

Chapter 1 Main Performance Data

1. Main Specification and Data

1.1.1 Technical Data of the engine

Model	TP12V190-2A	
Type	4 -stroke Spark plug ignition water-cooled	
Arrangement of cylinder	Vee-type, 60°in angle	
Bore (mm)	190	
Stroke (mm)	210	
Compression Ratio	8.3:1	
Displacement (L)	71.45	
Rated power (kW)	450	
Rated speed (r/min)	1000	
Stable speed with no load(r/min)	600	
Gas heat consumption (kJ/kWh)	≤14000	
Gas consumption M ³ /h	160 (Natural gas heat value is 35000kJ/m ³)	
Oil Consumption (g/kWh)	≤1.6	
Exhaust temp. ()	≤630	
Water outlet temp. ()	≤90	
Oil temp. in oil pan ()	≤90	
Oil pressure in oil main line (kPa)	392 784	
Stable speed droop (%)	≤5	
Cooling means	Forced cooling	
Lubricating means	Pressure and splash lubrication	
Cylinder serials number	Output end	1- 2- 3- 4- 5- 6 7- 8- 9-10-11-12
Ignition mode	SI	
Ignition order	1-8-5-10-3-7-6-11-2-9-4-12	
Starting mode	24V DC alternator	
Crankshaft Rotation	Counterclockwise (facing power output end)	
Power output	Flywheel output	
Dimensions (L×H×W) (mm)	2670×1588×2366	
Dry weight (kg)	5100	

1.1.2 Technical Data

1.2.1 Valve Timing (by crankshaft angle)

Intake valve: Intake valve open (BTDC)	$11^{\circ}\pm 7^{\circ}$
Intake valve close (ABDC)	$51^{\circ}\pm 7^{\circ}$
Exhaust valve: Exhaust valve open (BDC)	$51^{\circ}\pm 7^{\circ}$
Exhaust valve close (ATDC)	$11^{\circ}\pm 7^{\circ}$

1.2.2 Valve clearance (at cold state): Intake valve: $0.40\pm 0.05\text{mm}$; Exhaust valve: $0.45\pm 0.05\text{mm}$

1.2.3 Ignition advance angle: (BTDC) $32^{\circ}\pm 2^{\circ}$

1.2.4 Electrode clearance of spark plug: 0.65 0.85mm

1.2.5 Tighten torque for installing spark plug (N.m): 43~52

1.2.6 Tighten torque for key bolt and nut (N.m)

Nut for main bearing nut: 1176 1372 (tighten with 490N.m torque and then turn 60° ~ 70°)

Nut for cylinder head: 320 360 (Tighten evenly with torques of 100, 200, 320~360 N.m in turn .)

Connecting rod nut 250 270

Bolt for crankshaft balance weight 550 +50 Tighten evenly with torques of 150 300 550 +50N.m Bolt for fixing vibration damper 180 220

Bolt for fixing flywheel 500 550

1.2. Technical Specifications of Main Components

1.2.1 Magneto ignition system

Nameplate: ALTRONIC

Type: 12A33H-A

1.2.2 Ignition coil

Type: ALTRONIC

1.2.3 Spark plug

Nameplate: STITT

Model: 807BEX13.5

Type: Cold (running) spark plug

1.2.4 Mixer

Model: IMPCO 200T-1

Type: Diaphragm

1.2.5 Governor

Nameplate WOODWARD

Type 2301A, full electronic

Power 24VDC

1.2.6 Pressure Regulator

Type: S202

1.2.7 Solenoid valve

Model ZCTB-50B

Type: Explosion-proof

Grade B C

Power 24VDC

1.2.8 Oil filter

Type Paper element

Opening pressure at by-pass valve 200kPa

1.2.9 Centrifugal filter

Rotor speed 5000r/min

Flow capacity 16 18L/min oil temperature at 75 oil pressure at 600kPa

1.2.10 Oil cooler

Type Water-cooled, fin tube type

1.2.11 Water pump

Type Centrifugal

Speed 1909r/min

Displacement 1000L/min

Lifting: 20m

1.2.12 Air filter

Type Dry, paper element

Rated air flow 2400m³/h

Primitive Restriction 3.2kPa

1.2.13 Starting motor

Type ST710

Power 11kW

Voltage 24V

Rotation clockwise viewed from gear

Chapter 2 Installation of Engine

2.1 Lifting of the engine

The engine is lifted with a crane boom and steel cable by lifting hooks in front and rear side of the cylinder block. Lifting at another place is not allowed. Be careful not to lift the engine through the hooks machined on the cylinder block.

The bracket for supporting the engine should be rigid enough. The engine is fixed on the bracket with bolts and loaded on the vehicle firmly. As handling the engine, seal every inlet and outlet for oil, water and gas with

plastics or other suitable materials to prevent dust or soil into the engine. Some auxiliary components such as the air filter and silencer can be dismantled before handling the engine.

2.2 Requirement for installing the engine

The engine should be mounted on a platform or foundation as rigid and smooth as possible. The engine (without base frame) should be fixed on a supporting base, which is rigid and strong enough and connected with M27×150 bolts.

The engine should be aligned with the driven unit to get a stable and correct relative position. Coaxial degree error between the coaxial lines is below 0.5mm. It is no permitted to install directly pulley or any other transmission component on the power output disc.

2.3 Installing of gas, oil, water pipes and engine room

Make certain the external pipes clean, clear and neat. Their joints should be sealed closely without leakage.

2.3.1 Requirements for installing gas pipelines.

Regulating valves and pressure gauges are installed on the gas pipes to control natural gas pressure before it flows into the pressure regulator. Pipe diameter connecting to engine room should be above 2". Before starting the engine, check carefully the pipes for leakage.

2.3.2 Requirements for installing intake and exhaust system.

Every engine should be supplied with separate exhaust manifold. It is better to mount a silencer on the system. The silencer or pipes should be designed reasonably to prevent any water or other dirt from flowing back into cylinders.

2.3 Requirement for lubricating system

Oil should be stored in a clean barrel. It is not filled into the engine until it is settled and filtered strictly.

3.4 Facilities and requirements for engine room

3.4.1 The engine is structured in accordance with requirements of first-grade fireproof.

3.4.2 A set of forced ventilation equipment is mounted in the engine room in accordance with the explosion-proof demands. Because different compositions of the natural gas have different specific gravity, ventilating windows are positioned on both upper and down parts of the room and open towards outdoor.

3.4.3 The engine room should be separated from the operating room and be in well ventilation.

3.4.4 All of the electrical equipment should be proof – explosion. No fire can exist in the engine room.

3.4.5 Settle gas warning devices and fire-fighting experiment in the engine room and operating room.

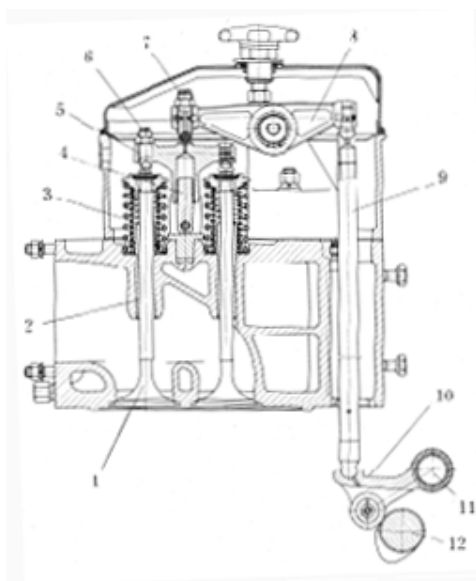
3.4.6 Settle lightening protector in the engine room.

Chapter 3 Adjustment of Engine

3.1 Adjustment of valve clearance

After 250h operation or while strip inspection of some part, such as the cylinder head, valve timing mechanism, etc., recheck and readjust the valve clearance in the following method.

The valve clearance means the sum of fit clearance between the moving parts of the valves at the state of the cold engine. The valve mechanism of TP12V190-2A natural gas engine is shown in fig. 3-1. Intake valve clearance is 0.40mm, and exhaust valve clearance is 0.45mm.



1. Valve 2. Valve Guide 3. Valve Spring 4. Guide Pin 5. Rocker Arm Bridge
 6. Rocker Arm Bridge Adjusting Screw 7. Rocker Arm Adjusting Screw 8. Rocker Arm
 9. Valve Tappet 10. Roller Rocker Arm 11. Rocker Arm Shaft 12. Camshaft

Fig 3-1. Valve Mechanism

Valve clearance is adjusted in the following methods:

Remove the rocker arm cover out of the cylinder head.

Unload the vent screw plug a little, and then turn the crankshaft to make the pointer at the scale “0” of the flywheel. It is at this time that the 1st cylinder is at top dead center. Turn the top of the tappet, and 1st cylinder is at working stroke if two tappets fail to move.

Table 3-1 List of Valve Clearance Adjustment

Firing Order	1	8	5	10	3	7	6	11	2	9	4	12
Crankshaft angle	0	60	120	180	240	300	0	60	120	180	240	300

Adjustment of valves can be done as shown in Table 3-1

- (1) Adjusting valve clearance; adjust the adjusting screw to make its bulbs on both ends contact top surfaces of both valves with same name without gap as shown in fig. 3-2; then adjust gap between the rocker arm and rocker arm bridge as shown in fig. 3-3. Loose the lock nuts, then insert a suitable feeler between the rocker

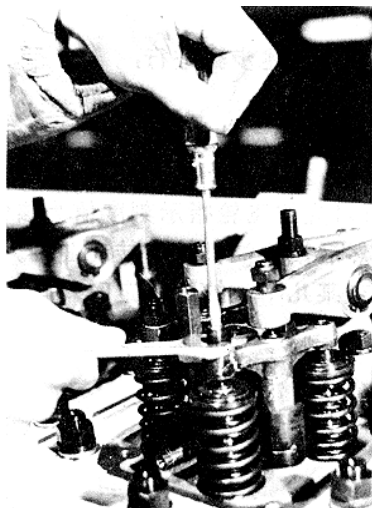


Fig 3-2

Adjusting of Rocker Arm

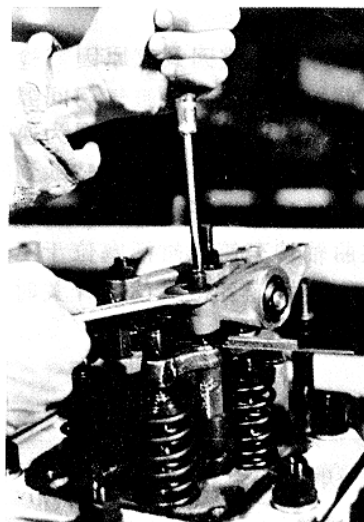


Fig 3-3 Adjusting of Valve Clearance

arm adjusting screw and bridge and then tighten the adjusting screw with a driver to make the screw pressed down slightly. On the condition of keeping the adjusting screw in original location, tighten the clamp nut.

After pulling out the feeler, check the valve clearance again for any change. All of the clearance should be checked till they are in accordance with requirements.

- (2) Turn crankshaft till next cylinder is on the TDC of working stroke according to engine firing order, and then perform step 3 again.

3.2 Adjustment of A/F ratio

A desirable A/F ratio shall response to gases with different contents. A/F ratio of TP12V190-2A engine shall be achieved by adjusting the mixer and pressure regulator. It is recommended to notify manufacturer or distributors to perform on-site commissioning according to local gas contents before the engine operates initially. Adjusting of gas flow pressure, density and valve on the mixer shall get a suitable A/F ratio.

3.2.1 Adjusting of mixer

The mixer is structured as shown in fig.3-4. TP12V190-2A engine is arranged with Vee-type and mounted with two mixers for each line. The mixer is to mix air with gas at a ratio. When the engine is in operation, a pressure drop resulting from the piston movement in cylinder line shall be sent to diaphragm (4) and then to the spring (3), so the pressure here shall drop. Diaphragm shall move toward the spring under the compressed air from the other side of diaphragm, and air and gas can flow through this channel. The openings of air valve and gas valve shall change with the pressure difference under the two sides of the diaphragm. Pressure difference shall be variable with the throttle opening. The throttle is controlled by lever of governor to adjust the air and gas to intake pipe. on the gas pipe, a gas regulator is installed. A/F ratio shall be changed by adjusting the gas regulator. The regulator is identified with "L" and "R". Opening of "R" gas valve shall have become large if adjusting against "L". It is recommended to make a suitable adjustment to meet on-site requirement.

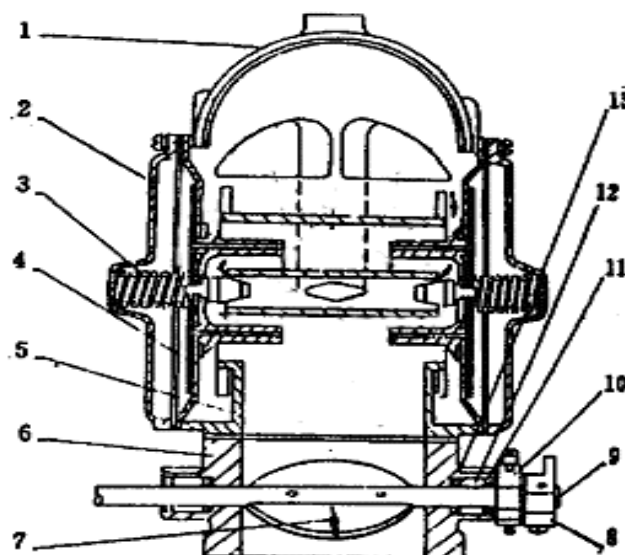


Fig 3-4 mixer

- | | | | | |
|-------------|-----------------------|-------------|-------------------|-----------------|
| 1. air pipe | 2. cover | 3. spring | 4. diaphragm | 5. mix assembly |
| 6. throttle | 7. throttle butterfly | 8. lever | 9. throttle shaft | |
| 10. Lever | 11. shaft seal | 12. bearing | 13. support | |

3.2.2 Adjusting of pressure regulator

The pressure regulator is shown in fig. 3-5. A diaphragm is inside the regulator. Under the diaphragm, a air cave is open to air or to mixer directly through a connecting pip, and a air cave is under the diaphragm. Spring pressure is adjustable. Valve shall move when the linkage moves. When the engine is in operation, a pressure difference p exits in the gas valve. p is variable for different natural gas contents. It is necessary to adjust the spring force properly and smoothly on site to have the engine a reliable operation. It is recommended to inspect engine operation for a desirable A/F ratio.

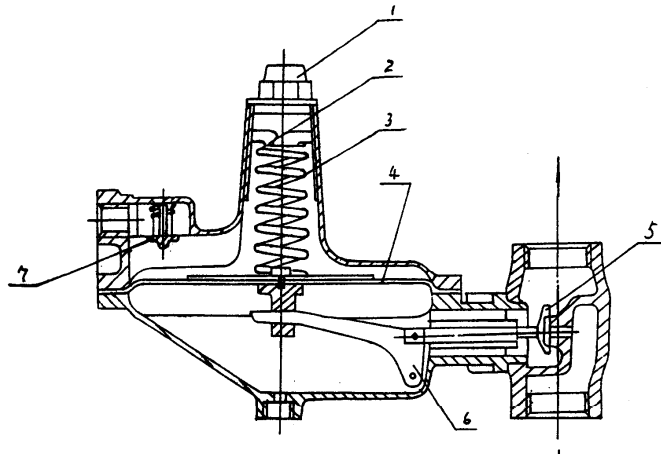


Fig . 3-5 pressure regulator

1. cap 2.. seat 3. spring 4. diaphragm 5. linkage 7. check -valve

3.3 Adjustment of ignition advance angle

3.3.1 Structure and installation of magneto

The magneto is non-contact type. No any spark occurs as it is operating, so it meets explosion –proof requirements. It output voltage is in the range of 160~180VDC. It is shown in fig. 3-6.

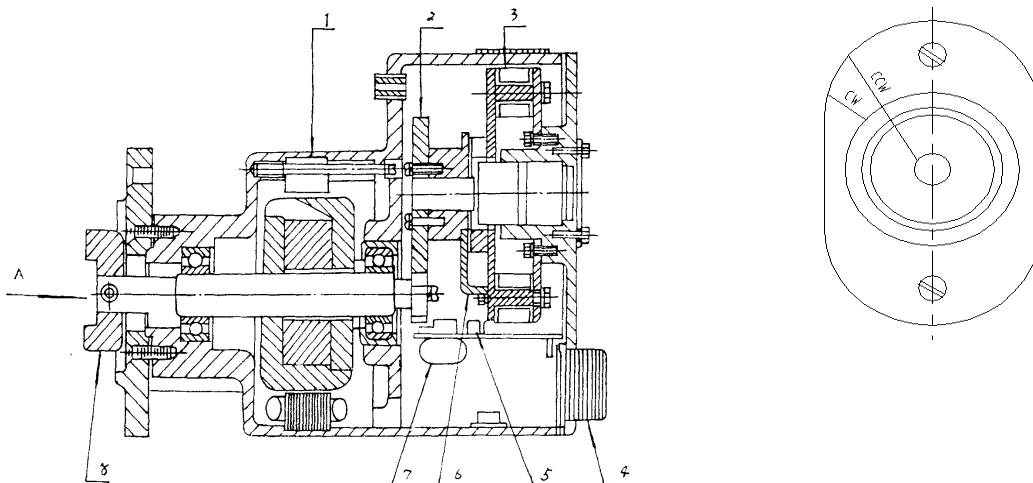


Fig. 3-6 Structure Diagram of Magneto

1. AC alternator 2. Gear 3. coil 4. socket for low voltage power supply output
5. SCR electronic switch 6. Timing distributor 7. capacitor 8. driver

The AC alternator shall output low voltage electricity and it is accumulated in capacitor 7. Ignition coil shall output a high voltage electricity to make spark ignites. Before installing the

magneto, first, turn the flywheel to keep the first cylinder at ignition advance position (32° , before top dead center at compressed stroke). From the timing window in the lower part of the magneto, we can see a red mark and CCW mark on the magneto housing, then turn the magneto driver until the red mark overlaps with the CCW mark, (as shown in the fig 3-6). At this time, mount the magneto on the engine and then tighten the bolts. The advanced ignition angle may be an approximation

3.3.2 Adjusting of ignition advance angle precisely

Set a precise ignition advance angle by driving the engine with motor. The methods is make the pointer on the cylinder block point to the scale "0" on the flywheel as the 1st cylinder is at the top dead center at compression stroke. Stick a piece of oscillogram paper within 60° of crankshaft degree and marks a scale as same as the value on the flywheel. Connect one end of the excessive high voltage ignition cable of 1st cylinder to output of the ignition coil and the other end to the pointer of the flywheel and keep 2~4mm distance between the cable and oscillogram paper. Drive the engine with a motor and sparks bursts between the high voltage cable and oscillogram paper. The paper is breakdown by sparks. As the motor stops, take out the paper. On the base of records on the paper, ignition advance angle is set.

If the ignition advance angle does not accord with the determined value, readjust digital ignition device and check ignition advance angle till it is correct. It can be adjusted by the methods: loose the bolts fixing magnet and driving device to allow the magneto to move to back and forth for the ignition timing adjustment which is corresponding to 6.7° and 6.7° crank angle. Perform adjustment according to the real ignition advance angle till a determined valve is gotten.

As the above-mentioned methods are used to adjust the ignition advanced angle, it is necessary to turn off natural gas valve to make certain the engine does not fire.

3.4 Adjustment of electrode gap of spark plug

In the case of the engine fails to fire because of spark plug, readjust and check. It is written as follows.

- 1) Remove the spark plug.
- 2) Clean off carbon deposit or any other dirty accumulated on electrode of the spark plug.
- 3) Adjust the electrode gap to the determined valves with tools which is used specially to adjust the gap.

If the spark plug fails to operate normally after adjusting, replace it with a new one.

Chapter 4 Operation of Engine

4.1 Cautions

When operating the engine, operators should consider the following items.

- a. Read the manual carefully to know how to operate the engine.
- b. Choose lub-oil referring to specified requirements. Storage oil in a clean container. Settle and filter the oil strictly before use.
- b. Perform technical maintenance strictly in schedule.
- d. Load the engine slowly after the engine is started in cold state. Engines with no-load operation at idle speed may have bad effects on their reliability and service life. While engines operate with no-load at idle speed, it will consume much oil and cylinder sleeves will wear easily, and more carbon deposit will appear.
- e. While the engine is at operation, pay much attention to working conditions and make records carefully. As soon as abnormal phenomenon exists, find out causes and remedy.
- f. Dismantling of the engine is forbidden in disorder. Operate the engine strictly according to required procedures. Because some technical parameters such as valve gap, are very important, checking and adjusting must be done after reassembling.

4.2 Gas, Oil, Cooling water

4.2.1 Gas Fuel

TP12V190-2A engine burns natural gas mainly or other combustible gases, such as associated oil gas, LPG, CMM gas, biogas, etc. All the gases for the engine fuel needs to be dewatered and filtered before application. Gas low heat value must be above 35 MJ/m³ and gas pressure is in the range of 0.08 ~ 0.35MPa. Hydrogen sulfide content is below 0.1%. Impurity size is smaller than 5μm, and impurity content is below 0.03g/m³.

4.2.2 Lub-Oil

For the engine, lub-oil will be selected in accordance with the specifications described in table 4-1. For main quality index, refer to table 4-2.

Table 4-1 Lub-oil type

Environment Temp. ()	Type	Remarks
-40 ~ 50	API CH-4, CG-4, SJ SAE 5W-40	Type 40CD
-20 ~ 40	API CH-4, CG-4, CF, SJ or SAE 15W-40	40CD
-20 ~ 40	API CG-4, CF-4, SH or SAE 15W-40	

4.2.3 Cooling Water

Clean softening water is used in the engine without any corrosive and component such as chloride, sulfate or acid and should be slightly alkaline. It is forbidden to use water from sea, well, fountain, industrial waste or salt and alkaline water. A suitable amount of antiseptic oil should be filled into cooling water in order to reduce corrosion or scale settling.

Cooling water quality may have bad effect on its cooling and service life. The unqualified cooling water can create water scale easily, which can block water passage and corrode seriously the parts and damage the sealing parts. Water quality for cooling must be controlled strictly.

4.3 Preliminaries before engine starting

4.3.1 Visual Inspection and Mounting Condition Check

Ensure all of the parts assembled completely and correctly, pipes connected in right way and sealed closely and the base mounted firmly. The output end should be jointed tightly.

4.3.2 Intake System

- Connect the gas source with a proper rubber hose to intake port of engine intake system.
- Turn on the natural gas valve to check the piping for leakage if this happens, repair or replace it.

4.3.3 Lubricating System

- Add clean oil into oil pan till oil gets to the top scale of the oil dipstick. Lub-oil trademark and its specification should be in accordance with the requirements in the manual.
- Supply oil by the priming oil pump; oil pressure in main oil passage is up to 100kPa. Remove the upper cover of cylinder to check the rocker arm bearing for normal oil.

4.3.4 Cooling System

- Check whether cooling water is clean and in accordance with the manual.
- Add cooling water into water tank till the water lever is at the required positions and then put suitable rust-proofing emulsion.
- If the ambient temperature is below 5 °C, heat cooling water and lub-oil up to 20 °C.

4.3.5 Starting System

Check wiring for reliability and then connect the starting power (24VDC) according to the requirements.

4.3.6 Cranking

Open the air vent a little and then crank the crankshaft not less than two circles. Any abnormal phenomenon such as bumping, sticking are not allowed.

4.4 Engine Startup

4.4.1 Before starting, power the control panel and monitor. The switches of “storage battery”, “electric governor power source”, “electromagnetic valve” and “emergency shutdown” are positioned on “On”. “Idle /Rated” is positioned on idle.

4.4.2 Turn the emergency switch, open the gas electromagnet valve to keep the engine at starting state.

4.4.3 Press service switch, turn the manual priming oil pump to supply fuel. When oil pressure is above 100kPa, press the starting button to drive motor, and then the engine fires. Starting motor operates continuously less than 5s. If the motor fails to run three times, don't restart until troubles are checked and remedied.

Note: Release the starting button rapidly and loses the service switch after the engine starts to avoid any damage on starting motor.

4.4.4 The engine shall operate to become warm at idle speed after the engine starts. Check if indicating parameters in the instruments are in accordance with specified requirements.

4.5 Engine Operation

4.5.1 After starting the engine, operate it without load. At the same time, check the following items.

4.5.1.1 Oil pressure \geq 350kPa.

4.5.1.2 Unlock the drain water valve in water pump, then the water pump will supply water.

4.5.1.3 Check the engine completely for water, gas and oil leakage. All of the parts should be tighten firmly. No vibration or looseness is allowed.

4.5.1.4 Exhaust smoke should be in normal conditions. No abnormal voice is allowed.

4.5.2 When the new engine runs for the first time, operate it with no load for not too long. Do not load the engine until oil and water temperature increases to 40 .

4.5.3 After he engine operates about 50h for the first time, it is time to replace the oil and clean out the oil pan and oil filter.

4.5.4 As the engine runs normally. Generally, it is better to keep water temperature between 65 80 , not less than 60 . Oil temperature is below 90 and oil pressure is in the range of 400 800kPa.

4.5.5 Cylinder shall be below 400 and exhaust temperature is below 610 when engine is operating with load.

4.6 Engine Shutdown

In normal condition, make the engine off-load before shutdown, reduce speed gradually and run in idle speed for a period before stopping. After oil and water temperature decreases to 60 , stop the engine.

Notice: pay much attention to the following items.

- a. Don't shut down the loaded engine except the accidents such as running –away or other abnormal things.
- b. If he environment temperature is below 5 and there is no antifreeze fluid , drain off cooling water before shutdown.
- c. If environment temperature is lower than the oil freezing point, drain oil at once as soon as the engine stops.
- d. If it is necessary to replace oil, drain oil before oil gets cool after the engine shut down in order to clean off oil easily.
- e. In emergency conditions, shutdown the engine in emergent conditions, then crank the engine and check.

Chapter 5 Engine Maintenance

Proper engine maintenance can ensure the engine operating reliably, have it much long service life and reduce cost. In normal condition, engine maintenance should be done according to the requirements of daily, monthly and seasonal maintenance.

5.1 Daily Maintenance

Operators should check the engine according to the following items.

- 5.1.1 Drain fluid in the natural gas separator in regular. Prevent it from freezing in winter;
- 5.1.2 Check the oil lever in oil pan and the governor for abnormal rising and dropping, exam oil quality and fill oil in to them if necessary.
- 5.1.3 Check water lever in engine; fill cooling water if necessary.
- 5.1.4 Check power source.
- 5.1.5 Check natural gas pipes whether pressure complies with requirement. Inspect them for leakage. If abnormal phenomenon exists, please remedy it.
- 5.1.6 Check all of the connecting sections and mounted parts for correct tightness.
- 5.1.7 Monitor the operating parameters of the engine indicated in the instrument. Please pay much attention to the variety of oil pressure, oil temperature if oil filter is above 150kPa.
- 5.1.8 Watch the engine exhaust smoke and monitor its sound. If any abnormal phenomenon appears, find out causes and then remedy them.
- 5.1.9 Check the engine for water, oil and gas leakage. Make sure the engine in clean and good working conditions. Keep its appearance clean.
- 5.1.10 Record operating conditions for the engine according to requirements.

5.2 Weekly Maintenance

- 5.2.1 Undertake all the items prescribed for daily maintenance.
- 5.2.2 Check the spark plug; clean out carbon deposit on it; adjust its gap by the methods prescribed in its manual.
- 5.2.3 Clean out the filter element of the breather.
- 5.2.4 Fill a suitable quantity of lub-oil into oil-cup to lubricate the bearings with an oil gun.
- 5.2.5 Clean out the engine.
- 5.2.6 If Pressure difference of flame arrester is above 1kPa, it is necessary to clean it to avoid holes blocked.
- 5.2.7 If the engine operates in the conditions where wind is much heavy, remove filter net and generator guard.

5.3 Monthly Maintenance

It is necessary to do the following technical maintenance after the engine operates every month or 500~700h:

- 5.3.1 Undertake all the jobs prescribed for weekly maintenance.
- 5.3.2 Clean out the oil filter and replace paper elements.
- 5.3.3 Clean out the centrifugal filter; align the marks on the rotor and housing when installing.
- 5.3.4 Replace oil in the oil sump (replace it or not according to oil quality).
- 5.3.5 Check and adjust valve clearance.
- 5.3.6 Check the ignition advance angle.
- 5.3.7 Inspect the warning system including the alarming device in the engine room.
- 5.3.8 Clean out cooling system.
- 5.3.9 Check the forced ventilation equipment in the engine room.

5.4 Seasonal Maintenance

Perform the following maintenance with the variety of environments temperature, season or after the engine

operates 1000h:

- 5.4.1 Undertake all the jobs prescribed in daily, weekly, and monthly maintenance.
- 5.4.2 Clean out the lubricating system and replace oil with new oil.
- 5.4.3 Inspect all of the instruments and alarming devices.
- 5.4.4 Examine the safety equipment such as the guard.
- 5.4.5 Dismantle to check the cylinder head. Reface the valve if necessary.

Chapter 6 Engine Troubleshooting

During operating, some parts of the engine may be damaged because of improper or incorrect operation and the engine shall be effected or fail to run. We call generally all of the problems having impact on the engine operation as troubles. Referring to the description written in the following table, check the engine and find out the causes when the engine is troubled. Contact with distributor or manufacturers if necessary.

6.1 Difficult or Disable for the Engine to Start

Table 1

Item	Probability	Solution
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1	<p>Troubles in starting system</p> <p>1) Starting motor damaged</p> <p>2) Storage Battery charged not enough</p> <p>3) Starting motor and gear engaging badly</p> <p>4) Starting wiring connected improperly or damaged</p>	<p>1) Repair the generator or replace with a new one.</p> <p>2) Charge the storage battery.</p> <p>3) Adjust position to be in gear</p> <p>4) Inspect the wiring and repair</p>
2	<p>Troubles in intake system</p> <p>1) Pipe blocked or leak seriously</p> <p>2) No gas in gas pipeline.</p> <p>3) Gas pressure not proper</p> <p>4) Incorrect ignition advanced angle</p>	<p>1) Repair the pipe.</p> <p>2) Open gas pipeline valve and electromagnetic valve</p> <p>3) Adjust to specified value</p> <p>4) Check and adjust ignition advance angle</p>
3	<p>5) Incorrect A/F ratio</p> <p>Trouble in intake and exhaust system</p> <p>1) Air filter blocked by dust</p> <p>2) Intake pipe blocked by dust</p> <p>3) Air leakage in intake, exhaust valves and piston rings results in compression pressure not enough.</p>	<p>5) Adjust air/fuel ratio</p> <p>1) Clean out the air filter</p> <p>2) Clean out the intake passage</p> <p>3) Reface intake and exhaust valves; replace the piston rings and gaskets for cylinder head.</p>
4	<p>Ignition system troubles</p> <p>1) Incorrect and not firmly wiring</p> <p>2) Spark plug do not spark.</p> <p>3) Protective devices fail</p>	<p>1) Connect the wiring correctly and firmly and grounded</p> <p>2) Adjust clearance or replace the spark plug with a new one</p> <p>3) Check and repair</p>
5	<p>Troubles in operation and maintenance</p> <p>1) Too low oil pressure</p> <p>2) Operate continuously at idle speed for a long period</p>	<p>1) Heat oil by filling hot water</p> <p>2) Clean out deposit carbon in the engine and the spark plug</p>

6.2 Too High Oil Temperature

Table 2

Item	Probability	Solution
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1	<p>Troubles in Lubricating System</p> <p>1) Lack of oil; too low oil level in oil sump</p> <p>2) Poor supply to oil pump</p>	<p>1) Add oil to setting scale.</p> <p>2) Check and repair oil pump.</p>
2	<p>Troubles in Cooling System</p> <p>1) Oil cooler blocked by dirty material</p> <p>2) Lack of coolant and too high water temperature</p>	<p>1) Clean out oil cooler.</p> <p>2) Add coolant and check water supply</p>
3	<p>Troubles in Operation and Maintenance</p> <p>1) Piston rings worn and blocked</p> <p>2) Bearing burned</p>	<p>1) Replace with piston rings.</p> <p>2) Replace with bearing.</p>

6.3 Under Power of the Engine

Table 3

Item	Probability	Solution
1.	<p>Troubles in Intake system</p> <p>1) Low natural gas pressure or pressure regulator damaged</p> <p>2) Unqualified gas</p>	<p>1) Adjust pressure to the setting valve or replace the pressure regulating valve</p> <p>2) Adjust natural gas pressure according to requirements</p>
2	<p>Troubles in Intake and Exhaust system</p> <p>1) Air filter blocked</p> <p>2) Not enough pressure caused by cylinder air leaks</p> <p>3) Not correct valve clearance</p> <p>4) Intake and exhaust passage blocked</p>	<p>1) Clean out the air filter</p> <p>2) Inspect and repair the sealing parts such as valves, cylinder gaskets and piston rings.</p> <p>3) Adjust valve clearance again.</p> <p>4) Clean out intake and exhaust passage.</p>
3	<p>Troubles in ignition system</p> <p>1) High voltage coil damaged</p> <p>2) The spark plug cannot spark normally</p>	<p>1) Inspect and replace it.</p> <p>2) Inspect electrode clearance; replace the spark plug if necessary.</p>
4	<p>Troubles in turbocharger</p> <p>The turbocharger operates in a lower speed because of carbon deposit.</p>	<p>Clean the turbocharger</p>

6.4 Low Oil Pressure

Table 4

Item	Probability	Solution
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1	<p>Troubles in Lubricating system</p> <ol style="list-style-type: none"> 1) Pressure of the pressure regulator adjusted unsuitably. 2) Lack of oil or oil not enough in oil sump. 3) Oil grade is not in accordance with the requirements. 4) Too low oil viscosity. 5) Lubricating system leaks. 6) Sensor for oil pressure damaged 7) Oil pump damaged 	<ol style="list-style-type: none"> 1) Adjust oil pressure to specified value. 2) Fill oil as required. 3) Replace with qualified oil. 4) Replace oil. 5) Repair and replace some parts. 6) Replace sensor for oil gauge. 7) Replace oil pump.
2	<p>Troubles in cooling system</p> <ol style="list-style-type: none"> 1) Oil cooler has a bad cooling effects. 2) Oil cooler blocked and too high oil temperature caused by too much oil. 	<ol style="list-style-type: none"> 1) Correct trouble in cooling system. 2) Clean out the oil cooler and drain the excessive oil.
3	<p>Bearing worn and too wide clearance.</p>	<p>Overhaul and replace with new bearing.</p>

6.5 Oil Dilution

Table 5

Item	Probability	Solution
1	<p>Trouble in cooling system –oil mixed with water</p> <ol style="list-style-type: none"> 1) Water leak in cylinder line ring 2) Water leak in oil cooler elements 3) Water leakage in water pump 	<ol style="list-style-type: none"> 1) Replace 2) Repair and replace elements 3) Replace sealing washers
2	<p>Water leakage in spark plug jacket</p>	<p>Replace the sealing washer in spark plug jacket</p>

6.6 Abnormal Breather Exhaust Gas

Table 6

Item	Probability	Solution
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1	1) Excessively worn or broken piston ring. 2) Piston or cylinder liner excessively worn, burned or strained. 3) Bearing burned. 4) Slots in piston rings coincident.	1) Replace piston ring. 2) Inspect piston and cylinder liner. 3) Check, repair or replace. 4) Adjust again.
2	Lub-oil mixed with water.	Check cylinder rings and oil cooler.

6.7 Too High Cooling Water

Table 7

Item	Probability	Solution
1	Trouble in cooling system 1) Lack of coolant. 2) Damaged water pump. 3) Broken sensor for water temperature gauge.	1) Add cooling water. 2) Replace water pump. 3) Replace sensor.
2	Troubles in operation and maintenance 1) Engine operating at over load. 2) Piston and cylinder seriously worn.	1) Decrease load. 2) Replace piston and cylinder liner.

6.8 Excessive Exhaust Temperature

Table 8

Item	Probability	Solution
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1	Troubles in intake system 1) Air passage blocked 2) Air filter blocked 3) Improper A/F ratio 4) Wrong ignition timing	1) Intake passage blocked. 2) Clean out air filter. 3) Adjust air/fuel ratio. 4) Adjust ignition advanced angle
2	Trouble in Operation and Maintenance 1) Engine operating at over load 2) Unusual valve clearance	1) Decrease load. 2) Readjust valve clearance.

6.9 High Gas Consumption

Table – 9

Item	Probability	Solution
1	Troubles in intake system	Tight connector and replace the damaged pipelines
2	Some spark plug fails to spark.	Adjust ignition advance angle
3	Wrong igniting	According to requirement.

6.10 Sudden Shut-Up

Table - 10

Item	Probability	Solution
1	Igniting System 1) Broken spark plug. 2) Protective system running. 3) Troubles in governor.	1) Replace spark plug. 2) Find out causes and remedy it. 3) Inspect governor.
2	Troubles in maintenance 1) Piston seriously blocked. 2) Connecting rod bearing and main bearing burned. 3) Timing gear and transmission mechanism of injection pump broken.	1) Replace piston and parts. 2) Dismantle to inspect and replace some parts. 3) Dismantle to inspect and replace some parts.

6.11 Unusual Noises

Table-11

Item	Probability	Solution
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1	Knock during combustion. 1) Deflagration 2) Too low coolant 3) Engine operating at overload 4) Incorrect ignition timing	1) Adjust air/fuel ratio and advanced angle of ignition 2) Raise coolant temperature 3) Decrease load 4) Readjust
2	Intake and exhaust pipe detonation 1) Firing not continuously. 2) Air/fuel ration unsuitable	1) Check igniting system and clean out deposit carbon in spark plug. 2) Adjust air/fuel ration.
3	Mechanical knock 1) Bearing clearance too wide main bearing, connecting rod bearing and sleeve 2) Excessively worn piston ring 3) Clearance between piston and cylinder too wide 4) Intake and exhaust valve clearance too wide 5) Piston collision with valve 6) Mechanical materials fallen into cylinder	1) Inspect and replace. 2) Replace piston ring. 3) Replace piston and cylinder liner. 4) Recheck and adjust valve clearance. 5) Inspect valve clearance. 6) Remove the material.
4	Gear noise 1) Gear gas too wide 2) Broken gears 3) Tightening bolts loosen 4) Gear bearing too wide	1) Adjust gear clearance. 2) Replace gear. 3) Tightened again. 4) Replace gear

6.12 Not smoothly operation

Table 12

Item	Probability	Solution
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1	Governor running unusually or incorrect governor.	Inspect or replace.
2	Governor lever positioned incorrectly.	Position the lever to ensure it smoothly.
3	Incorrect valve gap or air leakage	Adjust valve clearance and reface valves.

6.13 Strong Engine Vibration

Table 13

Item	Probability	Solution
1	Torsion damper failure	Inspect, repair or replace damper.
2	Flywheel unbalanced and loosen	Adjust, and fasten again.
3	Incorrect alignment of engine and driven parts.	Readjust and install.
4	Bolts loosen	Fasten.
5	Bedplate of the engine is not rigid enough	Strength the bedplate.
6	Bearing gap too wide	Overhaul
7	Crankshaft or bearing cap broken	Overhaul

Chapter 7 Generator Set**7.1 General Description**

400GF1-PT generator set is driven by TP12V190-2A natural gas engine manufactured by Shengdong, together with 50 Hz, 400V, 1FC6 series three-phase brushless synchronous generator made under Siemens License and control panel manufactured by the professional factory.

The generator set shall service for the areas with gas such as oil and gas field and industrial and mine field as to supply daily or standard power source.

The chapter describes technical performance, operation and other importance characteristics. Please refer the manuals about generator, control panel and other parts while reading the manual to operate the engine properly.

7.2 Main Technical Performance

Model of Generator set	400GF1-PT
Engine Model	TP12V190-2A
Generator Type	1FC6 456-6LA42-Z
Control Panel Type	PL-400
Rated Power (kW)	400
Rated Current A	722
Rated Voltage V	400
Rated Power Factor COS Φ	0.8 Lagging
Rated Frequency Hz	50
Starting Mode	24 V DC Motor
Controlling Mode	Manual
Voltage Regulating Mode	Automatic
Governing Method	Electronic Governing
Excitement	Brushless
Wiring Method	Three phase, four Wiring
Cooling by Circulating Water	With radiator
Connecting Method	Flexible coupling
Dimensions L×B×H mm	5925×1970×2458.5
Weight of Generator set kg	12500

7.3 Main Technical Performance

7.3.1 Working Conditions

7.3.1.1 The generator set should output rated power under the following conditions

Ambient pressure 100kPa

environment temperature: ≤ 30

Relative air humidity 50%

Low heat value of gas: $\geq 25\text{MJ}/\text{Nm}^3$

Gas pressure: $\geq 2\text{kPa}$

7.3.1.2 The generator set can operates reliably under the following conditions:

Altitude below 2000m

Environmental temperature -5 40

Relative air humidity $\leq 90\%$ at 25

No sand, dust, or corrosive gases surrounding the unit.

7.3.2 Technical Performance

The generator set shall provide the following protective devices.

- a. Over-speed shutdown safety protection
- b. Low oil pressure safety protection
- c. High oil pressure and high cooling water temperature alarm
- d. Overload protection
- e. Over current protection
- f. Reverse power protection
- g. Short voltage protection
- h. Generator overheat protection

7.4 Handling and Installing of Generator set

7.4.1 Handling the Generator Set

7.4.1.1 Before lifting the generating set, dismantle all of the gas pipeline, cables connecting with the generator set, close all of opens and rearrange the cable.

7.4.1.2 During lifting, use steel cables and lifting tools which are strong enough to bear the weight of the generating set. The steel cable should be hung in the lifting hooks in two ends of the base frame and may not touch with the parts of the generating set directly

7.4.1.3 During lifting, pay much attention to protect the control panel to avoid the buttons and instruments from damaged.

7.4.2 Installing of the Generator Set

7.4.2.1 Installation of 400GF1-PT generator set is shown in fig 7-1.

7.4.2.2 Installing Requirements:

- a. Good ventilation equipment in the engine rooms to avoid the leaked gas to reach combustible density. Gas warning devices should be mounted in the engine rooms.
- b. Do not put these substances, which can produce corrosive gases, such as, acid, alkali, etc.
- c. Outlet of the exhaust leading pipes should be open to air and the pipes are not too long. Gas exhaust silencer is fixed outdoor.
- d. Install the cables connecting generator and control panel in groove.

7.4.3 Mounting Foundation

Foundation structure of the generator set should be designed considering local soil. Generally, its depth is 300mm. The distance between the edges of foundation and base frame is above 150m. The foundation bed should be rammed. While casting concrete, leave square holes of 160 ×160mm ×500mm for fitting foundation bolts in positions. Installing foundation of 400GF1-PT natural gas generator set is shown in fig.7-2.

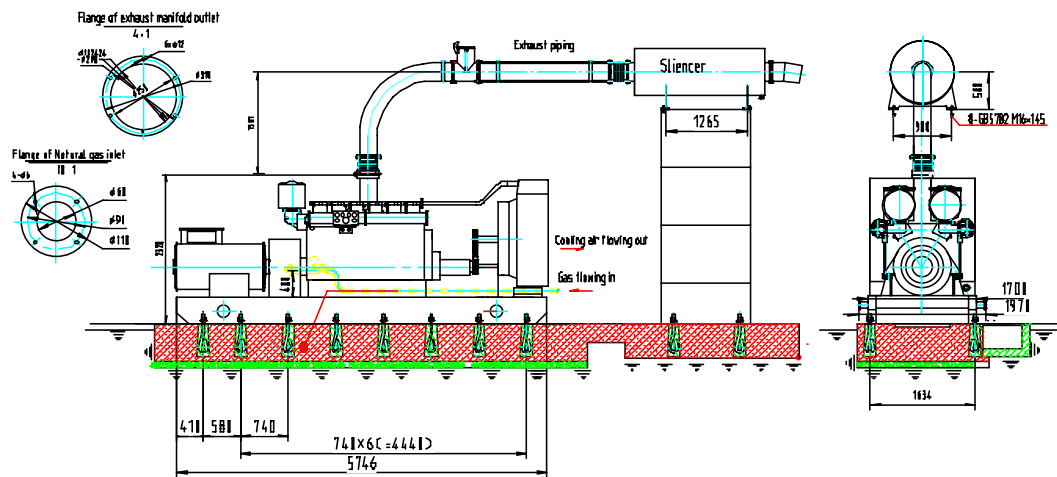


Fig 7-1 Overall and Installation Dimensions of 400GF1-PT generator set

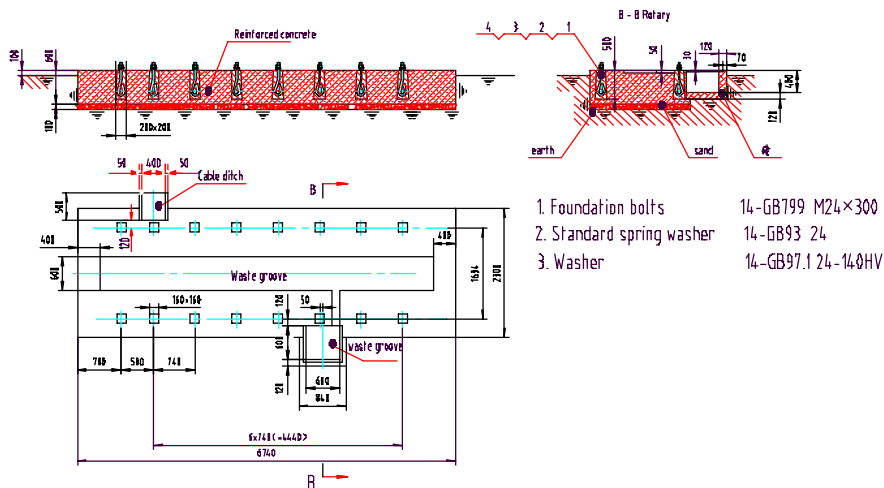


Fig. 7-2 Mounting Diagram of 400GF1-PT Natural Gas Generator Set

7.5 Generator Set Operation

7.5.1 Starting and Loading

7.5.1.1 Preliminary of starting the generator set

- After stalling the generator set, inspect if installation is in accordance with specified requirements. Check wiring for correctness and controlling parts for flexibility. Ensure every moving part can move flexible.
- Check systems including natural gas, lubrication, cooling, starting, controlling system for correctness referring to requirements on starting.
- Check the insulating resistance between circuits and circuit to ground for initial operation. During measuring, switch off electric component, semi-conductor, and capacitors. The measured values should be higher than 2M Ω .
- Check alarm indicator in monitor for correctness. The method is shown as follows: close the battery switch and press down the pre-alarmed button then all of the indicating lamps should glimmer simultaneously and the

electrical bell and hailer sound; press down silencer button and the sound will stop; press down the alarming relief button and all of the indicating lamps will be off.

e. Crank the crankshaft by hands for two circles at least without any sticking abnormal phenomenon. Before cranking, supply oil with a pre-lubricating oil pump.

Notice: If the bell or hailer cannot sound or some indicating lamps cannot light, find out the troubles and correct it at once.

Before operating the generator set, put the switches on the positions as described in the following tables.

Item	Name	State ready to run
1	Auto air switch	Off
2	Auto change-over switch	Any one of AB BC CA
3	Magnetizing/field suppressing switch	Running
4	Battery switch	On
5	Syno switch	Off
6	Starting switch	On (press down)

7.5.1.2 Starting and loading of generator set.

a. Turn the pre-lubricating oil pump by hands to pump oil to the engine. As oil pressure rises to 100kPa, stop pumping at once.

b. Turn the ignitions switch to starting position, set the protective switch to release position, and then press the starting switch to start the engine. After the engine starts, adjust the governor to warm up the engine at 700/min. Set the protective switch on protective position.

c. Adjust the speed button on the governor to make the engine operate at a little high speed than rated speed.

d. Adjust the voltage regulating potentiometer to 400V with no-load.

e. Turn on the “Switch” on the front chassis of the control panel, and then the generator set shall output electricity.

f. Load the engine gradually after oil and water is up to 40 . If generator set voltage and frequency drifted off the rated values, adjust the voltage regulating potentiometer and speed regulating button on the governor respectively to operate the engine at rated voltage and frequency.

g. Turn the voltage switch to check three-phase voltage for balance.

7.5.2 Operation of Generator Set

7.5.2.1 When the engine running with load, observe indications of electric instruments (current meter, voltmeter, frequency meter, power meter, etc) and monitoring instruments. Adjust in time referring to specified requirements if necessary. At the same time, observe whether each signal is correct.

7.5.2.2 It is recommended to raise or reduce load to keep balance for three phases.

7.5.2.3 Make records carefully according to the requirements of operation and maintenance manuals for engine, generator and control panel.

7.5.3.4 If the generator set shutdowns because of accident, look for the failure causes. Don't start it again until troubles are shoot.

7.5.3.5 Switching off and correction of main switch of generator

a. Main switch strips for short circuit of generator load circuit and divided circuit protection fails. Check the short circuit and remedy.

b. If low oil pressure protective device operates, the generator set stops automatically. Fill oil to specified level.

- c. If generator is under-voltage or no-voltage, inspect speed excitation loop and rectifier, find out causes and remedy, Replace with a new parts if necessary.
- d. Reduce load if generator operates at over load to keep it at rated load.
- e. If over speed protection for generator set activates, find out causes and remedy.

7.5.3 Shutdown

7.5.3.1 Before the generating set stopping, unload the generator set gradually, then turn the switch to make the main switch on “off” position.

7.5.3.2 Adjust the speed regulating button of the governor to decrease generator set speed to idle.

7.5.3.3 Stop the generator set after oil and water temperature below 60

7.5.4 Generator Set Paralleling

7.5.4.1 Preliminary and conditions for generator set paralleling operation

- a. Before the generator set paralleling, check their phase sequence to ensure the generator sets have the same phase sequence.
- b. The generator set should have same stable speed regulating and same stable voltage regulating rates. Set stable speed regulating rates in range of 3% ~5%.
- c. After voltage, frequency, phase of two generator sets or generator sets and electrified wire netting are same, parallel the units.

7.5.4.2 Paralleling of Generator set s

- a. If a generating set or electrified wire netting has been in normal electricity supply state, adjust voltage, frequency to the position almost equal to that of operating set or electrified wire netting after starting the generator set ; set sync switch at “paralleling ”position, and observe their sync meter.
- b. Turn the speed button on governor; trim frequency of the generator set to make it as same as that of the operating set or electrified wire netting. It means that frequency difference indicating pointer (“Hz”) of the sync meter is at center position.
- c. Adjust the low voltage regulating potentiometer to make voltage of the generator set as same as that of electrified wire netting. It means that voltage difference indicating pointer (“V”) is at the same position.
- d. Repeatedly adjust the generator set which is going to be paralleled, and observe the phase difference “S” indicating pointer of sync meter; make it turning counterclockwise. When it is close to vertical position gradually, turn the rotary switch to make the main switch on “On” position. Then, the generating set is in parallel operating.
- e. As soon as the main switch on “On” position, set the sync-measuring switch on “ Off” position, then the meter stops working. The sync meter is powered with at about less than 15min.
- f. Adjust the speed button on the governor and the voltage regulating potentiometer fixed on the chassis of the control panel to make the generating set share active and reactive power uniformly and operate reliably. If load is increasing, each of the generating sets can increase load automatically and uniformly.

Increase generator set power by adjusting speed potentiometer and voltage regulating potentiometer to keep power factor close to 0.8 (lagging).

7.5.4.3 Generating sets stepping-out

As total load of the generator sets reduces to 80% rated power of single generator set, step out some of the sets. Adjust speed button and voltage regulating potentiometer to reduce load of the generator sets which are to be stopped out to 20% of single generator set capacity then turn the switch to make the main switch down.

7.6 Maintenance of generator set

7.6.1 Daily, weekly, monthly, seasonal maintenance of the generator set should meet the maintenance requirements.

7.6.2 Please refer to their manuals about generators and control panels while performing maintenance.
7.6.3 As the generator sets operate every 500h, check the spring rings between the engine and generator for any damage. Replace it if necessary.

7.6.4 Add lub-grease every 2000h operation. Keep the bearings and lub-grease clean. Added lub-grease is $\frac{2}{3}$ of the bearing housing volume.

