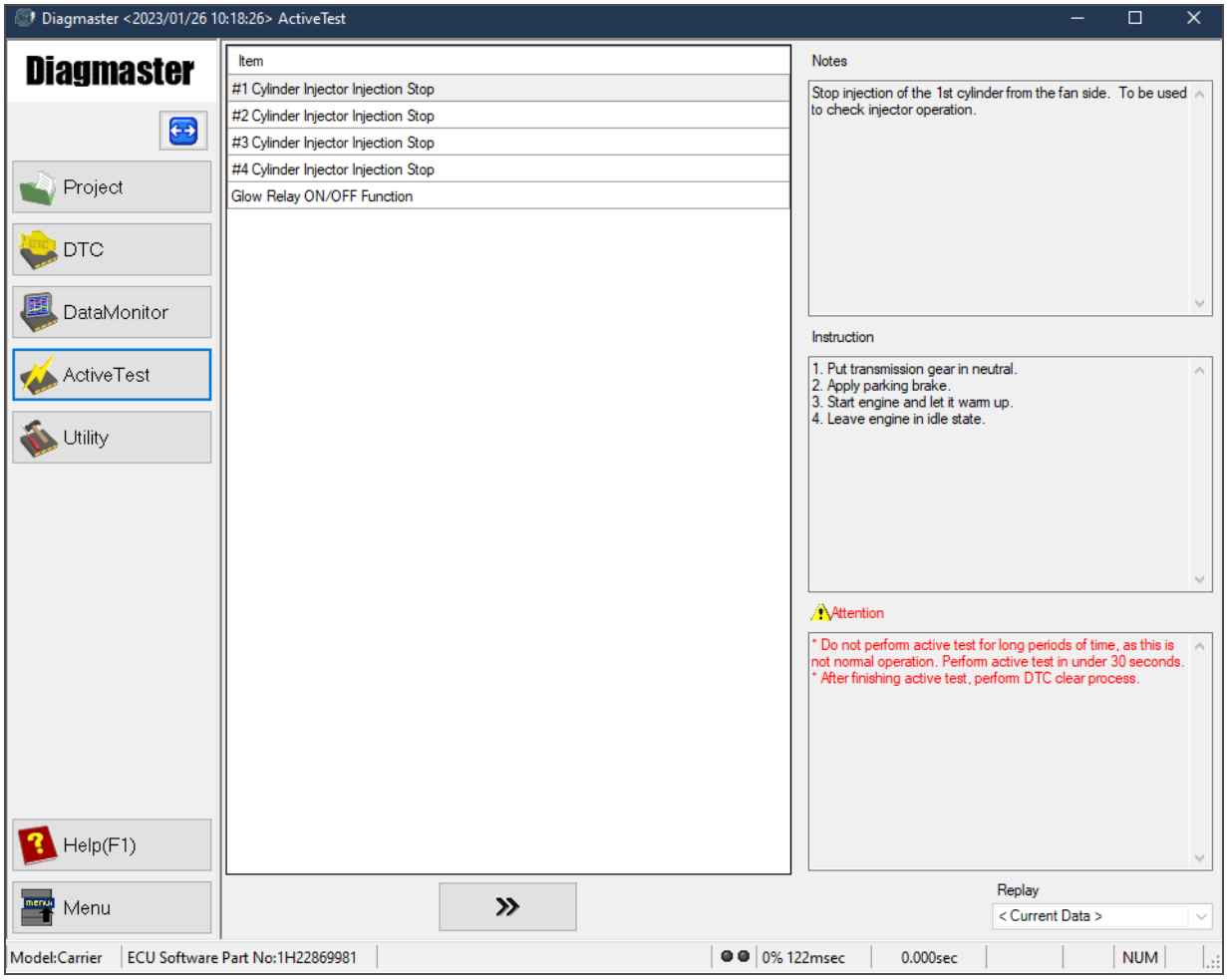


7.3.8 Active Test Item Select Screen

Active test is a function to forcibly drive components via command from Diagmaster. Active Test can assist with checking the circuit from the ECU to actuator and to test the ability of the actuator.

There are only two functions to perform on this screen:

- Stopping an individual injector cylinder (1-4).
- Turning the glow relay ON.



⚠ CAUTION

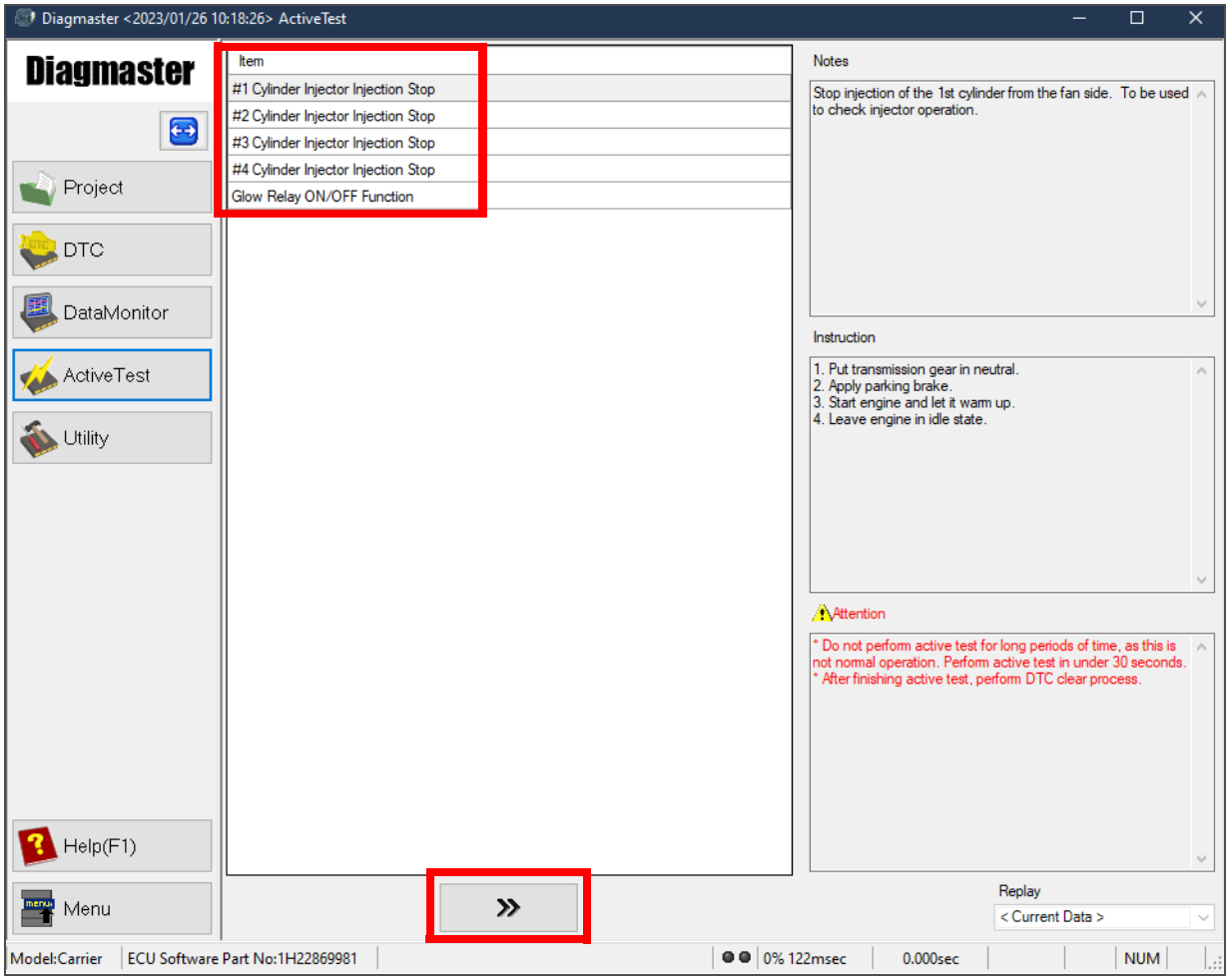
Before performing active tests, check the Notes, Instruction and Attention displayed in the right column for each item. Incorrect work or operation may result in an unexpected failure.

⚠ CAUTION

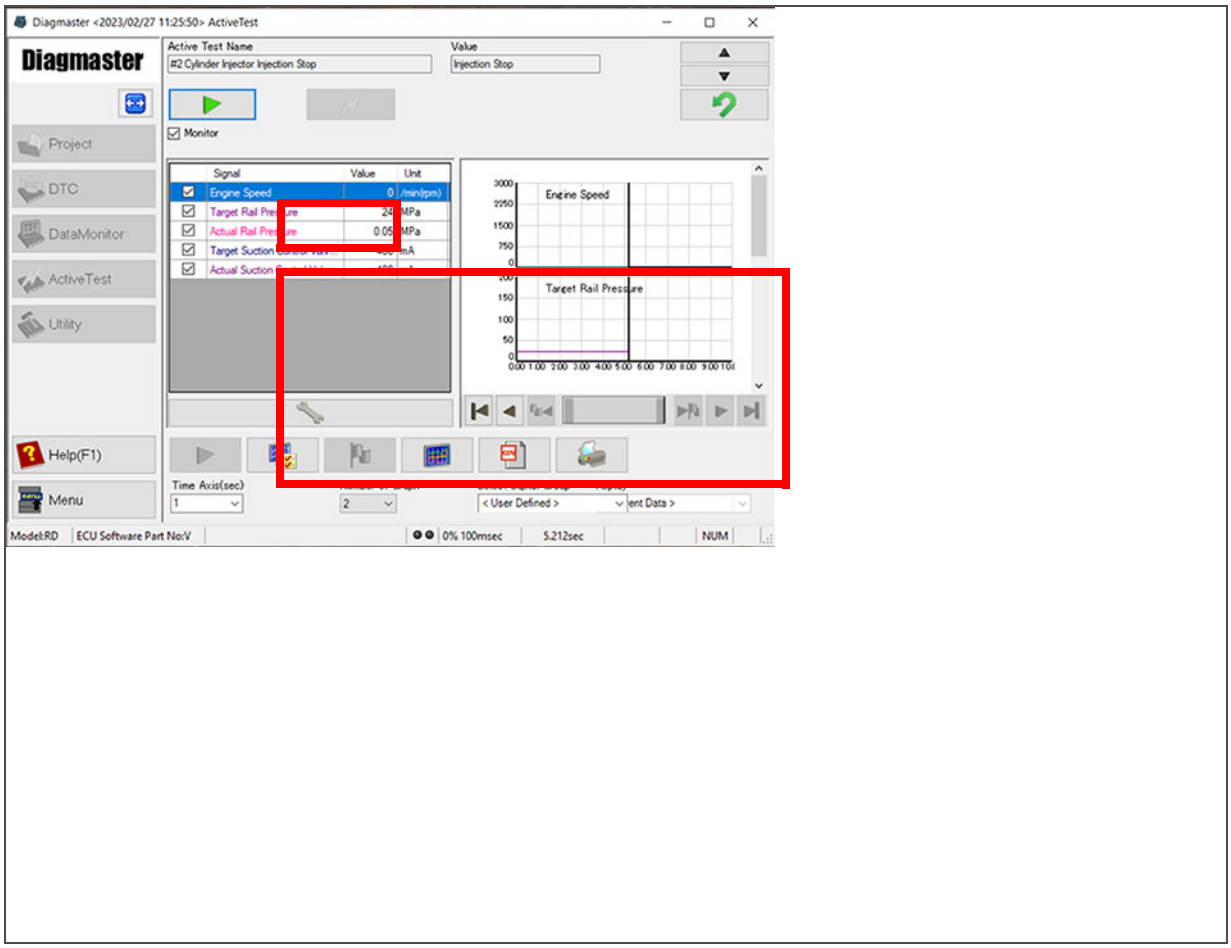
Since active tests are not a normal operation, prolonged execution may cause failure. Tests should take no more than about 30 seconds.

7.3.8.1 Performing an Active Test

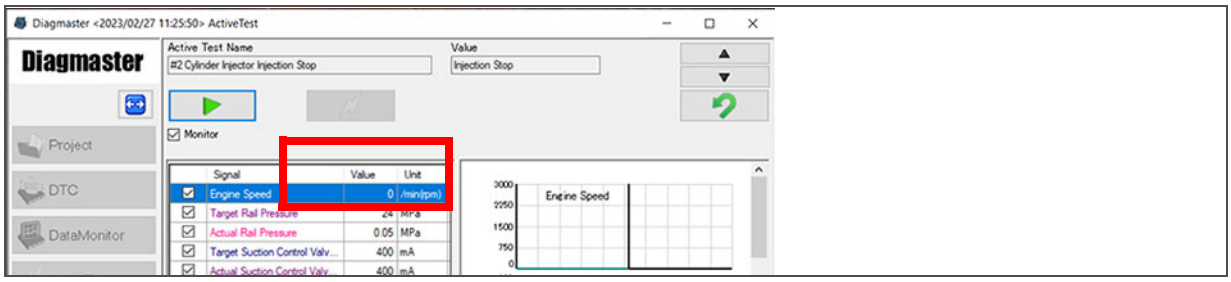
1. Select one of the items in the list and click the right arrow. The Active Test Execution screen appears.



2. Signals can be monitored during execution. To do this, set the signals to be monitored. See **Section 7.3.7.1**. Once the signal settings are set, click the Monitor check box to enable monitoring.



3. Click the green play button to make active tests ready to be executed. Data monitoring will start if simultaneous monitoring has been selected.



4. Click the yellow button to execute the active test. Driving instructions will be sent to the ECU. Check the operating noise of the actuator. During the active test, flags can be added by clicking the flag button.
5. Click the stop button to finish the test. If data was monitored, measured data can be saved with title and memo.
6. Click the green back button to return to the Active Test Item Select screen.

7.3.8.2 Replaying Active Tests

This procedure is to replay an active test that was performed simultaneously with data monitoring. You can not replay an active test unless data monitoring was also recorded.

1. From the Active Test Item Select screen, click on the Replay drop down box in the lower right corner. Select the target file saved from the list.
2. The Active Test Execution screen appears to display the replay of the selected data in the graph.
3. Click the stop button to cancel the replay.

7.3.9 Utility Item Select Screen

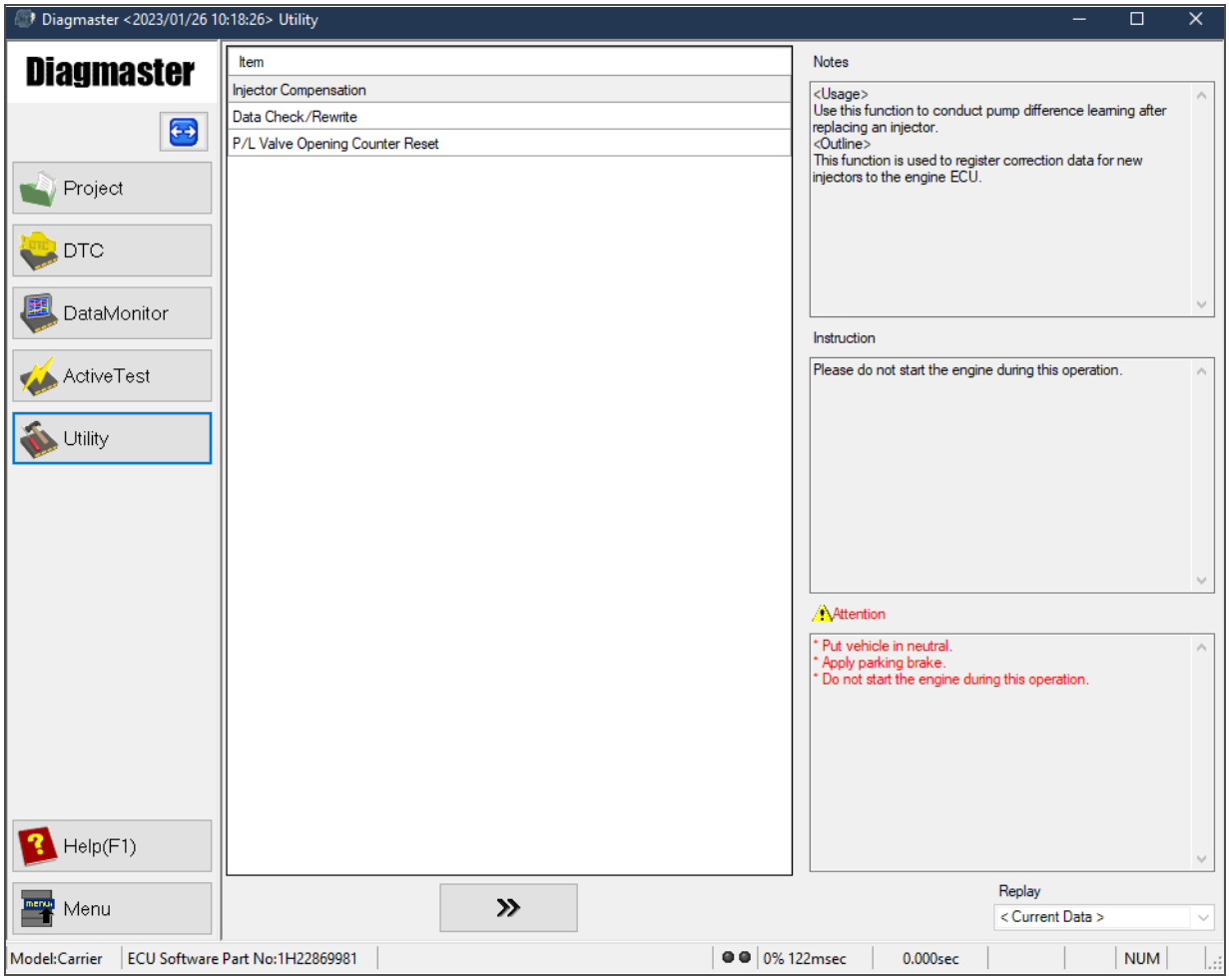
The Utility Item Select screen provides thee additional functions:

- Injector Compensation
- Data Check / Rewrite
- P/L Valve Opening Counter Reset

Select one of the items in the list and click the right arrow. The appropriate screen appears.

⚠ CAUTION

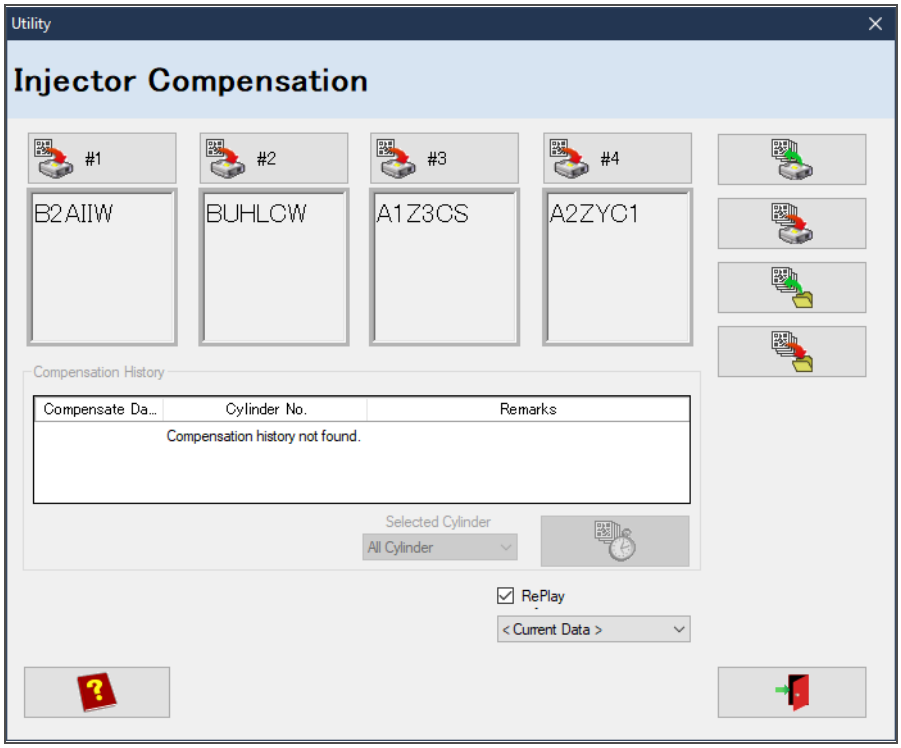
Before selecting a utility item to be performed, check the Notes, Instruction and Attention displayed in the right column of the screen for each item. Carefully read them and make sure you understand them before operation.



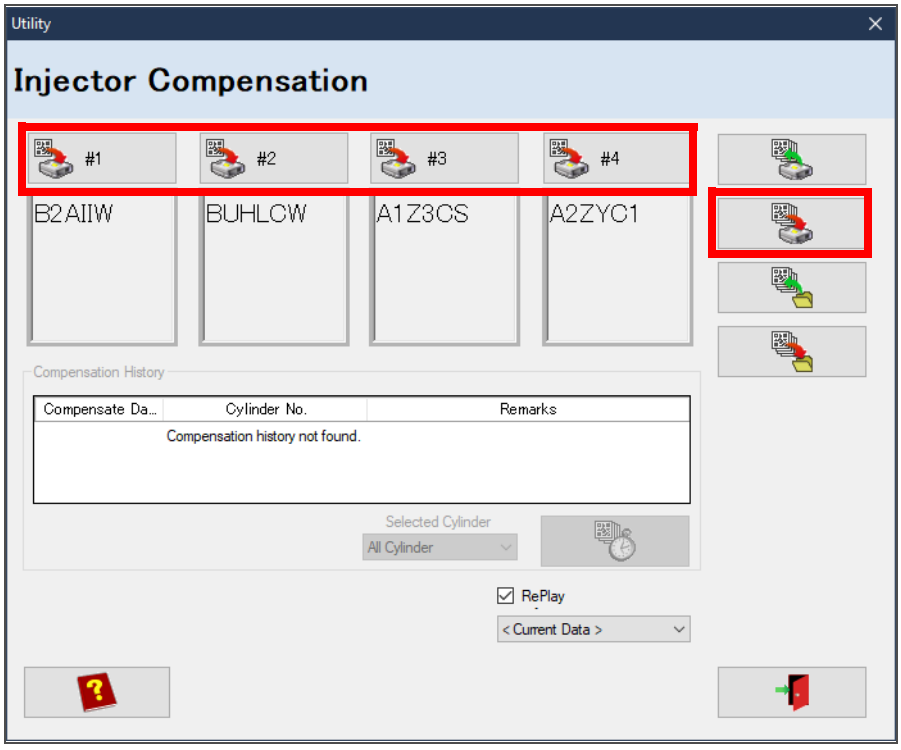
7.3.9.1 Injector Compensation

This function is performed when an injector or the ECU has been replaced. When registering compensation data to the ECU, stop the engine beforehand. Registration is not possible with the engine running.

1. Select Injector Compensation on the Utility screen and click the right arrow to open the Injector Compensation screen. The injector compensation values currently saved in the ECU are displayed.



2. Click on any register individual injector button. Or, click on the register all injectors button to register all injectors at once.

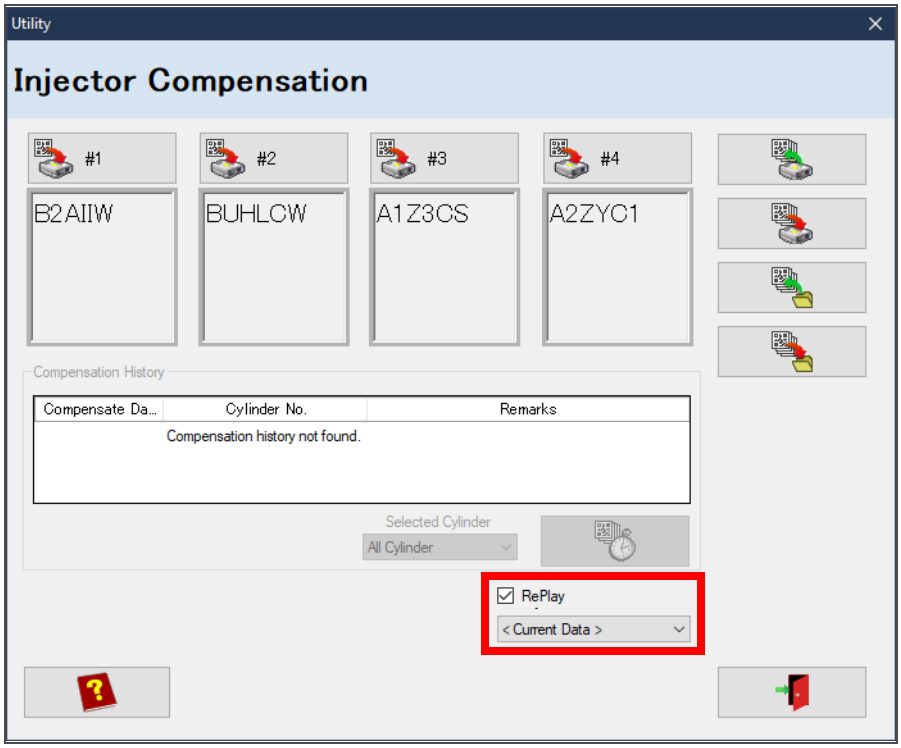


3. A confirmation screen will appear. To rewrite the data, click the OK button. When rewriting is complete, a Registered message will appear.

7.3.9.2 Replay Registered Compensation Data

When compensation data is registered, its history is automatically saved in the project.

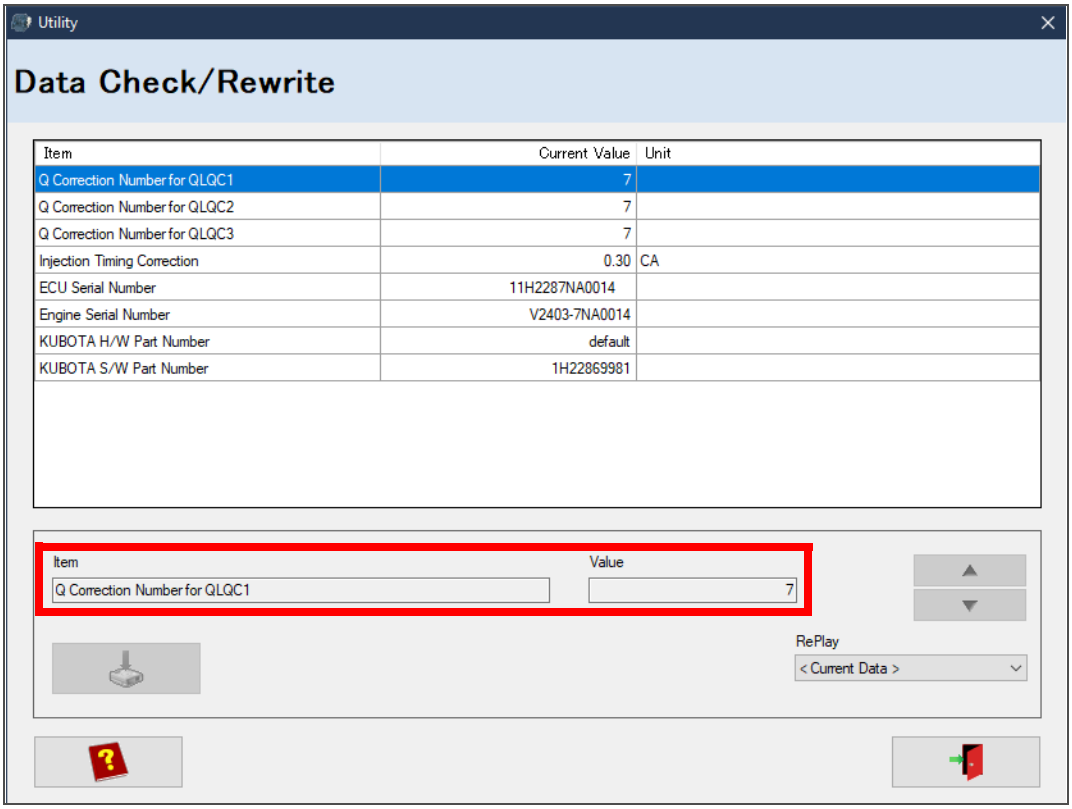
1. Click on the drop down list under Replay. Select the target saved file from the list. To cancel replay, click on Current Data from the drop down list.



7.3.9.3 Data Check / Rewrite

This screen will allow a user to check and rewrite the values contained in the ECU.

1. Select Data Check / Rewrite from the Utility screen to open the Data Check / Rewrite values.

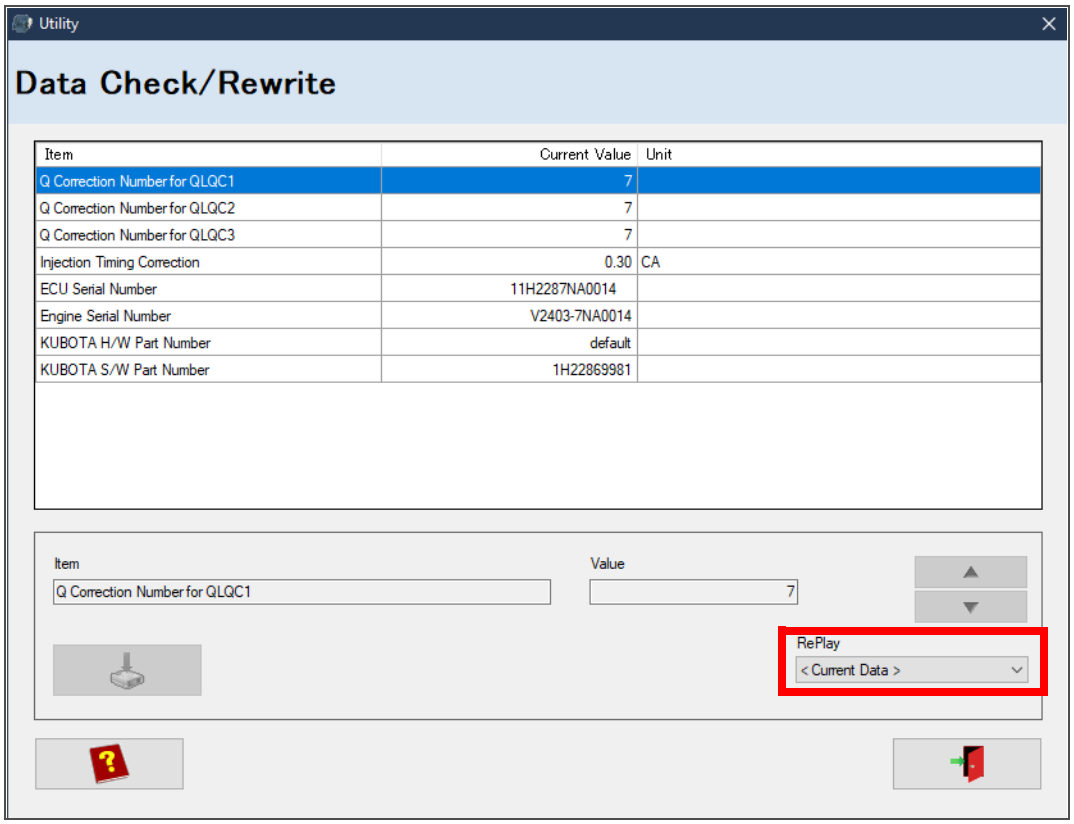


2. Select the item to be rewritten. Change the value and click the Save button to execute the change.
3. Check the content of the displayed precautions in the popup and click the blue checkmark to confirm.
4. A confirmation screen for rewriting will appear. Click OK to complete.
5. If the rewriting properly executed, the label of the rewritten signal changes to a blue color with a completion message.

7.3.9.4 Replaying Rewritten Data

When data is rewritten, its history is automatically saved in the project.

1. Click on the drop down list under Replay. Select the target saved file from the list. To cancel replay, click on Current Data from the drop down list.



Section 8
Schematics

8.1 Schematics

Figure 8.1 Schematic Legend

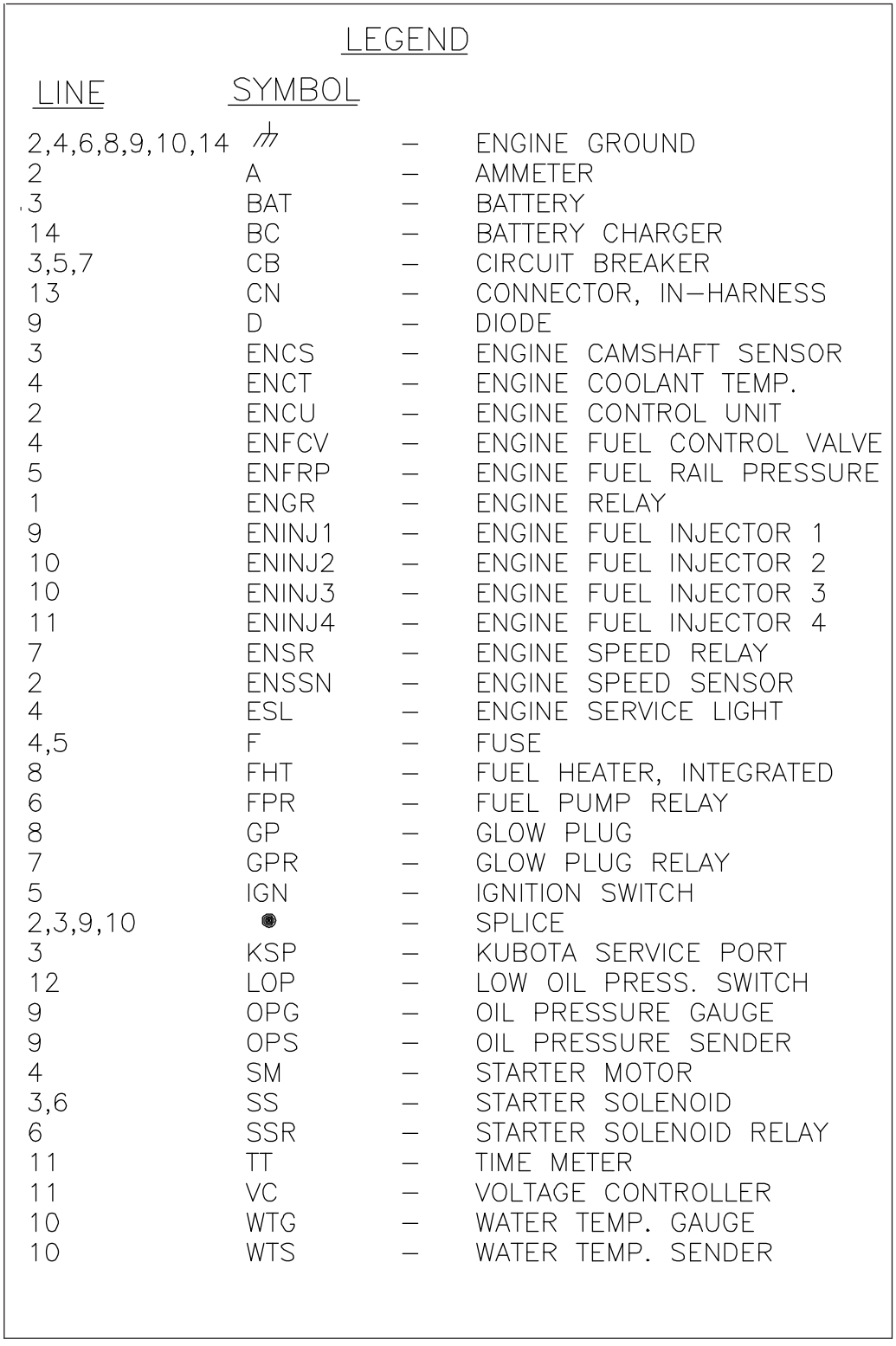


Figure 8.2 Schematic 12VDC Control Circuit

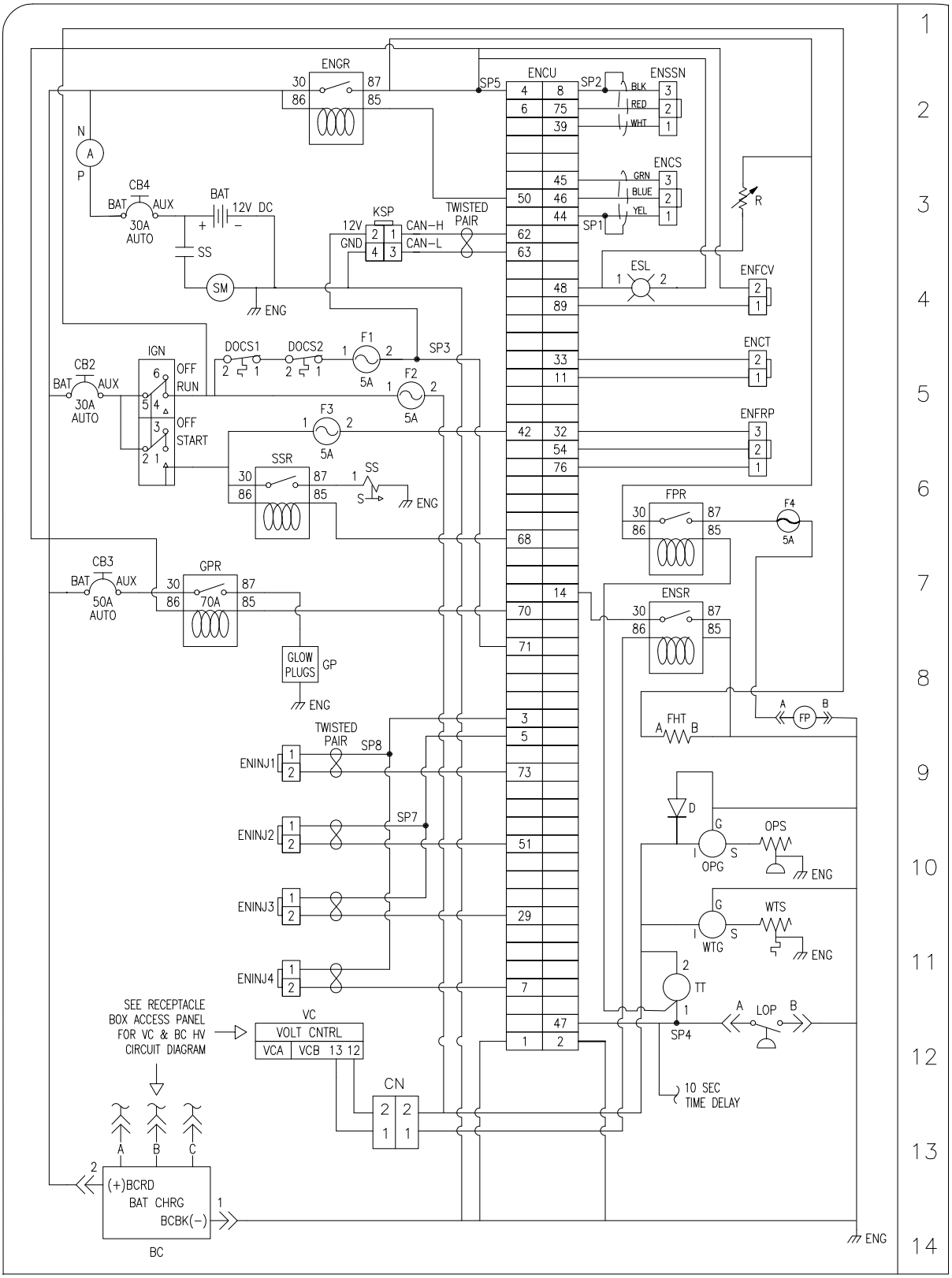


Figure 8.3 Schematic High Voltage Circuitry

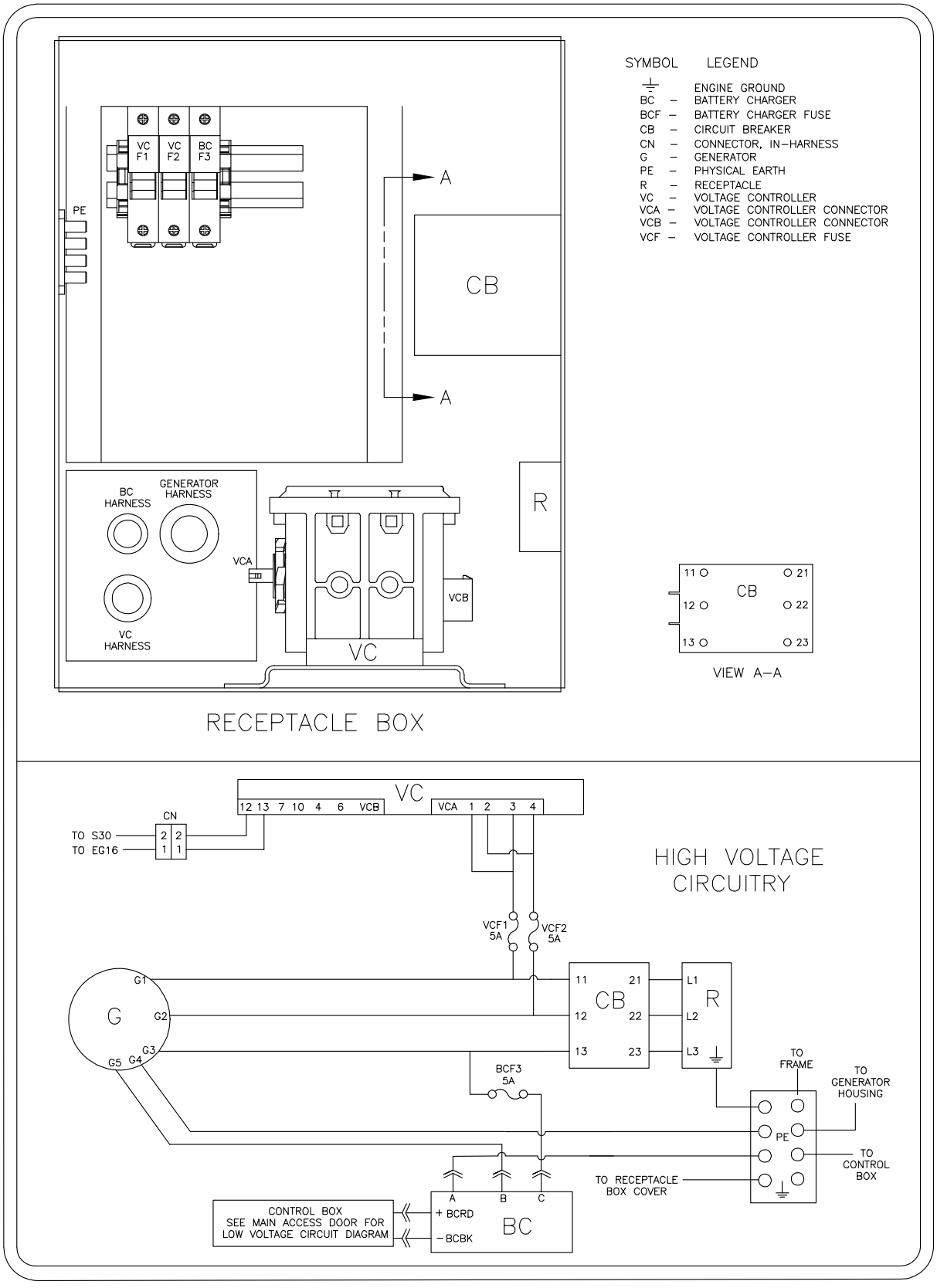
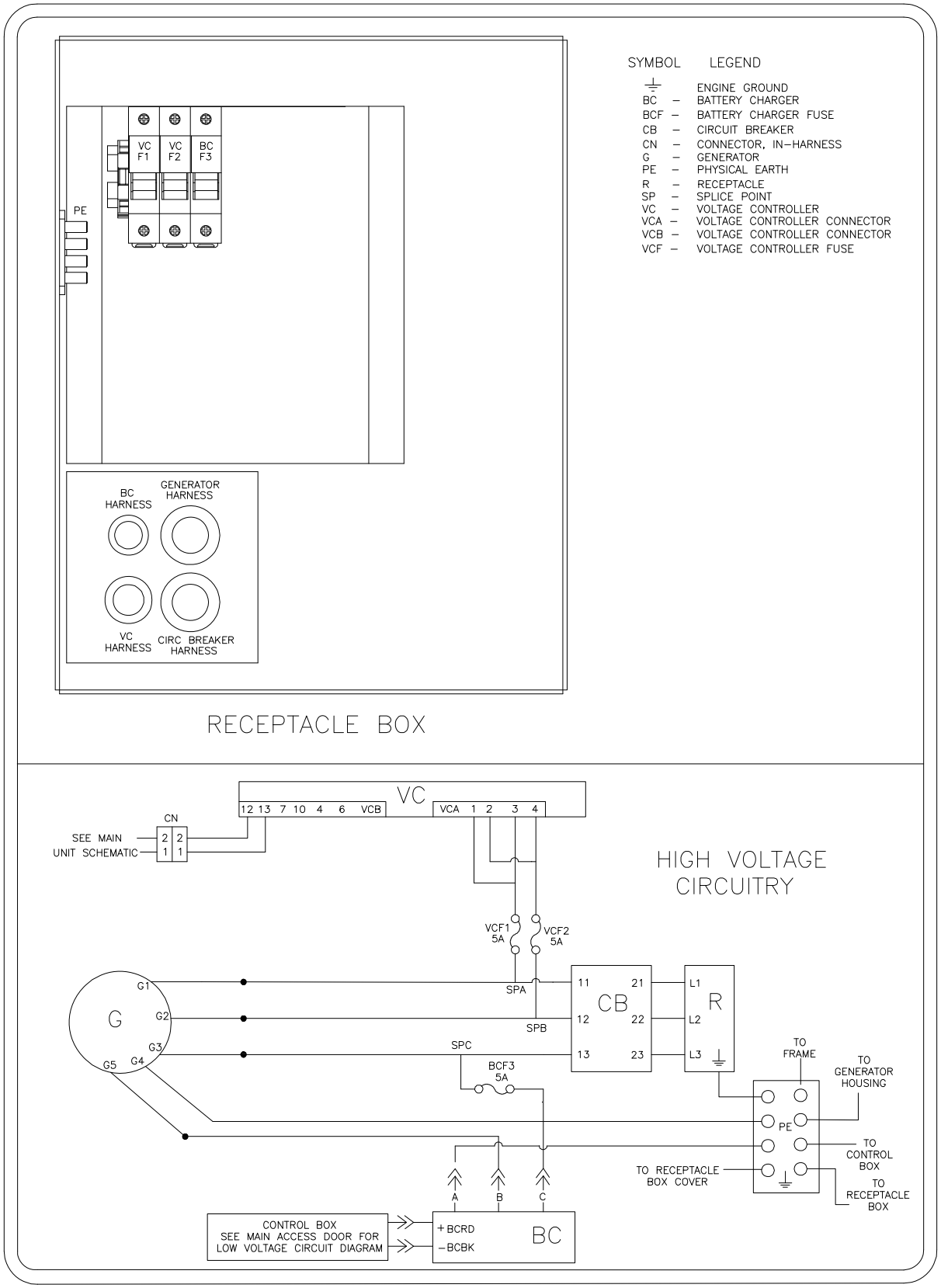
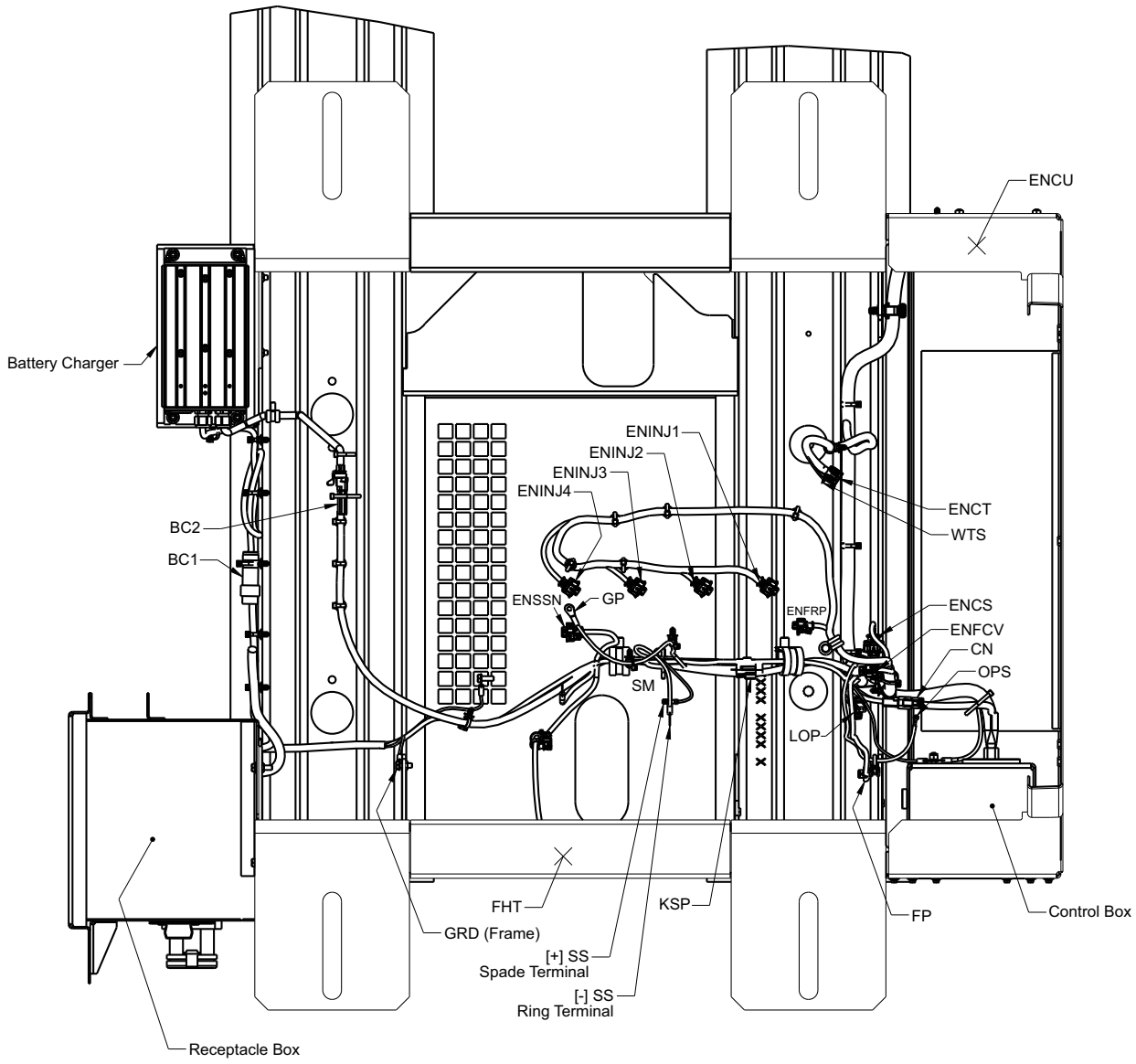


Figure 8.4 Schematic High Voltage Circuitry (PID UG2403 only)



Section 9
Appendix

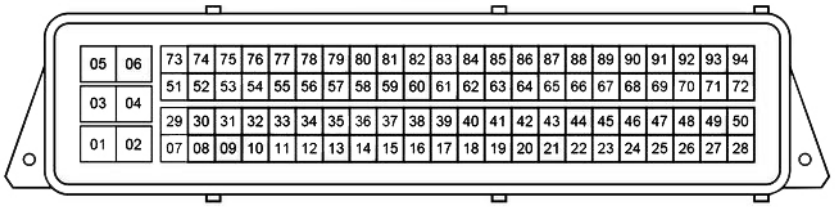
9.1 Voltage Wiring Layout



1) BC1: Battery Charger Input (HV Connector)
2) BC2: Battery Charger Output (LV Connector)
3) CN - Voltage Controller (HV Connector)
4) ENCS - Engine Camshaft Position Sensor
5) ENCT - Engine Coolant Temperature
6) ENCU - Engine Control Unit
7) ENFCP - Engine Fuel Control Valve
8) ENFRP - Engine Fuel Rail Pressure
9) ENINJ1 - Engine Fuel Injector 1
10) ENINJ2 - Engine Fuel Injector 2
11) ENINJ3 - Engine Fuel Injector 3
12) ENINJ4 - Engine Fuel Injector 4
13) ENSSN - Engine Speed Sensor (Correct)
14) FHT - Fuel Heater, Integrated
15) FP - Fuel Pump
16) G - Generator
17) GP - Glow Plug
18) GRD - Ground
19) KSP - Kubota Service Port
20) LOP - Low Oil Pressure Switch
21) OPS - Oil Pressure Sender
22) SM - Starter Motor
23) SS - Starter Solenoid
24) WTS - Water Temperature Sender

- - - - -

9.2 ECU Terminal Layout



Terminal Number	Abbreviation	Formal Name
1	P (-)	Power ground
2	P (-)	Power ground
3	#1/4 INJ (+)	Injector cylinder #1 / #4 VCC
4	+B	Battery
5	#2/3 INJ (+)	Injector cylinder #2 / #3 VCC
6	+B	Battery
7	#4 INJ (-)	Injector cylinder #4 ground
8	NE (-)	Crankshaft position sensor ground (ENSSN)
11	CT (-)	Coolant temperature sensor ground (ENCT)
14		Engine Speed Relay 1500/1800 (ENSR)
29	#3 INJ (-)	Injector cylinder #3 ground
32	RP (+)	Rail pressure sensor VCC (ENFRP)
33	CT	Coolant temperature sensor (ENCT)
39	NE (+)	Crankshaft position sensor VCC (ENSSN)
42	ST SW	Starter switch
44	G (-)	Camshaft position sensor ground (ENCS)
45	G (+)	Camshaft position sensor VCC (ENCS)
46	G	Camshaft position sensor (ENCS)
47	OL SW	Oil pressure switch (OPS)
48	WR LP	Engine Warning Lamp
50	M RY	Main Relay
51	#2 INJ (-)	Injector cylinder #2 ground
54	RP	Rail pressure sensor (ENFRP)
62	CAN2 H	CAN2 High
63	CAN2 L	CAN2 Low
65	CAN1 L	CAN1 Low
66	CAN1 H	CAN1 High
68	ST RY	Starter Relay
70	GL RY	Glow Relay
71	IG SW	Ignition Switch
73	#1 INJ (-)	Injector cylinder #1 ground
75	NE	Crankshaft position sensor (ENSSN)
76	RP (-)	Rail pressure sensor ground (ENFRP)
89	SCV (-)	Suction control valve ground (SCV)

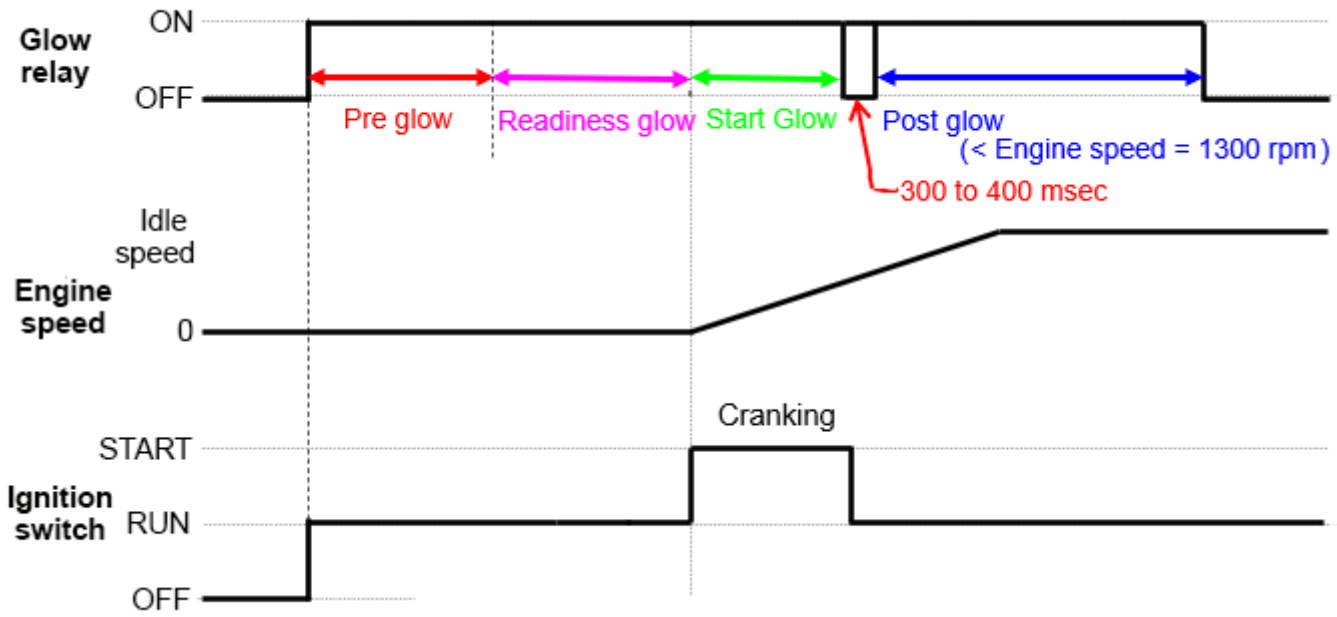
9.3 ECU Data Monitor Signals

Signal Name	Description	Reference Value / Behavior
Rotary / Pulse Signal		
Engine Speed [rpm]	Indicates engine RPM via a signal from the crankshaft position sensor. If this signal fails, the camshaft position sensor signal is used. This is a standard value for various controls	When engine stopped (switch in RUN): 0 is displayed. When engine running: engine speed is displayed.
Vehicle Speed [km/h]	Indicates vehicle speed via a signal from the vehicle speed sensor (CAN).	This is not currently being used.
Analog Signal		
Accelerator Pedal Position [%]	Indicates accelerator position via the accelerator sensor or CAN signal. One standard value that determines fuel injection quantity	This is not currently being used.
Accelerator Pedal Position Sensor 1 Output Voltage [V]	Indicates accelerator sensor output voltage value (system 1) Used to calculate accelerator position	This is not currently being used.
Accelerator Pedal Position Sensor 2 Output Voltage [V]	Indicates accelerator sensor output voltage value (system 2) Used to calculate accelerator position	This is not currently being used.
Coolant Temperature [°C]	Indicates coolant temperature via the coolant temperature sensor signal Used for deciding start mode when cold, and for various controls, including CRS controls, such as injection timing	About 4.24 V at -20°C (-4°F) About 3.40 V at 0°C (32°F) About 2.36 V at 20°C (68°F) About 0.88 V at 60°C (140°F) About 0.47 V at 80°C (176°F) About 0.39 V at 100°C (212°F) About 0.12 V at 120°C (248°F)
Coolant Temperature Sensor Output Voltage [V]	Indicates coolant temperature sensor output voltage value Used to calculate coolant temperature	About 4.24 V at -20°C (-4°F) About 3.40 V at 0°C (32°F) About 2.36 V at 20°C (68°F) About 0.88 V at 60°C (140°F) About 0.47 V at 80°C (176°F) About 0.39 V at 100°C (212°F) About 0.12 V at 120°C (248°F)
Atmospheric Pressure [kPa]	Indicates atmospheric pressure via the atmospheric pressure sensor signal Used in CRS controls, such as fuel injection amount	At flat ground: 100 (standard atmospheric pressure As altitude gets higher, the value gets lower
Atmospheric Pressure Sensor Output Voltage [V]	Indicates atmospheric pressure sensor output voltage value Used to calculate atmospheric pressure	About 4.0 V at 101 kPa
Battery Voltage [V]	Indicates battery voltage	When engine stopped (switch in RUN): around 12. When engine cranking: lower When engine running: around 14.

Signal Name	Description	Reference Value / Behavior
Digital Signal		
Key Switch	Indicates ignition switch ON/OFF state	Always ON when switch is in RUN, regardless of engine operating state
Start Switch	Indicates ignition switch start signal ON/OFF state Indicates cranking being done	When engine cranking: ON is displayed Otherwise: OFF
Neutral Switch	Indicates neutral position state Neutral switch or CAN signal	This is always Neutral ON..
Basic Control Signal		
Final Fuel Injection Quantity [mm3/st]	Indicates fuel injection amount per cylinder calculated by the ECU based on various sensors: such as engine speed, coolant temperature and atmospheric pressure	When engine stopped (switch in RUN): less than 0 During no-load maximum speed: about 4 to 6
Target Rail Pressure [MPa]	Indicates standard rail pressure calculated by the ECU in order to output the specific output and RPM	When engine stopped (switch in RUN): 0 During no-load maximum speed: about 90
Actual Rail Pressure [MPa]	Indicates rail pressure via the rail pressure sensor signal Used in CRS controls	Follows target rail pressure
Rail Pressure Sensor Output Voltage [V]	Indicates rail pressure sensor output voltage Used to calculate actual rail pressure	Proportional to actual rail pressure When engine stopped (switch in RUN): about 0.3 V During no-load maximum speed: about 1.6 V
Target Suction Control Valve (SCV) Current [mA]	Indicates target SCV current value Used in CRS controls	Proportional to target SCV current value When engine stopped (switch in RUN): about 0 mA During no-load maximum speed: about 1400 mA
Actual Suction Control Valve (SCV) Current [mA]	Indicates actual SCV current value Used in CRS controls	Follows target SCV current value
Idle Control Target [rpm]	Indicates target engine speed during idling	This is a fixed value, it does not change Actual engine speed at idle is close to this value
Engine Stop Flag	Indicates ON/OFF state of engine stop flag Indicates engine stop state	When engine stopped (switch in RUN): ON When engine running: OFF
Low Temperature Start Mode Flag	Indicates ON/OFF state of low temperature start mode flag Cold start mode trigger: a mode that compensates fuel injection amount at start when coolant temperature and/or engine speed are low.	When engine stopped (switch in RUN): OFF When engine cranking: ON When engine running: OFF
Actuator		
Glow Relay	Indicates glow relay ON/OFF state Indicates ON when glow plugs (or intake air heater) are energized	When ON in cold start mode: ON When OFF in cold start mode: OFF

Signal Name	Description	Reference Value / Behavior
Other		
Hour meter [h]	Indicates the hour meter value recorded to the ECU	Hours of ECU operation displayed
Source Address of TSC1	Indicates CAN communication address settings *May be disabled under some specifications	Always show: 0
Parking SW	Indicates parking switch ON/OFF state Parking switch signal or CAN signal	Always show: OFF
Oil Pressure SW	Indicates oil pressure switch ON/OFF state Oil pressure switch signal	When ignition switch ON (engine stopped): OFF When engine operating: ON
Target Speed of Isochronous Control [rpm]	Indicates target engine speed under isochronous control	Will show either 1500 or 1800 for 50-60 Hz.

9.4 Glow Plug Logic



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