GAS ENGINE
OPERATOR'S HANDBOOK

INDEX

Document: Gasengine_us3
Issue: 08/03

1 General Information

1. GENERAL INFORMATION

Introduction

Generating sets utilizing Ford and HM Ltd. Engines are tested and inspected before leaving the factory. However, certain checks should be made before putting them into regular operation. Read the Initial Start Up requirements in the Maintenance Instructions.

How To Use This Manual

This manual should be read in conjunction with the Alternator manual, Technical Operation and Maintenance Manual, Installation Manual and Generating Set Operators Manual, prior to operation of the unit. This will allow you to become familiar with the various controls and instruments, how to maintain your engine and what services need to be performed to keep it in excellent running condition.

This manual does not identify equipment as standard or optional. Some of the equipment described in this manual may not be found on your engine or power unit. The descriptions and specifications contained in this manual were in effect at the time it was approved for printing

Unit Identification

It is necessary for the serial number of the generating set to determine the parts or components required on this unit. Use this serial number when seeking information or ordering replacement parts for any unit. For a handy reference, record the generating set serial number in the space provided below.

Generating Set Serial Number

2. OPERATING INSTRUCTIONS

Set-up Procedure

The generating set will have been tested at full load for the specified fuel in the factory. Adjustments are not normally required at site. Refer to the Technical Operation and Maintenance Manual, for normal starting, stopping and control panel instructions. However, in certain circumstances, e.g. if a unit is converted from one fuel to another, or a major component is replaced some set-up will be required.

Tools Required

2 Manometers capable of reading between 0 to 20"H2O (50mBar) for Natural Gas or LP Vapor sets, 0 to 200PSI (14Bar) for LP Liquid sets.

Lambda sensor (e.g. part number 622-643) or Exhaust Gas Analyzer capable of reading %CO.

Steel Rule or Vernier gauge with mm scale.

Pre-Start Checks

Check the gas pressure at the inlet to the unit is within the specified pressure range (see below):

Natural Gas or LPG Vapor:	4"H_2O (10mBar) to 13.5"H_2O (34mBar)
Natural Gas to Ford Turbo genset	6"H_2O (15mBar) to 13.5"H_2O (34mBar)
Natural Gas to GM Turbo genset	7"H_2O (17.5mBar) to 20"H_2O (50mBar)
LPG Liquid:	58PSI (4Bar) to 180PSI (12Bar)

If a new regulator or LC50 have been installed, or if the unit is being converted from Natural Gas to LP Vapor or vice versa, set the regulator, Main Adjustment Screw (MAS) and ignition timing according to the following tables:

Natural Gas 50/60Hz	Isuzu Low Speed	Isuzu High Speed	Ford 425	Ford 642	Ford 1068	Ford 1068T
Regulator Setting (mm down from top edge)	14	16	14	15.5	16	17
MAS Setting (mm out from body)	10	11	11	15	19	20
Ignition Timing (DBTDC)	24(60Hz) 19(50Hz)	25	grnd-grnd	Wire 674 to wire 53A	Wire 674 to wire 53A	NA

LPG 50/60Hz	Isuzu Low Speed	Isuzu High Speed	Ford 425	Ford 642	Ford 1068	Ford 1068T
Regulator Setting (mm down from top edge)	14	14	14	12.5	14	NA
MAS Setting (mm out from body)	8	9.5	9	12	16	NA
Ignition Timing (DBTDC)	18	25	grnd-grnd	Wire 674 to wire 5	Wire 674 to wire 5	NA

Install the Lambda sensor in the port provided in the exhaust pipework (or insert an exhaust gas analyzer probe into the exhaust outlet). If using the Lambda sensor, connect as follows:

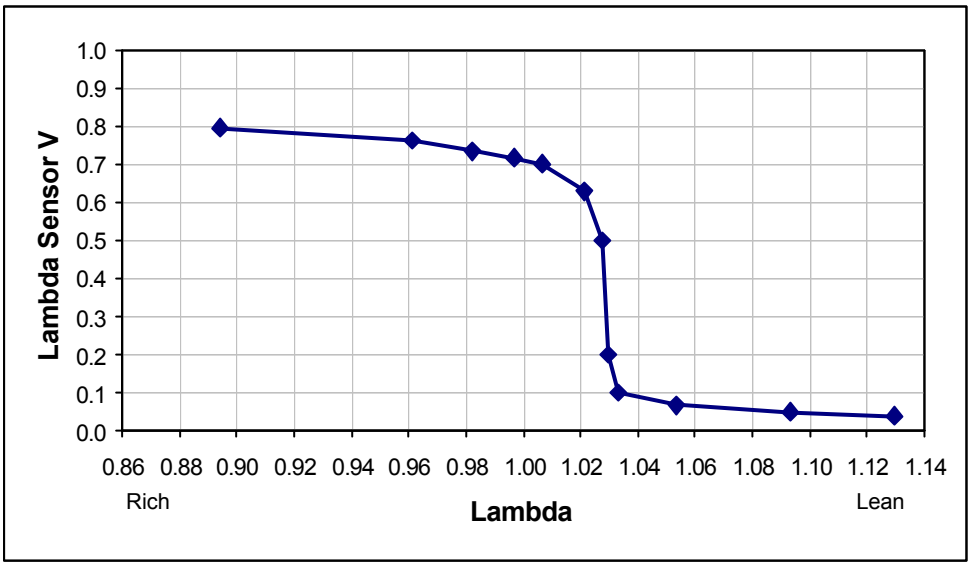
Black wire (signal +ve): Digital voltmeter (positive lead)

Gray wire (signal –ve): Digital voltmeter (negative lead)

White wires (heater): Fused 12V dc supply

Note: It's important to use a digital meter, because an analog meter typically has a low input impedance which can distort the signal.

The Lambda sensor gives an output as follows:



Engine Running Adjustments

When using a lambda sensor, correct lambda is achieved when the voltage is between 0.2V and 0.7V. Due to the characteristics of the sensor the voltage will be unstable and fluctuate randomly between the two points. When lambda is rich, the voltage remains constant above 0.8V. When lambda is lean the voltage remains constant below 0.1V.

When using a CO meter, correct lambda is when 0.7%<CO<1.2%. Below 0.7% lambda is too lean, above 1.2% lambda is too rich.

1500 / 1800RPM Sets (Isuzu & Ford)

1. Start the generating set and adjust for correct lambda at no load.
   If lambda is rich (lambda sensor >0.7V, or CO >1.2%) the regulator outlet pressure is set too high, adjust the regulator to reduce the outlet pressure.
   If lambda is lean (lambda sensor <0.2V or CO <0.7%) the regulator outlet pressure is set too low, adjust the regulator to increase the outlet pressure.
2. Increase the load to around 60% of nameplate rating using a load bank, or available building load. Allow the engine time to reach normal operating temperature.
3. Adjust the main adjustment screw (MAS) on the mixer for correct lambda.
4. Increase the load to 100% of nameplate rating using a load bank (if a load bank is available).
5. If required, adjust the MAS for correct lambda. If the screw has been opened completely and lambda is still too high, either the gas inlet pressure is too low or the gas quality is too poor. It may not be possible to achieve full load in this case.
6. Remove all load from the genset.
   Adjust the regulator again for correct lambda at no load
7. Repeat steps 2 to 6 until the generating set operates at correct lambda at all loads.
8. Stop the genset and check that it can re-start with the new MAS and regulator settings.

1800 RPM Sets using GM engines

1. Before starting connect a manometer to the inlet test port of the Maxitrol regulator. Connect a second manometer to the outlet test port of the regulator.
2. Install a Lambda sensor or CO meter in the port supplied with the exhaust pipework. Take note the sensor cannot be installed upstream of a turbocharger.
3. Start the engine and run with no load. Make sure the inlet pressure to the regulator is between 7 to 10" H_2O, adjust the outlet pressure to 3" H_2O for a turbocharged engine.
4. Adjust for correct Lambda or CO at no load using the idle screw on the carburetor.
   If mixture is rich lambda sensor >0.7V or CO>1.2%
   If mixture is lean lambda sensor <0.2V or CO<0.7%
5. Increase the load to 90% of nameplate rating using a load bank or available building load. Allow the engine time to reach normal operating temperature.
6. Observe the regulator inlet pressure, it should be a minimum of 7" H_2O. If it is not, check the fuel supply to the regulator for restrictions. Adjust the regulator pressure to achieve correct lambda. If this cannot be achieved check gas pressure or the gas quality may be poor. It may not be possible to achieve full load if this is the case.
7. Remove all load from the genset and observe the lambda. If it is not correct, readjust using the idle mixture screw.
8. Revalidate the 90% and 100% loads, repeating steps, 5 to 7 until the generating set operates at correct lambda for all loads.
9. Stop the genset and check that it can be restarted with the new settings.

3000 / 3600RPM Sets (Isuzu)

1. Start the generating set.
2. Increase the load to around 60% of nameplate rating using a load bank, or available building load. Allow the engine time to reach normal operating temperature.
3. Adjust the main adjustment screw (MAS) on the mixer for correct lambda
4. Increase the load to 100% of nameplate rating using a load bank (if a load bank is available).
5. If required, adjust the MAS for correct lambda if the screw has been opened completely and lambda is still too high, either the gas inlet pressure is too low or the gas quality is too poor. It may not be possible to achieve full load in this case.
6. Remove all load from the genset.
7. Stop the genset and check that it can re-start with the new MAS and regulator settings.

Problem Diagnosis

Most operating troubles that might be encountered with a new or well-maintained unit will be of a minor nature. Therefore, if you have troubles starting or operating your engine, look for some simple cause rather than failure of a major component. For instance: loose or corroded battery connections are much more likely than battery failure, or a loose ignition wire is much more likely than distributor, coil or ignition system failure.

In many cases, engine operating troubles are coupled with outside factors, such as climatic conditions, operating conditions, change of servicing or fueling source, or change of operator.

Engine troubles that occur as a result of normal use usually give plenty of advance warning. These troubles usually result from overlooking the Preventive Maintenance Schedule services.

Whenever engine performance seems less than normal in any category, it is best to consult with your dealer at the first symptom rather than wait until a serious problem develops. One of the aims of regular maintenance is to help you in just these circumstances.

Engine Won't Crank

1. Turn the control switch to the run position. If nothing happens, an electrical lead(s) may be loose or disconnected, the battery cables may be loose, disconnected or corroded or the battery discharged.
2. Another indication of loose battery connections or low battery condition is a stuttering noise from the engine compartment when the control switch is turned to the run position. Check the connections to the starter motor and the solenoid switch in addition to the battery and ground connections.
3. If all the electrical connections are tight and you need assistance to start, read the instructions under Emergency Starting.

Engine Cranks But Won't Start

1. Check the gas supply pressure: If gas is being supplied to the unit at the correct pressure, the trouble may be in either the ignition system or the fuel system.
2. Check the ignition system. Remove the wire from one of the spark plugs by grasping the molded cap of the wire only, and insert a short piece of bare wire or other metal in the terminal of the wire.

NOTE — Spark plug wires carry high-tension electrical current, capable of giving a shock. Be sure to grasp the molded boot well back from the open end.

Hold the cap so that the inserted bare wire is about l/4 inch from the engine block and crank the engine (with the control switch in the run position) for at least three seconds. If there is no spark between the wire and the metal, the trouble may be in the distributor or coil. If you see a spark, then check the fuel system for trouble.

3. The fuel system may have a leak or a faulty gas solenoid shut-off valve.

Engine Runs Hot

Listed below are items that could cause an engine to overheat.

1. Low coolant level.
2. Loose or broken fan belt.
3. Inoperative thermostat.
4. Dirty cooling system. Radiator fins restricted with leaves, dirt, etc.
5. Running engine with frozen coolant.
6. Leaky head gasket.
7. Overloading, especially during hot weather.
8. Recirculation of hot radiator outlet air.

Emergency Starting

Use of booster battery and jumper cables—particular care should be used when connecting to a booster battery in order to prevent sparks. To jump start (negative grounded battery):

- Shield eyes.

- Connect end of one cable to the positive (+) terminals of each battery.

- Connect one end of other cable to negative (-) terminal of "good" battery.

- Connect other end of cable to engine block of unit being started (NOT TO NEGATIVE (-) TERMINAL OF BATTERY).

To prevent damage to other electrical components on unit being started, make certain that engine is running at rated speed and at no load before disconnecting jumper cables.

WARNING—Batteries contain SULFURIC ACID. In case of acid contact with skin, eyes, or clothing, FLUSH IMMEDIATELY WITH WATER FOR A MINIMUM OF FIVE MINUTES. Get "on-the-spot" medical attention immediately.

Hydrogen and oxygen gases are produced during normal battery operation. This gas mixture can explode if flames or sparks are brought near the battery. When charging or using battery in an enclosed space always provide ventilation.

Keep fire away from the top of open battery cells. Combustion gas is always present.

3. MAINTENANCE INSTRUCTIONS

Preventative Maintenance Schedule

Initial Startup Sequence	Operation	100 Hrs	200 Hrs	300 Hrs	400 Hrs	500 Hrs	600 Hrs	700 Hrs	800 Hrs	900 Hrs	1000 Hrs
1	Check oil level	Daily									
2	Check coolant level in radiator	Daily									
3	Check for fuel, oil and coolant leaks	Daily									
	Engine oil change (1)	F	F/Z/ GM	F	F/Z/ GM	F	F/Z/ GM	F	F/Z/ GM	F	F/Z/ GM
	Oil filter change (1)	F	F/GM	F	F/Z/ GM	F	F/GM	F	F/Z/ GM	F	F/GM
4	Air cleaner. Replace (1)	F/Z	F/Z	F/Z	F/Z	F/Z	F/Z	F/Z	F/Z	F/Z	F/Z
	Replace Air cleaner Element (1)				GM				GM		
	Inspect & Clean Air Cleaner Element (1)	Weekly									
5	Battery. Check charge and level	F/Z/ GM	F/Z/ GM	F/Z/ GM	F/Z/ GM	F/Z/ GM	F/Z/ GM	F/Z/ GM	F/Z/ GM	F/Z/ GM	F/Z/ GM
	Radiator. Inspect and clean exterior	GM	F/Z/ GM	GM	F/Z/ GM	GM	F/Z/ GM	GM	F/Z/ GM	GM	F/Z/ GM
	Battery cables. Clean		F/Z/ GM		F/Z/ GM		F/Z/ GM		F/Z/ GM		F/Z/ GM
	Valve clearance (cold) – check and adjust		Z		Z		Z		Z		Z
6	Fan and battery charging alternator drive belts. Check and adjust	GM	F/Z GM	GM	F/Z GM	GM	F/Z GM	GM	F/Z GM	GM	F/Z GM
7	Cooling system. Check or refill				F/Z/ GM				F/Z©		
	Spark plugs. Clean, adjust and test or replace		Z		F/Z		Z		F/Z		Z
	Ignition timing. Check and adjust		Z		F/Z		Z		F/Z		Z
	PCV valve. Replace (If so equipped) & check hoses/tubes and fittings								F/GM		
	Spark plugs. Replace								F/GM		Z
	Coolant. Replace (2)								F/Z/ GM		
	Replace thermostat										Z
	Replace timing belt										Z
	Clean oil pump strainer and the sump										Z
	All bolts and nuts. Check for tightness (2)										

F – Ford engine service intervals

Z – Isuzu 4ZB1 service intervals

GM – GM Engine service intervals

(1) - More frequent intervals may be required in dusty areas.

(2) - Seasonal or as required

NOTE: Scheduled maintenance beyond 1000 hours should be continued at the same intervals as before.

Initial Start Up

Your generating set was inspected before leaving the factory. However, the initial start-up checks must be made before putting the unit into operation. The Preventative Maintenance Schedule provides a handy check-up list. Perform the operations in the sequence listed in the left-hand column.

Routine Service

Make sure your unit is ready to go whenever you need it. There are some things that you can do, or have done, to be sure it is well cared for:

- Make frequent checks of the engine oil and coolant levels.
- Check all air coolant and vacuum hoses for signs of deterioration.
- Check the battery fluid level often, especially if your engine is being operated in a warm, dry climate
- Keep engine air filter clean.
- Watch the engine temperature.

The operations listed in the Preventative Maintenance Schedule are covered in detail on the following pages.

4. ENGINE OIL

Checking Oil Level

The oil level should be checked frequently, at least daily, and maintained between the FULL and ADD marks on the dipstick. Allow a few minutes after shutting the engine off for the oil to drain down before checking.

CAUTION—Do not operate the engine with the oil level below the ADD mark on the dipstick.

Adding Oil

It is normal to add some oil between oil changes. The amount will vary with the severity of operations. When adding or replacing engine oil be sure oils meet the specifications listed.

Changing Oil and Filter

For most operations, the engine oil and filter must be changed every 100 hours or seasonally. Under normal operating conditions, you do not need to change more often if you use oil and filters of the recommended quality.

The oil and filter should be changed more often if the engine is operated in dusty areas, for extended low load operation, or frequent stops during cold weather. No break-in oil change is required.

Oil Quality

To help achieve proper engine performance and durability, it is important that you use only engine lubricating oils of the proper quality in your engine. Proper quality oils also provide maximum efficiency for the crankcase ventilation system, which reduces pollution.

Use oil that meets API categories SG or SH. It is best not to mix different brands of lubricants and oils, because sometimes they are not compatible and deteriorate when mixed. Stay with one brand to assure compatibility.

Oil Identification Logo

A logo has been developed to help you select the proper quality oil. It will be included on the oil can you purchase. The top section of the logo shows the oil quality by the API designation. The center section will show S.A.E. viscosity grade. The lower section will state "energy conserving" if the oil has proven fuel-saving capabilities.

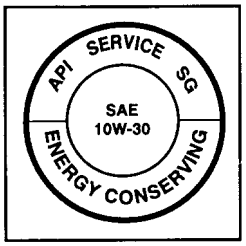


Figure 1: Oil Identification Logo

Oil Viscosity

When you change or add oil, you should select oil with the proper specifications and with the viscosity, (selected from the following table), which most closely matches the temperature range you expect to encounter for the next 100 hours of operation.

The use of engine oil that does not meet current API Specification is unacceptable and can result in premature engine failure.

4 Engine Oil

Single-Viscosity Oils

When Outside Temperature Is Consistently	Use SAE Viscosity Number
-10°F to +60°F	*10W
+10°F to +90°F	20W-20
Above +32°F	20W-30
Above +50°F	20W-40

Multi-Viscosity Oils

When Outside Temperature Is Consistently	Use SAE Viscosity Number
Below +10°F*	*5W-20
Below +60°F	5W-30
-10°F to 90°F	10W-30
Above -10°F	10W-40 or 10W-50
Above +20°F	20W-40 or 20W-50

* Not recommended for severe service operation.

Oil Filter

Use genuine GENPART Oil Filters.

These filters protect your engine by filtering harmful, abrasive, or sludgy particles without blocking the flow of oil to vital engine parts.

To replace, use a filter wrench to remove filter.

WARNING—Do not handle a hot oil filter with bare hands.

Clean the filter mounting base on the engine block, lightly coat the gasket surface of the new filter with engine oil and hand tighten until the gasket contacts the base, then tighten another half turn. Fill the crankcase and run the engine to check for leaks.

Air Cleaner

Your air cleaner filters air entering the engine induction system and acts as a silencer. Air that contains dirt and grit, if able to enter the engine, will cause severe damage to the cylinder walls and piston rings. Damage to the cylinder walls and piston rings will cause high oil consumption and short engine life. A restricted or dirty air cleaner will also cause a rich fuel mixture. Thus, it is extremely important that the air cleaner be serviced at the recommended intervals.

CAUTION—Service the air cleaner more frequently under severe dust conditions

Clean or replace the air cleaner paper filter element.

Remove the paper filter element from the air cleaner. Inspect the element for mud caking or signs of excessive wear or damage. Replace as necessary.

Remove all dust and foreign matter from the air cleaner housing.

Make sure that the air cleaner is seated properly.

5. COOLING SYSTEM

Coolant Level

Check the coolant level in the radiator daily, only when the engine is cool.

Maintain the coolant level at approximately 3/4 to 1-1/2 inches (19-38 mm) below the filler neck seat on the radiator when the coolant is cold.

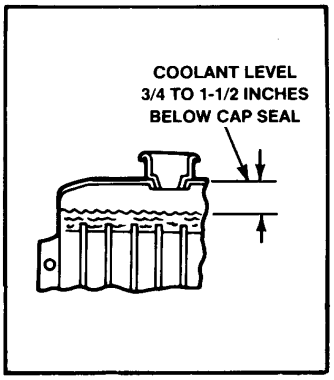


Figure 2: Coolant Level

Whenever coolant level checks are made check condition of radiator cap rubber seal. Make sure it is clean and free of any dirt particles. Rinse off with clean water if necessary. When replacing cap on radiator, also make sure radiator filler neck is clean.

WARNING — Never remove the radiator cap under any conditions while the engine is operating. Failure to follow these instructions could result in damage to the cooling system or engine and/or personal injury. To avoid scalding, use extreme care when removing the cap from a hot radiator. If possible, wait until the engine has cooled, then wrap a thick cloth around the radiator cap and turn it slowly to the first stop. Step back while the pressure is released from the cooling system. When you are sure all the pressure has been released, press down on the cap (still with a cloth), turn and remove it.

Do not add coolant to an engine that has become overheated until the engine cools. Adding coolant to an extremely hot engine can result in cracked block or cylinder head.

Use only a quality permanent-type ethylene glycol coolant with a corrosion inhibitor. The antifreeze mixture must be an efficient coolant at all ambient temperatures and must provide protection against corrosion. It must also have a specification at least as good as the requirements of ASTM D3306-74: “Ethylene Glycol Base Engine Coolant”. An antifreeze concentration of 40% is recommended. Refer to the coolant mixture chart on the container for additional antifreeze protection information. Do not use alcohol or methanol antifreeze, or mix them with the specified coolant.

Plain water may be used in an emergency, but replace it with the specified coolant as quickly as possible to avoid damage to the system.

Radiator

Inspect the exterior of the radiator for obstructions. Remove all bugs, dirt or foreign material with a soft brush or cloth. Use care to avoid damaging the fins. If available, use compressed air or a stream of water in the opposite direction to normal airflow.

Check all hoses and connections for leaks. If any of the hoses are cracked, frayed, or feel spongy, they should be replaced.

Drive Belts

Drive belt(s) where used, for driving such items as the water pump, battery charging alternator and cooling fan should be properly adjusted at all times. A loose drive belt causes improper alternator fan and water pump operation, in addition to overheating.

Overtightening the belt may result in excessive wear on the alternator and water pump bearings, as well as premature wear on the belt itself. Therefore, it is recommended that a belt tension gauge be used to check and adjust the belt tension. Any belt that has operated for a minimum of 10 minutes is considered a used belt, and when adjusted, it must be adjusted to the reset tension shown in the specifications.

Belt Tension

Install the belt tension tool on the drive belt and check the tension following the instructions of the tool manufacturer.

If the tension is not to specification, loosen the alternator mounting and adjusting arm bolts. Move the alternator away from the engine until the correct tension is obtained. Remove the gauge. Tighten the alternator adjusting arm and mounting bolts. Install the tension gauge and recheck the belt tension.

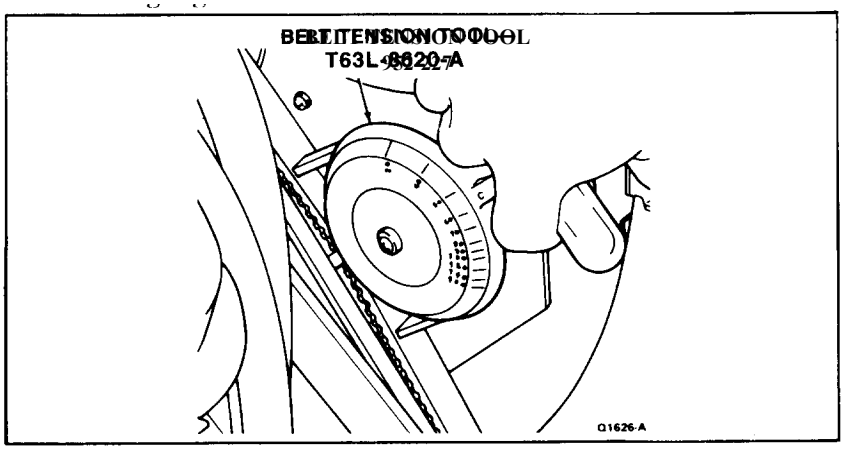


Figure 3: Belt Tension

Battery

If there is any corrosion on the cables and terminals, remove it with a wire brush and neutralize the acid with a solution of baking soda or ammonia with water. After cleaning, flush the top of the battery with clean water, install the terminal clamps on the battery posts, and coat the parts with grease to retard further corrosion,

Fluid Level - (Non-Maintenance Free Battery)

Because the battery is the "heart" of your unit's electrical system, periodic checks are necessary to keep it functioning properly. Keep the battery level in each cell up to the level indicator.

Distilled water must be used to top up the battery level. If distilled water is added during freezing weather, run the engine 20 to 30 minutes before shutting it off. This mixes the added water with the electrolyte and will prevent it from freezing and damaging the battery. Have the battery charge checked regularly during extreme cold weather. When the specific gravity falls below 1.230 (corrected to 80°F), recharge the battery. Make sure the cables are clean and tightly clamped to the battery terminals. Keep the top of the battery clean and dry.

WARNING — Batteries normally produce explosive gases that can cause personal injury. Therefore, do not allow flames, sparks or any ignited object to come near the battery. When charging or working near a battery, always shield your eyes. Always provide ventilation.

When lifting a plastic-cased battery, excessive pressure on the end walls could cause acid to spew through the vent caps, resulting in personal injury. Lift with a battery carrier or with your hands on opposite corners.

Closed Circuit Breathing System

Clean air is supplied to the crankcase via an opening in the rocker cover. The fumes are vented out of another opening in the rocker cover into the intake manifold.

6. IGNITION SYSTEM

Two types of ignition systems are used on this product range. A breakerless solid state type ignition system is used on the HM 4ZB1 engine. A distributorless ignition system is used on the Ford LRG425 ESG642 & WSG1068 and on the GM8100 engines. Use the appropriate maintenance procedures for the system in use on your engine.

The spark plug wires are inserted in the distributor cap in the firing order of the engine (1-3-4-2 for the HM 4ZB1 and Ford LRG425, 1-4-2-5-3-6 for the ESG642, 1-6-5-10-2-7-3-8-4-9 for WSG1068 and 1-8-7-2-6-5-4-3 for GM8100). Number one socket is identified by the number one on the cap. The cylinders are numbered from front to rear, 1-2-3-4 for the HM 4ZB1 and LRG425, 1-2-3 right side and 4-5-6 left side for the ESG642, 1-2-3-4-5 right side and 6-7-8-9-10 left side for the WSG1068 and 2-4-6-8 right side and 1-3-5-7 left side for the GM8100 (RHS & LHS - as viewed from the rear of the engine).

Solid State Ignition Systems

When installing a new distributor cap or rotor, coat the brass rotor electrode surfaces on all sides outboard of the plastic, including the outer edge, with silicone dielectric compound (GENPART part number 952-228), or equivalent to approximately 1/32-inch thickness. Do not reapply or attempt to remove any silicone coating from the distributor cap electrodes. As this compound ages, it has the appearance of being a contaminant of the cap and rotor electrode. This condition is normal and causes no performance loss.

Coat the inside of each spark plug boot with silicone dielectric compound (GENPART part number 952-228), or equivalent, using a small screwdriver blade. Connect each spark plug wire to the plug from which it was removed. Be sure each wire is fully depressed on each plug and molded boot is firmly in place.

At the specified intervals, apply a few drops of engine oil to the distributor oil felt (where applicable) and apply an appropriate lubricant at the pivot points of the throttle and governor.

The ignition timing should be checked and adjusted at the recommended intervals. Proper adjustment of ignition timing must be maintained to provide maximum engine power output and best possible fuel economy.

Distributorless Ignition Systems

As with the solid state ignition systems, coat the inside of each spark plug boot with silicone dielectric compound (GENPART part number 952-228), or equivalent, using a small screwdriver blade. Connect each spark plug wire to the plug from which it was removed. Be sure each wire is fully depressed on each plug and molded boot is firmly in place.

The ignition timing on distributorless ignition systems is factory set and cannot be manually adjusted.

Spark Plugs

The spark plugs should be cleaned, tested and gapped at the recommended intervals.

Remove the wires from each spark plug by grasping, twisting and then pulling the molded cap of the wire only. Do not pull directly on the wire because the wire connection inside the cap may become separated.

After loosening each spark plug one or two turns, clean the area around each spark plug port with compressed air, then remove the spark plugs.

After cleaning, examine the plug carefully for cracked or broken insulators, badly pitted electrodes, and other signs of malfunction. Replace as required.

After cleaning, dress the electrodes with a small file to obtain flat parallel surfaces on the electrodes. Set the spark plug gap to specifications by bending the ground electrode. All spark plugs, new or used, should have the gap checked as required. The recommended spark plug gap for the HM 4ZB1, LRG425, ESG642 and WSG1068 is 0.044 in. and GM8100 gap is 0.059 in.

Install the spark plugs and torque each plug 9-13 Nm (7-10 lb.ft).

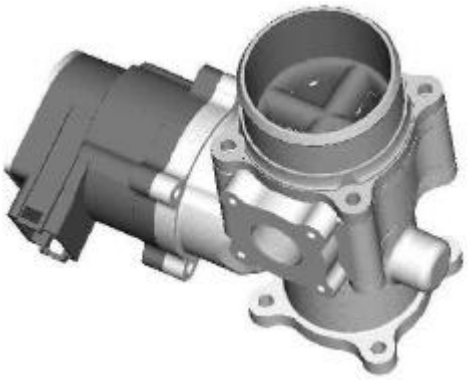
Connect the spark plug wires.

NOTE—Do not overtighten spark plugs. The gap may change considerably due to distortion of the plug outer shell.

7. CARBURETION

System Operation for Ford and Isuzu

The carburetion system starts with the fuel shut-off (vacuum operated lock-off with LP liquid systems and electric solenoid with natural gas and LP vapor systems). As the engine is cranked the fuel shut-off is opened and allows fuel to flow through the gas regulator to the carburetor. When the engine is shut down the fuel is shut off automatically.



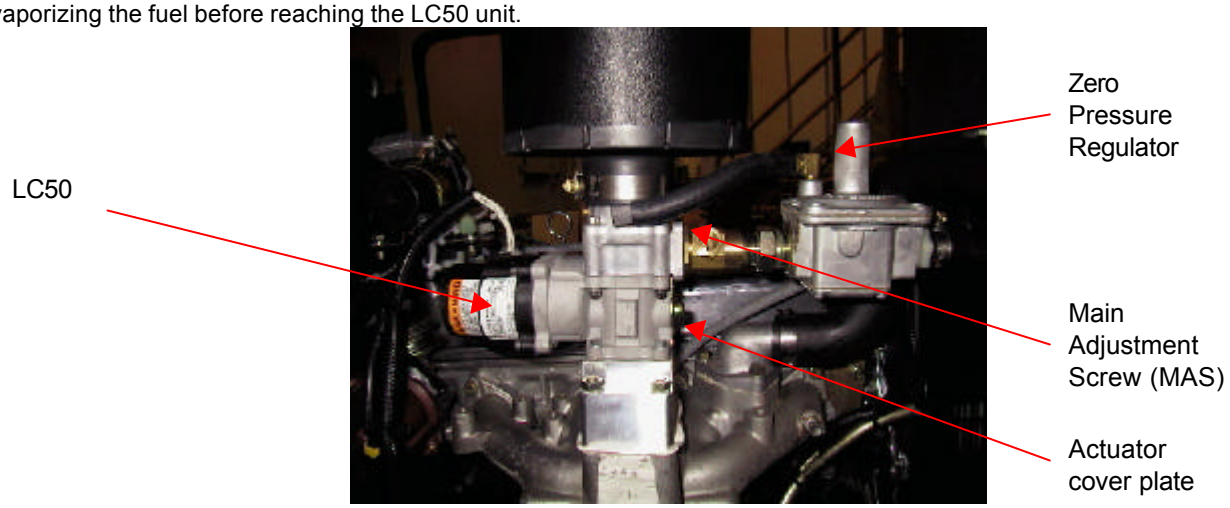
LC50

The LC-50 consists of a die-cast aluminum throttle body, integrated gas mixer featuring a venturi style annular ring mixer with no moving parts for superior mixing, plus a fully programmable integrated digital speed control and bi-directional actuator. The actuator connects directly to the butter-fly valve which regulates the amount of air/fuel mix being supplied to the engine.

When the engine is cranked, the flow of air through the venturi ring mixer draws in gas. As the airflow increases, more gas is drawn in, maintaining the air / fuel ratio under all load conditions. This system requires that the pressure of the gas be regulated to 0" pressure and that the flow of gas can be metered as required. For this reason, a Zero Pressure Regulator (ZPR) is incorporated between the gas supply and the LC50 unit and during running the gas flow to the LC50, is metered by means of the main adjustment screw (MAS), which is adjusted to give good air / fuel ratio for all load conditions.

The system operates using a tailored software configuration for the specific engine it is fitted to and can operate using both natural gas (CNG) and LPG.

When using LP liquid, the regulator is replaced with a vaporizer, which uses the heat from the engine coolant to assist in vaporizing the fuel before reaching the LC50 unit.



Problem Diagnosis for Ford and Isuzu

1. Gas carburetion, because of its simplicity, is unlikely to give any problems when properly installed with an adequate supply of gas. It would be well to exhaust every other avenue of possible mechanical or electrical failure before tampering with gas pressure or carburetor adjustments, particularly if the system has been functioning normally in the past.
2. Check all air, coolant, gas supply and vacuum hoses for deterioration.
3. The first corrective step is to measure the gas inlet pressure (before the shut-off) with a water manometer (do not attempt to measure gas pressure with a mercury manometer). The gas pressure should typically be between 4" – 13.5" water column. If the gas pressure is too high, it will prevent the solenoid valve from opening, if the gas pressure is too low, there will not be sufficient gas for the engine to run. In both cases the installation needs to be modified to bring the gas pressure within acceptable limits
4. The gas pressure downstream of the ZPR should be 0" water column; small changes in the gas pressure can be affected by adjusting the ZPR. If zero pressure cannot be achieved, the ZPR is not functioning correctly and should be replaced.
5. If conditions still indicate carburetor malfunction:
   5.1. Switch of the gas supply and remove the actuator cover plate.
   5.2. Check that the butterfly is operating correctly during engine cranking (the butterfly should open, indicated by movement of the shaft).
   5.3. Check the butterfly is free to move and does not bind. It should have a spring pressure which pushes it closed. If the butterfly is seized, binds or has no spring pressure, then replace the LC50 unit.
   5.4. Remove the deutch plug connector and test the supply voltage to the LC50 is within spec as follows; While cranking the engine, measure the dc voltage between pins 1 and 2 of the Deutsch connector on the wiring loom, it should be >8 volts. If the voltage is less than 8 volts investigate the reason and rectify.
   5.5. Test the magnetic pick-up signal is within spec as follows; While cranking the engine, measure the ac voltage between pins 11 and 3. It should be >1.5 volts. If the voltage is less than 1.5 volts investigate the reason and rectify (check the magnetic pick up hasn't been damaged and is correctly positioned ¼ turn out from the flywheel).
   5.6. If there is still a problem the LC50 has malfunctioned – if this is the case remove the complete unit and replace.

8. FUEL SYSTEMS

The positive pressure of both Natural Gas and LPG to the genset, should be in the range 10mBAR to 34mBAR (4" H_2O - 13.5" H_2O), except to the Turbo genset which should be in the range 15mBar to 34mBar (6" H_2O - 13.5" H_2O).

- If the pressure is less than 10mBAR (4" H_2O), the genset may not be able to achieve 100% load.
- If the pressure is greater than 34mBAR (13.5" H_2O), the solenoid valve may not be able to open and so the set will not run.
- The calorific value of natural gas should be above a minimum of 34MJ/m3 (913 BTU/ft3), if it is below this a de-rate may need to be applied to certain gensets.

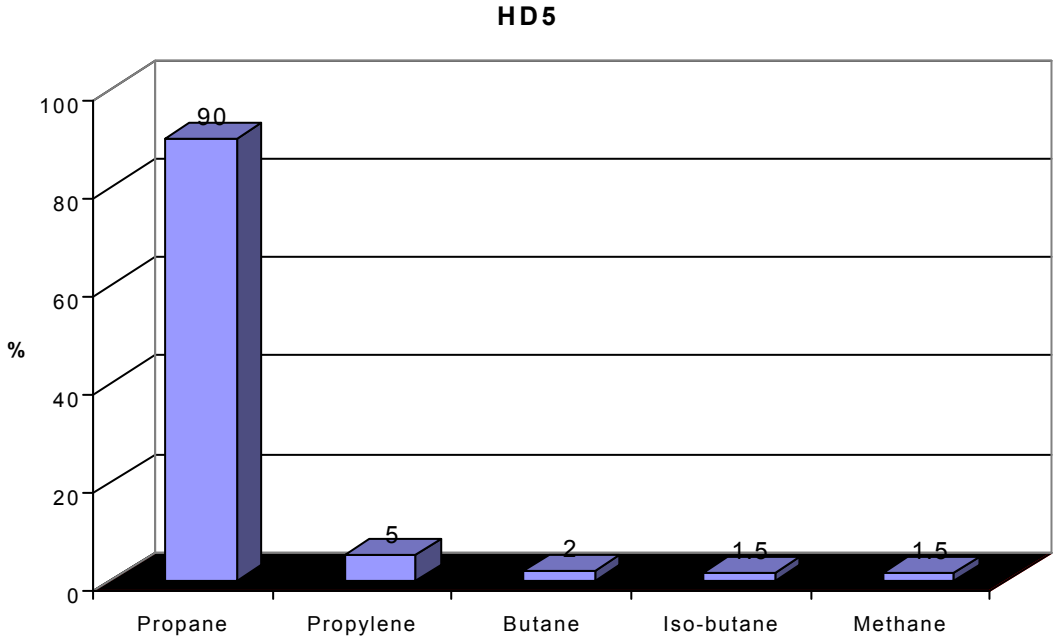
Impurities in the gas should be kept to a minimum as they can have a detrimental effect on engine durability, if quality of the gas is poor, the gas protection option is available.

What is LPG

LPG is "liquefied petroleum gas" commonly known as propane (C3H8), a combustible hydrocarbon based fuel. It comes from the refining of crude oil and natural gas. At normal pressure (29.92"HG) and temperatures above -44°F /-45°C Propane remains in it's gaseous form. At lower temperatures and/or higher pressures propane will become a liquid. Propane is colorless and odorless. For safety reasons propane is required to be odorized as to indicate positively, by distinct odor, the presence of gas in air down to a concentration of over 1/5th the lower level of flammability (0.4% in air). This is achieved by adding 1.0#s of ethyl mercaptan, or 1.0#s of thiophane, or 1.4#s of amyl mercaptan per 10,000 gallons of LPG. There are currently three grades of propane available, HD5 for internal combustion engines, commercial propane and commercial propane/butane mix for other uses. The exact composition of propane varies slightly between different parts of the country and different refineries. Compared to gasoline the energy content of LPG is 74%.

The following table shows approximate composition of HD5.

PROPANE					
Propane (C3H8)	Propylene	Butane (C4H10)	Iso-Butane	Methane (CH4)	Total
90.0% min.	Up to 5%	2.0%	1.5%	1.5%	100%



What is CNG

CNG is "compressed natural gas". Natural gas (CH4) is a naturally occurring mixture of combustible hydrocarbon gases found in porous formations beneath the earth's surface. Natural gas is created by the decomposition of plant and animal remains, under great heat and pressure, over very long periods of time. Natural gas can be found as

- Nonassociated gas - free gas not in contact with significant amounts of crude oil in the reservoir
- Associated gas - free gas in contact with crude oil in the reservoir
- Dissolved gas - gas in solution with crude oil in the reservoir

For safety reasons natural gas is required to be odorized as to indicate positively, by distinct odor, the presence of the gas in air down to a concentration of not over 1/5th the lower level of flammability (1.0% in air). This is achieved by adding ethyl mercaptan, or thiophane, or amyl mercaptan to the natural gas. Compared to gasoline the energy content on CNG is 25%.

The exact composition of natural gas varies between different parts of the country and different refineries. The following table shows the approximate composition of natural gas.

Natural Gas		
Component		**Volume = %**
Methane	CH4	92.3
Ethane	C2H6	3.6
Propane	C3H8	1.0
Butanes	C4H10	0.3
Pentanes	C5H12	0.1
Hexanes	C6H14	0.1
Carbon Dioxide	C02	1.0
Nitrogen	N2	1.6
Total	Natural Gas	100