

Caution

Be sure to read this instruction manual carefully and strictly observe the safety and operation instructions herein, especially the warnings and cautions, so as to reduce the possibilities of personnel injury, property loss, engine performance deterioration, premature wear or damage.

Warnings in this manual must be observed strictly. Failure to do so can cause burns, amputation, mutilation, asphyxiation, other personal injury or death. Cautions are provided for the user to operate the engine in a proper way, so as to avoid damage to engine parts and engine performance deterioration. Warnings and cautions in this manual are not complete since Shanghai Diesel Engine Co., Ltd. (SDEC) has no possibility and is not able to foresee all potential risks resulted from failures to follow the safety cautions and operation instructions.

Repair, Technical Consultation, Complaint and Suggestion

For engine repair, technical consultation, complaints or suggestions, please contact SDEC's after-sale service center: spare@sdecie.com.

Please provide the following information for product repair:

The engine model

The engine order number

The engine serial number

The date of the equipment procurement

The detailed description of the fault

The address and phone number of the contact person

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1 Introduction

1.1 To User and Operator

Thank you for purchasing a product of Shanghai Diesel Engine Co., Ltd!

The E series natural gas engine, available in two displacements of 10L and 12L, is a large-power four-valve electronic-controlled natural gas engine with four or six cylinders that is newly developed by SDEC. Featuring strong power and low gas consumption and with the emissions conforming to relevant national regulations, the E series natural gas engine is a perfect power for middle- and high-end vehicles and industrial equipment.

This manual mainly covers the technical specifications, operation and maintenance instruction, with an aim to familiarize you with the engine, as well as the proper operation and maintenance thereof. Before using the engine, read carefully the relevant contents and requirements in this manual. Due to the continuous improvement of performance and structure of the engine, the technical specifications and illustrations of the engine in this manual may be slightly different from those of the engine you have, please note that we will provide the supplement and perfection in the later editions without notice. In case of any question during your engine operation and maintenance, please never hesitate to contact SDEC's after-sale service center spare@sdecie.com for technical advice or guidance.

SDEC has adopted the latest technology and high-quality parts for the engine. The genuine SDEC spare parts are recommended to be used for repair and maintenance. Please contact SDEC's after-sale service center spare@sdecie.com for service parts.

1.2 Notices for Engine Quality Feedback

To better our service, please provide following information when you make feedback about quality issues, whereby, we can understand and analyze quality issues and the root causes thereof, and make the improvement in time:

- 1) When and where fault occurred;
- 2) Engine serial number, model, order number, delivery date and the detailed address of consignee;
- 3) Service conditions, cumulative operation time (in hours or kilometers), operating conditions (power, speed) and the specification of the lubricating oil that has been used;
- 4) The characteristics of the driven equipment (model, power consumption and structural feature, etc.)
- 5) The description of faults;
- 6) Parts or components claimed for compensation or repair should be mailed or sent in person to SDEC headquarter with the damage process record or description for facilitating analysis. If there are several problems or a very serious problem, please leave the site as it was and inform us promptly, and then SDEC will send staff for a joint analysis. Quality issues should be settled based on the relevant provisions in the quality warranty manual.

1.3 Safety Instructions

- Do not wear a loose garment or any jewelry when working around the engine or its driven equipment. If necessary, wear the safety goggles, work clothes, safety helmet or other protective items.
- All the exposed rotating parts should be provided with guards in firm installation to prevent personal injury.
- The workroom of the engine should be well ventilated with waste gas exhausted outside.
- Do not operate the gas engine in a place where there is or may be flammable gas, for the gas may enter the air intake system of the engine and cause the engine to speed up or overspeed, which leads to fire, explosion or serious engine damage.
- Take all tools, wires, other odds and ends away from the engine prior to starting.
- Make sure to shutdown the engine before any adjustment is performed to it and its driven equipment.
- Smoking is not allowed during filling gas, otherwise, gas steam can cause fire easily.
- Smoking is also not allowed when checking electrolyte level because electrolyte will release flammable gas.
- Contact between electrolyte and skin or eyes must be prevented when replenishing electrolyte for the battery, because it is an acid. In case of skin contact, please flush the contacted part with soap and clean water; in case of eyes contact, flush your eyes for 15 minutes with clean water and seek for medical treatment immediately.
- Added with an odorous chemist, natural gas can be smelled when it leaks. Be on alert when smelling natural gas. When entering the engine cabinet or being close to the engine and smelling natural gas, shut down the engine and check and remove gas leakage. And keep the area free from spark, arc switch or device, smoking, indicator lamp, fire or other fire source and take a good ventilation measures. Do not start the equipment or the equipment nearby until the leakage has been removed and the area has been well ventilated. Avoid placing the equipment fueled with natural

gas in a bad ventilated room overnight or for a longer period of time. Keep or maintain the equipment in a large, well ventilated place instead.

- Cool down the engine first when filling coolant to avoid being hurt by the coolant steam. Open the pressure cap only when the coolant is lower than 50°C, and then slowly loosen the cap to release the pressure of cooling system.
- Wipe up overflowed lubricating oil, coolant or other liquids. Put oily rags into a fire-protection container, but do not leave it on the engine.
- Before starting a repaired engine, make sure to be ready to cut ECM power supply. In case of any abnormal, switch off the power supply immediately.
- Do not rotate the engine with the fan, otherwise severe personal injury or damage to fan blades can be caused.
- The exhaust system experiences higher working temperature than that of diesel engine. Do not touch the parts of the exhaust system to avoid scald.
- Release the pressure in the air, lubricating or cooling system prior to dismantling or loosening any pipelines, permanent joints, connectors or relevant parts. Do not use hand to check leakage, otherwise the high temperature and high pressure natural gas, lubricating oil and coolant can cause personal injury.
- If the engine will not be used for a long time or is under repair, separate it from the battery to prevent an unexpected start-up.
- The ignition system of the engine will produce high voltage during engine operation. Never touch the ignition wire or ignition part when the engine is in operation unless using a proper insulated tool. A bad electric shock will happen if failing to do so.
- Used lube oil may contain carcinogenic substance which can result in reproductive toxicity, therefore, inhalation of or longtime exposure to oil steam should be avoided. Waste oil should be disposed in proper, safe and reliable manner.
- To prevent choke or cold injury, removal of air-conditioning refrigerant (Freon) pipeline should be conducted in well ventilated environment with protective clothing on. For environment protection, the refrigerating system should be emptied or filled using dedicated equipment so as to prevent diffusion of Freon into atmosphere. Refrigerant should be recovered and recycled.

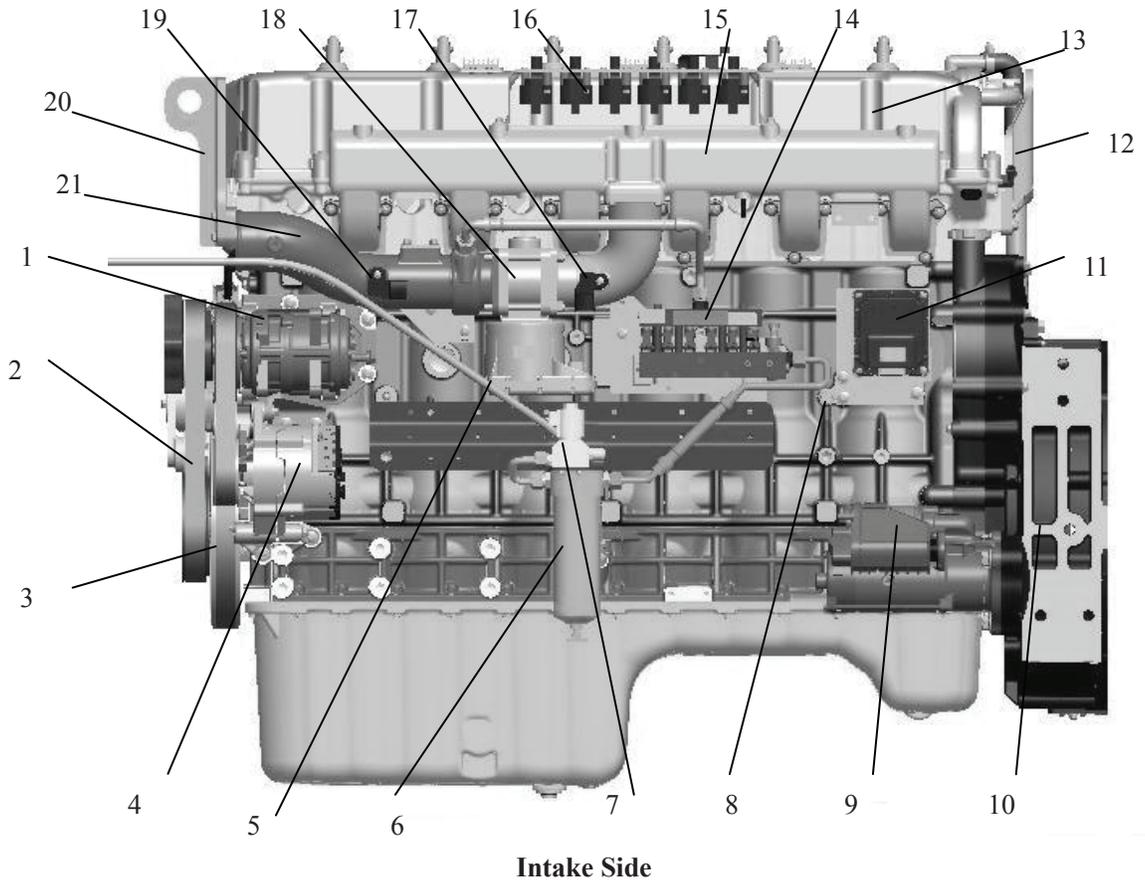
1.4 Engine Operation Instructions

- Read this manual carefully, and be in strict accordance with operation instructions and maintenance procedure specified in this manual.
- Conduct daily and 4-level maintenance as specified in this manual, and keep the record of scheduled maintenance.
- Use the proper gas, lubricating oil and coolant specified in this manual.
- 60 hours' running-in must be conducted for a new or overhauled engine. Refer to Section 3.6 for the running-in requirements.
- Do not run the engine without air filter, otherwise, early engine wear will happen.
- When welding is required, cut power supply for the vehicle or equipment before welding or it will cause damage to the ECM and sensors. Do not ground the welding device onto the ignition part or on the ignition wire. Ground the welding device to the place near the parts to be welded.
- Do not connect a starting jumper cable or battery charge cable to the ignition control circuit. Failure to do so will cause damage to the ignition system.
- The exhaust system experiences higher working temperature than that of diesel engine of same kind. So gas lines should not be located close to the exhaust system to prevent their hoses from deterioration due to hot.
- The cooling system of the engine should adopt a specified coolant in any kind of climate.
- When filling lubricating oil, it is not allowed to use the mixture of oil of different specifications.
- Preparations should be well done before starting the engine. Be sure to remember that the engine must be started without any load.
- Check if coolant, lubricating oil and gas are enough before starting the engine.
- Observe the engine operation and all instrument readings. In case of critical situation, an emergency stop should be performed to prevent the seizure of moving parts caused by low oil pressure or overheating due to lack of coolant.
- The belt tension and the other drive devices can only be inspected when the engine is in stop.
- Close the hand gas supply valve first when maintaining or repairing the engine.
- Malfunction thermostat should be replaced in time but the use of thermostat cannot be omitted.
- Do not water the engine for cleaning.

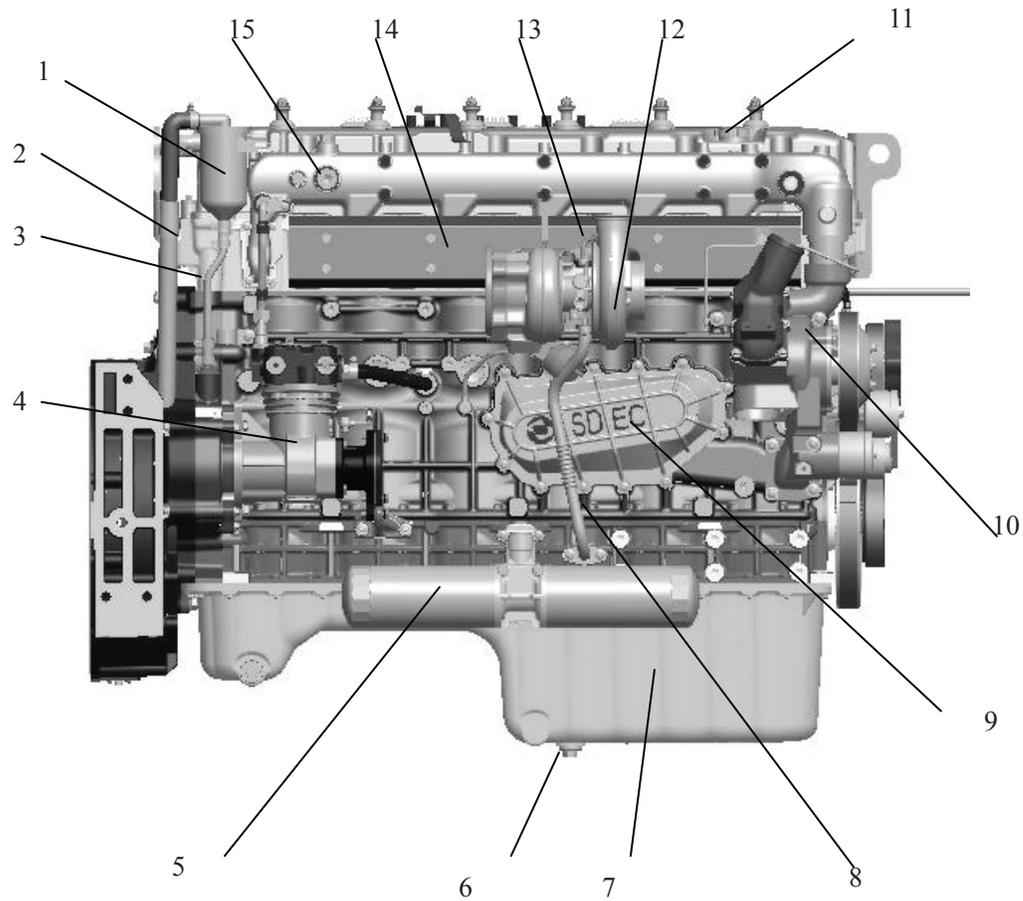
2 About the Engine

2.1 Engine Outline Diagrams

2.1.1 SC10ET natural gas engine (10L)

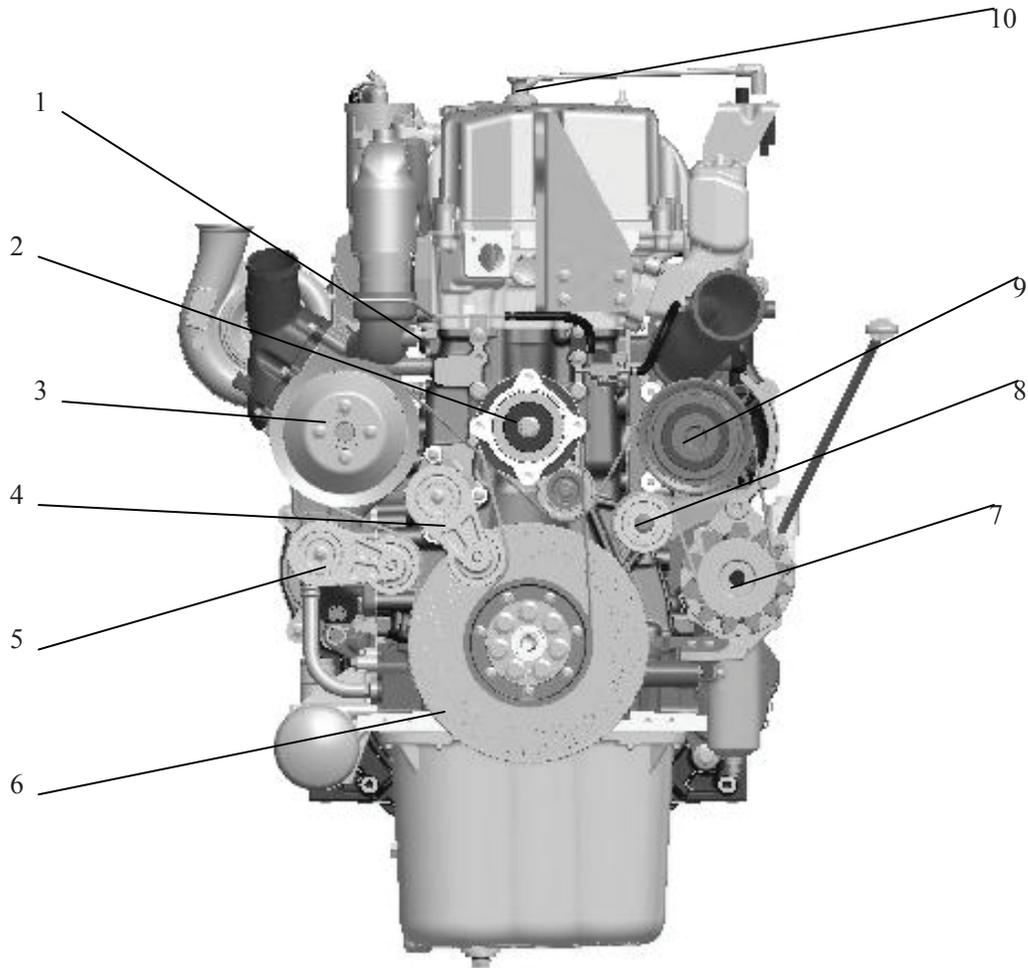


- | | | |
|-----------------------------------|-----------------------------------------------|---------------------------|
| 1 AC Compressor | 2 Fan belt (Outer) | 3 Fan belt (Inner) |
| 4 Alternator | 5 Oil dipstick | 6 Low pressure gas filter |
| 7 Low pressure gas shut-off valve | 8 Oil pressure sensor | 9 Starter motor |
| 10 Flywheel housing | 11 Ignition Module | 12 Rear lifting ring |
| 13 Valve cover | 14 Fuel metering valve | 15 Intake manifold |
| 16 Ignition coil | 17 Intake air temperature and pressure sensor | |
| 18 Electronic throttle | 19 Intake air pressure sensor | 20 Front lifting ring |
| 21 Gas mixture inlet pipe | | |



Exhaust Side

- | | |
|---------------------------------|---------------------------------|
| 1 Oil separator | 2 Oil separator gas outlet pipe |
| 3 Oil separator oil return pipe | 4 Air compressor |
| 5 Oil filter (2 Pcs) | 6 Oil drain plug |
| 7 Oil pan | 8 Turbocharger oil drain pipe |
| 9 Oil cooler | 10 Water pump |
| 11 Oil filler cap | 12 Turbocharger |
| 13 Turbocharger oil inlet pipe | 14 Exhaust manifold heatshield |
| 15 Engine coolant inlet pipe | |



Front End

1 Water temperature sensor

3 Water pump pulley

5 Alternator belt tensioner (inner)

7 Alternator

9 AC compressor pulley

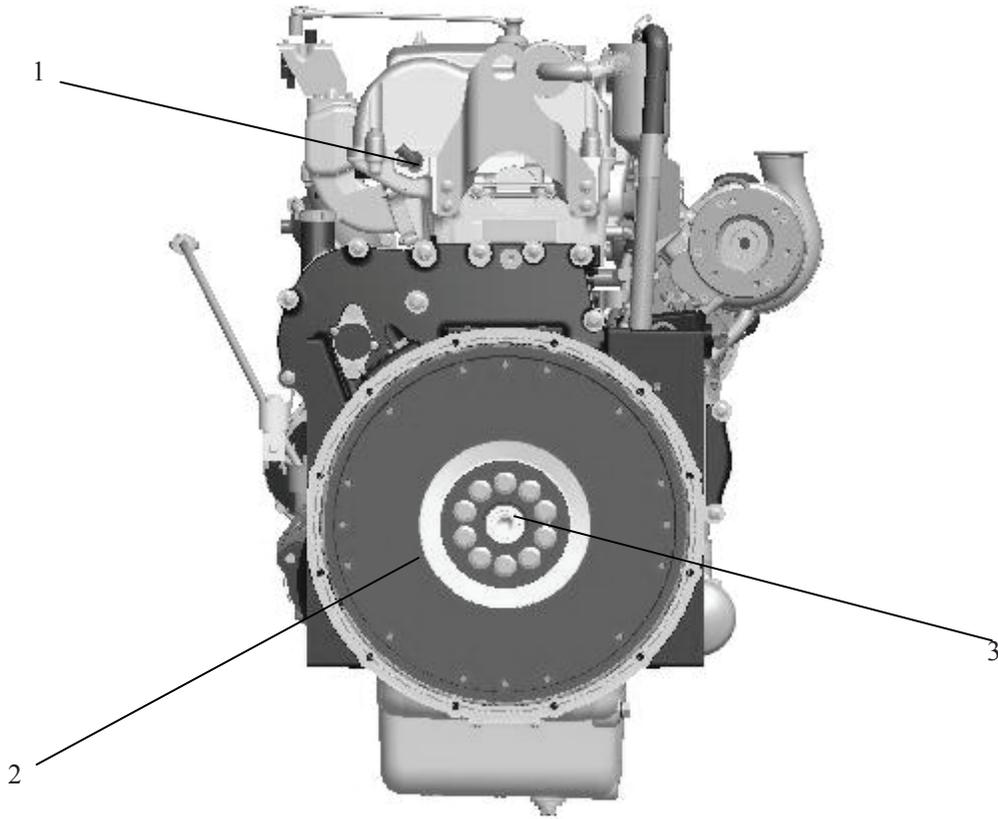
2 Fan pulley

4 Fan belt tensioner (outer)

6 Vibration damper

8 Idler pulley

10 Ignition wire



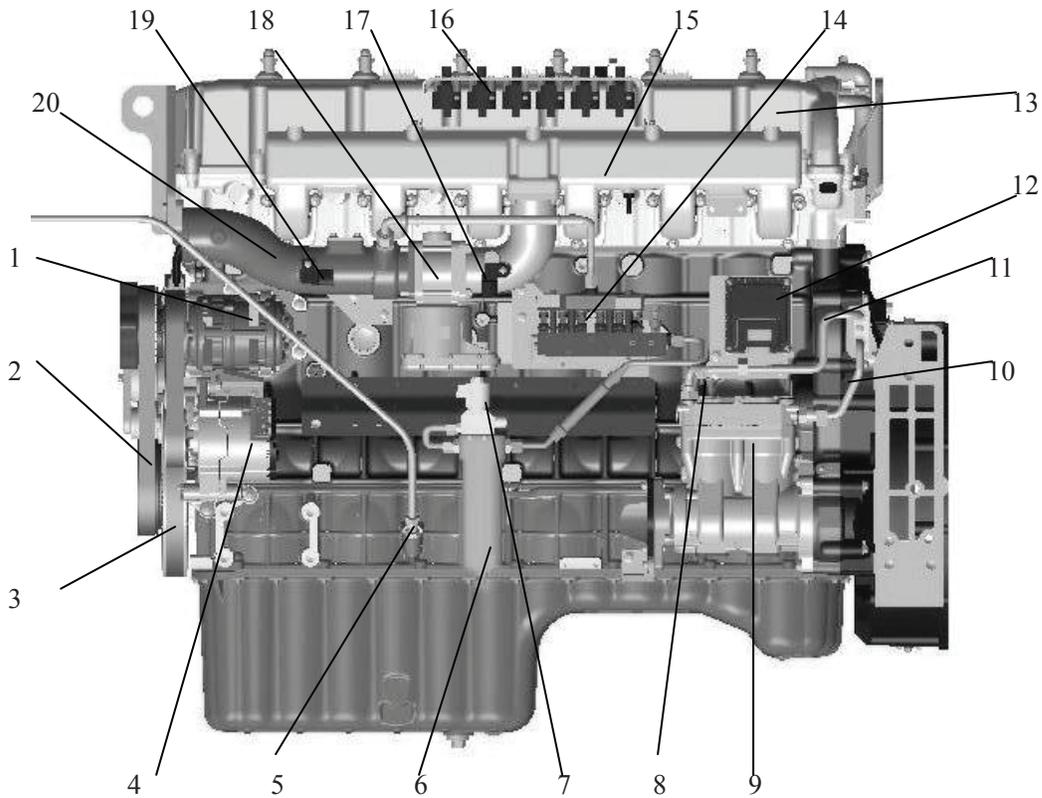
Rear End

1 Speed sensor

2 Flywheel

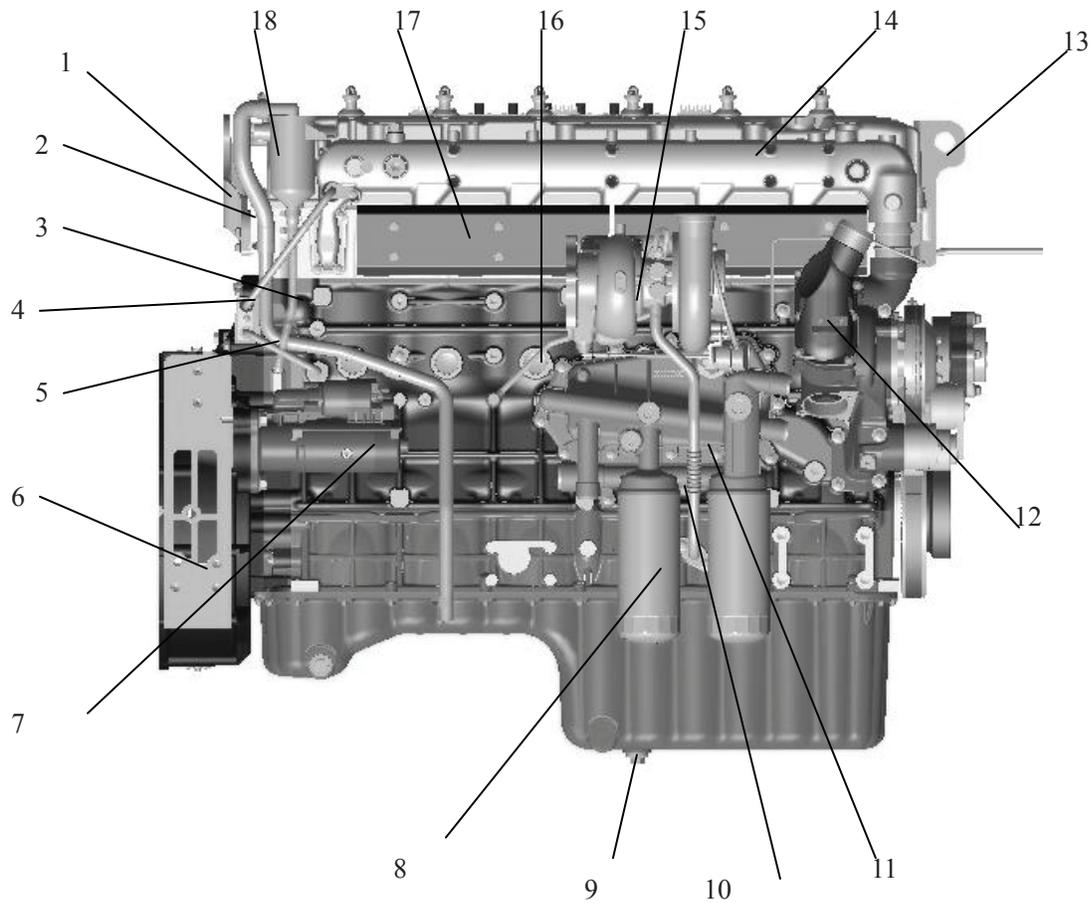
3 Roller bearing

2.1.2 SC12ET natural gas engine (12L)



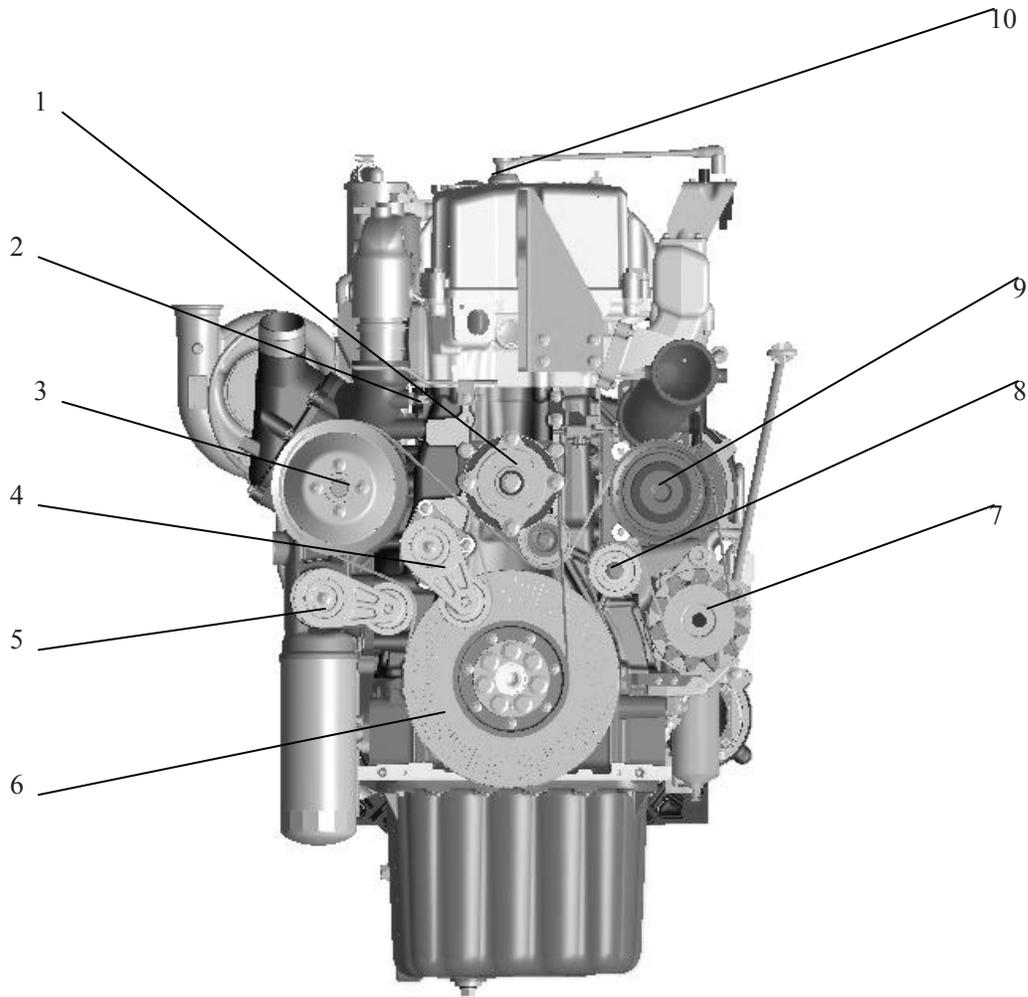
Intake Side

- | | |
|-----------------------------------------------|-----------------------------------------|
| 1 AC Compressor | 2 Fan belt (Outer) |
| 3 Drive belt (Inner) | 4 Alternator |
| 5 Oil dipstick | 6 Low pressure gas filter |
| 7 Low pressure gas shut-off valve | 8 Oil pressure sensor |
| 9 Air compressor | 10 Air compressor water outlet pipe (1) |
| 11 Air compressor water inlet pipe (2) | 12 Ignition module |
| 13 Valve cover | 14 Fuel metering valve |
| 15 Intake manifold | 16 Ignition coil |
| 17 Intake air temperature and pressure sensor | 18 Electronic throttle |
| 19 Intake air pressure sensor | 20 Gas mixture inlet pipe |



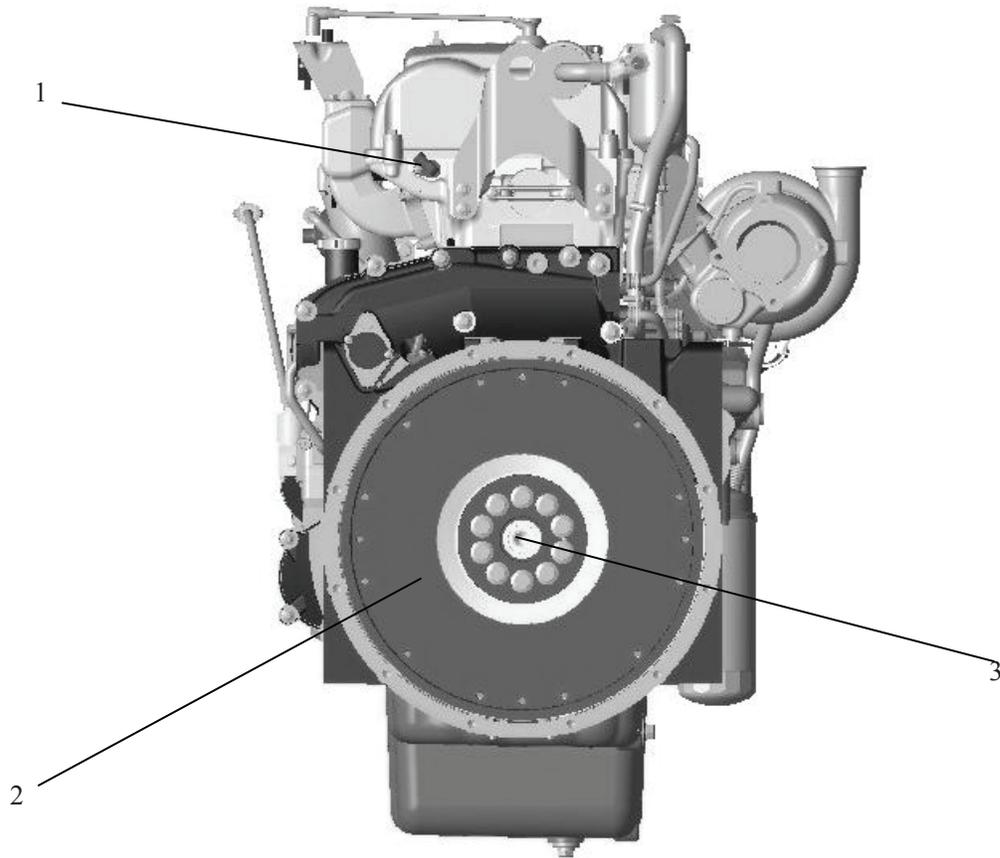
Exhaust Side

- | | |
|----------------------------------------|---------------------------------------|
| 1 Rear lifting ring | 2 Oil separator gas outlet pipe |
| 3 Oil separator oil return pipe | 4 Air compressor water inlet pipe (1) |
| 5 Air compressor water outlet pipe (2) | 6 Flywheel housing |
| 7 Starter motor | 8 Oil filter (2 Pcs) |
| 9 Oil drain plug | 10 Turbocharger oil drain pipe |
| 11 Oil cooler | 12 Water pump |
| 13 Front lifting ring | 14 Engine coolant inlet pipe |
| 15 Turbocharger | 16 Turbocharger oil inlet pipe |
| 17 Exhaust manifold heatshield | 18 Oil separator |



Front End

- | | |
|-------------------------------------|------------------------------|
| 1 Fan pulley | 2 Water temperature sensor |
| 3 Water pump pulley | 4 Fan belt tensioner (outer) |
| 5 Alternator belt tensioner (inner) | 6 Vibration damper |
| 7 Alternator | 8 Idler pulley |
| 9 AC compressor pulley | 10 Ignition wire |



Rear End

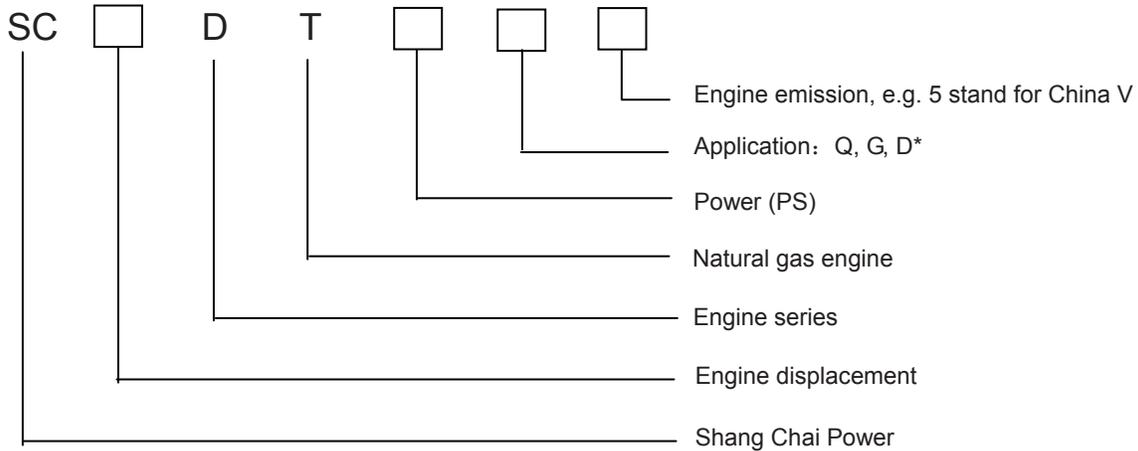
1 Speed sensor

2 Flywheel

3 Roller bearing

2.2 Engine Model Identification

The model represents the meanings as follows:



* Q stands for vehicle, G off-road equipment, D generator set.

For example: SC12ET390Q5 stands for Shang Chai E series four-valve vehicle natural gas engine of 12 liters with power of 390 PS and compliant with China V

2.3 Engine Nameplate

The engine nameplate indicates the main technical data and information: model, order number, serial number, date of manufacture, rated power and rated speed, which are the major basis for you to purchase service parts and for SDEC to conduct after-sale technical service. We hope you to put the information and data into the daily record of work of your engine or equipment for later repair and reflection of quality problems, which are helpful to the correct settlement of your problems. The nameplate locates at the side of the intake manifold. Protect it from being damaged.

	产品名称 PRODUCT NAME	天然气发动机		标定转速 RATED SPEED	r/min	许可证号 LICENCE NO.		
	型号 MODEL			标定功率 RATED POWER	kw	出厂日期 DATE	净质量 NET WT	kg
	机号 SER.NO.			燃料 FUEL	限于使用高热热量范围的天然气 ONLY FOR USE WITH NATURAL GAS RANGE H		执行标准 EXECUTED STANDARD	
	订货号 ORD.NO.			型式核准号 TYPE-APPROVAL NO			排放阶段 EMISSION LIM.	
	中国上海柴油机股份有限公司制造				MADE IN SHANGHAI DIESEL ENGINE CO., LTD. CHINA			

Note: Do not change the nameplate without our permission!

2.4 Specifications and Parameters

2.4.1 Specifications

Engine		SC10ET	SC12ET
Total displacement/L		10.4	11.8
Type		In-line, four-stroke, water-cooled, electronic-controlled	
Bore/mm		128	
Stroke/mm		135	153
Number of Cylinders		6	
Number of valves of each cylinder		4	
Compression ratio		10.5:1	
Firing order (Viewed from the free end)		1-5-3-6-2-4	
Aspiration		Turbocharged and charge air intercooled	
Crankshaft rotation (facing flywheel)		Counterclockwise	
Starting mode		Electric	
Dry weight/kg *		1000	1090
Dimension (basic model) **	Length/mm	1360	
	Width/mm	815	
	Height/mm	1168	

* The dry weight does not include the weight of starter motor, alternator, air compressor, power steering pump, clutch, coolant and oil but includes the weight of flywheel and flywheel housing according to DIN 70020.

** Outline dimensions listed above refer only to the basic engine model and those of other models are slightly different.

2.4.2 Parameters

Engine	SC10ET	SC12ET
Lubricating System		
Oil pressure/kPa		
@ Idle speed (minimum allowance)		70
@ Rated speed (minimum allowance)		350
@ Rated speed (maximum allowance)		600
Oil pan capacity/L (Oil dipstick "high-low")	35-29	41-33
Total system capacity/L	40	45
Cooling system		
Coolant capacity/L *	22	23.2
Intake-exhaust system		
Max. allowable intake resistance/kPa (@ rated condition, with dry-type air filter)	7.2 (with new filter element)	
Max. allowable exhaust resistance/kPa ** (Turbine outlet pressure @ rated condition)	15	
Electrical system		
Min. recommended battery capacity/Ah ***	180	
24V system	24	
Battery current of at -18°C for cold starting /CCA	950	
Starting motor		
Voltage/V	24	
Power/kW	6	
Alternator		
Voltage/V	28	
Current/A	70	

* Coolant capacity only refers to the coolant volume in the engine cooling system.

** The value does not include the resistance of the exhaust butterfly valve.

*** The capacity of battery should be properly increased for starting with higher requirement.

3 Engine Operation

Proper use of your engine can not only keep it in normal working order and good performance, but also extend its service life and reduce its operational cost. Adopt proper natural gas, oil and coolant, as well as the correct operation steps stipulated in this section.

3.1 Lubricating oil

Lube oil of good quality dedicated for natural gas engine should be used for the engine in all seasons. The quality grade of the oil is equivalent to CF 15W-40. It is recommended to use a dedicated lube oil of Shanghai Diesel Engine Co., Ltd.

There are two volume package are available. The part number of 18 liters is Y/1511000005 and that of 4 liters Y/1511000006.

3.2 Coolant

In order to ensure a normal operation and long service life of the engines, use SDEC- designated special organic coolant (anti-freezing type) in any climate. The coolant is proven to be of antifreeze, anticorrosion, good thermal conductivity, performance stability, and environmental friendliness.

Name	Part No.	Freezing point/°C	Boiling point/°C
SDEC-designated special organic coolant	F/LQY-45	-45	108

3.3 Engine Start

Before using the engine, choose proper lubricating oil and coolant according to actual ambient conditions. Besides, the following work should be done before starting the engine:

- Make a surround inspection of the engine and its starting system, and solve problems in time if any.
- Check oil pressure and coolant temperature gauges, gas volume indicator, warning lights and other instruments for normality.
- Check the malfunction indicator lamp (MIL) for being in normal working condition.
- Check the service indicator of the air filter for appearance of red piston.

△Caution: Do not to start the engine without an air filter to avoid early engine wear.

- Check the oil level for being within the specified range.
- Check the coolant level for being within the specified range.
- Check the electrolyte level for being within the specified range.
- Check the electric starting wires for normality.
- All the safety devices must be installed in place.
- Check the accelerator pedal for free movement.

3.3.1 Normal starting procedure

- Disengage the engine from the drive system, or put the transmission into the “neutral” position if equipped.
- Put the gas shut-off solenoid valve, eclectic switch or mechanical control device into the “running” position.
- Insert the electric key and turn the switch from the position OFF to the position ON to electrify the ECM at which the malfunction indicator lamp (MIL) comes on.

△Caution: Starting time should be no more than 15 seconds and there should be a 2-minute interval between two starts so as to prevent the damage to starter motor.

Each starting usually lasts 2 -3 seconds. If the engine cannot start up for three times, check the natural gas supply and

ignition systems or contact SDEC's service center.

- The switch goes back to the position ON from the position START automatically after the engine has started up.

△Caution: The oil pressure gauge should show reading within 15 seconds after the engine has started up; otherwise, stop the engine immediately to prevent damage to the engine and find the causes and remove the problem according to Section 7 Troubleshooting Guidelines.

- Having started up from a hot state, the engine should run at idle for 1-3 minutes before being accelerated and loaded gradually.

- Having started up from a cold state, the engine should run at idle for 3-5 minutes. Increase the engine speed slowly to have every bearing adequately lubricated and oil pressure stable. Gradually accelerate and load the engine after oil pressure is stable.

- Check the instruments for operational conditions during the engine running at idle.

△Caution: Do not accelerate and load the engine immediately after it has started up.

△Caution: OEM provides a hand gas shut-off valve for each vehicle. It is very important to know the location of the valve and how to operate it for emergency or for conducting repair to the engine, vehicle or equipment.

△Caution: If the engine is started by a jumper cable, parallel connection of the cable should be adopted by connecting the positive pole to the positive terminal and the negative pole to the negative terminal. If the engine is started by external power supply, the circuit breaker should be set to the position OFF. Take out the key before connecting the jumper cable to prevent accidental activation.

▲Warning: Do not operate the gas engine in a place where there is or may be flammable gas, for the gas may enter the air intake system of the engine, which can cause the engine to speed up or overspeed, thus leading to fire, explosion or serious engine damage.

3.3.2 Starting after a long-time stop or lubricating oil replacement

If the engine hasn't been used for more than 30 days or its lube oil has just been replaced, it is necessary to check the oil level first for being within the range of the level marks in the dipstick before starting. And then start the engine as per the Normal Starting Procedure.

3.4 Engine Operation

Cautions for operation of the engine:

- Pay frequent attention to the oil pressure, coolant temperature and malfunction indicator lamp (MIL). In case of any abnormality, stop the engine immediately for inspection.

- When engine overheating starts to happen that is indicated by the coolant temperature alarming, reduce engine speed or load, or take the both actions until the coolant temperature falls down into the normal range; otherwise, find the cause and remove the fault as per Section 7 Troubleshooting Guidelines.

- When driving down a steep slope, the transmission gear and brake should be used simultaneously to control the vehicle speed and engine speed; when driving up a steep slope, a proper gear must be chosen to prevent the vehicle from rushing on the slope.

△Caution: Over-speed running will cause serious damage to the engine.

- Proper lubricating oil and coolant must be used for the engine when it runs in an extremely cold area.

There are significant signs before most engine faults occur, such as changes in performance, sound, or engine appearance. Listening and observing will help to detect in advance or predict some problems of the engine that will occur later, with which the proper measures can be taken in time to eliminate such problems as would lead to a serious engine failure.

Typical engine fault signs:

- MIL flickers;
- Engine misfires;

- Engine vibrates abnormally;
- Engine sounds abnormal;
- Engine coolant temperature and oil pressure change abruptly;
- Engine power output is insufficient;
- Lubricating oil consumption is too much;
- Gas consumption is too much;
- There is leakage of oil, gas or/and coolant.

3.5 Engine Shutdown

If the engine has just worked at a high speed and heavy load for a long time, reduce its load and speed gradually and run it at idle for 3-5 minutes before shutting it down to let the engine cool down evenly and let the turbocharger speed fall considerably so as to protect the engine and turbocharger. For vehicle application, never stop the vehicle in such way as accelerating first, stopping and then sliding. Turn the switch from the position ON to the position OFF and take out the electric key after the engine has stopped.

If the engine will not be used for a period of time, keep it properly. Refer to Section 8 for engine storage.

3.6 Running-In of a New or Overhauled Engine

Before running a new or overhauled engine in full load condition, run it for 60 hours or about 2,000 km in running-in condition and change its oil thereafter to improve its moving parts working condition and its reliability and service life. The way of running-in varies from one engine application and loading manner to another. In principle, engine speed and load in running-in process will be increased gradually with the running-in going on. Load should be 50%-80% of its full one, and speed should not exceed 80% of its rated speed.

Do not run the engine at idle or with low load for a long-time either in running-in period or normal working period thereafter. Continuous running at idle is usually not longer than 5 minutes to avoid early engine wear due to carbon deposit or engine performance being affected.

4 Engine Maintenance

4.1 Maintenance Plan

The following table gives maintenance intervals and tasks. Make regular maintenance based on this table. If the engine frequently operates at the ambient temperature below -18°C or above 38°C, or in dusty environment or under a stop-and-go condition, the maintenance period should be shortened properly.

Maintenance tasks	Daily	Every 10,000 km or 250 h or 3 months	Every 20,000 km or 500 h or 6 months	Every 40,000 km or 1,000 h or 12 months	Every 80,000 km or 2,000 h or 2 years
Checking engine periphery	●	●	●	●	●
Checking air filter service indicator	●	●	●	●	●
Checking malfunction indicator lamp (MIL)	●	●	●	●	●
Checking oil level	●	●	●	●	●
Checking coolant level	●	●	●	●	●
Checking electrolyte level	●	●	●	●	●
Checking drive belt*	●	●	●	●	●
Checking cooling fan	●	●	●	●	●
Checking natural gas supply system	●	●	●	●	●
Checking electrical system	●	●	●	●	●
Removing dirt in low pressure gas filter		●	●	●	●
Checking engine wiring harness		●	●	●	●
Checking intake system		●	●	●	●
Replacing lubricating oil and oil filter		●	●	●	●
Checking or replacing spark plug		●	●	●	●
Checking or replacing ignition wire		●	●	●	●
Checking or replacing low pressure gas filter element		●	●	●	●
Cleaning gas injection valve		●	●	●	●
Replacing high and low pressure gas filter elements			●	●	●
Checking and adjusting valve clearance			●	●	●
Checking air filter element			●	●	●
Checking intercooler and its lines			●	●	●
Checking belt tensioner**				●	●
Checking fan bearing					●
Checking turbocharger					●
Checking vibration damper					●
Checking air compressor					●
Replacing coolant					●
* The drive belt must be replaced when it has crack or defect(s) that affects its use.					
** The belt tensioner must be replaced when its pulley doesn't rotate freely.					

Note: The maintenance intervals in this table are in kilometer, hour, or month, whichever comes first.

4.3 Tasks and Methods of Engine Maintenance

Checking engine periphery

Check the periphery of the engine each time before starting:

- Check if the engine is in clean state and free from useless things on it.
- Check the joints and connections of gas system, cooling system and lubricating system for leakage.
- Check if the fan and its safety guard are fastened in place.
- Check the fastenings condition of the accessories.
- Check the electrical circuits for looseness and the wires for being intact.
- Check the drive belt for being intact.

Checking air filter service indicator

Check the maintenance indicator of the air filter everyday. If the viewing window shows the red piston, it represents that the intake resistance of the air filter exceeds the specified value, and the filter element requires to be replaced. Press the button on the top of the service indicator for reset after the replacement.



△Caution: Be sure that both end faces of the air filter are reliably sealed without leakage after the air filter element is changed.

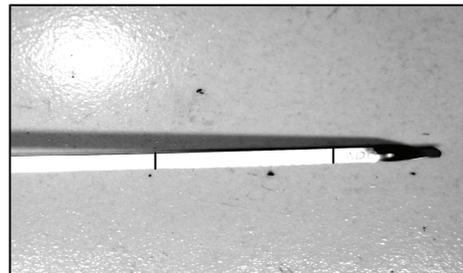
△Caution: Do not start the engine without an air filter, and failure to do so would easily cause early engine wear.

Checking malfunction indicator lamp (MIL)

Check the MIL daily before starting the engine. Turn the switch from the position OFF to the position ON. If the lamp comes on, it indicates that the MIL is in good order; otherwise there is a lamp problem or other faults. The MIL should go out when the engine is in start or operation, otherwise there is a fault with the ECM.

Checking oil level

Check the oil level daily before starting the engine or the engine is in stop (at least 10 minutes after the engine has stopped to provide enough time for oil to flow back to the oil pan). The oil level should be between the upper mark (high oil level) and lower mark (low oil level). If oil is not enough, supplement it. The oil volume difference between the upper and lower marks is about 6 L for SC10ET engine (10L) and 8 L for SC12ET engine (12L).



△Caution: Do not run the engine when the oil level is below the lower mark, otherwise it can result in poor engine performance, or even damage to the engine. But the oil level should not exceed the high level mark.

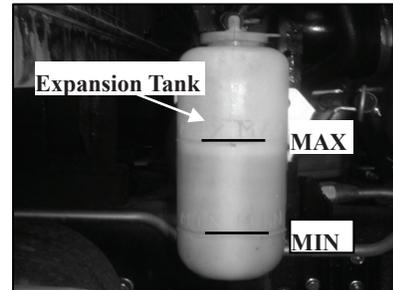
Checking coolant level

▲Warning: Avoid skin or eye contact with coolant to prevent personal injury for coolant contains alkali.

▲Warning: At operating temperature, engine coolant is hot and under pressure, and the steam can cause personal injury. Do not remove the pressure cap on the radiator until the engine stops and the coolant temperature drops to below 50°C. Slowly loosen the cap to release the system pressure before checking the coolant level or making supplement.

For vehicle application

Check the coolant level daily. It should remain between the marks MAX (high level) and MIN (low level) in the expansion tank, and add it if necessary. Coolant should be added near the upper mark (MAX). Before adding, wait until the coolant temperature drops to below 50°C and then slowly loosen the cap to release the system pressure.



For non- vehicle application

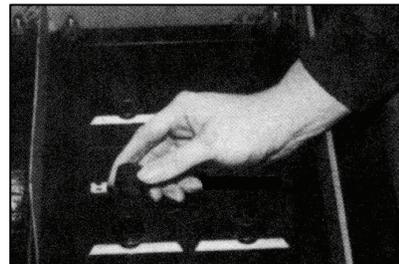
- (1) (1) Before starting the engine or after the engine has stopped and the coolant temperature has fallen below 50°C, slowly loosen the pressure cap (the coolant filler cap) on the radiator to release the system pressure.
- (2) Remove the pressure cap and check coolant level daily from the inspection port. The coolant level should remain between the marks in the radiator or expansion tank, or meet the requirement of the equipment manufacturer.
- (3) Add if necessary. Coolant should be added near the upper mark or meet the requirement of the equipment manufacturer.

△Caution: Coolant should be added slowly to avoid air block.

Checking electrolyte level

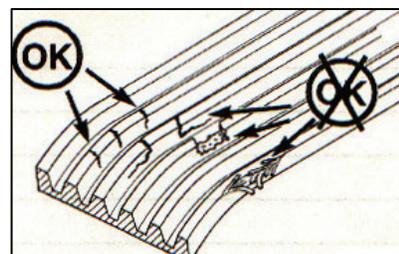
Batteries that are not maintenance-free need electrolyte level checking.

- (1) Check the electrolyte level before starting the engine. Remove the filler cap and check the electrolyte level. It should be at the bottom of the filler port. Add it as required.
- (2) Install the cap.



Checking drive belt

Perform visual check on the drive belt everyday for any intersecting cracks. Transverse cracks along the width direction of the belt are acceptable, while longitudinal cracks (along the length direction) that intersect with transverse cracks are not allowed. If any wear or abrasion occurs on the belt, replace it.



Checking cooling fan

Perform visual check on the cooling fan for crack or any other defect. The fan should be installed reliably. Tighten the fastening bolts (55-65 N·m) or replace the damaged fan if necessary.

▲Warning: Damaged fan blades can cause serious personal injury. Do not pull or pry the fan, and never rotate the engine crankshaft with the fan.

Checking natural gas supply system

Check daily the gas supply system for leakage and check the heating water circulation of the gas supply system (pressure regulator and heat exchanger) for normality. The gas supply system includes high pressure gas tank, hand gas shut-off solenoid valve, high and low gas filters, high pressure gas shut-off valve, pressure regulator, heat exchanger, gas thermostat, gas metering valve and mixer. The gas metering valve and mixer are installed on the engine, and the rest on the chassis of vehicle. When smelling gas, make leakage check. Use liquid with high surface tension to check whether all the connections are sealed properly. If any leakage is detected, check the pipe joints for looseness and tighten them to the required torque if necessary. If this does not work, discharge the gas as required, and then remove the joints to check the O-rings condition. Make replacement when required.

Checking electrical system

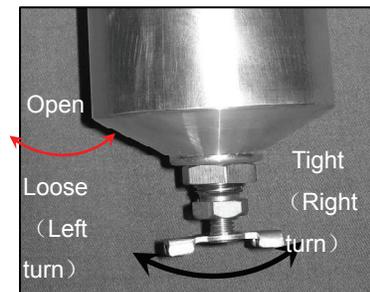
Check daily the battery power wire and cylinder block grounding wire carefully for reliable connection. Loose power wire connection will damage the electronic control system.

Discharging dirt in low pressure gas filter

Gas quality has a big impact on engine performance and poor gas can even damage to the engine in some extreme conditions.

Loosen the switch, drain deposit and then tighten the switch.

△Caution: The content of hydrogen sulfide in gas should not exceed 30 ppm. Long time use of high sulfide gas will lead to corrosion to heat exchanger and thermostat.



Checking engine wire harness

Perform visual check on the engine wiring harness for broken, abrasion, looseness, exposure and burn.

Checking intake system

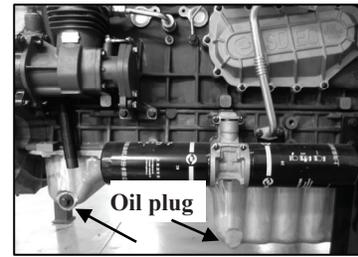
Check the intake hoses for any crack, as well as perforation, and clamps for looseness. Replace the hose(s) if any fault is found, and tighten the clamp screws if looseness is found to ensure the intake system free from leakage.

Replacing lubricating oil and oil filter

▲Warning: Be careful when replacing lubricating oil and oil filter because skin contact with hot oil or hot engine surface can cause scald.

(1) Don't stop the engine until the temperature of coolant reaches 60°C, then remove the oil drain plug, scrap the washer and drain the lubricating oil.

Note: There are two oil drain plugs for some engine models: one on the bottom of the large oil pan, the other on the side of the small oil pan.



△Caution: Do not drain lube oil when the engine is in cold-state at which foreign particles has deposited and attached to the bottom of the oil pan, and will not drain with the oil. When the lube oil is warm, foreign particles suspend in it and can easily drain with it.

(2) Clean the installation surface of the oil drain plug on the oil pan. Fit the drain plug with a new washer and tighten it to 80 N·m.

(3) Clean the periphery of the oil filter heads. Remove the oil filters with tool and scrap them.

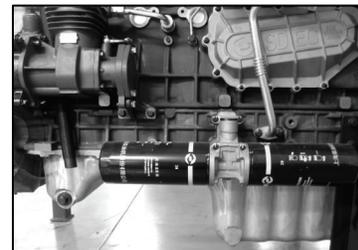
(4) Clean the seal faces of the filter heads, and there should be no old O-ring left.

(5) For the SC12ET engine, fill the filters with clean lube oil from the 8 peripheral holes before installation. The oil level should be 3-15 mm below the threaded hole. Apply a light film of Vaseline or clean lube oil to the O-rings on the new filters to form a lubricating film.



△Caution: Do not add oil from the central hole of a filter.

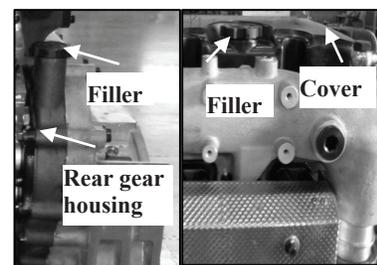
For the SC10ET engine, only apply a light film of Vaseline or clean lube oil to the O-rings on the new filters to form a lubricating film.



(6) Turn the filters by hand until the O-rings contact the seal surfaces of the filter heads, and further tighten them to 38 - 42 N·m with tool. For the SC10ET engine, it is required to use a special too to tighten the filters.



(7) Open the filler cap, and fill the engine with clean lube oil until the oil level is near the upper mark in the oil dipstick (high level).



Lubricating system capacity	
40 L (SC10ET)	45 L (SC12ET)

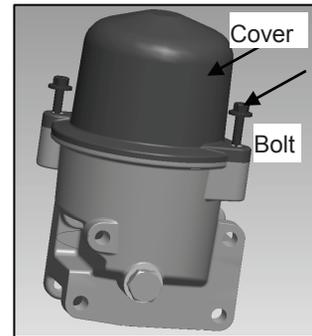
- (8) Start the engine and keep it running at idle, and then check the oil filter and drain plug for oil leaks.
- (9) Shut off the engine, wait for about 10 minutes to provide enough time for the oil to flow back to the oil pan, and check the oil level. If required, add engine oil until it is near the upper mark in the oil dipstick (high oil level).
- (10) Install the filler cap and tighten it until you feel suitable.

Replacing oil centrifugal filtration spool

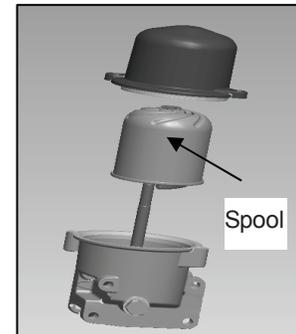
Oil centrifugal filtration spool should be replaced with the replacement of oil and oil filter if the engine is equipped with it.

- (1) Shut down the engine and make sure the oil centrifugal filtration completely stops operation before replacement.
- (2) Wait until the engine cools down without hot felt with hand. Loosen two locking bolts below the cover with tool and remove the cover.

△Caution: Check the O ring and replace it if damaged.



- (3) Raise the spool along the axial of the filtration and drain the oil in it. Remove the spool along the axial. Be sure not to damage its bearing.
- (4) Install a new spool and check it for free spin.
- (5) Install the O ring and the cover. Tighten the bolts.
- (6) Start the engine and let the oil centrifuge filtration operate. Check the all joints for leakage.



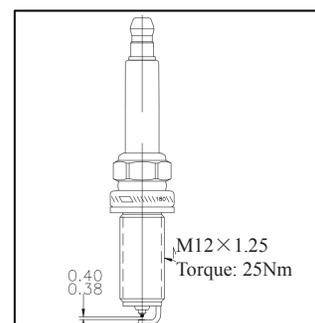
Checking and replacing spark plug

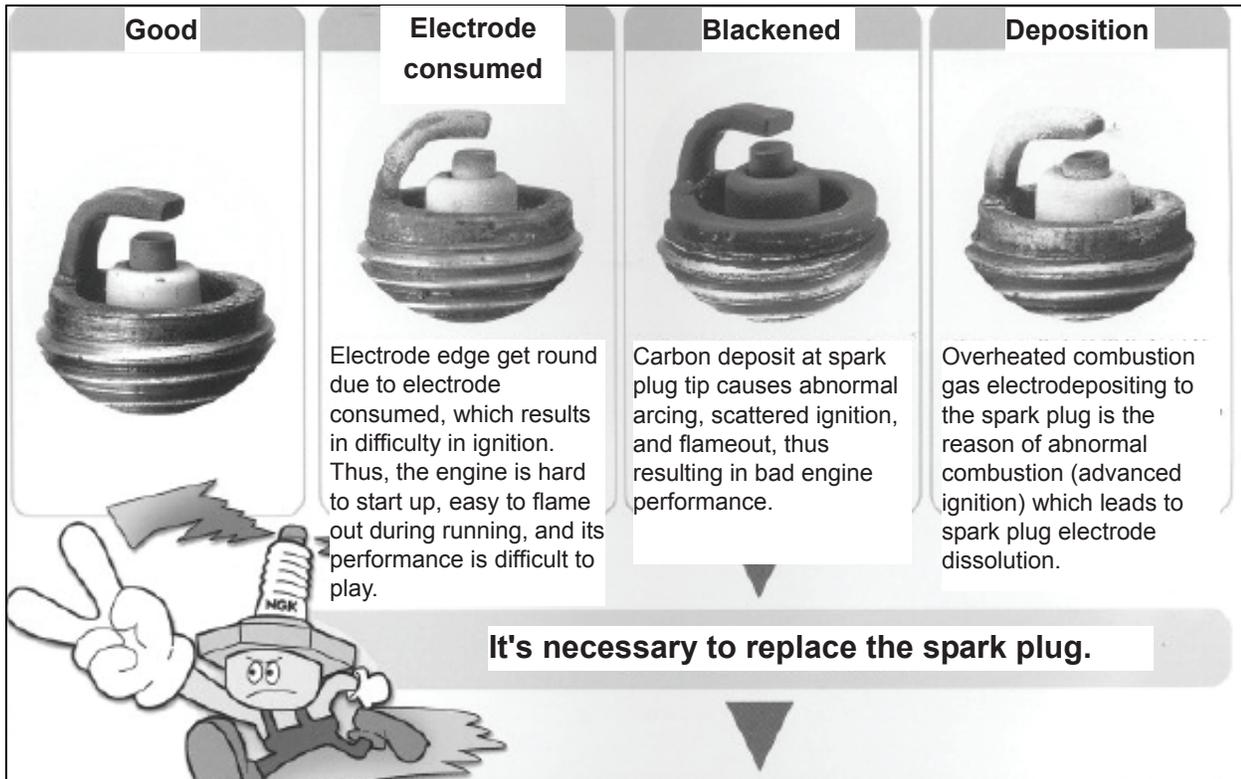
Removal

Remove the spark plug to be replaced when the engine is not in operation, Remove the wire from the coil end and then from the spark end before removing a spark plug. Use a special tool to remove a spark plug.

Check

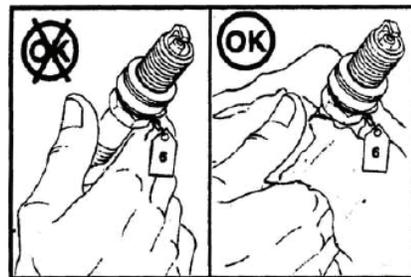
Check the plug electrode for erosion, damage and burn. Measure the clearance by a feeler gauge. The clearance should be within 0.38- 0.4 mm.





Installation

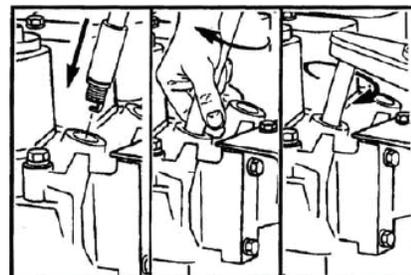
Pay attention to the plug sleeve and make sure to keep it free from dirt and oil.



Do not touch the ceramic body of the spark plug by hand when installing it. Use a torque wrench to install the plug and tighten it by torque of $25 \pm 2 \text{ N}\cdot\text{m}$.

△Caution: Over-tightening will damage the spark plug and cylinder head.

△Caution: Only special NGK spark plug (double platinum aurum, iridic gold) can be used for the engine.



Checking and replacing high-voltage ignition wire

Check

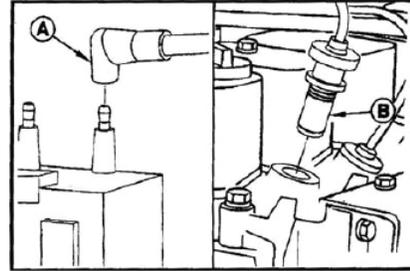
Check visually if high-voltage ignition wire(s) is aged, cracked, worn, naked or burned-out. Replace the wire(s) with problem if necessary.

Removal

(1) Remove a wire at the coil end (A), and then at the spark plug end (B).

Note: To avoid confusion, only one high-voltage ignition wire shall be replaced at a time. When removing a wire from the coil and spark plug, pull up the wire back and forth.

△CAUTION: To avoid damage to a high-voltage ignition wire, do not pull it during replacement.



Installation

Firmly push down the casing of wire till a pop is heard and feel that the casing is installed to the spark plug. Then install the other end to the coil terminal. Check if all high-voltage wires are at the same height after installation.

Checking or replacing low pressure gas filter element

The gas filter element replacement time is based on gas quality. A filter element must be replaced every 6 months.

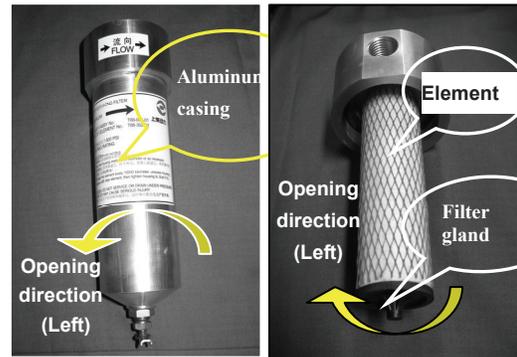
Removal

(1) Stop the engine. Close the main gas supply valve, and empty the gas line.

▲Warning: Don't perform maintenance or drainage dirt when the valve is open.

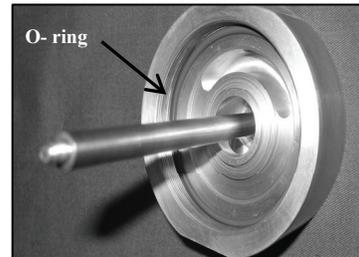
(2) Unscrew the drain valve with your hand. Drain off impurities in the housing, and then tighten the drain valve with hand.

(3) Remove the filter element with a proper tool. Check the filter element, and replace it if necessary.

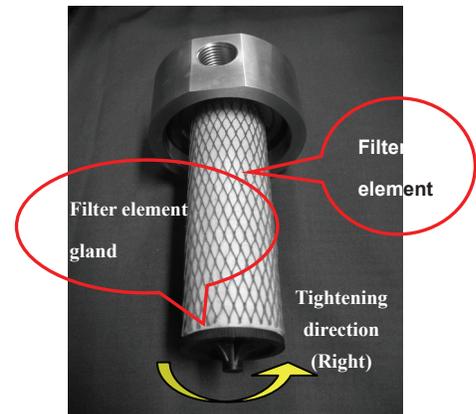


(4) Remove the O- ring on the upper casing, and replace it with a new one (enclosed in the service filter element package).

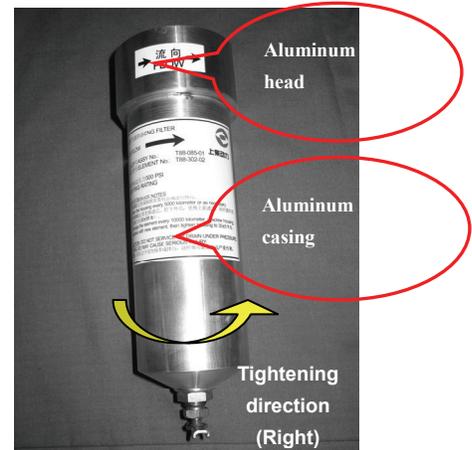
△Caution: The seal ring must be completely fitted into the slot; otherwise it will cause O-ring damage and gas leakage.



(5) Install the filter element or a new one to the mounting surface. Tighten the filter element gland with hand in the direction showed.



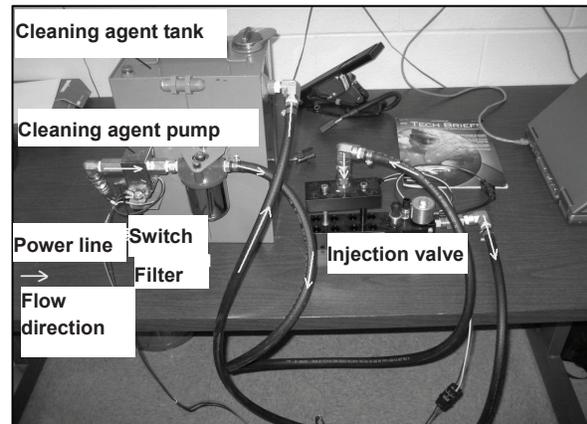
(6) Tighten the housing with a proper tool (in the direction showed) to 40 ± 7 N·m.



(7) Open the main valve of the gas line and start the engine. Use soapy water to check the joints between the aluminum head and aluminum casing as well as the thread of the drain valve for gas leakage. Make sure there is no gas leakage to let the engine work normally. If there is any gas leakage, retighten the aluminum casing or drain valve, and then perform leakage test with soapy water again.

Cleaning gas injection valve

(1) Stop the engine, and close the main gas supply valve. Remove the inlet and outlet pipes of FMV. Connect the FMV inlet to the outlet of the filter of a cleaning tool. The FMV outlet goes directly to a cleaning agent tank. Refer to the figure for connection.



(2) A battery (12 V) is required for the cleaning tool. Connect the positive and negative terminals of the cleaning agent pump to those of the battery respectively. Place a switch in the circuit to control the start and stop of the pump.

(3) Add cleaning agent to the cleaning agent tank. Cleaning agent shall be added over the neck of cleaning agent pump. The cleaning agent is normal heptane.

(4) Switch on the ignition key (do not start the engine) to supply power to the control system. Choose the injection valve cleaning mode on the computer. When the FMV nozzle is energized, it produces sound like "bang bang". Switch on the cleaning agent pump immediately after hearing the sound. The cleaning agent is pumped into FMV and then flows back to the cleaning agent tank until the FMV stops working. Repeat cleaning as per the aforesaid steps if necessary.

(5) After cleaning is completed, disconnect the inlet and outlet pipes of FMV. Firstly only install the FMV inlet pipe. Open the main gas supply valve and restore gas supply. Start the engine for 3-4 seconds. Repeat it again 5 minutes later to make gas go through the FMV and blow out the residual cleaning agent. Then install the FMV outlet pipe. Get the engine back to its normal state.

△Caution: Don't clean the FMV with corrosive cleaning agent. It's recommended to use n-butane as the cleaning agent.

Replacing high and low pressure gas filter elements

For the replacement of the low pressure gas filter element, refer to "Checking or replacing low pressure gas filter element". The replacement of the high pressure gas filter element is as follows:

Unscrew the bowl using a wrench, remove the element, and install a new one. Lubricate O-ring on the bowl with any non-petroleum based lubricant before installing it onto the head and tighten the bowl to $40 \pm 6 \text{ N}\cdot\text{m}$.

△Caution: Replacement of the filter element must not be made under pressure, or it will cause serious injury. Close the shut-off valve and slowly release the pressure in the line before the replacement.

Checking and adjusting valve clearance

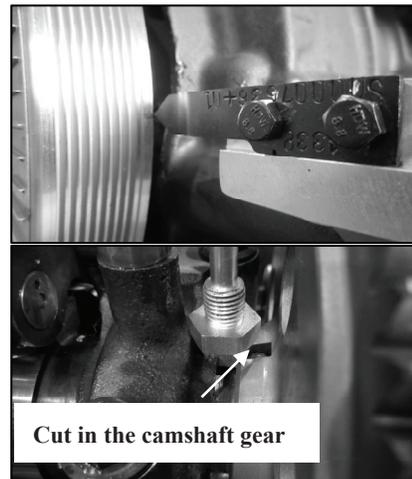
When doing the first maintenance for a new or overhauled engine, conduct valve-clearance checking to timely regulate and correct the initial changes of the valve clearances. Later valve clearance checking and regulating should be based on the maintenance plan if the engine operates normally.

Valve clearance checking should be conducted after the engine has stopped and the coolant temperature falls below 60°C .

(1) Unscrew the valve cover bolts and remove the cover.

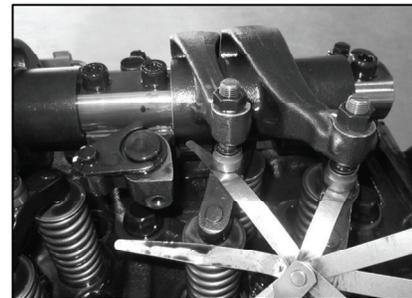
(2) Crank the engine anticlockwise with barring tool to position the first cylinder piston at the top dead center on compression stroke.

Note: When the indicator points at the mark 0 in the vibration damper and the cut in the camshaft gear faces up, the piston of No. 1 cylinder is at the top dead center on compression stroke.



(3) Check the valve clearances with feeler gauge. Check the intake valve clearance of No. 1, 2 and 4 cylinders, as well as the exhaust valve clearances of No. 1, 3 and 5 cylinders.

Note: The clearance is correct when some resistance is felt at which the feeler gauge is slipped between the valve bridge and the rocker arm.



(4) If a valve clearance fails to meet the requirement, loosen the valve clearance adjusting locknut on the corresponding rocker arm, adjust the clearance to specified value and tighten the locknut to $28 \text{ N}\cdot\text{m}$. Check the valve clearance again and it should not change.

Valve clearance:

Intake: $0.40 \pm 0.08 \text{ mm}$

Exhaust: $0.65 \pm 0.08 \text{ mm}$



(5) Mark a sign on the damper and rotate the crankshaft for 360 degrees. Follow the same steps to check and adjust the rest intake and exhaust valve clearances.

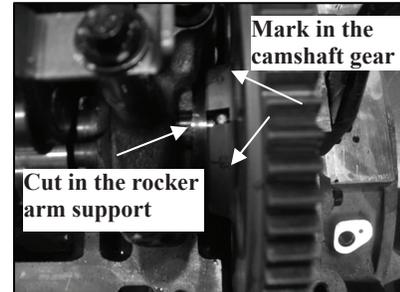
Checking/adjustment exhaust brake clearance (if equipped)

Check the exhaust brake clearance with a feeler gauge. There is a cut in the seventh rocker arm support (near the rear engine end) and number marks in the camshaft gear. When the cut is allied with number “1”, check the exhaust the brake clearance of cylinder 1; when the cut is allied with number “2”, check the exhaust brake clearance of cylinder 2 and so on.

Note: The clearance is correct when some resistance is felt at which the feeler gauge is slipped between the valve bridge and the rocker arm.

If clearance is out of the requirement, loosen the adjusting locknut on the rocker arm, make adjustment and tighten the nut to 28 N·m. Then recheck the clearance and it should not change.

Clearance: 4.25 ± 0.05 mm.



(7) Install the valve cover and tighten the cover bolts by 18 N·m.

△Caution: The cover sealing strip should be replaced if it is damaged.

Checking air filter element

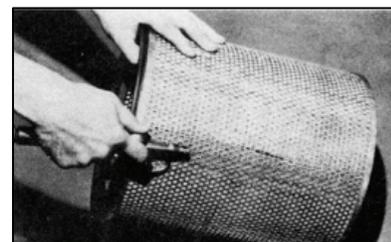
Check the air filter element for damage. Clean the element before checking. Use compressed air to clean the element.

▲Warning: The protective work should be done well before using the compressed air. The highest pressure of compressed air should be no more than 205 kPa. Do not clean the filter element with collision or strike, and check the element after cleaning. Do not use a filter element with damaged pleats, sealing gaskets or rings.

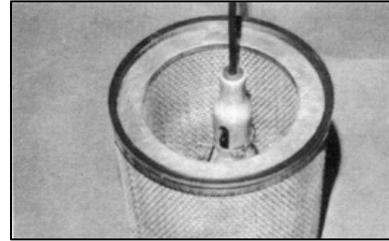
(1) Direct compressed air along the length of pleats inside of the element for cleaning.



(2) Direct compressed air along the length of pleats outside and then inside of the element for cleaning.



(3) Put an inspection lamp into the cleaned element to check it for broken holes or tears based on transmittance, and replace the element with a new one if any problem is found.



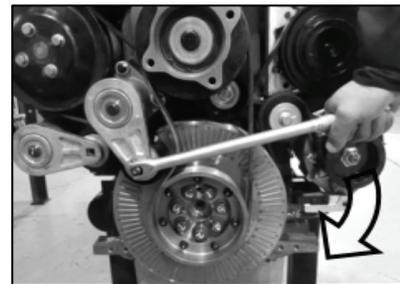
Checking intercooler and its lines

Perform visual check on the air inlet and outlet chambers of the intercooler for crack, perforation or other damages, and on the air inlet and outlet pipes for sealing-off and other damages. Replace the intercooler if necessary. Perform visual check on the hoses of air inlet and outlet pipes and water inlet and outlet pipes (water-to-air cooler) for crack and check the clamps for looseness. Replace the hose(s) if necessary and tighten the clamps.

Checking belt tensioner

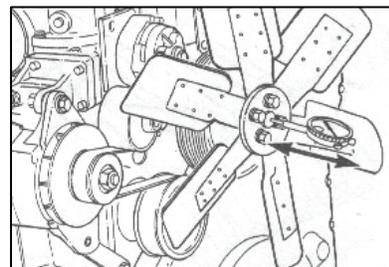
(1) Rotate the belt tensioner clockwise, and remove the drive belt. Turn the tensioner pulley to check it for seizure or radial or/and axial movement, by which to determine if there is scratch in or wear on the bearing surface of the tensioner. Swing the tensioner arm to check if the spring performs well.

(2) Install the drive belt and make a visual inspection after the installation to make sure that the belt center line is in alignment with the center lines of the pulleys.



Checking fan bearing

Rotate the belt tensioner anticlockwise and remove the drive belt. Turn the fan to check the fan bearing for normality. When rotating the fan, there should be no vibration or excessive axial movement.



Checking turbocharger

Perform visual check on turbine and compressor impellers of the turbocharger for damage, crack, or contact with their housings when a light finger pressure applied on them. And check the turbocharger shaft for not being free spinning. In case that any of the above problems occur, the turbocharger should be replaced.

Checking vibration damper

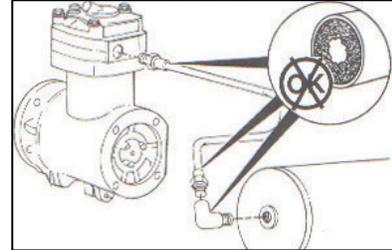
Check the vibration damper for damping fluid (silicon fluid) leak and surface dents. Also examine the thickness of damper to confirm if the damper has become deformed. In case that any of the above problems occur, the damper should be replaced.

Checking air compressor

▲Warning: Air pressure should be released from the air system before removing parts from the air compressor to avoid personal injury.

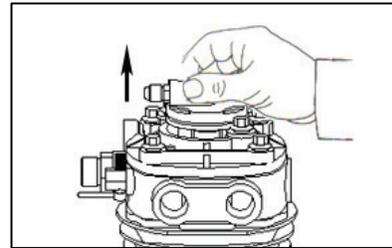
Air outlet pipe

Check the air outlet pipe and joints for carbon deposit.
Clean or replace relevant parts based on the deposit.



Air inlet unloader valve

Carefully check the unloader valve for carbon deposit. Clean and remove deposit if it is serious.
Check the air compressor head, inlet and outlet for any problems and replace them or relevant parts if necessary.



Replacing coolant

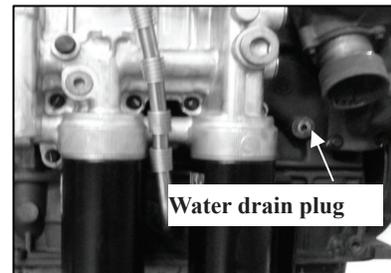
In order to ensure the engine coolant to be good in cooling and anticorrosion, the replacement of coolant is required every 80,000 km, 2,000 hours or 2 years, whichever comes first. The cooling system must be cleaned before the replacement.

▲Warning: At operating temperature, engine coolant is hot and under pressure, and coolant steam can cause personal injury. Do not remove the pressure cap on the radiator until the engine stops and coolant temperature goes below 50°C. Slowly unscrew the pressure cap to release the cooling system pressure.

▲Warning: The anti-rust additive in the coolant contains alkali. Avoid skin or eyes contact with coolant to prevent personal injury.

(1) Stop the engine and wait until the temperature of coolant falls to below 50°C. Slowly unscrew the pressure cap to release pressure and remove the cap. Loosen the drain cock on the radiator to completely drain the coolant in the radiator.

(2) Unscrew and remove the water drain plug on the engine, and completely drain the coolant in the cooling system. Loosen the water drain cock on the air compressor and completely drain the coolant in it.



(3) Clean the cooling system according to the following steps.

(a) Install and screw up all the drain cocks and plug, and add the sodium carbonate solution (or the mixture of sodium carbonate and water that is available in market) into the cooling system from the coolant filler.

△Caution: Each 23 L of water should be mixed with 0.5 kg sodium carbonate. Do not use caustic cleaner, or it will do harm to aluminum parts.

△Purge the air in the coolant system while adding the cleaning fluid. Pour the cleaning fluid slowly to avoid air block. Cleaning fluid should be added up to the bottom of the filler in the radiator and wait for about 3-5 minutes for a full purge of air.

(b) Start the engine and keep it running for 5 minutes after the cleaning fluid temperature goes up to above 80°C, then stop the engine and completely drain the cleaning fluid in the cooling system.

△Caution: During the whole cleaning process the pressure cap should not be on and the engine runs without the cap on.

(c) Add clean water into the cooling system.

△Caution: Pour clean water slowly to avoid air block. Clean water should be added up to the bottom of the filler in the radiator and wait for about 3-5 minutes for a full purge of air.

(d) Start the engine and keep it running for 5 minutes after the water temperature goes up to above 80°C, then stop the engine and completely drain the clean water in the cooling system.

△Caution: If the discharged water is still dirty, clean the cooling system again according to the aforesaid steps until discharged water becomes clean.

(4) Tighten the water drain cock on the radiator after cleaning. Apply Loctite 515 sealing glue to the water drain plug on the engine and tighten it to 25 N·m.

(5) Add coolant. Fill the cooling system with the specified coolant, and the total volume is as follows.

Engine coolant capacity	
22 L (SC10ET)	23.2 L (SC12ET)

△Caution: Engine coolant capacity listed above refers to the coolant volume in the engine cooling system. The actual amount should refer to the vehicle or equipment data.

△Caution: Add coolant slowly to avoid air block. Coolant should be added up to the bottom of the filler in the radiator or meet the requirement of vehicle or equipment manufacturer. Wait for about 3-5 minutes for a full purge of air.

(6) Install the pressure cap on the radiator, start and run the engine until coolant temperature goes up to 80°C, then stop the engine and check the cooling system for leakage.

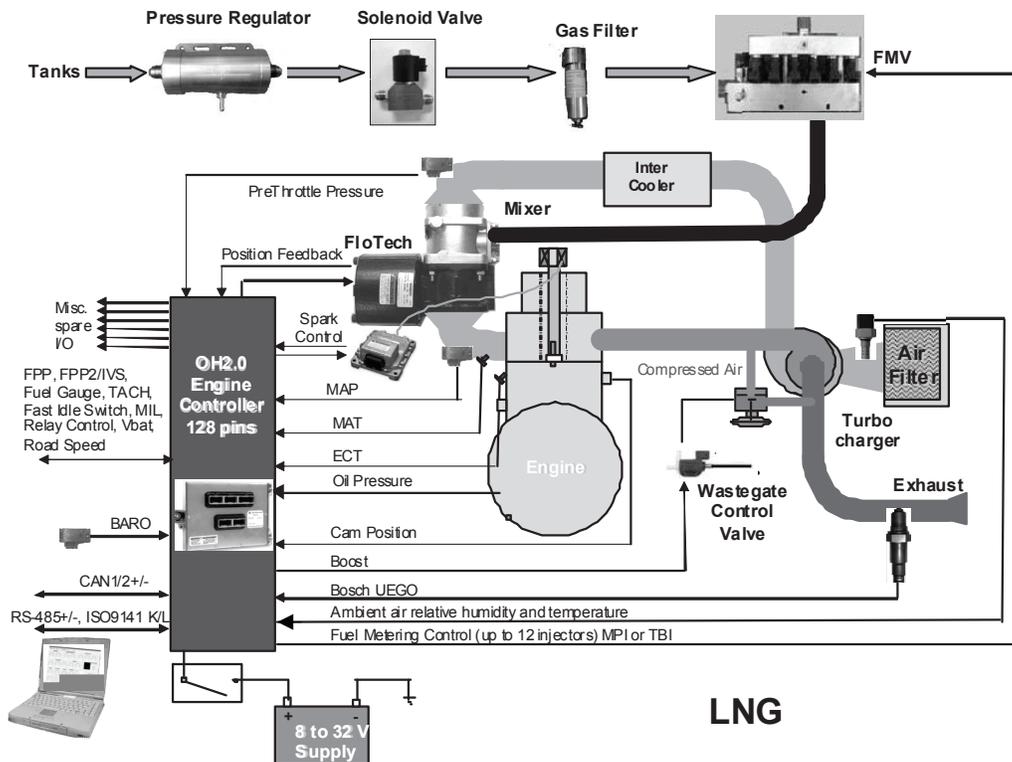
(7) Stop the engine and wait until the coolant temperature falls to below 50°C. Then open the pressure cap and recheck the coolant level. Supplement properly, if necessary.

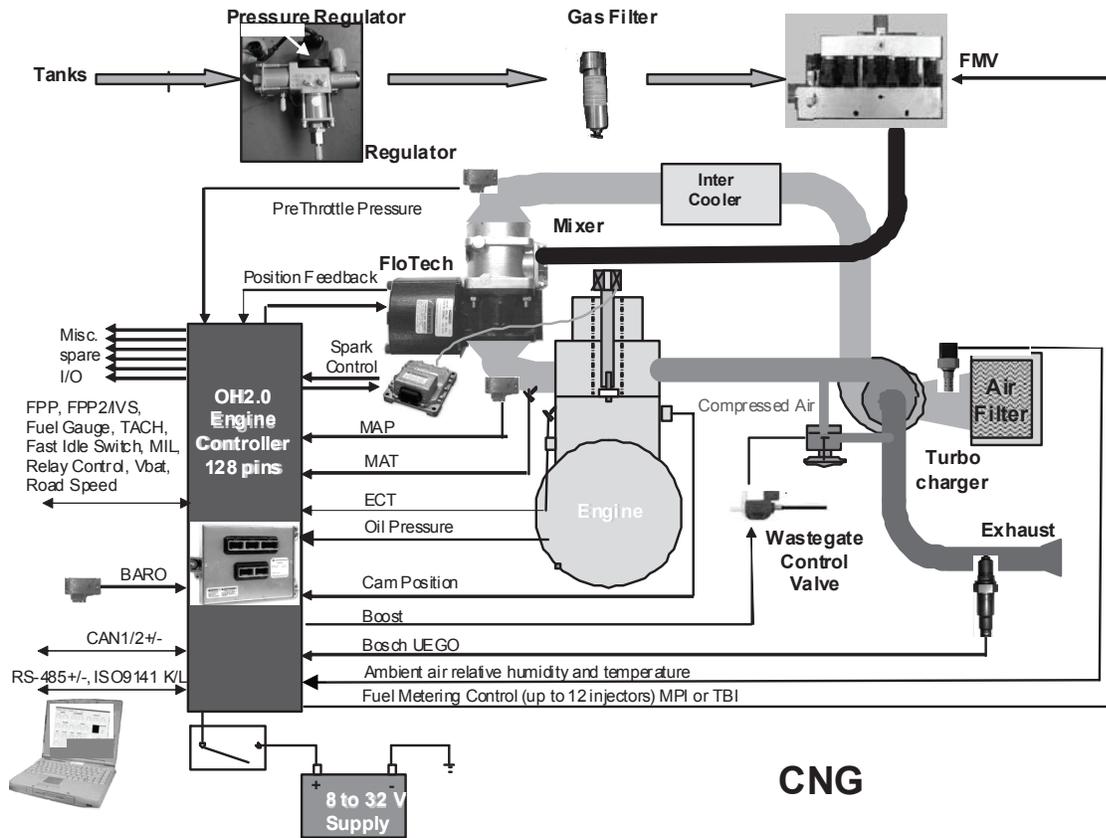
5 Engine System and Dedicated Components

5.1 Abbreviation

CNG	Compressed natural gas	MAP	Absolute pressure in intake manifold
ECM	Electronic control module	NGP	Natural gas pressure (sensor)
EPS	Engine position sensor	NGT	Natural gas temperature (sensor)
FloTech	Electronic throttle	OEM	Original equipment manufacturer
FMV	Fuel metering valve	TPS	Throttle position sensor
FSV	Fuel shut-off valve	UEGO	Universal Exhaust Gas Oxygen
GVW	Gross vehicle weight	WG	Waster gate
ICU	Ignition control unit		
Hg	Mercury	MPa	Macro Pascal
kg	Kilo Gramm	N	Newton
kPa	Kilo Pascal	N-m	Newton meter
kW	Kilo Watt	ppm	Parts per million
L	Liter	r/min	Revolution per minute

5.2 Engine Control System





5.3 Dedicated Components

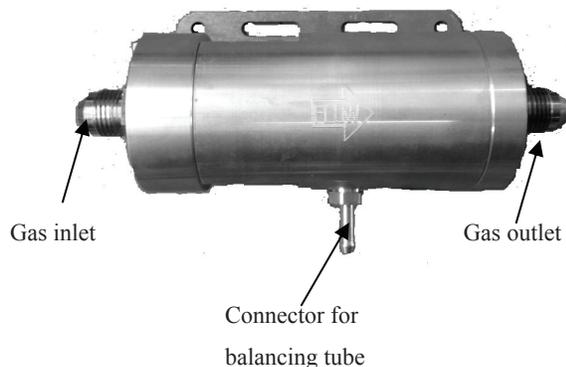
5.3.1 Gas pressure regulator (for CNG)

By throttling and heating, the gas pressure regulator makes the gas pressure drop from the gas tanks pressure to 7-9 bars.



5.3.2 Gas pressure regulator (for LNG)

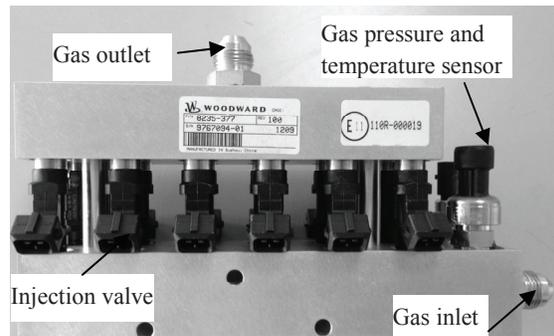
By throttling, the gas pressure regulator makes the gas pressure drop from the gas tanks pressure to 8-9.5 bars.



5.3.3 Fuel metering valve (FMV)

A FMV includes natural gas nozzles, a natural gas pressure sensor (NGP) and a natural gas temperature sensor (NGT).

A FMV is equipped with 12 nozzles, which are parallel arranged into 2 groups. Every two nozzles use a driver. In normal injection mode, the nozzles inject in turn. In some variable working conditions, all nozzles inject at the same time to accelerate the system response speed.



The decompressed gas flows through the shut-off valve of the FMV, NGP sensor, NGT sensor and the nozzles that control the flow. According to the engine working condition, the ECM controls the gas injection quantity by adjusting the pulse width duty ratio of FMV nozzles to ensure the engine works under the set air-to-fuel ratio.

The low pressure shut-off valve assembly, coil, NGP sensor, NGT sensor and nozzles of the FMV can be maintained at component level. Use spare parts provided by SDEC for replacement.

As part of gas supply system leakage check, it's necessary to perform leakage check on FMV connections. When using detecting fluid to check FMV, some bubbles will appear between the FMV body and some fasteners and that will last several minutes, which may be wrongly taken as gas leakage in FMV. In fact, the generation of bubbles is mainly because that the detecting liquid is emptying air out of the checked areas, rather than the leakage in the FMV. Because of the surface tension of detecting fluid, the detecting liquid will go further to the areas to be checked, and the discharged air goes out slowly from fasteners periphery.

5.3.4 Universal exhaust gas oxygen sensor (UEGO)

The UEGO sensor is the key sensor to realize the control of closed loop air-fuel ratio of lean-burn. It passes the oxygen concentration signal of exhaust to ECM. ECM determines whether the actual air-to-fuel ratio of gas mixture is sparse or dense against the set value and controls the increase or decrease of gas injection quantity correspondingly, and thereby to keep the air-to-fuel ratio at the set value.



The UEGO sensor contains a calibration resistor. Even in the case of the sensor changes, OH5 ECM can also accurately measure the fuel-air equivalence ratio with this resistor.

▲Warning: The UEGO sensor wire is not allowed to interfere with the exhaust pipe and it should be properly fixed.

The UEGO sensor mounting position is very critical in terms of its normal work. The sensor cannot be installed at the exhaust pipe elbows. It should be installed at the downstream of the exhaust brake device. When meeting the above limiting conditions, the sensor is preferably mounted as close as possible to the turbocharger. Change of the sensor mounting position requires recalibration.

The UEGO sensor adopts advanced contact sensing elements. Under the premise of proper use, these elements are usually very durable. However, the UEGO sensor is very sensitive to certain types of contaminants including silicon, PTFE, and superfluous lubricating oil, etc. These contaminants will shorten the service life of the sensor and no repair can be made to the sensor once damaged. Therefore, parts of any intake components can not be made of PTFE or PTFE-based materials. After the maintenance of the turbocharger or engine, remove the sensor from the exhaust system. Don't install it till the engine burns out anti-rust oil in all relevant parts.

△Caution: Do not run the engine when the UEGO sensor is disconnected (not powered), because the sensor may be contaminated.

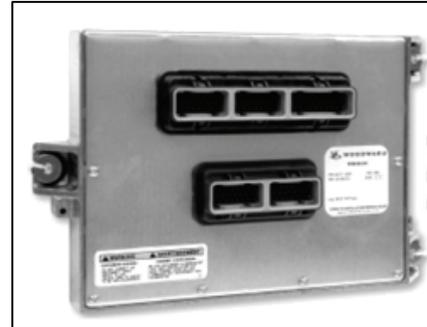
During cold starting, the engine runs with slightly dense gas mixture to enhance engine stability and maintain the margin for not flaming out. After getting warm, the engine runs under normal air-to-gas fuel ratio. After the engine gets complete warm, the control system enters into a gas control mode of closed loop + adaptive learning. Adaptive learning mode will be closed when the engine system produces some serious faults. Some faults can even result in exit of the closed loop mode.

5.3.5 Electronic control unit (ECM)

The electronic control unit is the neural center of the engine control system. It receives signals from all sensors, collects engine operating conditions in time and drives actuators to accomplish injection control, ignition control, boost control, throttling control and fault diagnosis.

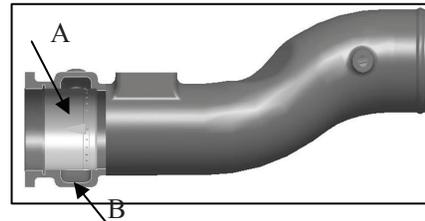
The control system collects such signals as speed, fuel pedal position (FPP), intake pressure and temperature, barometric pressure, coolant temperature, gas temperature, gas pressure, oxygen content, etc. The conducts of the actuators are gas metering, gas pressure control, throttling control, waste gate control, ignition control and diagnosis.

ECM will lose all temporary data if it is out of electricity power. After re-energized, ECM will automatically reset.



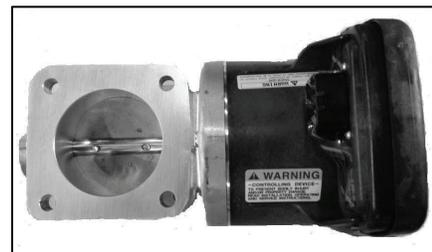
5.3.6 Mixer

The mixer makes full mixture of natural gas and cooled charge air, which makes combustion more complete and smooth. This can effectively reduce NOx emissions and exhaust temperature. A is the mixer core, and B is the mixer body (they are integrated). During installation, thread sealant must be applied to the taper thread to prevent leakage.



5.3.7 Electronic throttle

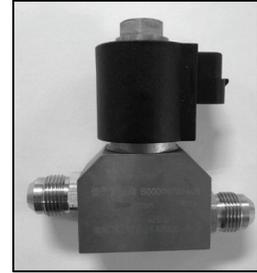
The electronic throttle controls the amount of mixture entering into the cylinder by controlling the openness of the butterfly valve, which thereby controls engine speed and load. A driver or operator gives the power demand to ECM through the accelerator pedal. After getting the accelerator pedal signal, ECM controls the openness of the butterfly valve of the electronic throttle according to engine working conditions, with which to control idle speed and governor characteristic curve.



A throttle openness position sensor is contained in the electronic throttle. The ECM determines whether the electronic throttle is under normal working state by comparing the difference between the feedback signal of the throttle position sensor and the command signal for the throttle openness. Once the electronic throttle fails to work, the ECM will enter into a specified limp home mode. In this mode, the gas flow is significantly reduced, and the engine will run at very low speed.

5.3.8 Low-pressure gas shut-off valve

The core of the low pressure gas shut-off valve is driven by coil and its state is controlled by ECM. It is closed when the engine is not in work. Its function is to stop or restore gas supply timely. It is usually installed after the high pressure regulator. This shut-off valve is used for LNG engine.



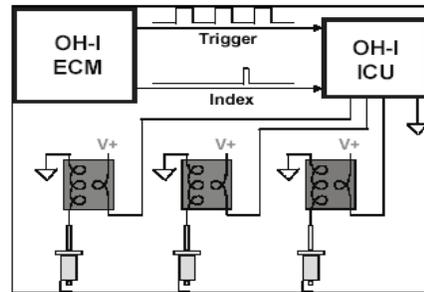
5.3.9 Low pressure gas filter

The low pressure gas filter can filter out over 95% impurities of 0.3 - 0.6 μm without affecting the supply of natural gas. It can filter oil, protecting downstream gas components.



5.3.10 Ignition system

The engine employs a distributorless ignition system (DIS), including ignition module, ignition coils, high voltage ignition wires and spark plugs. Every cylinder has one ignition coil. The ECM can automatically adjust ignition timing according to engine speed and load.



Ignition control module (ICM)

The ICM is the driving element of the ignition system. As per ECM commands, the ICM controls the charge and discharge of primary ignition coil circuit. And it sends monitoring signals of primary ignition coil circuit back to the ECM.



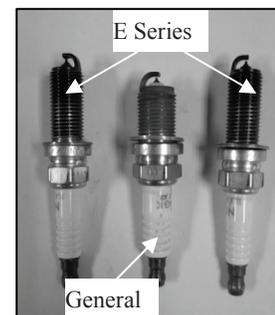
Ignition coil

An ignition coil can store in its magnetic field the energy required for spark plug arcing. It can also convert low voltage (provided by power source) into high voltage of 15-20 kV which is sufficient to generate breakdown ignition between spark plug electrodes. Use a special wiring plug to supply power to the coil and connect the ICM driver to the coil. In the system, every spark plug is equipped with one coil. The ignition sequence is controlled by connecting the ICM output to the corresponding cylinder.

5.3.11 Spark plug

Under the control of the ignition module, the spark plugs arc according to the engine firing order, igniting gas mixture in the cylinders.

The engine employs a spark plug of iridium platinum electrode. The plug is lengthened and its mounting thread is M12, which is different from those of general spark plugs.



6 Electronic Control Module Fault Code

6.1 MIL and System Fault Code

When the key switch is at "ON" position while the engine is in stop, the MIL comes on first and then dims after 2 seconds. This indicates that the engine is normal, and the engine is ready to start. If the MIL does not come on, the system has problem. Start the engine only after the problem has been solved. During engine starting or running, the MIL is should go out. During engine running, the ECM carries out real-time fault diagnosis. When the engine has a problem, the ECM will set a fault code, and MIL will come on and store this fault diagnosis code.

For some occasional minor faults, the ECM will automatically turn off the MIL after they disappear. For some partial faults, the MIL will not go out automatically even if they disappear. MIL will not light until the key switch has been turned off and then on. If the MIL always keeps on, it indicates that this fault is in activation all the time.

6.2 Fault Diagnosis without Diagnostic Tool

Malfunction indicator lamp (MIL) flash

When the key is at "ON" position but the engine is not in starting, push down the accelerator pedal (from idle) to the full position for three times in a row within 20 seconds and PCM-HD will be triggered and glisteningly display all SFCs. If the accelerator pedal circuit fails to work, this approach may become invalid.

The fault code will be displayed in the following form:

A SFC comprises 3 digital numbers. Zero (0) is not in use. Every time before starting or after finishing displaying a SFC, a special SFC mark i.e. number 12 will be displayed to remind the start and end of display of all SFCs.

Each number is represented by the flicker frequency between two medium length intervals. For example, between 2 medium length intervals, the lamp flicking for 3 times quickly indicates number 3.

Two numbers are separated by lighting for a medium interval.

There is a long length interval between 2 SFCs. The order in which SFCs appear is from the minimum value to the maximum value, which has nothing to do with the occurring time and importance of a fault.

For example, if there are 2 SFCs (231 and 711) recorded in the event manager, MIL will flicker in the following order.

- 1) 12 - the special SFC, indicating the start of fault code display;
- 2) 231 -the first SFC displayed according to the order of from a small number to a large number ($231 < 711$);
- 3) 711 -the second SFC displayed according to the order of a small number to a large number;
- 4) 12 - the special SFC, indicating the end of fault code display;

Then repeat again from top to bottom, till the key turns off or the engine starts.

Clear SFC History and Adaptive Learning Results

When the key is at "ON" position, continuously push down the accelerator pedal for 8 times, all SFCs will be cleared away; and continuously push down the accelerator pedal for 12 times, the adaptive learning results will be cleared away. When the accelerator pedal is pushed down 3 times, the MIL will flicker and display all SFCs information; and it is pushed down 8 times, the MIL will stop flickering and displaying, which indicates all SFCs have been cleared away. If the accelerator pedal circuit fails to work, this approach may become invalid.

6.3 Fault Code

WOODWARD system

Fault code	Fault Description	Fault code	Fault Description
SFC 133	UEGO Heater Voltage Low	SFC 554	Low Flash Memory Available
SFC 134	UEGO Heater Voltage High	SFC 555	Low EEPROM Available
SFC 139	UEGO Air Cal Learned Outside Limits	SFC 556	Low Calibrate Memory Available
SFC 141	NGT Voltage High	SFC 557	Primary EEPROM Fault
SFC 151	NGT Voltage Low	SFC 558	Secondary EEPROM Fault
SFC 161	XDRP_A (+5V) Voltage High	SFC 561	TPS Voltage Low
SFC 162	XDRP_A (+5V) Voltage Low	SFC 571	TPS Higher Than Expected
SFC 163	XDRP_B (+5V) Voltage High	SFC 611	Relative Humidity Sensor High Fault
SFC 164	XDRP_B (+5V) Voltage Low	SFC 612	Relative Humidity Sensor Low Fault
SFC 165	14V Power Supply High	SFC 613	Relative Humidity Temperature Sensor High Fault
SFC 166	14V Power Supply Low	SFC 614	Relative Humidity Temperature Sensor Low Fault
SFC 181	Barometer Voltage Low	SFC 641	NGTT Voltage High
SFC 182	Barometer Voltage High	SFC 651	NGTT Voltage Low
SFC 191	Oil Pressure Voltage Low	SFC 654	Air Inlet Temperature sensor Voltage High
SFC 192	Oil Pressure Voltage High	SFC 655	Air Inlet Temperature sensor Voltage Low
SFC 211	FPP Voltage High	SFC 661	NGTP Voltage High
SFC 221	FPP Voltage Low	SFC 664	Post air filter absolute pressure sensor voltage high
SFC 231	MAT Voltage High	SFC 665	Post air filter absolute pressure sensor voltage low
SFC 241	MAT Higher Than Expected	SFC 667	Air Filter DP Higher than Expected
SFC 251	MAT Voltage Low	SFC 668	Air Filter DP Lower than Expected
SFC 261	ECT Voltage High	SFC 671	NGTP Voltage Low
SFC 271	ECT Voltage Low	SFC 691	Wastegate Control Valve Open Circuit Fault
SFC 281	ECT Higher Than Expected	SFC 692	Wastegate Control Valve Short Circuit Fault
SFC 311	UEGO UN Fault	SFC 693	DRVP lower than expected
SFC 312	UEGO VM Fault	SFC 711	Boost Pressure Higher Than Expected
SFC 313	UEGO IP Fault	SFC 721	Boost Pressure Lower Than Expected
SFC 314	UEGO IA Fault	SFC 731	Overboost
SFC 331	MAP Higher Than Expected	SFC 741	Oil Pressure Low
SFC 341	MAP Voltage Low	SFC 751	Injector Duty Cycle Too High
SFC 342	MAP Voltage High	SFC 781	IVS Higher Than Expected
SFC 351	Barometer Lower Than Expected	SFC 791	IVS Lower Than Expected
SFC 361	Barometer Higher Than Expected	SFC 811	TPS Voltage Lower Than Expected

Fault code	Fault Description
SFC 371	PTP Higher Than Expected
SFC 372	PTP Voltage Low
SFC 373	PTP Voltage High
SFC 381	NGP Voltage High
SFC 391	NGP Voltage Low
SFC 411	NGP Higher Than Expected
SFC 412	System Overpressure Fault
SFC 413	NGP low fault
SFC 421	CAM Sensor Fault
SFC 423	Engine Timing Config Fault
SFC 424	Engine Overspeed
SFC 425	PCM Chassis Error
SFC 426	PCM Temperature Alarm
SFC 427	Vehicle Speed Sensor Fault
SFC 428	Clutch Switch Stuck On
SFC 429	Neutral Switch Stuck On
SFC 431	NGP Lower Than Expected
SFC 432	Brake Switch Stuck
SFC 441	Closed Loop Correction on High Limit
SFC 451	Closed Loop Correction on Low Limit
SFC 461	Adaptive Learn Correction on High Limit
SFC 471	Adaptive Learn Correction on Low Limit
SFC 491	PTP Lower Than Expected
SFC 521	Battery Voltage Low
SFC 531	Battery Voltage High
SFC 541	TPS Voltage High
SFC 551	Low RAM Available
SFC 553	CPU Load Higher Than Expected

Fault code	Fault Description
SFC 911	SmartCoil 1 Open Faults
SFC 912	SmartCoil 2 Open Faults
SFC 913	SmartCoil 3 Open Faults
SFC 914	SmartCoil 4 Open Faults
SFC 915	SmartCoil 5 Open Faults
SFC 916	SmartCoil 6 Open Faults
SFC 921	Coil 1 Shorted
SFC 922	Coil 2 Shorted
SFC 923	Coil 3 Shorted
SFC 924	Coil 4 Shorted
SFC 925	Coil 5 Shorted
SFC 926	Coil 6 Shorted
SFC 951	Injector 1 open or shorted to ground
SFC 952	Injector 2 open or shorted to ground
SFC 953	Injector 3 open or shorted to ground
SFC 954	Injector 4 open or shorted to ground
SFC 955	Injector 5 open or shorted to ground
SFC 956	Injector 6 open or shorted to ground
SFC 957	Injector 7 open or shorted to ground
SFC 958	Injector 8 open or shorted to ground
SFC 961	Injector 1 shorted to voltage
SFC 962	Injector 2 shorted to voltage
SFC 963	Injector 3 shorted to voltage
SFC 964	Injector 4 shorted to voltage
SFC 965	Injector 5 shorted to voltage
SFC 966	Injector 6 shorted to voltage
SFC 967	Injector 7 shorted to voltage
SFC 968	Injector 8 shorted to voltage

7 Troubleshooting Guidelines

Some simple typical natural gas engine fault modes, possible causes and troubleshooting steps are listed in the tables below. If any one of modes occurs in engine operation, it is required to eliminate it by taking appropriate measures. Otherwise, it would lead to severe engine failure. For simple engine faults, you can locate and eliminate them on your own. For complex faults, contact SDEC's after-sale service center (spare@sdecie.com) for technical guidance.

No	Fault mode	No	Fault mode
1	Diagnostic tool fails to communication with ECM	14	Poor acceleration
2	MIL doesn't work	15	Unexpected engine halt or misfire in deceleration
3	MIL keeps on without obvious problems	16	Engine will not stop
4	Alternator refuses to charge or fails to charge enough	17	Excessive vibration
5	Starting system fault	18	Excessive noise
6	Engine will not start	19	Oil pressure too high
7	Engine is difficult to start or takes longer time to start	20	Oil pressure too low
8	Engine surges at low or idle speed	21	Oil consumption too much
9	Rough running at idle speed	22	Coolant temperature below normal
10	Engine power output low	23	Coolant temperature above normal —sudden overheat
11	Rough running or misfiring	24	Coolant temperature above normal —gradual overheat
12	Engine cannot reach rated speed with load	25	Coolant contamination
13	Poor deceleration	26	Natural gas consumption too much

Fault mode 1: Diagnostic tool fails to establish communication with ECM

Possible cause	Correction
The electric key switch is at the position OFF	Turn the electric key switch to the position ON
There is no battery voltage or the voltage is lower than 8 V at the engine wiring harness	Check the battery voltage at the engine wiring harness
There is no battery voltage on the ECM or the voltage is lower than 8 V	Check the connector of the ECM for voltage
The Engine harness fuse is burnt	Check the fuse and replace it if necessary
Fault of the data connector	Check the connector for voltage and polarity

Fault mode 2: MIL doesn't work

Possible cause	Correction
The MIL burned out	Replace the light bulb
The MIL circuit problem	Check the MIL
The battery has no voltage or problem with the electric key switch	Check battery for voltage and electric key switch circuit, and refer to the vehicle or equipment manual for relevant information

Fault mode 3: MIL keeps on without obvious problems

Possible cause	Correction
The fault is shown by the fault code	Refer to the fault code table in Chapter 6.3 for the cause
Operation error of the ECM	Shut off the engine and cut off power supply and restart the engine
The MIL circuit problem	Check the MIL circuit

Fault mode 4: Alternator refuses to charge or fails to charge enough

Possible cause	Correction
The instrument or indicator lamp failure	Check and replace the instrument or indicator lamp
The battery connector(s) is loose or eroded	Clean and tighten the battery connector(s)
The drive belt slip or failure of the belt tensioner	Check and replace the belt and check the tensioner for its performance
Poor terminal contact of the alternator	Tighten all terminals of the alternator

Fault mode 5: Starting system fault

Possible cause	Correction
The terminals and connectors of the starting circuit and/or the battery are loose, open or eroded	Clean and tighten all the terminals and the connectors
Insufficient battery output	Use a battery with sufficient output or add some more batteries in parallel
Starting motor fault	Check the starting motor

Fault mode 6: Engine will not start

Possible cause	Correction
The drive system is engaged	Disengage the drive system
Starting system problem	Refer to Starting System Fault for the cause
Problem of the key switch	Check the key switch circuit for open or loose connection
Crankshaft rotation is restricted	Rotate the crankshaft and check for restriction
The ECM connector is not plugged	Plug the ECM connector
The ECM has no or lower voltage than 8 V	Check ECM for voltage by checking MIL
The fault is shown by the fault code	Refer to the fault code table in Chapter 6.3 for the cause
No or low gas pressure	Check and fill up gas
The hand gas supply valve is closed	Open the hand gas supply valve
No gas pressure before the gas filter	Check high pressure gas shut-off valve for damage and replace coil or body if necessary
No gas pressure before the pressure regulator	Check the gas filters for block and replace the filter
Low gas pressure at the gas metering valve (FMV)	Make gas flow diagnosis and refer to the fault code table in Chapter 6.3 for the cause
The harness circuit between the ECM and ignition module is in short or open	Refer to the fault code table in Chapter 6.3 for the cause
The fuse of the ignition module is bunt	Check and replace the fuse
Ignition problem	Check spark plug, ignition wire
Poor connection of the joints of the ECM or ignition module	Reconnect the joints
Problem of the engine position sensor	Refer to the fault code table in Chapter 6.3 for the cause
Camshaft timing problem (the timing may be changed after engine overhaul)	Check and adjust gear timing

Fault mode 7: Engine is difficult to start or takes long time to start

Possible cause	Correction
Improper starting method	Refer to the operating instruction manual of the vehicle or the equipment for proper starting method
Time for engine start up is 2-3 seconds	It is normal and needs no adjustment
The drive system is engaged	Disengage the drive system
Too low starting speed (minimum starting speed is 100 rpm)	Check the battery for voltage and check starting motor for looseness or eroded connection
The fault is shown by the fault code	Refer to the fault code table in Chapter 6.3 for the cause
Intake air is insufficient	Check the air filter element and make replacement if necessary. Check the intake system for block or leakage
Pressure at the FMV is too low (lower than 5.5 bar) or there is no pressure	Make diagnosis on the gas supply system
Wrong ECM calibration	Refer to the fault code table in Chapter 6.3 for the cause
Crankshaft rotation is restricted	Barring the crankshaft and check for restriction
Wrong valve clearance error	Check and adjust valve clearance
No or low gas pressure	Check and fill up gas

Fault mode 8: Engine surges at low or idle speed

Possible cause	Correction
The fault is shown by the fault code	Refer to the fault code table in Chapter 6.3 for the cause
Engine temperature is too low	Warm up the engine
Load at idle speed is too heavy (more than 50 horsepower)	Reduce the load at idle speed
Gas supply pressure is too low	Check and fill up gas
Leakage in the gas supply line	Check and repair the line and joints, or replace if necessary
accelerator pedal loose	Check, repair or replace the accelerator pedal
The high pressure gas shut-off valve is closed or the gas filter(s) blocked	Check the shut-off valve and replace the gas filter element(s)
Ignition system problem	Make diagnosis on the ignition system
Leakage of the intercooler or its pipeline	Check intercooler and its pipeline for leaks
Leakage of the intake manifold or pipeline	Check the intake manifold or pipeline for leaks
Alternator fault	Disconnect the alternator to the engine temporarily and run the engine to check for the problem
Wrong valve clearance error	Check and adjust the valve clearance

Fault mode 9: Rough running at idle speed

Possible cause	Correction
The fault is shown by the fault code	Refer to the fault code table in Chapter 6.3 for the cause
Engine temperature too low	Warm up the engine to the operational temperature
The load at idle speed too heavy (more than 50 horsepower)	Reduce the load at idle speed
Gas supply pressure too low	Check and add gas
Leakage in the gas supply line	Check and repair the line and joints, or make replacement if necessary
The accelerator pedal loose	Check, repair or replace the accelerator pedal
The high pressure gas shut-off valve is closed or the gas filter(s) blocked	Check the shut-off valve and replace the gas filter element(s)
Ignition system problem	Make diagnosis on the ignition system
The UEGO sensor is unplugged or has poor contact	Reconnect the sensor
Poor gas quality	Gas contains too low methane content, higher impurity of nitrogen, moist, carbon dioxide, and has poor anti-knock performance. Different calibration for different gas quality
Wrong valve clearance error	Check and adjust the valve clearance
The engine support damaged or loose	Check the engine support

Fault mode 10: Engine power output low

Possible cause	Correction
Inquire the driver or operator	Obtain all the information related to the problem
The drive system has been changed and cannot match the engine	Check the drive system for mismatch of the engine
The fault is shown by the fault code	Refer to the fault code table in Chapter 6.3 for the cause
Overloaded operation	Reduce the load to allowed range
The accelerator pedal doesn't arrive at the full position	Check the accelerator pedal for restriction
There is no pressure or low pressure at the FMV	Check the high pressure gas shut-off valve, gas pressure regulator, low pressure gas filter, FMV strainer and high and low pressure gas liens
The resistance of the intake system exceeds the specified value	Check the intake system for resistance and replace the air filter element if necessary
Leakage in the intake system	Check the connection of the intake manifold, intake pipe, intercooler and its pipeline for looseness or leakage
Leakage of the exhaust manifold or turbocharger	Check the exhaust manifold and boost pressure to find and eliminate the source of leakage
The resistance of exhaust system fails to meet the requirements	Check the exhaust system for resistance
The oil level too high	Check and lower the oil level to the specified range
Voltage on ECM too low, which leads to abnormal gas supply and ignition	Check the ECM fuse and the voltage at the ECM relay

Possible cause	Correction
The waste gate valve is stuck on open or close	Check the boost pressure
Problem of the ignition system or misfire	Check the ignition coil connectors and wires for looseness and check spark plug for clearance
The gas line(s) and gas filter(s) are blocked	Check the lines and replace the filter element(s)
The UEGO sensor is deviation, aging or contaminated	Replace the UEGO
Poor gas quality	Gas contains too low methane content, higher impurity of nitrogen, moist, carbon dioxide, and has poor anti-knock performance. Different calibration for different gas quality
Vehicle or equipment operates on the high plateau beyond the specification	Drive on the specified plateau. Engine power decreases with increase of altitude
Fault of the turbocharger	Check the boost pressure
Wrong valve clearance error	Check and adjust valve clearance

Fault mode 11: Rough running and misfiring

Possible cause	Correction
The fault is shown by the fault code	Refer to the fault code table in Chapter 6.3 for the cause
Only happens at idle speed	Refer to the fault mode "Rough running at idle" for the cause
Low running temperature	Refer to the fault mode "Coolant temperature below normal"
There is no or facultative pressure at the gas injection valve	Check the high pressure gas shut-off valve, gas pressure regulator, gas filters, FMV strainer, high and low gas lines
Ignition system problem	Check the ignition module, ignition wire, ignition coil, spark plug
Poor gas quality	Gas contains too low methane content, higher impurity of nitrogen, moist, carbon dioxide, and has poor anti-knock performance. Different calibration for different gas quality
Wrong valve clearance error	Check and adjust the valve clearance
Problem of the camshaft timing	Check the camshaft position sensor

Fault mode 12: Engine cannot reach rated speed with load

Possible cause	Correction
The fault is shown by the fault code	Refer to the fault code table in Chapter 6.3 for the cause
The drive system has been changed and cannot match the engine	Check the drive system for mismatch of the engine
The load is too heavy	Reduce the load
Fault of tachometer	Check the tachometer
Low power output	Refer to "Engine power output low" for the cause
The movement of the accelerator pedal is restricted or the wire connection is poor	Check the pedal for its movement and check the wire connection to the ECM
There is no or too low pressure at the FMV	Check the high pressure gas shut-off valve, gas pressure regulator, gas filters, FMV strainer, high and low gas lines
Gas leakage	Check the gas system for leakage
Problem the ignition system or misfire	Check the ignition wires, harness connection, and spark plugs
The low pressure gas filter blocked	Check the gas filter and discharge the dirt in the filter or replace the filter element
Fault of the turbocharger	Check the turbocharger
Leakage in the intake system	Check the connection of intake manifold, intake pipe, intercooler and its pipeline for looseness or leakage
The resistance of the intake system exceeds the specified value	Check the intake system for resistance and replace the air filter element if necessary

Fault mode 13: Poor deceleration

Possible cause	Correction
The fault is shown by the fault code	Refer to the fault code table in Chapter 6.3 for the cause
The movement of the accelerator pedal is restricted or the wire connection is poor	Check the pedal for its movement and check the wire connection to the ECM
The deceleration set is not correct	Reset the control system for deceleration

Fault mode 14: Poor acceleration

Possible cause	Correction
Inquire the driver or operator	Obtain all the information related to the problem
The drive system has been changed and cannot match the engine	Check the drive system for mismatch of the engine
The fault is shown by fault code	Refer to the fault code table in chapter 6.3 for the cause
Overload of accessories	Check the cooling fan, air conditioning and the vehicle braking system for resistance and reduce the load of the accessories
The accelerator pedal movement is restricted	Check the pedal for restriction
Leakage of the intake system	Check the intake manifold, intake pipe, intercooler and its pipelines for leakage
The intake system or exhaust system is blocked	Check intake and exhaust systems for resistance

Possible cause	Correction
Wrong calibration of ECM	Refer to the fault code table in Chapter 6.3 for the cause
The high pressure gas shut-off valve is closed or the high pressure gas filter is blocked	Check the shut-off valve, or replace the gas filter element
Too low pressure at FMV	Check the gas pressure regulator and the low pressure gas line for block
Wrong measurement by the EUGO sensor, which leads to overlean mixture	Check the measurement by monitoring tool and make an open loop test. Replace the sensor if required
Problem of the boost pressure sensor	Check the measurement of the pressure sensor with monitoring tool and compare it with the pressure measured by mechanical way to find the cause
The waste gate valve is stuck on open	Check the spring of the valve pulling lever for failure, and the boost pressure for overboost, and check if the solenoid valve discharges exhaust gas under diagnosis mode
Wrong valve clearance	Check and adjust the valve clearance
Spark plug or ignition system problem	Check the spark plugs, make diagnosis on the ignition system with monitoring tool

Fault mode 15: Unexpected engine halt or misfire in deceleration

Possible cause	Correction
Causes related to the protective system of the vehicle or equipment	Contact the manufacturer of the vehicle or equipment
The fault is shown by the fault code	Refer to the fault code table in chapter 6.3 for the cause
There is no or low pressure at the FMV	Check gas supply in the gas tank, check gas lines, solenoid, pressure regulator, gas filters, etc.
The voltage on the ECM too low	Check the battery power supply circuit, and check the control system for the condition of the fuses
Problem of the key switch circuit	Check the key switch circuit for loose connection or short

Fault mode 16: Engine will not stop

Possible cause	Correction
Fault of the electric key switch	Refer to the manual of the vehicle or equipment manufacturer for instruction
External power supply	Check and make sure there is no external power supply being connected to the power supply circuit of the vehicle or equipment

Fault mode 17: Excessive vibration

Possible cause	Correction
The engine runs unsteadily	Refer to the fault mode "Rough running or misfire"
Engine idle speed set too low	Reset the idle speed
Problem of the engine support	Check the support and cushion of the engine for problem by referring to OEM's instruction. Make replacement if necessary

Possible cause	Correction
Pulleys or vibration damper bolts or nuts loose	Check and tighten loose bolts or nuts
The fan blades not in balance	Remove the drive belt and operate the engine for a short time at the speed that the vibration was present. If vibration is not present any more, make a replacement of the fan and fan hub
Damage of the fan or accessories	Check, and replace relevant parts if required
Wear or damage of the alternator bearing	Check the alternator, and replace it if required
The vibration damper is damaged	Check/replace the damper
Over wear or unbalance of drive system parts	Check and repair according to the instruction of the vehicle or equipment manufacturer

Fault mode 18: Excessive noise

Possible cause	Correction
Noise from drive belt due to poor tension or heavy load	Check the belt tension and ensure all pulleys rotate freely
Leakage of the intake system and exhaust system	Check the intake and exhaust systems for leakage. Tighten the loose components and replace the related parts if necessary
Valve clearance too large	Check and adjust valve clearance
Noise from the turbocharger	Check the blades of compressor and turbine for their contact with their housings
Abnormal or early combustion or cylinder knock	Refer to the fault mode "Rough operation and misfire"

Fault mode 19: Oil pressure too high

Possible cause	Correction
Fault of the oil pressure meter	Check the pressure meter and replace it if necessary
The operating temperature of the engine is too low and the oil viscosity is high	Refer to the fault mode "Coolant temperature below normal"
The lubricating oil fails to meet the requirements	Use the lubricating oil specified in this manual and replace the oil filter

Fault mode 20: Oil pressure too low

Possible cause	Correction
The oil level is too low	Check the oil level and adjust it to the specified range
Water in the lubricating oil	Check the oil filler cover or the oil dipstick for their missing. Replace the oil if required
The oil filter is blocked	Replace the oil and oil filter
The lubricating oil fails to meet the requirements and the oil viscosity is too low	Check the oil specification and replace the oil and oil filter if necessary
Oil temperature is higher than the specified value	Refer to the fault mode "Coolant temperature above normal"
Fault of the oil pressure meter	Check the meter and make replacement if necessary
Hydraulic oil in the lubricating oil	Check for hydraulic oil leak, replace the oil and oil filter if required

Fault mode21: Oil consumption too much

Possible cause	Correction
The engine runs at idle speed for too long time	Shorten the time of the engine running at idle
External oil leakage of the engine	Check the external pipeline, sealing gasket and crankshaft seals for leakage and replace the damaged components
The oil level is too high	Check the oil level and make adjustment if necessary
The oil being used is not correct	Check the oil for its specification. Use correct oil and change the oil and oil filter
The air compressor pumps oil	Check the air compressor outlet for oil trace, replace the air compressor if necessary
There is a big blow-by that pushes oil in crankcase into the oil separator	Check the oil separator for oil trace on its periphery
The oil in the turbocharger leaks into the intake system or exhaust system	Check the compressor inlet, air intake pipe and turbine outlet for oil trace

Fault mode 22: Coolant temperature below normal

Possible cause	Correction
The radiator shutter is stuck at the maximum opening	Check the radiator shutter and replace it if necessary
Too much cold air flows though the radiator	Check the fan and fan clutch (if equipped) for operation
Fault of the coolant thermometer	Check the coolant thermometer and replace it if necessary

Fault mode 23: Coolant temperature above normal—sudden overheat

Possible cause	Correction
The coolant level is too low	Check the coolant level and check the engine external for leakage, eliminate the leakage and add the coolant to be within the specified range
The coolant system hose(s) is collapsed or/and leaks	Check the hose(s) and replace it if necessary
The drive belt is broken	Check the belt and replace it if necessary
Fault of the coolant thermometer	Check the coolant thermometer and replace it if necessary

Fault mode 24: Coolant temperature above normal -- gradual overheat

Possible cause	Correction
Overload operation	Reduce the load
The coolant level is too low	Check the coolant level and engine external for leakage, eliminating the leakage and adding the coolant to be within the specified range
The oil level is too high or too low	Check oil level and adjust it to be within the specified range
The radiator core is broken or blocked	Check the radiator core and repair or replace it if necessary
The coolant hose(s) is collapsed or/and leaks	Check the hoses, tighten clampers and make replacement if necessary
The drive belt is loose	Check the belt and replace it if necessary

Possible cause	Correction
Fault of the pressure cap of the radiator or pressure calibration is too low	Check the function of the pressure cap
Fault of the thermometer	Check the thermometer and replace it if necessary
Fault of the thermostat	Check the thermostat and replace it if necessary
Air in the cooling system	Check the connector at water pump inlet for leakage
Fault of the water pump	Check the water pump and replace it if necessary

Fault mode 25: Coolant contamination

Possible cause	Correction
Improper coolant	Choose the coolant specified in this manual
Too long coolant change interval	Change coolant at the specified interval

Fault mode 26: Natural gas consumption too much

Possible cause	Correction
Inquire the driver or operator	Obtain all the information related to the problem
Something related to operating technique	Check the operation of driver or operator for the gear shift, deceleration and idle speed
The drive system cannot match the engine	Check the drive system and make sure that the components of the engine and drive system are matched
The fault is shown by fault code	Refer to the fault code table in chapter 6.3 for the cause
The resistance of the intake or exhaust is too great	Check the intake and exhaust systems, especially the air filter and exhaust muffler
Gas leakage	Check the gas pipelines, valve, filters, solenoid valves, pressure regulator and other gas supply elements for seal condition and tighten the joints when needed
Poor ignition and poor combustion	Check whether the high-voltage ignition wires are properly connected, whether the spark plug clearance is too large, or whether spark plugs are seriously burnt; make replacement if necessary
The oil level too high	Check the oil dipstick and make sure that the oil level is correct
Display error of the odometer	Adjust or replace the odometer
Waste gate valve is stuck on close	Visually check the pulling lever and the valve for being not in free movement, and check if the air pressure before the throttle is lower than 85 kPa. Make adjustment if required
Poor gas quality	Gas contains too low methane content, higher impurity of nitrogen, moist, carbon dioxide, and has poor anti-knock performance. Different calibration for different gas quality
Poor seal of intake valve or exhaust valve	Check and adjust valve clearance

8 Engine Storage

If the engine is to be shutdown for a period of time (6 months at most), measures of cleaning and necessary oil seal should be taken for rust protection.

△Caution: Rustproof measures should be taken on the surfaces of the front drive pulleys.