

GAS ENGINE OPERATOR'S HANDBOOK

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1. GENERAL INFORMATION

Introduction

Generator 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 Generator 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 generator 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 generator set serial number in the space provided below.

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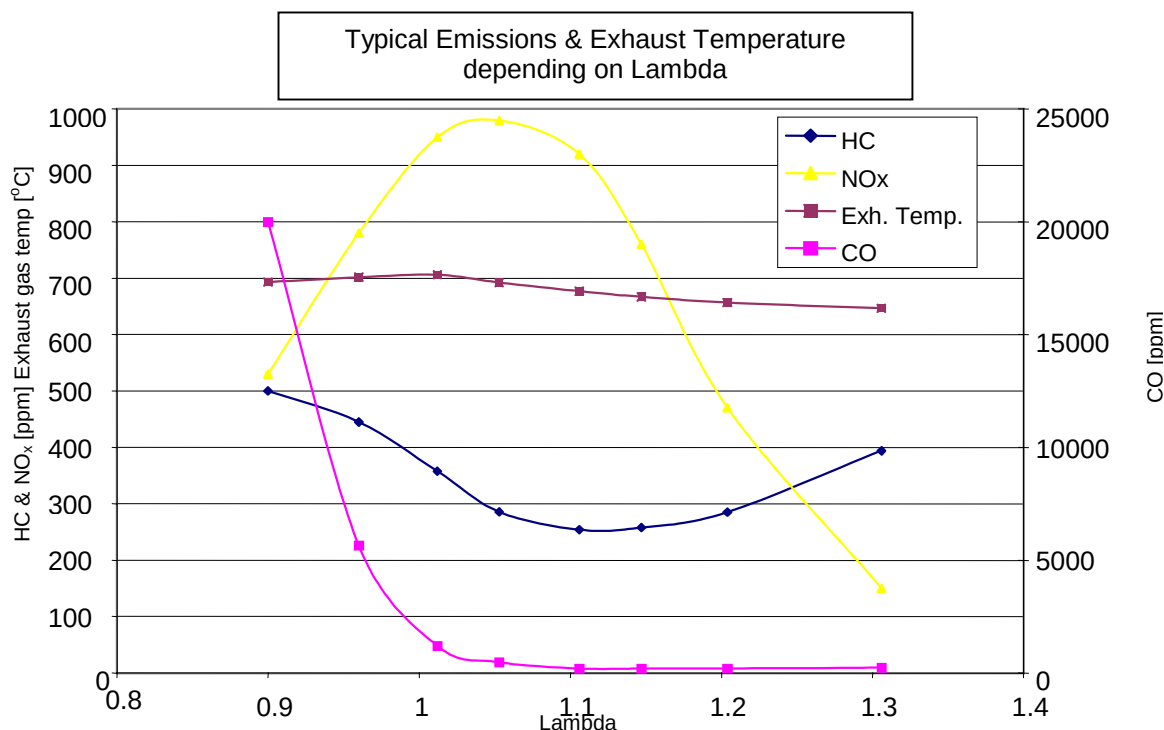
Generator Set Serial Number

2 Operating Instructions

2. OPERATING INSTRUCTIONS

Adjustment during running

1. Start the generator set and check lambda or CO% at no load.
If $\lambda < 0.9$ or $\text{CO} > 2.5\%$ the outlet pressure is set too high, decrease the pressure.
If $\lambda > 1.1$ or $\text{CO} < 0.05\%$ the outlet pressure is set too low, increase the pressure.
2. Warm up the engine and check 60% of maximum power point.
3. Adjust lambda on the right value (0.925) or adjust CO to 1.0% by opening main adjustment screw
4. Run the genset at the maximum power point
5. If required, adjust lambda on the right value (0.925) or adjust CO to 1.0% by opening main adjustment screw.
If the screw has been opened completely and lambda is still too high or CO is still too low, 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. Run the genset at no load
If lambda (0.9 – 1.1) or CO (0.05% - 2.5%) is okay, adjustments are okay.
If settings are too lean ($\lambda > 1.1$ or $\text{CO} < 0.05\%$) increase outlet pressure
If settings are too rich ($\lambda < 0.9$ or $\text{CO} > 2.5\%$) decrease outlet pressure
7. Repeat steps 2 to 6 until the generator set operates with lambda between 0.9 – 1.1 or CO between 0.05% - 2.5% at all loads.
The graph below shows the typical relationship between CO and lambda and also how this affects HC and NO_x emissions and exhaust gas temperature.



Normal Conditions

Please refer to the Technical Operation and Maintenance Manual for specific instructions on starting and stopping the engine, using the generator set control panel.

Abnormal Conditions

If the engine is overheated due to a loss of coolant, it is best to stop the engine immediately, if necessary by applying the load. Allow the engine to cool, then check the coolant and oil levels. Add engine oil if necessary, then after the engine has returned to a normal temperature add coolant slowly until the radiator is full.

WARNING—Avoid injury when checking a hot engine. Cover the radiator cap in a thick cloth and turn it slowly counterclockwise to the first stop. After the pressure has been completely released, press the cap downward and finish removing the cap.

The above instructions also apply to engines that stop due to operation of the low oil pressure-high water temperature safety switch. However, if the engine stops due to low oil pressure, do not restart until the cause has been determined and corrected.

Special Situations

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.
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Hold the cap so that the inserted bare wire is about 1/4 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.
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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

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)	X	X	X	X	X	X	X	X	X	X
	Oil filter change (1)	X	X	X	X	X	X	X	X	X	X
4	Air cleaner. Clean or replace element	X	X	X	X	X	X	X	X	X	X
5	Battery. Check charge and level	X	X	X	X	X	X	X	X	X	X
	Radiator. Inspect and clean exterior		X		X		X		X		X
	Battery cables. Clean		X		X		X		X		X
6	Fan and battery charging alternator drive belts. Check and adjust		X		X		X		X		X
7	Throttle and governor linkage. Lubricate		X		X		X		X		X
	Cooling system. Check or refill				X				X		
	Spark plugs. Clean, adjust and test or replace				X				X		
	Distributor. Clean (if so equipped)				X				X		
	Distributor. Lubricate				X				X		
	Ignition timing. Check and adjust				X				X		
	PCV valve. Replace (if so equipped)								X		
	Spark plugs. Replace								X		
	Coolant. Replace								X		
	All bolts and nuts. Check for tightness (2)										

(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 generator 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.

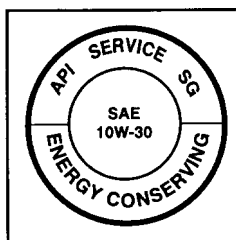


Figure 1: Oil Identification Logo

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.

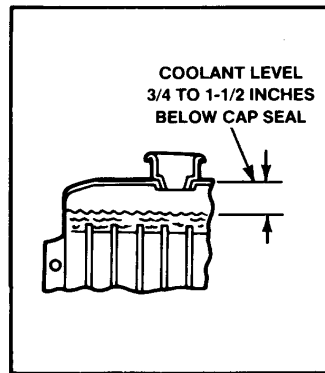


Figure 2: Coolant Level

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.

5 Cooling System

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.

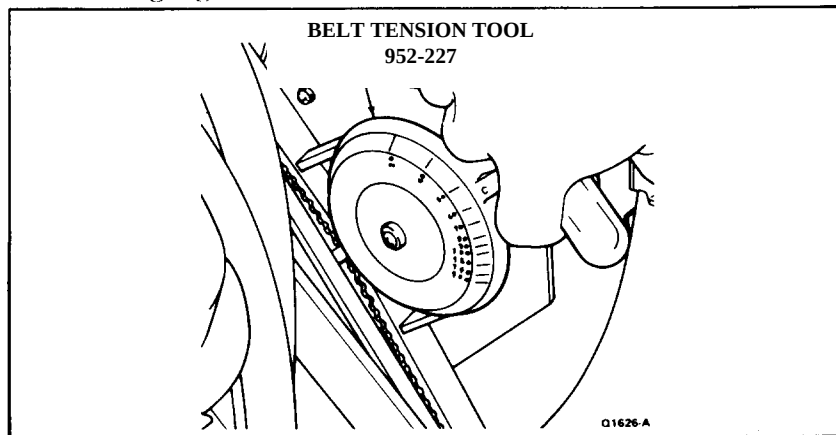


Figure 3: Belt Tension

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 engines HM 4ZB1, Ford CSG649 and Ford LSG875. A distributorless ignition system is used on the Ford LRG425. 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 LRG425, 1-5-3-6-2-4 for the CSG649, 1-5-4-2-6-3-7-8 for the LSG875). 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, 1-2-3-4-5-6 for the CSG649, 1-2-3-4 right side and 5-6-7-8 left side for the LSG875 (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, CSG649 and LSG875 is 0.044 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

7. CARBURETION

System Operation

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.

The carburetors used are all air valve design, utilizing a relatively constant pressure drop to draw fuel into the carburetor from cranking to full load. The advantage of this type of construction is a strong "signal" or vacuum set up by a metering spring (S) holding the air valve (V) closed. A pressure drop under the air valve of approximately six inches of water column is required to open the valve during cranking. This vacuum is also communicated to the fuel lock off with LP liquid systems to allow fuel flow. For natural gas and LP vapor systems an electric solenoid shut-off is used to allow fuel flow.

With the engine stopped, fuel is sealed off within the carburetor as well as in the vacuum lock-off with LP liquid systems or in the electric solenoid shut-off with LP vapor and natural gas systems.

All of the air valve carburetors use diaphragms of fiberglass and synthetic rubber or silicone material. Cranking the engine lowers the pressure in the shaded area as the piston descends. Through passages (P) in the air valve, this lowered pressure is communicated to upper side of diaphragm (D). As a result, atmospheric pressure pushing upward on the diaphragm lifts it against the downward pressure of the metering spring (S).

The lowered pressure communicated to the top of the diaphragm varies with the position of the throttle valve opening (T). The air valve assembly 'measures' the airflow into the engine by moving precisely in response to the demands of the engine and throttle valve position.

The controlled pressure drop set up by the metering spring provides the signal or force necessary to draw fuel into the air stream within the carburetor. The gas metering valve (V) is attached to the air valve assembly and is shaped to admit the correct amount of fuel from the gas jet to mix with incoming air at any opening of the air valve.

The carburetors used also provide two limited-range mixture adjustments:

1. Idle Air Bypass Adjustment (I). The total volume of air and fuel passing the closed throttle at idle is constant. The idle adjustment bypasses a portion of incoming air around the air valve opening. As the idle adjustment is opened, the air valve partially closes, thereby closing the gas metering valve and leaning the idle air-fuel mixture. However, this idle bypass adjustment will have little affect on constant speed engines operating at engine speeds of 1500 rpm or higher.
2. Power Mixture Adjustment (A). This controls mixtures when the gas metering valve is withdrawn from the jet, which occurs when the engine approaches full load. With the gas metering valve withdrawn from the jet, the major restriction to gas flow becomes the power mixture adjustment. This adjustment is most effective at full load, and decreasingly effective down to approximately one half load where it no longer has much effect.

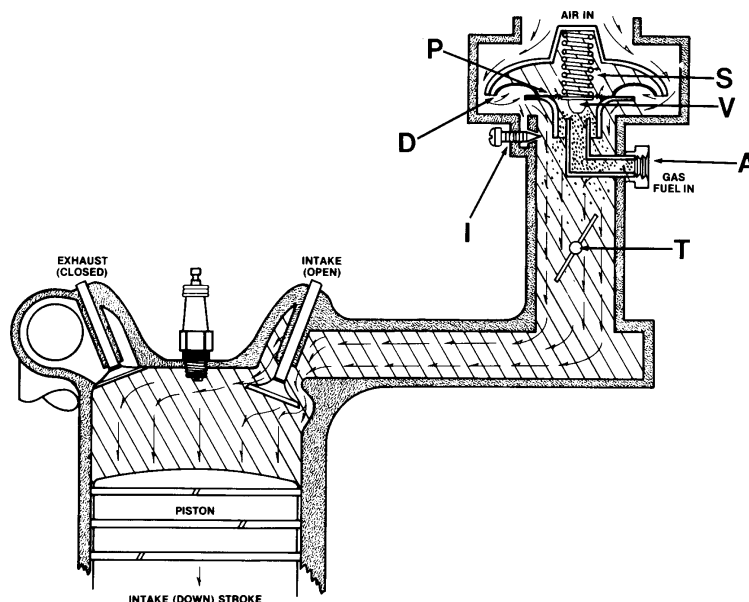


Figure 4: Diaphragm Operated Air-Gas Valve Operation

Mixtures between zero and full-load conditions are controlled by the gas metering valve shape. The gas metering valve is shaped to produce lean mixtures at light loads and increasingly rich mixtures at heavier loads and higher engine speeds.

Problem Diagnosis

1. Gas carburetion, because of its simplicity, is unlikely to give any problems when properly installed with an adequate supply of gas, since the carburetor has the least complicated function to perform, and has the least moving parts. 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 and vacuum hoses for deterioration.
3. If carburetion is definitely at fault, the first corrective step is to measure the gas inlet pressure (before the shut-off) at idle and full load with a water manometer (do not attempt to measure gas pressure with a mercury manometer). The gas pressure should typically be between 7" - 20" water column for natural gas and 5" - 20" water column for LP vapor at full load. If the B.T.U. content of the natural gas supply is low, an increase in the minimum gas inlet pressure to 10" to 12" water will compensate for fuel down to 900 - 950 BTU heat value. Natural gas with even less heating value, e.g. in the 800 BTU range, requires a special gas valve. If the gas pressure is shown to be correct, proceed to the next step described under paragraph 3.
4. If conditions still indicate carburetor malfunction, remove the air valve cover (or covers) and lift out the spring and air-gas valve complete with diaphragm.
 - a. Inspect diaphragm for possible holes, or charring from excessive heat or backfiring. The diaphragm should be reasonably flexible. Diaphragm life under normal conditions should be as much as five years without difficulty. Heat from proximity to exhaust manifolds, or from turbo-charged air can shorten diaphragm life.
 - b. If diaphragms prove sound, check the inside diameter of the air valve cup and the fins on the outside of the gas jet which guide the air valve. Grooves worn into the cup by the fins, may lead to poor metering as the valve tries to pass up and down over the step.
 - c. Also, inspect the inside diameter of the gas jet, and the O.D. of the small tapered gas valve for possible wear from the same cause.
 - d. If everything to this point appears OK, wash all the parts thoroughly in kerosene or the equivalent.
 - e. Reassemble cleaned or replaced parts in the bowl, centering the spring on the air valve, and replace and fasten the cover. From the air-fuel outlet of the mixer to the throttle body, reach in with fingers or non-sharp rod, and lift valve several times to assure free travel with the spring closing the valve. Check the gas inlet. It should be sealed.
5. For LP liquid systems, with the carburetor air-gas valve and cover removed, it is a simple matter to check the converter and fuel lock for leaks.
 - a. Turn fuel on at the tank and check carburetor open gas jet for leakage. If fuel lock and converter are operating properly, no fuel will leak through.
 - b. Press primer button on front of converter to open gas regulator valve. A small amount of gas should pass through the jet as the system is emptied back to the fuel lock. If the fuel lock is operating properly, the gas flow will cease as soon as the fuel down stream of the fuel lock is exhausted.
 - c. Next, remove the vacuum hose to the fuel lock from the fitting at the source of vacuum. With the primer button depressed, suck lightly on the fuel lock vacuum hose. Fuel should flow immediately and stop flowing when suction is relieved.

These checks should indicate each component is operating properly.

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 butterfly valve which will regulate the amount of air/fuel mix being supplied to the engine.

The system operates using a tailored software configuration for the specific engine it is fitted to. There are no external adjustments or linkages and the controller also features a "self learn" feature which automatically adjusts the dynamics of the controller as required.

The mixer can be used with natural and propane gas and requires a zero pressure regulator.

GAS

The positive pressure of both Natural Gas and LPG to the genset, should be in the range 10mBAR to 45mBAR (4" H₂O - 13.5" H₂O).

- If the pressure is less than 10mBAR (4" H₂O), the genset may not be able to achieve 100% load.
- If the pressure is greater than 45mBAR (13.5" H₂O), the solenoid valve will may 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, 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.

8 Fuel Systems

8. FUEL SYSTEMS

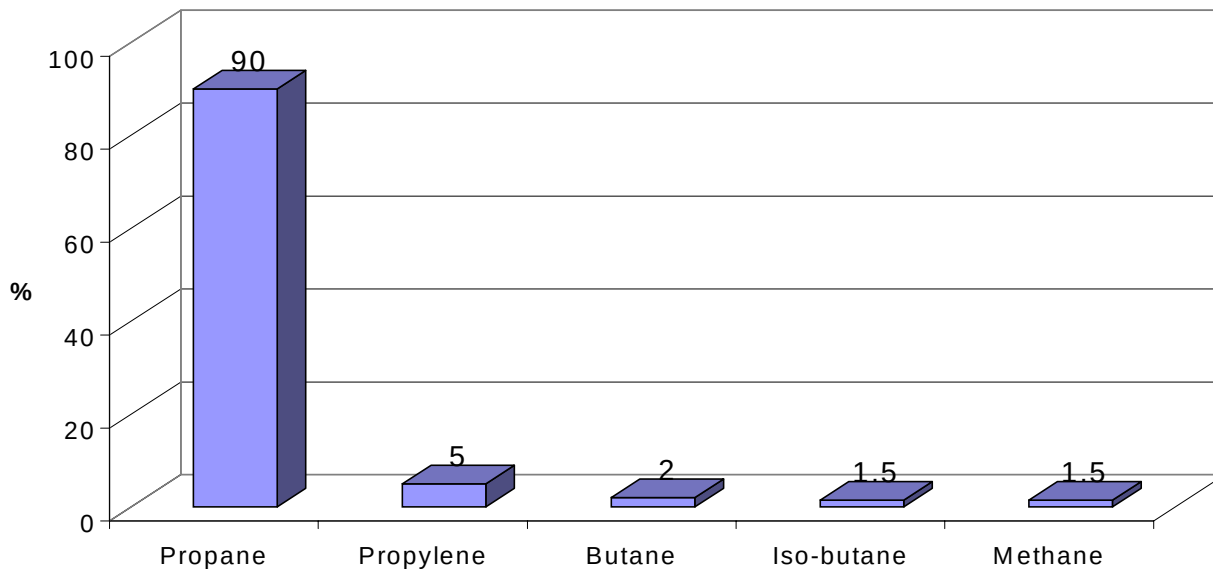
What is LPG

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 (C ₃ H ₈)	Propylene	Butane (C ₄ H ₁₀)	Iso-Butane	Methane (CH ₄)	Total
90.0% min.	Up to 5%	2.0%	1.5%	1.5%	100%

HD5



What is CNG

CNG is "compressed natural gas". Natural gas (CH_4) 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	CH_4	92.3
Ethane	C_2H_6	3.6
Propane	C_3H_8	1.0
Butanes	C_4H_{10}	0.3
Pentanes	C_5H_{12}	0.1
Hexanes	C_6H_{14}	0.1
Carbon Dioxide	CO_2	1.0
Nitrogen	N_2	1.6
Total Gas	Natural	100

Natural Gas

