U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION
Air Traffic Organization Policy

ORDER
JO 6980.11C

Formerly 6980.11C

Effective Date:
12/15/2006

SUBJ: MAINTENANCE OF ENGINE GENERATORS

1. This maintenance handbook cover page is updated to:

a. Comply with Order 1700.6C, FAA Branding Policy, Use of the FAA Logo, FAA Signature, and DOT Seal.

b. Comply with Order JO 1320.1, Air Traffic Organization (ATO) Prefixes for Directives.

c. To identify new Office of Primary Responsibility (OPR) within the ATO organizational structure.

2. A hardcopy cover page will be issued when a handbook revision is performed and may be issued with the next page change if deemed appropriate by the office of primary responsibility.

Robert J. Morgan Jr.

for Mary Golia
Director, Air Traffic Control Facilities

DISTRIBUTION: Web Release Only INITIATED BY: AJW-223

ORDER

6980.11C

MAINTENANCE OF ENGINE GENERATORS

November 11, 1997

DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

Distribution: A-FAF-O(MAX); AX(AF)-3; ZAF-607 Initiated By: AOS-220

RECORD OF CHANGES

DIRECTIVE NO. XXXXXX

CHANGE TO BASIC	SUPPLEMENT			OPTIONAL	CHANGE TO BASIC	SUPPLEMENT			OPTIONAL

FAA Form 1320-5 (6-80) USE PREVIOUS EDITION

FOREWORD

1. PURPOSE.

a. This order provides guidance and prescribes technical standards and tolerances, and procedures applicable to the maintenance and inspection of engine generators (E/G) when in standby or prime power status at an FAA facility, or mobile powerplants in readiness reserve status. It also provides information on special methods and techniques that will enable maintenance personnel to achieve optimum performance from the equipment. This information augments information available in instruction books and other handbooks, and complements the latest edition of Order 6000.15, General Maintenance Handbook for Airway Facilities.

b. This order implements Configuration Control Decision (CCD) N12415, Revise Order 6980.11B.

2. DISTRIBUTION. This directive is distributed to selected offices and services within Washington headquarters, the William J. Hughes Technical Center, the Mike Monroney Aeronautical Center, branch level in the regional Airway Facilities divisions, and to all Airway Facilities field offices.

3. CANCELLATION. Orders 6980.11B, Maintenance of Engine Generators, and 6980.21, Maintenance of Mobile Powerplants, are canceled.

4. MAJOR CHANGES. This revision combines Orders 6980.11B, Maintenance of Engine Generators, and 6980.21, Maintenance of Mobile Powerplants. The material is updated, and field comments are incorporated throughout the handbook. Chapter 3, Standards and Tolerances, was expanded to include liquid petroleum gas (LPG) and natural gas engines.

5. MAINTENANCE AND MODIFICATION POLICY.

a. Order 6000.15, this handbook, and the applicable equipment instruction books shall be consulted and used together by the maintenance technician in all duties and activities for the maintenance of engine generators used at airway facilities or mobile powerplants in readiness reserve status. These documents shall be considered collectively as the single official source of maintenance policy and direction authorized by Operational Support. References located in the chapters of this handbook entitled Standards and Tolerances, Periodic Maintenance, and Maintenance Procedures shall indicate to the user whether this handbook and/or the equipment instruction book shall be consulted for a particular standard, key inspection element or performance parameter, performance check, maintenance task, or maintenance procedure.

b. The latest edition of Order 6032.1, Modifications to Ground Facilities, Systems, and Equipment in the National Airspace System, contains comprehensive policy and direction concerning the development, authorization, implementation, and recording of modifications to facilities, systems, and equipment in commissioned status. It supersedes all instructions published in earlier editions of maintenance technical handbooks and related directives.

6. FORMS. In addition to forms required by Order 6000.15, FAA Form 6980-5, Technical Performance Record - Engine Generator and FAA Form 6000-8, Technical Performance Record - Continuation or Temporary Record/Report form, shall be used. FAA Form 6980-5 is available from the FAA Logistics Center on NSN 0052-00-697-0001, unit of issue is pad (PD). FAA Form 6000-8 is available on NSN 0052-00-686-0001, unit of issue PD.

7. RECOMMENDATIONS FOR IMPROVEMENT. Preaddressed comment sheets are provided at the back of this handbook in accordance with the latest edition of Order 1320.58, Equipment and Facility Directives—Modification and Maintenance Technical Handbooks. Users are encouraged to submit recommendations for improvement and configuration control via an NCP.

George W. Terrell
Program Director for Operational Support

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TABLE OF CONTENTS

CHAPTER 1. GENERAL INFORMATION AND REQUIREMENTS

Paragraph *Page*

CHAPTER 2. TECHNICAL CHARACTERISTICS

SECTION 1. GENERAL

SECTION 2. ENGINE GENERATOR COMPONENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

Paragraph *Page*

TABLE OF CONTENTS (Continued)

Paragraph *Page*

SECTION 4. LPG AND NATURAL GAS ENGINES

SECTION 5. GAS TURBINE POWERPLANT

CHAPTER 4 PERIODIC MAINTENANCE

SECTION 1. STANDBY ENGINE GENERATORS WITHOUT REMOTE MAINTENANCE MONITOR (RMM)

SUBSECTION 1. ENGINE GENERATORS GENERAL

SUBSECTION 2. DIESEL ENGINE GENERATORS

SUBSECTION 3. GASOLINE ENGINE GENERATORS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

Paragraph *Page*

TABLE OF CONTENTS (Continued)

Paragraph *Page*

SECTION 4. MOBILE POWERPLANTS (EXCLUDING GAS TURBINE UNITS)

SUBSECTION 1. MAINTENANCE SCHEDULE

SUBSECTION 2. SYSTEM PERFORMANCE CHECKS

SUBSECTION 3. PERIODIC MAINTENANCE TASKS

SECTION 5. GAS TURBINE MOBILE POWERPLANTS

CHAPTER 5. MAINTENANCE PROCEDURES

SECTION 1. MAINTENANCE RECORDS AND LOAD TESTS

TABLE OF CONTENTS (Continued)

Paragraph *Page*

TABLE OF CONTENTS (Continued)

Paragraph *Page*

TABLE OF CONTENTS (Continued)

Paragraph *Page*

SUBSECTION 7. ENGINE LUBRICATION

SUBSECTION 8. ENGINES

SUBSECTION 9. GENERATORS

SUBSECTION 10. CONTROL PANEL

TABLE OF CONTENTS (Continued)

Paragraph *Page*

SUBSECTION 11. SAFETY DEVICES

TABLE OF CONTENTS (Continued)

Paragraph *Page*

CHAPTER 1. GENERAL INFORMATION AND REQUIREMENTS

1-1. OBJECTIVE. This order provides the necessary guidance to be used in conjunction with the information available in instruction books and other handbooks, for the proper maintenance of FAA stationary and mobile engine generators.

1-2. SCOPE AND APPLICATION.

a. This order provides system-oriented maintenance information and establishes a maintenance program for all FAA standby power, prime power, and mobile engine generators, except engine generators located at the Air Route Traffic Control Centers (ARTCC). Maintenance guidance for ARTCC engine generators is contained in the latest edition of Order 6470.5, Maintenance of Air Route Traffic Control Center Environmental Systems, Appendix 2, Electrical Systems. This order establishes a maintenance program for mobile powerplants prior to storage, while in storage, upon removal from storage, and while in transit to and from a facility. Mobile powerplants are those powerplants which are officially categorized and used as temporary or emergency powerplants. However, where applicable and desired by Airway Facilities organizations, this maintenance guidance may also be applied to portable powerplants used functionally as maintenance equipment support systems; e.g., powerplants mounted on trucks to supply temporary electrical power during field maintenance activities.

b. While the mobile powerplant is in storage, the assigned maintenance technician and the respective Systems Maintenance Office (SMO) manager, FAA Logistics Center manager, or regional office division manager, have the responsibility for ensuring that the equipment is maintained in immediate operating condition at all times, unless it is undergoing major repair or overhaul. While the equipment is in operational standby or prime power use, the assigned maintenance technician and respective organizational manager have the responsibility for ensuring that it is operated and maintained properly and is returned to the storage organization in satisfactory operating condition.

1-3. MAINTENANCE PROCEDURES. The maintenance procedures published herein pertain to maintenance to be performed on an agency-wide basis. Other referenced maintenance handbooks and equipment instructions pertaining to specific equipment installed at a particular site shall be consulted for equipment maintenance procedures.

1-4. COORDINATION OF MAINTENANCE ACTIVITIES. Maintenance activities on facilities engine generators shall be closely coordinated with air traffic control (ATC) personnel at all times to preclude unanticipated interruption of services provided by the system. Maintenance personnel shall be responsible for maintaining the engine generators in an operational condition within the tolerances specified in the applicable section of chapter 3. Cognizant personnel shall be advised immediately upon equipment failure, upon restoration to service, and whenever the established tolerances are exceeded or expected to be exceeded.

1-5. PERIODIC MAINTENANCE. The periodic maintenance tasks and schedules provided in chapter 4 shall be followed. These are the minimum essential preventive maintenance activities and the frequency with which they shall be performed, so as to meet minimum performance standards.

1-6. SAFETY.

a. Safety shall be a primary concern of all personnel involved in the maintenance of all engine generators, especially when operational situations involve high-voltage levels and where maintenance activities involve the removal of inspection plates, dust covers, or access doors, exposing internal wiring. Personnel shall observe the safety practices prescribed in Order 6000.15, General Maintenance Handbook For Airway Facilities, and the pertinent electrical safety references given in appendix 1 of that order. Generally, no electrical apparatus or equipment should be repaired while energized. When it is necessary to work near energized equipment, all safety precautions should be followed, such as using rubber gloves and using properly insulated tools and equipment. Particular care shall also be exercised when personnel are working around operating engines, rotating machinery, and turbines.

b. Equipment safety must also be given consideration in planning and accomplishing maintenance of engine generators. All maintenance work on engine generators and associated electrical system connections shall be performed in compliance with the National Electrical Code and local and state codes.

c. Special precautions shall be taken with regard to the connection of fuel hoses, fuel lines, and fittings to fuel supply and storage tanks in the operational setup and maintenance of engine generators. Connections and arrangements of fuel lines shall be made appropriately to avoid electrostatic spark or other potential ignition sources and fire hazards.

d. Battery maintenance safety precautions shall be taken. Protective equipment, in particular, eyewash and clothing requirements, shall meet the standards in Order 3900.19A, Occupational Safety and Health, Chapter 8. Refer to paragraph 5-49 of this handbook for additional battery safety requirements.

e. Special safety precautions shall be taken in transporting mobile powerplants. Preparations for movement shall include securement of the mobile powerplant trailer with safety chains to the towing vehicle in compliance with the applicable state law. Also, check to ensure that the tires are inflated properly, the trailer brakes are operating correctly, and the running, brake, and turn indicator lights are working properly. In movement, safe speeds of 50 mph or less, as determined by driving conditions and type of roadway, shall be maintained. Follow the safest routes for transporting the mobile powerplant to the operation site and back to the storage area.

f. Trailer-mounted mobile powerplants have a safety-type hitch, breakaway safety chains, and turn indicator and brake lights. Trailers with electrically operated mechanical brakes usually carry a dry battery that is used to set the brakes if the trailer breaks away from the towing vehicle. The electrical-generating equipment has safety devices and alarm indicators that function during operation setup periods.

g. Maintenance personnel should wear appropriate hearing protection equipment when working around operating gas turbine units with the noise silencer enclosure panels removed.

1-7. RECORDS AND FORMS.

a. Order 6000.15B provides guidance in the use of records and forms in the maintenance of engine generators. Also, this handbook includes information on the use of special records, forms, and maintenance/fuel consumption reports pertaining to the respective types of engine generators.

b. When performing the monthly maintenance tasks on the remote instrumented engine generators (see paragraph 4-32), a printout of the applicable test results is required. The printout must include the date of the test and the person performing the test. The printout is retained as the logbook entry (replaces the normal logbook entry).

1-8. AIRCRAFT ACCIDENTS.

a. Refer to the latest edition of FAA Order 8020.11, Aircraft Accident and Incident Notification, Investigating, and Reporting, for the general requirements following an aircraft accident/incident.

b. To report the operational status of a facility engine generator for this purpose, perform the following maintenance checks:

(1) Performance check, paragraph 4-31, Weekly.

(a) If the facility is operating on commercial power with no system alarms, proceed to step 2.

(b) If the facility is operating on standby engine generator power with no system alarms, proceed to step 3.

(2) Key inspection element, paragraph 3-2, Start/Transfer Time

(3) Performance check, paragraph 4-32, Monthly (Facility Load Test), subparagraphs b and c.

NOTE: Record all "as-found" engine generator data and system conditions, for this purpose, on FAA Form 6980-5, Technical Performance Record—Engine Generator. If the engine generator is not equipped with RMM, perform all of the foregoing maintenance checks on site. Correct any existing system problem and record corrected conditions, also.

1-9. thru 1-19. RESERVED.

CHAPTER 2. TECHNICAL CHARACTERISTICS

SECTION 1. GENERAL

2-1. PURPOSE. Engine generators contribute vitally to the dependable operation of the National Airspace System. They are used as standby and primary power sources for FAA facilities. They must provide continuous service over extended periods of time, operating under a wide range of temperatures, altitudes, and remote geographical locations. It is essential that aids to air navigation and traffic control be reliable under all conditions. Standby or mobile engine generators can provide a facility with emergency power if the prime source of power is interrupted. Engine generator plant reliability depends largely upon the care and skill of the technical personnel responsible for its maintenance.

2-2. SYSTEM DESCRIPTION. FAA engine generators are used for either prime power or standby power. FAA engine generators are fueled by diesel, natural gas, or liquid petroleum fuel. The generator is usually either three-phase, three- or four-wire, or single-phase, two- or three-wire. Sizes range from 1.5 kW to more than 550 kW. Three-phase plants normally operate at 120/208 or 240 volts or 277/480 volts.

a. Standby Power Systems. Where commercial power is available, facilities are equipped with FAA-owned and -maintained engine generators to provide emergency standby power in accordance with the latest edition of Order 6030.20, Electrical Power Policy. Most units are fully automatic; however, some manual controlled units are in use. The automatic units are designed to assume the facility load promptly if the prime power is interrupted for a set period of time. Circuits on the generator control panel continuously monitor prime power characteristics; and any variation in voltage beyond established tolerances for the facility will start the standby engine, bring the generator up to operating parameters, and transfer the facility load to the generator. Protective devices monitor the engine for over-speed, overcrank, high temperature, and low oil pressure. These conditions will cause an alarm and will shut down manually, or automatically controlled units. In the event of an automatic power plant safety shutdown, prior to commercial power return, control circuitry bypasses the normal transfer time delay and immediately returns the transfer switch to the normal position when commercial power is available. When prime power is restored and monitoring devices sense a steady state condition for a prescribed time, automatically controlled units transfer the facility load to prime power. The transfer sequence will stop the engine after a preset time delay and reset automatic controls for the next prime power failure. Manual units will transfer the facility load to prime power and then stop only upon command.

b. Prime Power Systems. In remote areas where commercial power is not available, prime power is furnished from the agency's own engine generators. In these installations at least one unit is usually available for standby use in case other units fail or require maintenance.

c. Mobile Powerplants. FAA mobile powerplants can be used for either prime power or standby power. Generally, mobile powerplants are mounted on trailers which have been either assembled by the FAA or purchased in ready-made form, with the unit installed by FAA personnel. These trailers generally have a standard frame design and a tandem axle configuration. Most of the units have weatherproofed hinged-panel enclosures, but van-type enclosures are also used. Some mobile powerplants are mounted on skids or are mounted inside a skid-mounted van-type enclosure. Many of the trailer-mounted mobile powerplants have an electrically operated mechanical brake system, which is controlled from the towing vehicle. Some have an independent hydraulic brake system actuated by a hydraulic piston within the trailer tongue.

SECTION 2. ENGINE GENERATOR COMPONENTS (Continued)

2-3. ENGINES. The FAA is presently using three types of engines on powerplants. These are spark ignition engines using gasoline, natural gas or liquid petroleum gas (LPG) fuel; diesel compression engines; and gas turbine units on some mobile powerplants. Since there are many different horsepower ratings and engine manufacturers, specific engine characteristics will not be discussed. This information may be obtained from the manufacturers' instruction books.

2-4. COOLING SYSTEM. Circulating through the water jacket of the engine, the liquid coolant picks up the heat of combustion and friction from the cylinders. The coolant may be water or may be a cooling solution of water and antifreeze. The coolant is circulated through the engine in a pressurized, closed system, which includes the water pump, hoses, and a fan-cooled radiator. Liquid-cooling systems consist basically of the following items.

a. Water Pump. The water pump circulates the coolant through the engine water jacket. The pump is usually mounted on the engine, and is belt driven from the engine crankshaft. A separate motor-driven water pump may be found on engine generators above 100 kW.

b. Radiator. The radiator dissipates heat from the coolant leaving the engine water jacket. A fan removes heat from the coolant as it flows through the finned tubes of the radiator. If the radiator is engine mounted, the fan is also engine mounted and belt driven from the engine crankshaft. If the radiator is located outside the engine room, a thermostatically controlled fan is mounted with the radiator.

c. Bypass Thermostatic Control. Most liquid-cooled engines have a thermostatically operated valve that controls engine temperature by varying the flow of coolant in the water jacket. The coolant is circulated but confined to the water jacket during engine warmup. As engine temperature increases, the valve gradually opens to allow coolant from the radiator to enter the water jacket. This valve action maintains the engine at normal operating temperature.

d. Intercooler. Some large engines are equipped with an intercooler to cool the combustion air as it enters the intake manifold after leaving the turbocharger. As the turbocharger increases the pressure of the combustion air, it also raises its temperature. If the combustion air is not cooled, engine power and efficiency are decreased. The heated and pressurized combustion air passes through the intercooler where the heat is transferred to the circulating coolant.

e. Oil Cooler. Some engines require a radiator to cool the engine oil and maintain a normal operating temperature under all conditions. This helps prevent oil deterioration as well as helping to remove heat from the engine. Engine oil is circulated through the oil cooler by the engine oil pump.

f. Immersion Heater. An immersion heater is used on all FAA liquid-cooled engine generator plants. The heater warms the coolant in the engine block and cylinder heads for easier starting. Operation of the heater is controlled by a thermostat inserted into the water jacket of the cylinder head or into the coolant outlet of the engine. The thermostat may be adjustable or nonadjustable.

2-5. thru 2-9. RESERVED.

2-10. STARTING SYSTEMS. Engine generators use electric starting systems. Some small units may be equipped with a handcrank for manual emergency starting, or for use when performing maintenance.

2-11. thru 2-13. RESERVED.

2-14. BATTERIES. Engine generators use lead-acid or nickel-cadmium-alkaline batteries for starting and control purposes. The most common type is the lead-acid battery. The basic unit of any battery is the cell. A lead-acid cell has a nominal voltage of 2 V dc and a nickel-cadmium-alkaline cell has a nominal voltage of 1.2 V dc per cell. The term "battery" may apply to a single cell or to several cells in one container, the cells being connected in series. A battery system consists of one or more batteries connected in series and/or in parallel. The typical lead-acid battery system used for FAA engine generators will be three or four 4-cell (2 volts per cell) batteries in a series arrangement, resulting in either a 24- or 32-volt system; however, other voltages may be used. The ampere-hour rating of a battery is a measure of the battery's capability to provide current for a period of time. The ampere-hour rating is the product of discharge current in amperes multiplied by the time in hours that the current exists before the cell voltage decreases to the cutoff voltage. The cutoff voltage is a point at which further discharging is no

SECTION 2. ENGINE GENERATOR COMPONENTS (Continued)

longer useful. The ampere-hour rating of a typical lead-acid battery is based on an 8-hour discharge period to a cutoff voltage of 1.75 V dc. The ampere-hour rating of a typical nickel-cadmium-alkaline battery is based on a cutoff voltage of 1.00 V per cell at a 5-hour discharge rate. The latest edition of Order 6980.25, Maintenance of Batteries for Standby Power, provides maintenance requirements and information for all types of batteries used.

2-15. BATTERY CHARGERS.

a. General. All engine generator battery chargers are connected to the output of the E/G transfer switch.

b. TVR Type Battery Charger. Older model engine generator battery chargers use a temperature-compensated voltage relay (TVR). This relay controls the length of time for battery charging. An equalize charge (8 hours) can be applied by energizing an 8-hour timer that bypasses the TVR.

c. Solid-State Battery Charger. The battery chargers of the more recent engine generators are typically solid-state, full-wave rectifier systems. The charger unit is frequently located separate from the engine generator control cabinet. Most chargers use silicon diode or thyristor type rectifier devices such as the silicon controlled rectifier (SCR). These chargers are constant voltage type with precise, automatic dc voltage regulation circuitry to optimize battery life. Temperature compensation of the output voltage prevents under- or overcharging of batteries subjected to extreme ambient temperatures. These chargers are usually equipped with dc current limiting as well as ac overload protection. Switching capability is provided to transfer from float charge to high rate equalize charge (usually including a selectable equalize charge timer). Provision is also made for separate adjustment of thc float and equalize voltages to meet specific battery manufacturer recommendations. These chargers are typically furnished with front panel metering, switching, controls, alarm annunciation, and a chassis-mounted remote alarm output connector.

2-16. thru 2-18. RESERVED.

2-19. IGNITION SYSTEMS. There are two general types of ignition systems: compression ignition and spark ignition.

a. Compression Ignition. All diesel engines operate by compression ignition. A charge of air is compressed by the piston and at the proper instant, fuel is injected into the cylinder. The fuel-air mixture is ignited from the heat created by compressing the air.

b. Spark Ignition. All natural gas and LP engines operate by spark ignition. The spark is generated by a magneto, or by a battery powered ignition coil.

(1) Magneto Ignition. Basically, the magneto is a high-voltage generator that is geared to the engine crankshaft. The magneto generates a voltage of 15,000 to 20,000 volts. A cam actuates a contact breaker/distributor system that applies an impulse of high voltage to each spark plug, in sequence, according to the firing order of the engine cylinders.

(2) Battery Powered Ignition. The primary voltage supplied to the ignition coil is obtained directly from a battery. The contact/distributor system is similar to that of the magneto system. The battery voltage is maintained by a battery charger.

2-20. thru 2-21. RESERVED.

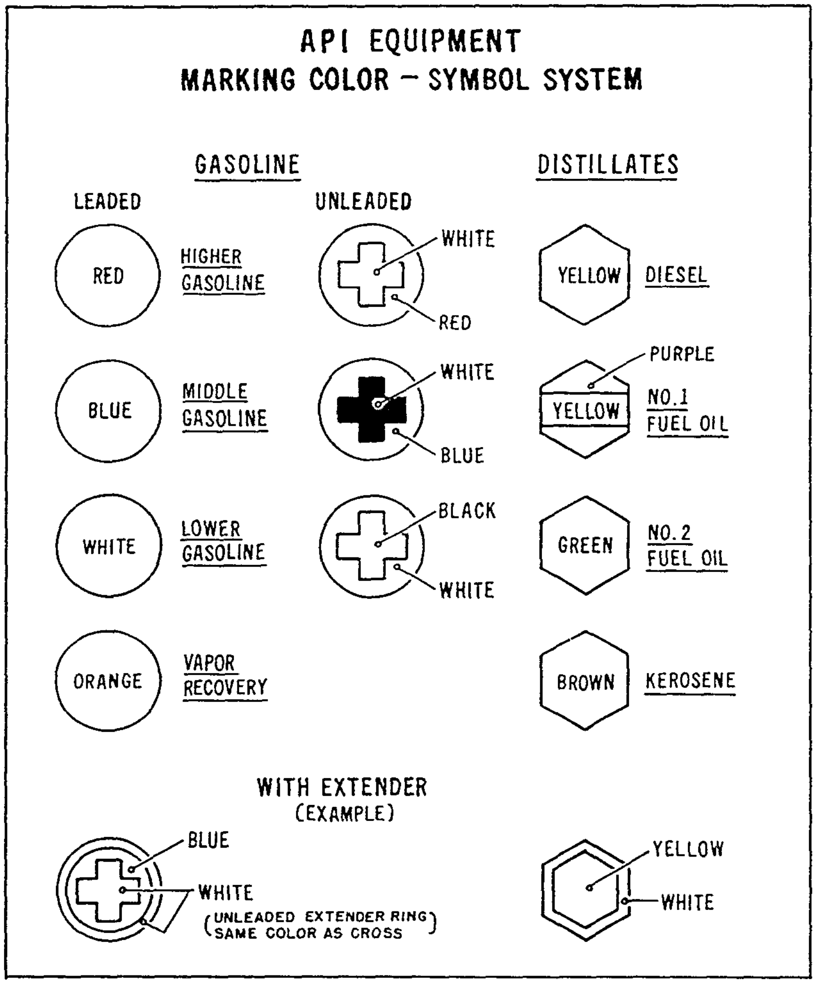
2-22. FUEL STORAGE.

a. General. Underground storage tanks must comply with the requirements specified in the latest edition of Order 1050.15, Underground Storage Tanks at FAA Facilities. While storage tanks and their associated fuel lines are seldom a source of trouble, it will be worthwhile to review some of the features of their construction and installation.

b. Storage Tank. The location of the inlet foot valve on the fuel supply line in a storage tank should be as indicated in installation drawing D-2 111-1, Fuel Tank Installation, Underground Gasoline and Diesel. This allows the tank to act as a sediment bowl. Some of the dust, dirt, rust particles, and other contaminants held in suspension

SECTION 2. ENGINE GENERATOR COMPONENTS (Continued)

FIGURE 2-1. API EQUIPMENT, MARKING COLOR-SYMBOL SYSTEM



2-27. FUEL SYSTEMS.

a. General. In most gasoline engines the flow of air and gasoline to the cylinders is controlled by the carburetor; in others the fuel to the cylinder is controlled by a fuel injection pump. The diesel engine uses a constant volume of air, and the amount of fuel is metered by an injection pump. This type of engine is known as a self-aspirated type. Where a turbocharger is used to increase the amount of air entering the cylinder, more horsepower will be developed, but more fuel must be injected to obtain the correct air-fuel ratio. Three types of fuel systems are used on engine generators.

(1) Gasoline. Gasoline is atomized by a carburetor and fed through the intake manifold into the cylinders.

(2) Gas. Natural or liquid petroleum gas is controlled by a pressure regulator and fed in a gaseous state to the combustion chamber.

SECTION 2. ENGINE GENERATOR COMPONENTS (Continued)

(3) Diesel. Diesel fuel is forced through a small orifice at the injector tip by a high pressure pump atomizing the fuel and spraying it into the combustion chamber.

b. Fuel Injection Pump, Diesel. It is necessary to deliver the fuel to each diesel engine cylinder fuel injector under constant pressure. The fuel must be metered in the correct amount when injected into the cylinder. This may be accomplished either by a high or low pressure injection pump system. The Cummins “PT” system is an example of a low pressure injection system. The Bosch “AB” series pump is an example of a high pressure metering system. In recent years, the Roosa Master “distributor” type pump has found almost universal application on FAA power plants. This pump meters the fuel to be injected at a low pressure and injects it at high pressure.

c. Transfer Pump. Diesel plants require a fuel transfer pump to create a positive pressure at the suction side of the fuel injection pump. A positive pressure is necessary at the intake of the fuel injection pump to charge each stroke equally. The cylinders will then receive adequate and even fuel injection. A regulator is located in the manifold of the injection pump to maintain this pressure. A gear, diaphragm, or piston-type pump is generally used to draw fuel from the day tank and deliver it to the fuel injection pump.

d. LPG Fuel System. LPG fuel systems shall conform to the National Fire Protection Association (NFPA) standard for the storage and handling of liquid petroleum gases, NFPA 58. The potential fife hazard of LPG vapor is comparable to that of natural gas except that LPG vapors are heavier than air, therefore provisions for exhausting any accumulated vapors should be provided. The LPG fuel system may be broken down into four basic components.

(1) Storage. Liquid petroleum gases, are gases at normal room temperature and atmospheric pressure. They liquefy under moderate pressure, readily vaporizing upon release of this pressure. The boiling point of pure propane LPG is -44 °F (-42.2 °C) at standard atmospheric pressure. The pressure inside a storage tank, as a result of the ambient temperature, would be 0 pounds per square inch gauge (psig) at -44 °F, increasing to 216 psig at 105 °F. The boiling point of pure butane at standard atmospheric pressure is 31 °F (-0.56 °C) with the vapor pressure increasing to 41 psig at 105 °F (40.5 °C). Since commercial LPG may consist of varying amounts of propane and butane, the boiling point and resulting vapor pressure will be determined by the percentage of each in the mixture. Storage tanks are equipped with a pressure relief device normally set to relieve the pressure inside the tank if it exceeds the designated working pressure of the tank, usually 250 psig. A pressure relief valve is marked with the pressure at which it will start to leak and the relieving capacity. A valve marked 250-4050 AIR indicates it will start to leak at 250 psig and that its relieving capacity is 4050 cubic feet per minute (cfm) of air. Storage tanks should be protected from mechanical damage and not be exposed to excessive heat.

(2) Fuelock/Filter. Liquid is taken from the storage tank at a pressure determined by the ambient temperature surrounding the storage tank. The carburetion system starts with the fuel lockoff and filter (fuelock/filter). The fuelock/filter is vacuum operated. When a slight vacuum is sensed, 2-inch water column (2-inch W.C.), as a result of the engine cranking or running, the fuelock/filter opens and allows fuel from the tank to flow through a fuel filter to the converter. Any time the engine stops and loses vacuum, the fuel is shut off automatically. The fuelock/filter screens any large particles of solid material from the fuel before the particles can reach the high pressure side of the converter.

(3) Converter. The converter is a combined two-stage regulator and vaporizer. It receives liquid fuel at tank pressure from the fuelock/filter and reduces that pressure in two stages to slightly less than atmospheric. When the engine is cranking or running, a partial vacuum is created in the fuel line to the carburetor. The vacuum opens the regulator, permitting fuel to flow to the carburetor. In the process of reducing the pressure from approxrmately 150 psi in the tank to atmospheric pressure, the liquid propane expands to become a vapor, with a resulting refrigeration effect. To compensate for the refrigeration effect and to assist in vaporization of the fuel, coolant from the engine cooling system is circulated through the converter. The regulator seals off fuel flow when the engine is stopped.

(4) Carburetor. A typical carburetor is of air-gas valve design, using a relatively constant pressure drop to draw fuel into the carburetor from cranking to full load. The advantage of this type of construction is that the air-gas valve is held closed by a metering spring until a vacuum is created by the intake stroke of the piston. A pressure drop of approximately 6-inch W.C. is required to

SECTION 2. ENGINE GENERATOR COMPONENTS (Continued)

open the valve during cranking. The vacuum is communicated to the converter to draw out fuel and also actuates the vacuum fuelock. With the engine stopped, fuel is sealed off within the carburetor as well as in the converter and fuelock, giving a triple seal for safety. The air-gas valve within the carburetor is operated by pressures acting on a diaphragm, and a metering spring acts to close the valve. The manifold vacuum offsets the spring pressure and allows atmospheric pressure to open the valve. Cranking the engine lowers the pressure (increases vacuum) in the manifold. The vacuum is felt on the diaphragm, and the valve opens. Approximately 0.2 psi (6-inch W.C.) of pressure is required to lift the valve off its seat. Approximately 0.5 psi (13.8-inch W.C.) lifts the valve to the top of its travel in the full open position. The manifold pressure applied to the diaphragm varies with engine speed and position of the throttle valve opening. The air valve assembly measures the air flow to the engine by moving exactly in response to the demand of the engine and throttle valve position. The gas metering valve 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 for the air valve. Mixtures between idle 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 speed.

2-28. thru 2-33. RESERVED.

2-34. TURBOCHARGERS. Turbochargers are exhaust-gas turbine-driven compressors and consist of twin turbines mounted on a single shaft. The exhaust gases passing through nozzles drive one turbine, which in turn drives the air intake turbine on the opposite end of the shaft. The turbocharger is used to pressure-charge and scavenge two- and four-cycle engines. The compressed air delivered by the turbocharger accomplishes two functions: First, it scavenges the hot residual gases otherwise left in the cylinder at the end of the exhaust stroke and replaces these with cooler fresh air; second, it fills the cylinder with an air charge of higher density at the end of the suction stroke. The provision of a greater amount of fresh air permits the combustion of a correspondingly greater amount of fuel, and, consequently, a higher power output from the engine. The valve timing of a turbocharged engine differs from that of a naturally-aspirated engine. The exhaust valves of the turbocharged engine close later, and the intake valves open earlier. The scavenging of the combustion space aids in cooling the engine. At full load, the turbocharger has a speed of approximately 20,000 revolutions per minute (rpm). A silencer is installed between the air intake filter and the turbocharger to reduce the objectionable high pitched sound.

2-35. thru 2-39. RESERVED.

2-40. CRANKCASE VENTILATION. Most engines are equipped with a positive crankcase ventilation system. This system consists of a vent line and filter assembly interconnected between the crankcase and the engine air intake. Deflector plates prevent oil from being drawn or forced from the crankcase. When the engine is in operation, a slight negative pressure is maintained in the crankcase, thereby removing harmful vapors. Fresh air is drawn into the crankcase through a filter (breather) which removes dust and airborne solid particles.

2-41. VIBRATION DAMPERS. Mechanical vibrations are inherent in all rotating machinery, especially large engine generators, which are often installed on spring-loaded dampers. Several of these dampers are installed under the assembly between the floor and engine base. They are adjustable, and designed to keep the weight distributed for proper alignment. They also minimize stress concentrations on the crankshaft. Other engines may rest on rubber dampers.

2-42. thru 2-44. RESERVED.

2-45. GOVERNORS. A governor is essentially a speed-sensing and speed-changing device designed to maintain a constant engine speed, regardless of load variations. Four types of governors are associated with engine generators.

a. Mechanical. A mechanical governor consists of flyweights mounted on a rotating shaft directly coupled to and driven by the engine and arranged so that the centrifugal force of the flyweights is opposed by a spring. A change in speed will change the centrifugal force, causing a direct movement or mechanically linked movement of the fuel pump throttle, thus, controlling the speed of the engine.

b. Hydraulic. A hydraulic governor is a type of mechanical governor that controls the flow of oil to a power piston. This power piston in turn operates the fuel pump throttle. Hydraulic governors are often used in place of mechanical governors on large diesel engines where

SECTION 2. ENGINE GENERATOR COMPONENTS (Continued)

greater force is required to move the fuel control mechanism.

c. Electric. The electric governor installed on some engine generators uses a magnetic amplifier circuit. This circuit detects frequency and load changes, then transmits these signals to an actuator, which in turn controls the fuel flow to the engine. Electric governors using a magnetic amplifier type control are becoming obsolete and only a few are currently being used on FAA power plants.

d. Electronic. Electronic governors generally operate by developing an internal reference frequency. This reference frequency is adjustable and is set to match the signal supplied by a magnetic pickup to monitor engine rpm. When the engine is loaded, lowering the rpm, the magnetic pickup signal frequency (tooth count) decreases. This results in a difference between the reference oscillator and the magnetic pickup frequency. The magnitude of this difference causes increased current flow to the fuel control actuator. This additional current flow opens the throttle, providing additional fuel to maintain engine speed and load.

2-46. thru 2-49. RESERVED.

2-50. FILTERS.

a. Fuel. Because small abrasive particles suspended in the fuel can damage pistons used in injection pumps, fuel filters are more vital on diesel engines than on gasoline engines. Diesel fuel filter systems generally consist of three filters prior to reaching the injector. These are the "primary," "secondary," and "final" filters. The primary removes water and relatively large particles picked up by the supply pump from the tank. The secondary filter, being designed to block passage of those impurities leaving the primary filter. The final filter is rated in micron capability, passing fuel adequately clean to supply the injection pump and injectors.

b. Oil. An oil filter maintains the oil and oil system in a clean condition by the continuous removal of contaminants. Contaminants such as atmospheric dust, moisture, core sand, scale, rust, metal chips, and carbon soot accumulate in oil during normal operation. The oil itself may break down or oxidize to form acid, varnish, carbon sludge, etc. These various contaminants, if not removed, cause excessive wear and reduced efficiency. A good filter must be able to remove the solids mechanically and absorb or neutralize the various contaminants. FAA engine generators utilize a "full flow" oil filter system. Oil picked up by the oil pump circulates through the full flow filter first, and is directed into the engine oil gallery to lubricate and cool the engine. In a full flow filter system, should the filter become blocked, an automatic bypass system takes over to lubricate the engine. This bypassing action usually may be noticed by a slight drop in normal oil pressure.

c. Air. All engines are furnished with air intake filters to provide clean air free of dust particles, which damage highly machined internal parts. Types of air intake filters may be oil-bath, oil-saturated, or dry-cartridge. The most common is the oil-bath type which consists of a circular container with a small sump in the form of a trough. A circular screen with a copper gauze filter dips lightly into the oil. The centrifugal force produced by the intake air making three 1800 turns forces out the heavier particles, while the filter traps smaller particles. The air cleaner is connected to the carburetor either directly or by a short section of pipe or hose. A simpler type may consist of a perforated metal sleeve covered by a layer of oil-impregnated polyurethane foam. Dust is collected by the oil film on the foam. The foam is cleaned in solvent, oiled, and reused. The dry-cartridge type is similar to the oil saturated type, except that no oil is used. The filter cartridge is made of dry filtering media instead of oil-saturated copper mesh or polyurethane foam.

2-51. ENGINE LUBRICATION. The primary purpose of lubrication is to reduce friction. The reduction of friction is a vital factor in the operation of any engine. Lubricating oil also prevents wear, acts as a cooling medium and sealing agent, retards the formation of deposits on engine parts, prevents rust and corrosion, and acts as a hydraulic medium. Lubricating oil is circulated and supplied to engine components by means of an oil pump, supply piping, and passages. Pressure is built up in the circulating system immediately upon starting of the engine and is maintained while the engine is in operation. Engine oil should be selected carefully, using the engine manufacturer's recommendations for viscosity and service classification.

2-52. thru 2-57. RESERVED.

SECTION 2. ENGINE GENERATOR COMPONENTS (Continued)

2-58. CONTROL PANEL.

a. General. Engine generators have control panels containing circuitry for monitoring commercial power for a low voltage or no voltage condition. The engine starts and the facility load is transferred to the unit by a transfer switch located within the control panel. The control panel may be mounted on the unit, or may be remotely located. The control panel may consist of a separate ac panel (with the transfer switch) and a separate dc panel, both remotely located. Control circuits sense the return of commercial power, and after a preset time delay, transfer the load back to commercial power and terminate the operation of the engine generator. The control panel contains a safety lockout device to prevent operation of the unit during maintenance. It has potential relays that sense the generator voltage and frequency and will not allow the load to be transferred to the standby plant until both the frequency and voltage have attained preset values. If the engine is shut down by one of its safety devices, or if the generator loses its voltage for any reason, a circuit is set up, which will immediately cause a transfer of the load if commercial power is available. This is accomplished with the bypassing of the time delay relay. The control panel also contains the generator voltage regulator, battery charger, ammeter, voltmeter, and a frequency meter to indicate the load conditions and power characteristics of the engine generator or commercial power source.

b. Uninterrupted Power Transfer (UPT). Selected engine generators are equipped with a make-before-break power transfer system, which incorporates auxiliary power contactors located in parallel with the existing transfer switch. This arrangement permits both power sources to be paralleled momentarily during scheduled power transfer, to prevent loss of power to critical national airspace equipment. Suitable safeguards are provided in the system to prevent power transfer to a dead buss or to prevent power transfer to an unserviceable power source. In the event of a commercial power failure with power plants equipped with a UPT system, the control transfer action occurs as though UPT system does not exist.

2-59. GENERATORS. Most ac generators in use are of the revolving field type. The application of revolving armature alternators is limited because the revolving field type is less expensive and as a rule has better inherent characteristics. Revolving armature ac generators are seldom made for capacities exceeding 20 kW, three-phase, or 15 kW, single-phase, or exceeding 600 volts. Regulation of the revolving armature ac generators is poor, and the alternating voltage is impressed on the armature and collector rings, making economical insulation for high voltages difficult. The revolving parts of revolving field generators are not subjected to high voltages. FAA specifications require the generator field to be augmented with short-circuited or “Amortisseur” windings in the pole faces. Since hunting is accompanied by a shifting of the flux across the pole face, the winding placed in the path of this flux will oppose any such change and tend to damp out the oscillations as soon as they begin.

2-60. EXCITERS. Field current for the ac generator is provided by one of two basic types of exciters, both having rotating armatures. The older type is a conventional direct current (dc) generator having an armature and commentator, and the other is commonly referred to as the brushless type. The latter type has hermetically sealed silicon rectifiers mounted on a heat sink fan assembly that rotates with the exciter armature and ac generator rotor. The output of the exciter armature is converted to dc by the rectifiers and fed directly to the ac generator rotor. The ac output of the generator is regulated by controlling the current through the stationary field of the exciter.

2-61. SAFETY DEVICES. Operating in conjunction with the control panel are a series of engine operation sensing devices that will shut down the engine in case of overheating, overspeed, or low oil pressure. If the engine cranks for a preset time without starting, an overcranking safety device will terminate the cranking cycle. To correct for a butt-tooth engagement of the starter motor pinion with the flywheel ring gear, a cycling circuit is included. The butt-tooth circuitry recycles the starter to provide gear reorientation, allowing the starter pinion gear to engage the flywheel on the next cycle. The internal construction of the pinion drive causes the pinion to rotate a half gear tooth in position each time the solenoid is energized. Correct engagement of the starter pinion with the ring gear must be made before the starter can be energized. On units equipped with medium duty starters, the butt-tooth engagement is overcome by utilizing a helix arrangement to drive the pinion into mesh with the ring gear before any load is placed on the starter. On some units the safety device circuit operates a single shutdown relay in the control panel. This relay opens the starting circuit, stops the engine, and locks out the system to prevent another attempt at starting. It must be manually reset. On other units, the safety device circuit operates a separate relay for each safety device. Once tripped, this safety device must

SECTION 2. ENGINE GENERATOR COMPONENTS (Continued)

be manually reset. The cranking circuit of early model units contains an overcurrent circuit breaker to protect the start motor in case the engine has a locked rotor condition.

2-62. LOAD BANKS. Resistive load banks permit testing and exercising of engine generators under simulated load conditions.

2-63. PYROMETERS. A pyrometer measures exhaust manifold temperatures. These temperature measurements are used to determine the efficiency of fuel burning. Most pyrometers use thermocouple sensors and electrical meters calibrated to indicate the intensity of the heat at the thermocouple junction. The output temperature of each cylinder is sensed by a thermocouple sensor mounted in each exhaust port. Each sensor is connected to a single meter through a selector switch on the control or starting and alarm panel. A check of the cylinder temperatures for a given load can be made to determine if any abnormal combustion is occurring. Data on exhaust temperatures are available in the instruction books, furnished with the engine generators equipped with pyrometers.

2-64. REMOTE CONTROL AND MONITORING. Numerous critical FAA facilities have been modified to provide remote starting and stopping of the standby engine generator to provide uninterrupted operation during threatening or inclement weather. Many of these modifications include provisions for remotely monitoring the status of the facility commercial power and standby power, and to monitor to which of the two sources of power the facility load is connected. Start-stop command signals or voltages and monitoring signals or voltages may be carried by landlines or by radio transmissions. Modification of the standby units may require the addition of one or more interfacing relays, auxiliary contacts, and time delays to work in conjunction with existing control devices in the engine generator control cabinet. An understanding of the operation and function of these interfacing devices is necessary before some types of maintenance can be performed. Refer to the engine generator instruction book for this information. Additional information concerning ground-to-ground radio remote control and monitoring is contained in Order 6650.6, Maintenance of Radio Control Equipment for Plant Facilities, AF P 6980.3, Change 141, Chapter 147, including instruction book supplement TI 6980.50, Engine Generator Radio Remote Control and Monitor System. This supplement shows the wiring diagram and contains theory of operation for a typical interface relay assembly used in conjunction with radio remote control and monitoring.

2-65. AC AND DC TEST METERS.

a. General. A volt-ohmmeter test instrument may be inaccurate when used to measure true root-mean-square (rms) ac voltages at the control cabinet in the presence of stray radio frequencies generated by the facility. This type meter is suitable for measuring dc voltage.

b. Iron-Vane Meter. An iron-vane rms reading ac meter is more accurate than a volt-ohmmeter since it is not influenced by stray rf voltages. However, some iron-vane meters may be influenced by their proximity to a ferrous material, such as the control cabinet, or by proximity to conductors carrying heavy current. Therefore, an ironvane meter should be placed outside the control cabinet when measuring rms ac voltage.

c. Digital Meter. A well-shielded digital voltmeter is suitable to measure both dc and ac rms voltages. The waveshape of the commercial power source voltage is a near-perfect sinewave, and most calibrated rms reading digital voltmeters will be accurate. The waveshape of the generator voltage, however, may be a distorted sinewave, possibly caused by the generator voltage regulator, or by a voltage regulator on the facility equipment. Many digital voltmeters will show an average instead of rms ac voltage reading when the waveshape is distorted. A true-rms digital voltmeter should be used to measure generator output voltage. Even if a true-rms digital voltmeter is used to measure the rms voltage of the distorted generator ac waveform, the relays and devices may respond differently to commercial power voltage with a better waveform.

2-66. thru 2-72. RESERVED.

SECTION 3. GAS TURBINE MOBILE POWERPLANTS

2-73. ALTURDYNE 60 kW GAS TURBINE UNIT.

a. Currently, the Alturdyne model ALT60-60T gas turbine generator mobile powerplant is the only turbine-powered equipment used by Airway Facilities. This unit is mounted on a factory-built trailer, uses liquid fuel, is self-supporting for 12 hours without refueling, and is equipped with a gas turbine engine-driven, electrical generator. It will provide automatic emergency electrical power if commercial power is interrupted or fails. It can be connected to provide 60 Hz ac, 60 kW power in any one of the following configurations:

(1) 120/208 volts, 4-wire, 3-phase output (wye-connected generator)

(2) 120/240 volts, 4-wire, 3-phase output (delta-connected generator)

(3) 120/240 volts, 3-wire, 1-phase reduced kW output (grounded-neutral, delta-connected generator)

The powerplant can also be used independently in a manual mode of operation. Two or more mobile powerplants of this design can be connected in parallel to increase the power available to the load. The unit is designed to perform satisfactorily in a wide variety of weather conditions. The powerplant is trailer-mounted, is enclosed from the weather, and carries enough fuel to operate for 12 hours before refueling. An external fuel supply (such as an existing underground fuel tank) can be connected to the powerplant. The unit is operated in either the automatic or manual mode. The powerplant generally can be described as consisting of three major assemblies: the gas turbine engine, the generator, and the trailer.

b. Gas Turbine Engine. The gas turbine engine is an Alturdyne-modified Solar Titan T-62T-32-2 radial gas turbine engine. It is a single-shaft engine and is bolted to the reduction gear box. The engine operates at a speed of approximately 61,090 rpm and is controlled to this speed with a precision governing system. The precision governing system will keep the engine speed controlled so that, with a steady load on the generator, the output frequency of the generator will not vary more than ±0.25 Hz. The governor also has a manual control that can be adjusted to control the generator output frequency between 57 and 63 Hz. The engine is mounted within the protective enclosure, which also provides filtered air for the engine in the same manner as for the generator. An air inlet silencer and an exhaust silencer are connected to the engine to reduce operating noise. The engine runs on most diesel fuels (refer to the instruction book TI 6980.51, 60 KW Automatic Turbine Driven Electric Generator Powerplant, for specific fuels) and normally draws its fuel from the trailer fuel tank. When the engine is expected to run for extended periods, provisions are incorporated for connection to an external fuel supply. In either the manual or automatic mode of operation, the engine can be started and will be at the operating speed within 15 seconds or less. Cranking power to start the engine is provided by a 24 V starter motor mounted on the reduction gear box. The oil pressure, engine speed, and exhaust gas temperature are visually indicated and continuously monitored electrically while the engine is running; an abnormal condition will automatically cause the engine to shut down. The oil temperature is also visually indicated, but there is not an associated automatic shutdown feature.

c. Generator. The generator is mounted on the trailer within a protective enclosure. It is manufactured by Kato Engineering Company and is a brushless, rotating-field, synchronous, alternating-current generator. It is the single-bearing type that is directly driven by the turbine engine through the reduction gear box and flywheel assemblies. The rotor is turned at 3,600 rpm by the turbine engine and will generate 60 Hz, 3-phase, wye- or deltaconnected output power from the stator. The selection of wye- or delta-connected outputs is manually made at the stator reconnection board. The generator is air cooled with the circulating fan mounted on the rotor shaft. Ambient air enters the enclosure, is filtered, cools the generator, and is exhaust-ducted out of the enclosure.

d. Trailer. The trailer is a two-axle, heavy-duty, steel-constructed mounting platform for all components of the power plant. The fuel tank, three leveling jackstands (the unit must be level to ensure 12 full hours of operation before refueling), and the cable storage box are integral to the basic trailer. It is designed to be towed safely up to a maxmum of 50 mph over improved roads and 10 mph over rough roads or trails. The trailer has an electrical braking system that is actuated either from the towing vehicle, by installing the provided brake controller unit, or by an automatic breakaway switch located on the trailer. Tail lights and clearance lights are also part of the trailer. A leveling bubble, a grounding terminal, and four tiedown rings are provided to facilitate a level, safe, and secure installation at the selected site of operation.

SECTION 3. GAS TURBINE MOBILE POWERPLANTS (Continued)

e. Components. Components of the unit include the brake system, a 12-volt electrical system with electro-mechanical-actuated brake shoes; 12-volt electrical system of the trailer; 224.4-gallon fuel tank; the battery charger; and various accessories, including a fife extinguisher and two 20-foot, 1/2-inch inside-diameter, flexible hose assemblies. The electrical system of the trailer is powered by and operated from the towing vehicle; a special 7-pin connector is mounted on the left side of the trailer tongue to facilitate connections with the towing vehicle. The fuel tank is located in the center of the vehicle between the fenders. The battery charger, which is installed in a box at the left side of the battery box, rectifies a portion of the ac power from the output of the transfer switch or is externally connected to the 120 V ac power to keep the batteries charged automatically. The fife extinguisher is dry chemical with a 10-pound capacity and is installed on the right rear running board when the equipment is set up for operation. The hose assemblies provide fuel input and fuel return connections between the mobile powerplant and an external fuel source.

f. Generator Controls. Generator controls include a transfer switch, installed in a cubicle on the left side of the enclosure, a turbine control assembly board, a voltage regulator, and a paralleling module, which provides a joint operational setup with another gas turbine unit.

2-74. thru 2-79. RESERVED.

CHAPTER 3. STANDARDS AND TOLERANCES

3-1. GENERAL. This chapter prescribes the standards and tolerances for stationary and mobile standby and prime power engine generators, as defined and described in Order 6000.15, General Maintenance Handbook for Airway Facilities. All key performance parameters and key inspection elements are clearly identified by an arrow (→) placed to the left of the applicable item. Order 6470.5A, Maintenance of Air Route Traffic Control Center (ARTCC) Environmental Systems is used to maintain engine generators at ARTCC's.

SECTION 1. ENGINE GENERATORS - GENERAL

SUBSECTION 1. ENGINES

Parameter	*Reference Paragraph*	*Standard*	*Tolerance/Limit*	
			Initial	*Operating*
→ 3-2. **START/TRANSFER TIME**	NA	15 seconds or less	Same as standard	Same as standard
3-3. **BLOCK TEMPERATURE PRODUCED BY IMMERSION HEATER.**	5-17			
a. **Adjustable Thermostats, Block Temperature.**		90 °F or as mfr specifies	±10 °F or as mfr specifies	Same as initial
b. **Nonadjustable Thermostats**		90 °F or as mfr specifies	±10 °F or as mfr specifies	Same as initial
3-4. **OVERSPEED**	5-134	120 percent of generator nameplate speed rating	±5 percent	Same as initial
3-5. **COOLANT TEMPERATURE**	5-13			
a. **Operating**	5-13	160 to 200 °F	Same as standard	Same as standard
b. **Shutdown**[1]	5-132	Boiling point −10 °F	Same as standard	Same as standard
c. **Freeze Protection**[2]	5-16	As required	Same as standard	Same as standard
3-6. **ENGINE OVERCRANK (MAX)**	5-135	60 seconds steady, 120 seconds intermittent	±10 seconds	Same as initial
3-7. **LUBRICATION**	5-73	Instruction book	Same as standard	Same as standard

[1] The shutdown temperature setting of a system that is pressurized and/or that has ethylene glycol antifreeze will vary with elevation, system pressure, and coolant mixture. The setting should not exceed a temperature that is 10 °F below the boiling point of the coolant. See table 5-1.

[2] Use a solution of 50 percent ethylene glycol and 50 percent water or see table 5-2.

SECTION 1. ENGINE GENERATORS - GENERAL (Continued)

SUBSECTION 1. ENGINES (Continued)

Parameter	Reference Paragraph	Standard	Tolerance/Limit	
			Initial	*Operating*
3-8. FUEL SUPPLY[1]	5-56	72-hour operation		
→ **3-9. BATTERY, STARTING**	5-135	60 seconds over-crank steady/ 20 seconds intermittent	±10 seconds	Same as initial
3-10. OIL PRESSURE	Instruction book (IB)			
a. Normal Operating		As mfr specifies	Same as standard	Same as standard
b. Alarm	5-133	As mfr specifies	Same as standard	Same as standard
c. Shutdown	5-133	As mfr specifies	Same as standard	Same as standard
3-11. CYLINDER TEMPERATURE	IB	As mfr specifies	Same as standard	Same as standard
3-12. COOL DOWN	IB	3 minutes	+2 minutes −0 minutes	Same as standard
3-13. thru 3-18. RESERVED.				

[1] In general, a 72-hour fuel supply shall be provided. A 36-hour fuel supply is recommended at locations where fuel is readily available and delivery agreements are in place; e.g., major airports and where fuel volume is continuously remotely monitored. At facilities with difficult access, fuel supplies shall be determined on a site-by-site basis. In all cases, fuel supplies shall be based on facility power requirements, not on maximum engine fuel consumption rates. (Reference to the latest edition of Order 6950.2.)

SECTION 1. ENGINE GENERATORS - GENERAL (Continued)

SUBSECTION 2. CONTROLS

Parameter	Reference Paragraph	Standard	Tolerance/Limit Initial	Tolerance/Limit Operating
3-19. POTENTIAL RELAYS (PR-1, PR-2, PR-3) OR UNDERVOLTAGE DEVICES, COMMERCIAL POWER.[1]	5-112			
a. 120 V System.				
(1) Dropout		108 volts, 90 percent	±3 volts	Same as initial
(2) Pickup		114 volts, 95 percent	±3 volts	Same as initial
b. 208 V System.				
(1) Dropout		191 volts, 92 percent	±3 volts	Same as initial
(2) Pickup		197 volts, 95 percent	±3 volts	Same as initial
c. 240 V System.				
(1) Dropout		222 volts, 93 percent	±3 volts	Same as initial
(2) Pickup		228 volts, 95 percent	±3 volts	Same as initial
d. 480 V System.				
(1) Dropout		455 volts, 95 percent	−0, +5 volts	Same as initial
(2) Pickup		465 volts, 97 percent	−0, +5 volts	Same as initial
3-20. POTENTIAL RELAY (PR-4) OR UNDERVOLTAGE DEVICE, STANDBY POWER.	5-113			
a. 120 V System.				
(1) Pickup voltage		112 volts, 93 percent	±3 volts	Same as initial

[1] At facilities where the commercial power source has a record of momentary transients resulting in voltage drops, unnecessary engine starts and power transfers may be eliminated by increasing the tolerances of the PR relay dropout and pickup voltage settings shown in this chapter. The tolerances may be extended to, but not exceed, the acceptable frequency and voltage characteristics of the facility equipment. Any voltage regulators installed to stabilize the commercial voltage to the facility, will be considered facility equipment. The TR relay time delay may be extended beyond 3 seconds to where, under normal starting conditions, the power from the engine generator will be available to the facility within 15 seconds after commercial power failure. The locally established tolerances shall be posted on the inside of the engine generator control panel door near the PR and TR relays.

SECTION 1. ENGINE GENERATORS - GENERAL (Continued)

SUBSECTION 2. CONTROLS (Continued)

Parameter	Reference Paragraph	Standard	Tolerance/Limit	
			Initial	Operating
(2) Dropout voltage		NA	NA	NA
(3) Pickup frequency		60 Hz	57 to 60 Hz	Same as initial
b. 208 V System.				
(1) Pickup voltage		197 volts, 95 percent	±3 volts	Same as initial
(2) Dropout voltage		NA	NA	NA
(3) Pickup frequency		60 Hz	57 to 60 Hz	Same as initial
c. 240 V System.				
(1) Pickup voltage		210 volts, 88 percent	±3 volts	Same as initial
(2) Dropout voltage		NA	NA	NA
(3) Pickup frequency		60 Hz	57 to 60 Hz	Same as initial
d. 480 V System.				
(1) Pickup voltage		465 volts, 97 percent	±3 volts	Same as initial
(2) Dropout voltage		NA	NA	NA
(3) Pickup frequency		60 Hz	57 to 60 Hz	Same as initial
3-21. TIME DELAY (TD) RELAY[1] (maximum before transfer to commercial power).	5-116	15 minutes	12 to 18 minutes	Same as initial
3-22. VOLTAGE REGULATOR	5-141 thru 5-144	Set to match commercial power	±3 volts	Same as initial
3-23. FREQUENCY SENSING DEVICE[2]	5-115	Contacts to open below 57 Hz	Same as standard	Same as standard

[1] Not valid where manual transfer of load to commercial power is made.

[2] Installed on units for category II approach lighting systems (ALSF-2) in accordance with AF P 6980.3, Chap. 143, Change 135, to provide quick transfer back to commercial power if engine fails.

SECTION 1. ENGINE GENERATORS - GENERAL (Continued)

SUBSECTION 2. CONTROLS (Continued)

Parameter	Reference Paragraph	Standard	Tolerance/Limit	
			Initial	Operating
3-24. **TRANSFER RELAY (TR)**[1]	5-116	1 to 3 seconds	Same as standard	Same as standard
3-25. **UNDERVOLTAGE MONITOR (TYPE UVE).**[2]	2-58b,5-112, 5-113			
a. **208 V System.**				
(1) Pickup		198 volts	±3 volts	Same as initial
(2) Dropout		185 volts	±3 volts	Same as initial
b. **240 V System.**				
(1) Pickup		228 volts	±3 volts	Same as initial
(2) Dropout		213 volts	±3 volts	Same as initial
c. **480 V System.**				
(1) Pickup		456 volts	±5 volts	Same as initial
(2) Dropout		428 volts	±5 volts	Same as initial
3-26. **UNDERFREQUENCY MONITOR (TYPE UFE).**[2]	2-58b, 5-113, 5-115			
a. **Pickup**		60 Hz	57 to 60 Hz	Same as initial
b. **Dropout**		57 Hz	+0 Hz −1 Hz	Same as initial
c. **Time Delay on Dropout**		3 seconds	±1 second	Same as initial

[1] At facilities where the commercial power source has a record of momentary transients resulting in voltage drops, unnecessary engine starts and power transfers may be eliminated by increasing the tolerances of the PR relay dropout and pickup voltage settings shown in this chapter. The tolerances may be extended to, but not exceed, the acceptable frequency and voltage characteristics of the facility equipment. Any voltage regulators installed to stabilize the commercial voltage to the facility, will be considered facility equipment. The TR relay time delay may be extended beyond 3 seconds to where, under normal starting conditions, the power from the engine generator will be available to the facility within 15 seconds after commercial power failure. The locally established tolerances shall be posted on the inside of the engine generator control panel door near the PR and TR relays.

[2] The UVE and UFE monitors are used to control the 4PR relay on engine generators that have UPT systems installed.

SECTION 1. ENGINE GENERATORS - GENERAL (Continued)

SUBSECTION 2. CONTROLS (Continued)

Parameter	Reference Paragraph	Standard	Tolerance/Limit	
			Initial	Operating
3-27. INPHASE MONITOR (TYPE IM PN 214A320).[1]	2-58b, 5-120			
a. Delay on Enable		2 seconds	±10 percent	Same as initial
b. Window Width		20 V ac	+2 V ac –4 V ac	Same as initial
c. Voltage Window	5-120	±5 percent	±1 V ac each end point	Same as initial
d. Center Voltage	5-120	Nominal commercial voltage	±1 V ac	Same as initial
3-28. thru 3-37. RESERVED.				

[1] The IM (PN 214A320) is used in the UPT system to signal the proper voltage relationship for an uninterrupted power transfer.

SUBSECTION 3. GENERATORS

Parameter	Reference Paragraph	Standard	Tolerance/Limit	
			Initial	Operating
3-38. FREQUENCY	IB	60 Hz	±0.3 Hz	Same as initial
3-39. OUTPUT VOLTAGE[1]	IB			
a. 120 V System		120 volts	±6 volts	Same as initial
b. 208 V System		208 volts	±10 volts	Same as initial
c. 240 V System		240 volts	±12 volts	Same as initial
d. 480 V System		480 volts	±24 volts	Same as initial
3-40. OUTPUT CURRENT	IB			
a. Maximum Continuous		As mfr specifies	Same as standard	Same as standard
b. Maximum 2-Hour Overload		As mfr specifies	Same as standard	Same as standard
3-41. thru 3-68. RESERVED.				

[1] Adjust output voltage under load to match service entrance voltage or facility requirements.

SECTION 2. DIESEL ENGINE GENERATORS

Parameter	Reference Paragraph	Standard	Tolerance/Limit	
			Initial	Operating
3-69. DIESEL FUEL	IB	As mfr specifies	Same as standard	Same as standard
3-70. FUEL INJECTION SYSTEM	IB	As mfr specifies	Same as standard	Same as standard
3-71. FUEL TRANSFER PUMP	IB			
a. Input Pressure		As mfr specifies	Same as standard	Same as standard
b. Output Pressure		As mfr specifies	Same as standard	Same as standard
3-72. thru 3-79. RESERVED.				

SECTION 3. GASOLINE ENGINE GENERATORS

Parameter	Reference Paragraph	Standard	Tolerance/Limit	
			Initial	Operating
3-80. COMPRESSION VARIATION	IB	Less than 10 psig	Same as standard	Same as standard
3-81. FUEL PUMP VACUUM	IB	As mfr specifies	Same as standard	Same as standard
3-82. FUEL PUMP PRESSURE	IB	As mfr specifies	Same as standard	Same as standard
3-83. GASOLINE	IB			
a. Type	IB	As mfr specifies[1]	Same as standard	Same as standard
b. Octane		82 octane or greater	Same as standard	Same as standard
3-84. MANIFOLD VACUUM	IB	As mfr specifies	Same as standard	Same as standard

[1] If white marine or aviation fuel is specified but not readily available, leaded or unleaded automotive gasoline may be used.

SECTION 3. GASOLINE ENGINE GENERATORS (Continued)

Parameter	Reference Paragraph	Standard	Tolerance/Limit	
			Initial	Operating
3-85. ANTIDIESEL DEVICE	IB	As mfr specifies	Same as standard	Same as standard
3-86. IGNITION SYSTEM	IB	As mfr specifies	Same as standard	Same as standard
3-87. thru 3-91. RESERVED.				

SECTION 4. LPG AND NATURAL GAS ENGINES

Parameter	Reference Paragraph	Standard	Tolerance/Limit	
			Initial	Operating
3-92. COMPRESSION VARIATION	IB	Less than 10 psig	Same as standard	Same as standard
3-93. FUEL SYSTEM	IB	As mfr specifies	Same as standard	Same as standard
3-94. MANIFOLD VACUUM	IB	As mfr specifies	Same as standard	Same as standard
3-95. IGNITION SYSTEM	IB	As mfr specifies	Same as standard	Same as standard
3-96. thru 3-102. RESERVED.				

SECTION 5. GAS TURBINE POWERPLANT

3-103. GENERAL. Refer to the Alturdyne Instruction Book, TI 6980.51, table IV-1 for applicable operating standards and tolerances for the gas turbine engine and subsystems.

3-104. thru 3-112. RESERVED.

CHAPTER 4. PERIODIC MAINTENANCE

4-1. GENERAL.

a. This chapter establishes the maintenance activities that are required for diesel, gasoline, liquefied petroleum gas (LPG), and natural gas engine generators on a periodic, recurring basis and the schedules for their accomplishment. The chapter is divided into five sections; Section 1, Standby Engine Generators without Remote Maintenance Monitor (RMM); Section 2, Standby Engine Generators with Remote Maintenance Monitor (RMM); Section 3, Prime Power Engine Generators; Section 4, Mobile Powerplants (Excluding Gas Turbine Units); and Section *5,* Gas Turbine Mobile Powerplants. Each of the first three sections is divided into subsections. Subsection I applies to all engine generators of the particular category, while subsections 2, 3, and 4 concentrate on diesel, gasoline, and LPG and natural gas engines, respectively. Section 4 establishes the minimum maintenance requirements for mobile power plants prior to storage, while in storage, and upon removal from storage. The maintenance requirements for gas turbine mobile powerplants are located in section *5.*

b. This chapter identifies each performance check or maintenance task to be observed, accomplished, anti/or recorded. Maintenance activities are necessary to determine whether the operation is within the established tolerance/ limits and to prevent deterioration of plant operation. Frequency of checks and tasks outlined in this chapter is minimum. Regional or local policy may require more frequent performance. Refer to Orders 6000.15, General Maintenance Handbook for Airway Facilities, and Order *6980.25,* Maintenance of Batteries for Standby Power, for additional guidance. Refer to instruction books (IB's) for maintenance procedures on air-cooled engine generators. This small-engine category of engine generators is not covered in Order 6980.11.

SECTION 1. STANDBY ENGINE GENERATORS WITHOUT REMOTE MAINTENANCE MONITOR (RMM)

SUBSECTION 1. ENGINE GENERATORS - GENERAL

Maintenance Activities	*Reference Paragraph*	
	Standards and Tolerances	*Maintenance Procedures*
4-2. MONTHLY. Perform the following prior to the monthly load test specified in paragraph 5-3.		
a. Record hours of operation (FAA Form 6980-5)	NA	NA
b. Check engine oiling system for:		
(1) Oil level	NA	IB
(2) Oil leaks (including turbocharger)	NA	IB
c. Check engine cooling system for:		
(I) Coolant level	NA	5-16; IB
(2) Coolant leaks	NA	5-16; IB
(3) Cracked or loose fan blades	NA	NA
(4) Fan belt condition and tension	NA	5-12; IB

SECTION 1. STANDBY ENGINE GENERATORS WITHOUT REMOTE MAINTENANCE MONITOR (RMM) (Continued)

SUBSECTION 1. ENGINE GENERATORS - GENERAL (Continued)

Maintenance Activities	Reference Paragraph	
	Standards and Tolerances	Maintenance Procedures
(5) Air leaks in cooling shroud, ducts, panels, and doors	NA	NA
(6) Operation of immersion heater	3-3	5-17
(7) Operation of fan and engine room ventilation louvers	NA	NA
d. Check engine fuel system for:		
(1) Adequate level in storage tank	3-8	5-56
(2) Leaks	NA	NA
e. Cheek level of oil in governor oil sump	IB	IB
* **Withdrawn by CHG 1**		*
g. Check battery charging rate (use battery charger test switch)	IB	IB
h. Perform scheduled one-hour load test and record (FAA Form 6980-5):	NA	5-3
(1) Time for engine start	3-2	5-3
(2) Control relays and devices, and transfer switch sequence of operation, including paralleling operation if installed.	IB	5-3
i. After engine warmup, and with load connected, check and record (FAA Form 6980-5):		
(1) Engine oil pressure	IB	IB
(2) Generator output voltage	3-39	IB
(3) Generator frequency	3-38	IB
(4) Generator output current	Facility load	NA
(5) Coolant temperature	3-5; IB	5-13 thru 5-23
j. Examine exhaust and combustion air systems for leaks	NA	NA
k. Restore plant to standby status and check:		
(1) Control relays and devices, transfer switch sequence of operation.	NA	IB
(2) Engine shutdown time delay after transfer switch operates	3-12	IB

SECTION 1. STANDBY ENGINE GENERATORS WITHOUT REMOTE MAINTENANCE MONITOR (RMM) (Continued)

SUBSECTION 1. ENGINE GENERATORS - GENERAL (Continued)

Maintenance Activities	*Reference Paragraph*	
	Standards and Tolerances	*Maintenance Procedures*
4-3. QUARTERLY.		
a. Inspect transfer switch for:	NA	5-118
(1) Movement, solenoid, and linkage.		
(2) Condition and wiping action of main and auxiliary contacts, and paralleling contacts if installed.		
b. Reserved.		
4-4. ANNUALLY.		
a. Inspect facility bypass switch for:	NA	5-121
(1) Switch movement.		
(2) Condition of contacts.		
(3) Timing of make-before-break contacts.		
(4) Automatic lock-in feature.		
* **b. Inspect transfer switch**	NA	5-118
(1) Disassemble, inspect, and lubricate solenoid plunger assembly and all other moving parts.		
(2) Check condition and wiping action of main and auxiliary contacts, and paralleling contacts if installed.		*
c. Check control panel for:		
(1) Tightness of relays and device terminals and for signs of overheating.	NA	NA
(2) Condition of relay and device contacts. Clean or replace as necessary.	NA	5-111
(3) Condition of electrical insulation	NA	NA
d. Inspect battery charger timer cams, gears, and switch lever	NA	IB
e. Perform scheduled battery maintenance	Order 6980.25	Order 6980.25
f. Check engine cooling system for:		
(1) Condition of hoses and fittings	NA	5-14

SECTION 1. STANDBY ENGINE GENERATORS WITHOUT REMOTE MAINTENANCE MONITOR (RMM) (Continued)

SUBSECTION 1. ENGINE GENERATORS - GENERAL (Continued)

Maintenance Activities	Reference Paragraph	
	Standards and Tolerances	Maintenance Procedures
(2) Lubrication of pulleys and pumps		
(3) pH of coolant		
(4) Condition of radiator fan exhaust duct	NA	NA
(5) Adequate coolant freeze protection	3-5	5-16
g. Check combustion air cleaner[1]	NA	IB
h. Examine fuel tanks for contamination	NA	5-56
i. Conduct required tank integrity testing	Order 1050.15	5-56
j. Replace fuel filters and fuel lines as necessary, and clean fuel traps annually, or after 100 hours of engine operation, whichever occurs first.	NA	IB
k. Inspect and clean positive crankcase ventilation system filter, valve, and connecting lines, and hoses.	NA	IB
l. Inspect generator bearings and lubricate, if required		
m. Visually check generator for signs of misalignment with engine	NA	5-104
n. Check generator terminals for tightness, signs of overheating, and condition of insulation.	NA	5-95
o. Check condition of exciter slip rings or commutator and brushes. Check for dust, dirt, and grease buildup on rectifiers commutator and heatsinks.	NA	5-100
p. Operate unit with facility on bypass, and check:		
(1) Proper operation and cranking speed of starting motor	NA	5-26 thru 5-30; IB
(2) Time to lock out overcrank safety and cranking voltage[2]	3-6	5-135
(3) Engine ignition timing accuracy at operation speed	IB	NA
(4) Operation of engine overtemperature alarm and safety	IB	5-132

[1] Check air cleaner more often where dusty operating conditions exist.

[2] Record battery cranking voltage after 50 seconds of cranking during overcrank safety check. Compare to previous recordings as an aid to determine condition of batteries.

SECTION l. STANDBY ENGINE GENERATORS WITHOUT REMOTE MAINTENANCE MONITOR (RMM) (Continued)

SUBSECTION l. ENGINE GENERATORS - GENERAL (Continued)

Maintenance Activities	*Reference Paragraph*	
	Standards and Tolerances	*Maintenance Procedures*
(5) Operation of overspeed lockout	3-4	5-134
(6) Operation of low-oil-pressure safety	IB	5-133
(7) Dropout of frequency sensing device (FSD)[1]	3-23	IB
(8) Pickup voltage and frequency of 4PR device or undervoltage device (lockout relay).	3-20, 3-25, 3-26	5-113
q. Check pickup and dropout voltages of PR-1, PR-2, and PR-3 devices.	3-19	5-112
r. Check calibration of UPT inphase monitor	3-27	5-120
s. Perform scheduled 4-hour load test and record, on FAA Form 6980-5, the following:	NA	5-3
(1) Transfer relay (TR): time to deenergize after simulated prime power loss	3-24	IB
(2) Transfer switch delay relay (CR): time to energize with generator voltage.	IB	IB
(3) Hours of operation	NA	NA
t. After engine warmup, check and record:		
(1) Engine oil pressure	IB	NA
(2) Generator output voltage	3-39	NA
(3) Generator frequency	3-38	NA
(4) Generator output current	Facility load	NA
(5) Accuracy of temperature gauge and coolant temperature	IB	IB
u. Restore commercial power.		
(1) Check TD relay: time delay before transfer to commercial power.	3-21	IB
(2) Check time delay of engine shutdown timer after transfer	IB	IB

[1] On CATEGORY II ALSF-2 system.

SECTION l. STANDBY ENGINE GENERATORS WITHOUT REMOTE MAINTENANCE MONITOR (RMM) (Continued)

SUBSECTION l. ENGINE GENERATORS - GENERAL (Continued)

Maintenance Activities	*Reference Paragraph*	
	Standards and Tolerances	*Maintenance Procedures*
v. Drain water and sediment from fuel system (if applicable)	NA	IB
w. Check load bank connections (where applicable)	NA	IB
4-5. BIENNIALLY.		
a. Drain and replace engine crankcase oil and filter(s) every 2 years or 200 hours, whichever comes first.	NA	IB
b. Drain and replace oil in hydraulic governor sump every 2 years, or after 200 hours of engine operation, whichever occurs first.	NA	5-73; IB
c. Operate unit on load bank at operating temperature for at least 15 minutes. Lock out engine, with facility on bypass and:		
(1) Drain coolant and flush	NA	IB
(2) Drain and clean immersion heater element and housing	NA	IB
(3) Clean radiator fins as required	NA	IB
(4) Refill coolant system	NA	5-16; IB
(5) Operate plant for 15 minutes. Check coolant level with engine stopped. Add coolant if necessary.	NA	IB
d. Inspect starter, lubricate and burnish contacts	NA	IB
4-6. AS REQUIRED.[1]		
Check to determine need for overhaul of engine, accessories and turbocharger. Overhaul if required.	NA	IB
4-7. thru 4-9. RESERVED.		

[1] Engines perform under a variety of climatic and operational conditions. Therefore, a thorough analysis of the engine by a qualified technician using appropriate tools, test equipment, and oil laboratory analysis will be the determining factor in scheduling and defining the depth of overhaul for a particular engine.

SECTION l. STANDBY ENGINE GENERATORS WITHOUT REMOTE MAINTENANCE MONITOR (RMM) (Continued)

SUBSECTION 2. DIESEL ENGINE GENERATORS

Maintenance Activities	*Reference Paragraph*	
	Standards and Tolerances	*Maintenance Procedures*
4-10. MONTHLY.		
In addition to the maintenance activities of paragraph 4-2 for all engine generators, perform the following for diesel units.		
a. Operate compressed air safety valve (if applicable)	NA	IB
b. Drain water from air compressor tank and moisture traps (if applicable).	NA	IB
c. Observe action of fuel solenoid	IB	IB
d. Check operation of turbocharger and engine oil circulating system.	NA	5-58; IB
e. Check turbocharger for unusual noise	NA	5-58
4-11. QUARTERLY.		
Observe action of intake air shutoff solenoid for diesel units in conjunction with maintenance activities of paragraph 4-3.	IB	IB
4-12. ANNUALLY.		
Perform the following for diesel units in conjunction with maintenance activities of paragraph 4-4.		
a. Clean and service fuel injectors, if required	NA	5-56; IB
b. Check compressed air system for leaks (if applicable) In addition:	NA	IB
(1) Inspect air filters.		
(2) Check and clean moisture traps.		
(3) Inspect and operate air receiver safety valve.		
4-13. thru 4-15. RESERVED.		

SECTION l. STANDBY ENGINE GENERATORS WITHOUT REMOTE MAINTENANCE MONITOR (RMM) (Continued)

SUBSECTION 3. GASOLINE ENGINE GENERATORS

Maintenance Activities	*Reference Paragraph*	
	Standards and Tolerances	*Maintenance Procedures*
4-16. MONTHLY.		
In addition to the maintenance activities of paragraph 4-2 for all engine generators, perform the following for gasoline units.		
a. Observe choke operation	NA	IB
b. Observe anti-diesel solenoid operation	NA	IB
4-17. ANNUALLY.		
Perform the following for gasoline units in conjunction with maintenance activities of paragraph 4-4.		
a. Inspect and service carburetor as required	NA	IB
b. Check compression of all cylinders	IB	IB
c. Inspect, clean, and gap sparkplugs annually or after 100 hours, whichever occurs first.	IB	IB
d. Check complete ignition system	NA	IB
e. Measure the following with the engine loaded and at operating temperature.		
(1) Intake manifold vacuum	IB	IB
(2) Fuel pump pressure and vacuum	IB	IB
4-18. thru 4-22. RESERVED.		

SECTION l. STANDBY ENGINE GENERATORS WITHOUT REMOTE MAINTENANCE MONITOR (RMM) (Continued)

SUBSECTION 4. LPG AND NATURAL GAS ENGINES

Maintenance Activities	*Reference Paragraph*	
	Standards and Tolerances	*Maintenance Procedures*
4-23. MONTHLY. (RESERVED)		
4-24. ANNUALLY. Perform the following for LPG and natural gas engines in conjunction with the maintenance activities of paragraph 4-4.		
a. Inspect and service fuel system	IB	IB
b. Inspect and service carburetor	IB	IB
c. Check compression of all cylinders	IB	IB
d. Check complete ignition system	IB	IB
e. Measure the intake manifold vacuum with the engine loaded and at operating temperature.	IB	IB
4-25. thru 4-30. RESERVED.		

SECTION 2. STANDBY ENGINE GENERATORS WITH REMOTE MAINTENANCE MONITOR (RMM)

SUBSECTION l. ENGINE GENERATORS - GENERAL

Maintenance Activities	*Reference Paragraph*	
	Standards and Tolerances	*Maintenance Procedures*
4-31. WEEKLY. Observe remote monitors to determine the alarm status and the condition of all static reading sensors that determine the condition of critical standby parameters. (DO NOT START ENGINE.)		
a. Fuel level	3-8	5-56a
b. Battery voltage	Order 6980.25	5-47
c. Facility status	Facility on commercial power	NA
d. Alarm status	No alarms	RMM IB

SECTION 2. STANDBY ENGINE GENERATORS WITH REMOTE MAINTENANCE MONITOR (RMM) (Continued)

SUBSECTION l. ENGINE GENERATORS - GENERAL (Continued)

Maintenance Activities	Reference Paragraph	
	Standards and Tolerances	Maintenance Procedures
4-32. MONTHLY.		
* Facility load test (30 minutes duration).[1] *		
a. Start engine; assume facility load.		
(1) Record time for engine to start and transfer	3-2	IB
(2) Make a monitor scan to determine status of critical parameters.		
b. During the last 15 minutes of test, check and record:		
(1) Engine oil pressure	IB	IB
(2) Generator output voltage	3-39	IB
(3) Generator frequency	3-38	IB
(4) Generator output current	Facility load	NA
(5) Coolant temperature	IB	5-10 thru 5-17; 5-21 thru 5-23
c. Check engine fuel system for:		
(1) Adequate level in storage	3-8	NA
(2) Presence of water in fuel tank (if detectable with installed remote sensors)	5-56	RMM IB
4-33. QUARTERLY.[2] Perform the following in conjunction with the quarterly onsite load test specified in paragraph 5-3. Record all data on FAA Form 6980-5.		
a. Record hours of operation	NA	NA
b. Check engine oiling system for:		
(1) Oil level and dilution	NA	IB
(2) Oil leaks (including turbocharger)	NA	5-73; IB

[1] These checks are performed remotely. Refer to remote maintenance publications for procedures.

[2] During each site visit, visual checks will be made and logged in the facility log unless they have been made within the last 30 days. If any discrepancies are found, note them in the log; otherwise make a log entry stating “Visual checks made of all facility supply systems.”

SECTION 2. STANDBY ENGINE GENERATORS WITH REMOTE MAINTENANCE MONITOR (RMM) (Continued)

SUBSECTION l. ENGINE GENERATORS - GENERAL (Continued)

Maintenance Activities	*Reference Paragraph*	
	Standards and Tolerances	*Maintenance Procedures*
c. Check engine cooling system for:		
(1) Coolant level	NA	5-16; IB
(2) Coolant leaks	NA	5-16; IB
(3) Cracked or loose fan blades	NA	NA
(4) Fan belt condition and tension	NA	5-12c
(5) Air leaks in cooling shroud, ducts, panels, and doors	NA	MA
(6) Operation of immersion heater	3-3	5-17
(7) Operation of fan and engine room ventilation louvers	NA	NA
d. Check engine fuel system for:		
(1) Adequate level in storage tank to minimize water contamination effects	3-8	NA
(2) Leaks	NA	NA
(3) Presence of water in fuel tank	NA	5-56
e. Check level of oil in governor oil sump	NA	IB
f. Perform scheduled battery maintenance	Order 6980.25	Order 6980.25
g. Check battery charging rate (use battery charger test switch)	IB	IB
h. Perform scheduled 1-hour load test, and check and/or record the following:	NA	5-3
(1) Time for engine start	3-2	IB
(2) Control relays and devices, and transfer switch sequence of operation, including paralleling operation if installed.	IB	IB
i. After engine warmup, check and record the following with load connected.		
(1) Engine oil pressure	IB	NA
(2) Generator output voltage	3-39	NA

SECTION 2. STANDBY ENGINE GENERATORS WITH REMOTE MAINTENANCE MONITOR (RMM) (Continued)

SUBSECTION l. ENGINE GENERATORS - GENERAL (Continued)

Maintenance Activities	*Reference Paragraph*	
	Standards and Tolerances	*Maintenance Procedures*
(3) Generator frequency	3-38	NA
(4) Generator output current	Facility load	NA
(5) Coolant temperature	IB	5-13, 5-15, 5-23
j. Examine exhaust and combustion air systems for leaks	NA	NA
k. Restore plant to standby status and check:		
(1) Control relays and devices, transfer switch sequence of operation.	NA	IB
(2) Engine shutdown time delay after transfer switch operates	NA	IB
l. Inspect transfer switch for:	NA	5-118
(1) Movement, solenoid, and linkage.		
(2) Condition and wiping action of main and auxiliary contacts, and paralleling contacts if installed.		
4-34. ANNUALLY.		
a. Inspect facility isolation switch for:	NA	5-121
(1) Switch movement.		
(2) Condition of contacts.		
(3) Timing of make-before-break contacts.		
(4) Automatic lock-in feature.		
b. Inspect transfer switch	NA	5-118
(1) Disassemble, inspect, and lubricate solenoid plunger assembly and all other moving parts.		
(2) Check condition and wiping action of main and auxiliary contacts, and paralleling contacts if installed.		
c. Check control panel for:		
(1) Relays and device terminals tightness and for signs of overheating.	NA	NA

SECTION 2. STANDBY ENGINE GENERATORS WITH REMOTE MAINTENANCE MONITOR (RMM) (Continued)

SUBSECTION l. ENGINE GENERATORS - GENERAL (Continued)

Maintenance Activities	Reference Paragraph	
	Standards and Tolerances	Maintenance Procedures
(2) Condition of relays and devices contacts. Clean or replace as necessary.	NA	NA
(3) Condition of electrical insulation	NA	NA
d. With engine locked out and facility on bypass, check for:	NA	TI 6980.501
(1) Pitted or burned contacts on relays used to interface the control cabinet with remote start-stop and/or monitoring equipment.		
(2) Condition and wiping action of remote start-stop control and/or monitoring auxiliary contacts on transfer switch.		
e. Inspect battery charger timer cams, gears, and switch lever	NA	IB
f. Perform scheduled battery maintenance	Order 6980.25	Order 6980.25
g. Check engine cooling system for:		
(1) Condition of hoses and fittings	NA	5-14
(2) Lubrication of pulleys and pumps	NA	5-12
(3) pH of coolant	NA	5-16
(4) Condition of radiator fan exhaust duct	NA	NA
(5) Adequate coolant freeze protection	3-5	5-16
h. Check combustion air cleaner2	NA	IB
i. Examine fuel tanks for contamination	NA	5-56
j. Conduct required tank integrity testing	Order 1050.15	5-56
k. Replace fuel filters and fuel lines as necessary, and clean fuel traps annually or after 100 hours of engine operation, whichever occurs first.	NA	IB

1 Instruction Book Supplement, TI 6980.50, Engine Generator Radio Remote Control and Monitor System.

2 Check air cleaner more often where dusty operating conditions exist.

SECTION 2. STANDBY ENGINE GENERATORS WITH REMOTE MAINTENANCE MONITOR (RMM) (Continued)

SUBSECTION l. ENGINE GENERATORS - GENERAL (Continued)

Maintenance Activities	*Reference Paragraph*	
	Standards and Tolerances	*Maintenance Procedures*
l. Inspect and clean positive crankcase ventilation system filter, valve and connecting lines, and hoses.	NA	IB
m. Inspect generator bearings, and lubricate if required		
n. Visually check generator for signs of misalignment with engine		
o. Check generator terminals for tightness, signs of overheating and condition of insulation.		
p. Check condition of exciter slip rings or commutator and brushes. Check for dust, dirt, and grease buildup on rectifiers and heatsinks.		
q. Operate unit with facility on bypass, and check:		
(1) Proper operation and cranking speed of starting motor	NA	5-26 thru 5-30; IB
(2) Time to lock out overcrank safety and cranking voltage[1]	3-6	5-135
(3) Engine timing accuracy at operating speed	IB	NA
(4) Operation of engine overtemperature alarm and safety		
(5) Operation of overspeed lockout	3-4	5-134
(6) Operation of low-oil-level alarm and safety		
(7) Dropout of frequency-sensing device (FSD)[2]	3-23	5-115
(8) Pickup voltage and frequency of 4PR device or undervoltage device (lockout relay).		
r. Check pickup and dropout voltage of PR-1, PR-2 and PR-3 devices.	3-19	5-112
s. Check calibration of UPT inphase monitor	3-27	5-120

[1] Record battery cranking voltage after 50 seconds of cranking during overcrank safety check. Compare it to previous recordings as an aid to determine condition of batteries.

[2] On CATEGORY II ALSF-2 systems.

SECTION 2. STANDBY ENGINE GENERATORS WITH REMOTE MAINTENANCE MONITOR (RMM) (Continued)

SUBSECTION l. ENGINE GENERATORS - GENERAL (Continued)

Maintenance Activities	*Reference Paragraph*	
	Standards and Tolerances	*Maintenance Procedures*
t. Perform the following in conjunction with the annual 4-hour onsite load test by simulating a power failure to start engine.	--	5-3
(1) Check transfer relay (TR) time to deenergize after simulated prime power loss.	3-24	IB
(2) Check transfer switch delay relay (CR) time to energize with generator voltage.	IB	IB
(3) Record hours of operation	NA	NA
u. After engine warmup, check and record (FAA Form 6980-5):		
(1) Engine oil pressure	IB	NA
(2) Generator output voltage	3-39	NA
(3) Generator frequency	3-38	NA
(4) Generator output current	Facility load	NA
(5) Accuracy of temperature gauge and coolant temperature	IB	IB
v. Restore commercial power:		
(1) Check TD relay: time delay before transfer to commercial power.	3-21	IB
(2) Check time delay of engine shutdown timer after transfer	IB	IB
w. Drain water and sediment from day tank	NA	IB
x. Check load bank connections (where applicable)	NA	NA
y. Verify remote PC data values against engine control panel meter readings.	IB	IB
4-35. BIENNIALLY.		
a. Drain and replace engine crankcase oil and filter(s) every 2 years or 100 hours, whichever occurs first.	NA	IB

SECTION 2. STANDBY ENGINE GENERATORS WITH REMOTE MAINTENANCE MONITOR (RMM) (Continued)

SUBSECTION l. ENGINE GENERATORS - GENERAL (Continued)

Maintenance Activities	Reference Paragraph	
	Standards and Tolerances	*Maintenance Procedures*
b. Drain and replace oil in hydraulic governor sump every 2 years or after 200 hours of engine operation, whichever occurs first.	NA	5-73; IB
c. Operate unit on load bank at operating temperature for at least 15 minutes. Lock out engine, with facility on bypass, and:	NA	IB
(1) Drain coolant and flush.		
(2) Drain and clean immersion heater element and housing.		
(3) Clean radiator fins as required.		
(4) Refill coolant system.		
(5) Operate plant for 15 minutes. Check coolant level with engine stopped. Add coolant if necessary.		
d. Inspect starter, lubricate, and burnish starter contacts	NA	IB
4-36. AS REQUIRED.[1] Check to determine need for overhaul of engine, accessories and turbocharger. Overhaul unit if required.	NA	IB
4-37. thru 4-40. RESERVED.		

[1] Engines perform under a variety of climatic and operational conditions. Therefore, a thorough analysis of the engine by a qualified technician using appropriate tools, test equipment, and oil laboratory analysis will be the determining factor in scheduling and defining the depth of overhaul for a particular engine.

SECTION 2. STANDBY ENGINE GENERATORS WITH REMOTE MAINTENANCE MONITOR (RMM) (Continued)

SUBSECTION 2. DIESEL ENGINE GENERATORS

Maintenance Activities	Reference Paragraph	
	Standards and Tolerances	*Maintenance Procedures*
4-41. QUARTERLY.[1] In addition to the maintenance activities of paragraph 4-33 for all engine generators, perform the following for diesel units.		
a. Operate compressed air safety valve (if applicable)	NA	IB
b. Drain water from air compressor tank and moisture traps (if applicable).	NA	IB
c. Observe action of fuel solenoid	IB	IB
d. Check operation of turbocharger and engine oil circulating system	NA	5-58; IB
e. Check turbocharger for unusual noise	NA	5-58
f. Observe action of intake air shutoff solenoid for diesel units (if applicable).	IB	IB
4-42. ANNUALLY. Perform the following for diesel units in conjunction with maintenance activities of paragraph 4-34.		
a. Clean and service fuel injectors, if required	NA	5-56; IB
b. Inspect compressed air system (if applicable)	NA	IB
(1) Check for leaks.		
(2) Inspect air filters.		
(3) Check and clean moisture traps.		
(4) Inspect and operate air receiver safety valve.		
(5) Check pipe supports and downward slope of piping to permit gravity flow of moisture to receiver and traps.		
4-43. thru 4-44. RESERVED.		

[1] During each site visit, visual checks will be made and logged in the facility log unless they have been made within the last 30 days. If any discrepancies are found, note them in the log; otherwise make a log entry stating “Visual checks made of all facility supply systems.”

SECTION 2. STANDBY ENGINE GENERATORS WITH REMOTE MAINTENANCE MONITOR (RMM) (Continued)

SUBSECTION 3. GASOLINE ENGINE GENERATORS

Maintenance Activities	*Reference Paragraph*	
	Standards and Tolerances	*Maintenance Procedures*
4-45. QUARTERLY.[1] In addition to the maintenance activities of paragraph 4-33 for all engine generators, perform the following for gasoline units.		
a. Observe choke operation	NA	IB
b. Observe anti-diesel solenoid operation	NA	IB
4-46. ANNUALLY. Perform the following for gasoline units in conjunction with maintenance activities of paragraph 4-34.		
a. Inspect and service carburetor as required	NA	IB
b. Check compression of all cylinders	IB	IB
c. Inspect, clean, and gap spark plugs annually or after 100 hours, whichever occurs first.	IB	IB
d. Check complete ignition system	NA	IB
e. Measure the following with the engine loaded and at operating temperature.		
(1) Intake manifold vacuum	IB	IB
(2) Fuel pump pressure and vacuum	IB	IB
4-47. thru 4-48. RESERVED.		

[1] During each site visit, visual checks will be made and logged in the facility log unless they have been made within the last 30 days. If any discrepancies are found, note them in the log; otherwise make a log entry stating "Visual checks made of all facility supply systems."

SECTION 2. STANDBY ENGINE GENERATORS WITH REMOTE MAINTENANCE MONITOR (RMM) (Continued)

SUBSECTION 4. LPG AND NATURAL GAS ENGINES

Maintenance Activities	*Reference Paragraph*	
	Standards and Tolerances	*Maintenance Procedures*
4-49. QUARTERLY. (RESERVED)		
4-50. ANNUALLY. Perform the following for LPG and natural gas engines in conjunction with the maintenance activities of paragraph 4-34.		
a. Inspect and service fuel system	IB	IB
b. Inspect and service carburetor	IB	IB
c. Check compression of all cylinders	IB	IB
d. Inspect, clean, and gap spark plugs annually or after 100 hours, whichever occurs first.	IB	IB
e. Check complete ignition system	IB	IB
f. Measure the intake manifold vacuum with the engine loaded and at operating temperature.	IB	IB
4-51. thru 4-52. RESERVED.		

SECTION 3. PRIME POWER ENGINE GENERATORS

SUBSECTION l. ENGINE GENERATORS - GENERAL

Maintenance Activities	*Reference Paragraph*	
	Standards and Tolerances	*Maintenance Procedures*
* **4-53. Withdrawn by CHG 1**		
4-54. BIWEEKLY.		
a. Check engine oil pressure	IB	5-73
b. Check coolant temperature	3-5	5-13, 5-23
c. Check engine for:		
(1) Oil leaks	NA	NA
(2) Coolant leaks.	NA	5-10
(3) Fuel leaks	NA	NA
d. Check generator:		
(1) Output voltage	3-39	5-95 thru 5-104
(2) Output current	Facility load	5-95 thru 5-104
(3) Output frequency	3-38	5-95 thru 5-104
e. Record hours of operation	NA	NA
f. Check oil level of engine oil system	NA	5-73
g. Check cooling system coolant level	NA	5-10
h. Check fuel storage level in tanks	3-8	NA
i. Check hydraulic governor oil sump level	NA	5-65
j. Check control panel and adjust as required	NA	5-110
k. Check engine oil system for oil contamination	NA	5-73
l. Visually check battery charger timer and gears	NA	IB
m.Record battery charger output current (battery charger switch on).	NA	IB
n. Observe sequence of operation during power transfers	NA	5-110

SECTION 3. PRIME POWER ENGINE GENERATORS (Continued)

SUBSECTION l. ENGINE GENERATORS - GENERAL (Continued)

Maintenance Activities	Reference Paragraph	
	Standards and Tolerances	*Maintenance Procedures*
4-55. MONTHLY.		
a. Change engine oil and filter except where spectral analysis tests show oil still usable.	3-7	5-73
b. Check, clean, or replace combustion air cleaner	NA	IB
c. Perform scheduled battery maintenance	Order 6980.25	Order 6980.25
d. Check complete sequence of operation during a power transfer	NA	5-110
e. Check all terminals for tightness and for signs of overheating	NA	5-110
f. Check condition of electrical insulation	NA	5-110
g. Visually check alignment of generator with engine	NA	5-104
h. Check and adjust generator as required	NA	5-101, 5-102
i. Check brush/rectifier assembly	NA	5-101, 5-102
j. Measure battery cranking voltage	NA	IB
k. Check radiator fan belt tension and condition	NA	5-12
l. Check all cooling system hoses and hose connections for leaks	NA	5-14
m. Check hydraulic governor oil	NA	5-63, 5-65
n. Inspect crankcase ventilation system. Clean if necessary	NA	5-87
4-56. QUARTERLY.		
a. Perform scheduled battery maintenance	Order 6980.25	Order 6980.25
b. Measure battery voltage:		
(1) Before cranking (charger off)	NA	IB
(2) During cranking (charger off)	NA	IB
c Check for cracked fan blades and loose hub bolts	NA	IB
d. Lubricate generator	NA	5-97

SECTION 3. PRIME POWER ENGINE GENERATORS (Continued)

SUBSECTION l. ENGINE GENERATORS - GENERAL (Continued)

Maintenance Activities	*Reference Paragraph*	
	Standards and Tolerances	*Maintenance Procedures*
e. Clean fuel traps and filters	NA	IB
f. Drain water and sediment from day tank	NA	5-56
4-57. ANNUALLY.		
a. Check operation of all control devices	NA	5-110 thru 5-123
b. Check operation of all switches	NA	5-110 thru 5-123
c. Check operation of all safety devices	NA	5-131 thru 5-136
d. Remove covers and inspect generator bearings for wear and lubrication.	NA	IB
e. Check generator ventilation system	NA	IB
f. Check generator/exciter brushes for wear and seating	NA	5-100, 5-101
g. Conduct required fuel tank integrity testing	Order 1050.15	5-56
h. Perform scheduled battery maintenance	Order 6980.25	Order 6980.25
i. Adequate coolant freeze protection	3-5	5-16
j. Check engine value clearance. Adjust as necessary	IB	IB
4-58. BIENNIALLY.		
a. Drain and replace oil in hydraulic governor sump every 2 years, or after 200 hours of engine operation, whichever occurs first.	NA	IB
b. Operate unit on load at operating temperature for at least 15 minutes. Lock out engine.		
(1) Drain coolant and flush	NA	IB
(2) Drain and clean immersion heater element and housing	NA	IB
(3) Clean radiator fins as required	NA	IB
(4) Refill coolant system	NA	IB
(5) Operate plant for 15 minutes. Check coolant level with engine stopped. Add coolant if necessary.	NA	IB

SECTION 3. PRIME POWER ENGINE GENERATORS (Continued)

SUBSECTION l. ENGINE GENERATORS - GENERAL (Continued)

Maintenance Activities	Reference Paragraph	
	Standards and Tolerances	Maintenance Procedures
4-59. AS REQUIRED.[1] Check to determine need for overhaul of engine, accessories, and turbocharger. Overhaul if required.	NA	IB
4-60. RESERVED.		

[1] Engines perform under a variety of climatic and operational conditions. Therefore, a thorough analysis of the engine by a qualified technician using appropriate tools and test equipment will be the determining factor in scheduling and defining the depth of overhaul for a particular engine.

SUBSECTION 2. DIESEL ENGINE GENERATORS

Maintenance Activities	Reference Paragraph	
	Standards and Tolerances	Maintenance Procedures
4-61. DAILY. (RESERVED)		
4-62. BIWEEKLY. In addition to the maintenance activities of paragraph 4-54 for all engine generators, perform the following for diesel prime power units only.		
a. Drain water from air compressor receiver and moisture traps	NA	IB
b. Check turbocharger for:		
(1) Oil leaks	NA	5-58
(2) Unusual noises	NA	5-58
4-63. MONTHLY. (RESERVED)		
4-64. QUARTERLY. In addition to the maintenance activities of paragraph 4-56 for all engine generators, perform the following for diesel prime power units only.		
a. Check engine timing	IB	IB
b. Operate compressed air safety relief valve	NA	IB

SECTION 3. PRIME POWER ENGINE GENERATORS (Continued)

SUBSECTION 2. DIESEL ENGINE GENERATORS (Continued)

Maintenance Activities	*Reference Paragraph*	
	Standards and Tolerances	*Maintenance Procedures*
4-65. ANNUALLY. In addition to the maintenance activities of paragraph 4-57 for all engine generators, perform the following for diesel prime power units only.		
a. Remove, clean, and reinstall pyrometer thermocouples in exhaust manifold.	NA	IB
b. Check compressor air system for leaks. In addition:	NA	IB
(1) Inspect air filters elements.		
(2) Check and clean moisture traps.		
(3) Inspect and operate air receiver safety valve.		
4-66. thru 4-67. RESERVED.		

SUBSECTION 3. GASOLINE ENGINE GENERATORS

Maintenance Activities	*Reference Paragraph*	
	Standards and Tolerances	*Maintenance Procedures*
4-68. DAILY. (RESERVED)		
4-69. WEEKLY. (RESERVED)		
4-70. MONTHLY. (RESERVED)		
4-71. QUARTERLY. In addition to the maintenance activities of paragraph 4-56 for all engine generators, perform the following for gasoline prime power units only.		
a. Check engine timing. Replace distributor points and condenser if necessary.	IB	IB
b. Measure intake manifold vacuum	IB	IB
c. Measure fuel pump pressure	IB	IB
d. Clean fuel traps and filters	NA	IB

SECTION 3. PRIME POWER ENGINE GENERATORS (Continued)

SUBSECTION 3. GASOLINE ENGINE GENERATORS (Continued)

Maintenance Activities	*Reference Paragraph*	
	Standards and Tolerances	*Maintenance Procedures*
e. Inspect crankcase ventilation system. Clean if necessary	NA	5-87
f. Check sparkplugs, clean and gap or replace as necessary	NA	IB
g. Check ignition wiring	NA	IB
4-72. thru 4-73. RESERVED.		

SECTION 4. LPG AND NATURAL GAS ENGINES

Maintenance Activities	*Reference Paragraph*	
	Standards and Tolerances	*Maintenance Procedures*
4-74. DAILY. (RESERVED)		
4-75. WEEKLY. (RESERVED)		
4-76. MONTHLY. (RESERVED)		
4-77. QUARTERLY. In addition to the maintenance activities of paragraph 4-56 for all engine generators, perform the following for LPG and natural gas engines.		
a. Check engine timing. Replace distributor points and condenser if necessary.	NA	IB
b. Measure intake manifold vacuum	IB	IB
c. Inspect and service fuel system as required	IB	IB
d. Clean fuel traps and filters	NA	IB
e. Inspect crankcase ventilation system. Clean if necessary	NA	5-87
f. Check sparkplugs, clean gap or replace as necessary	IB	IB
g. Check ignition wiring	NA	IB
4-78. thru 4-79. RESERVED.		

SECTION 4. MOBILE POWERPLANTS (EXCLUDING GAS TURBINE UNITS)

SUBSECTION l. MAINTENANCE SCHEDULE

4-80. GENERAL. This section establishes the minimum periodic maintenance activities required for mobile engine generator powerplants, excluding gas turbine units, prior to storage, while in storage, and upon removal from storage, on a periodic, recurring basis, and the schedules for their accomplishment. These activities include both performance checks (i.e., tests, measurements, and observations) of normal operating controls and functions that are necessary to determine whether operation is within established tolerances or limits, and maintenance tasks that are necessary to ensure a reliable operation. The unit must be maintained in a state of operational readiness at all times, except when undergoing repairs. Refer to Order 6000.15 for additional general guidance. Refer to section 5 for maintenance requirements of gas turbine mobile powerplants.

4-81. PREPARATION FOR STORAGE. Prior to storage, accomplish the performance checks and maintenance tasks identified in paragraphs 4-88, 4-89, and 4-90 to ensure that the mobile powerplant is in satisfactory operating condition. After checks and tasks are completed, check the powerplant trailer tires for proper inflation and provide block-up support for units that will remain in storage for an extended period. Provide an external power where feasible, to maintain the starting battery charge, using the powerplant charger. Ground the unit if external power is connected.

4-82. WHILE IN STORAGE. While the unit is in storage, accomplish the performance checks and maintenance tasks identified in paragraphs 4-88, 4-89, and 4-90 on a monthly basis. Annually, in addition to the monthly requirements, perform the tasks identified in paragraph 4-96 on all engine generators, including the 4-hour load test; complete either paragraph 4-96n or 4-96o as applicable. Biennially, perform the tasks in paragraph 4-97.

4-83. REMOVAL FROM STORAGE. Upon removal from storage, accomplish the performance checks and maintenance tasks identified in paragraphs 4-99, 4-89, and 4-90. Refer to paragraph 4-96 and accomplish any other maintenance tasks needed to ensure that the unit is fully operational prior to transporting the mobile powerplant to the operational site.

4-84. OPERATIONAL STATUS. Refer to the appropriate section of this order for operating parameters and maintenance requirements for engine generators in either a prime power or standby status.

4-85. thru 4-87. RESERVED.

SECTION 4. MOBILE POWERPLANTS (EXCLUDING GAS TURBINE UNITS) (Continued)

SUBSECTION 2. SYSTEM PERFORMANCE CHECKS

Maintenance Activities	*Reference Paragraph*	
	Standards and Tolerances	*Maintenance Procedures*
* **4-88. Withdrawn CHG 1** *		
4-89. PREOPERATIONAL CHECKS. (Record all data on FAA Form 6980-5.)		
a. Record hours of operation.		
b. Check engine oil for:		
(1) Adequate level	IB	5-73; IB
(2) Contamination	IB	IB
(3) Leaks	NA	IB
c. Check coolant system for:		
(1) Adequate level	IB	IB
(2) Leaks	NA	NA
(3) Proper immersion heater operation	3-3	5-17
(4) Condition and tension of fan belt	IB	5-12c
(5) Air leaks in cooling shroud, panels, and doors	NA	5-13
(6) All connecting hoses and fittings for deterioration	NA	5-14
(7) Lubrication of pulleys and pumps	IB	5-16
CAUTION: Do not over lubricate.		
(8) Condition of filter elements	IB	IB
(9) Freedom of movement and manual operation of ventilation louvers.	NA	IB
(10) Clean radiator fins	NA	NA

SECTION 4. MOBILE POWERPLANTS (EXCLUDING GAS TURBINE UNITS) (Continued)

SUBSECTION 2. SYSTEM PERFORMANCE CHECKS (Continued)

Maintenance Activities	Reference Paragraph	
	Standards and Tolerances	*Maintenance Procedures*
d. Examine the fuel system for:		
(1) Leaks	IB	5-56
(2) Moisture contamination	IB	5-56
(3) Fuel level	IB	IB
e. Check starting battery	Order 6980.25	Order 6980.25
f. Check for adequate governor oil level (if applicable)	IB	IB
g. On the control panel, check:		
(1) Visually, all relays and terminals for tightness and signs of overheating.	NA	5-110; IB
(2) The condition of electrical insulation	NA	5-110; IB
h. Inspect the generator for:		
(I) Signs of misalignment with engine	NA	5-104; IB
(2) Tightness and signs of overheating at all terminals	NA	NA
(3) The condition of electrical insulation	NA	NA
i. Check combustion air cleaner	NA	IB
* **j. Load test**	NA	5-3
(1) Perform a 30 minutes load test of engine generators. Observe requirements of paragraph 4-90.		
(2) The generator should be connected to a load bank equal to at least 100 percent of the generator kW rating. An operator shall be present continuously during the test. Readings shall be recorded during the last 15-minute interval of the load test.		*
4-90. OPERATIONAL CHECKS. (Record all data on FAA Form 6980-5.)		
a. Measure the battery voltage	Order 6980.25	Order 6980.25
(1) No load.		
(2) Cranking.		
b. Start engine; determine time to start engine and operate transfer switch, if equipped with a transfer switch.	IB	IB
c. Check engine oil pressure	IB	IB
d. Check engine operating temperature	IB	IB
e. Check battery charging rate	IB	IB

SECTION 4. MOBILE POWERPLANTS (EXCLUDING GAS TURBINE UNITS) (Continued)

SUBSECTION 2. SYSTEM PERFORMANCE CHECKS (Continued)

Maintenance Activities	*Reference Paragraph*	
	Standards and Tolerances	*Maintenance Procedures*
f. Observe sequence of operation at control panel	IB	IB
g. Check the generator:		
(1) Output voltage	3-39	IB
(2) Output current	Facility load	5-3
(3) Output frequency	3-38	IB
(4) For abnormal heating	IB	IB
h. Examine engine exhaust and induction system for leaks	NA	NA
i. On gasoline engines, observe:		
(1) Choke operation	IB	5-56
(2) Anti-diesel solenoid	3-85	5-56
j. On diesel engines, check:	3-69, 3-70, 3-71	IB
(1) Action of fuel solenoid	3-69, 3-70, 3-71	IB
(2) Operation of turbocharger and engine oil circulating system	IB	5-58, 5-73
(3) Turbocharger for unusual noise	IB	5-58
4-91. thru 4-95. RESERVED.		

SECTION 4. MOBILE POWERPLANTS (EXCLUDING GAS TURBINE UNITS) (Continued)

SUBSECTION 3. PERIODIC MAINTENANCE TASKS

Maintenance Activities	*Reference Paragraph*	
	Standards and Tolerances	*Maintenance Procedures*
4-96. ANNUALLY.		
a. Check control panel for:		
(1) Relays and device terminals tightness, and for signs of overheating.	NA	5-110
(2) Condition of relays and devices contacts. Clean or replace as necessary.	NA	5-110
(3) Check complete sequence of operation	NA	IB
(4) Check condition of electrical insulation	NA	5-110
b. Visually check alignment of generator with engine	NA	5-104
c. Remove covers and inspect generator bearings for wear and lubrication.	NA	5-96, 5-97
d. Check generator/exciter brushes for wear and seating or diode assembly condition.	NA	5-101, 5-102
e. Clean and adjust generator as required	IB	IB
f. Check pickup and dropout voltages of the PR relays	3-19, 3-20	5-112, 5-113
g. Check operation of all safety devices	3-4, 3-5, 3-6, 3-10	5-132 thru 5-136
h. Perform scheduled battery maintenance	Order 6980.25	Order 6980.25
i. Check engine cooling system for:		
(1) Condition of hoses and fittings	NA	5-14
(2) Lubrication of pulleys and pumps	NA	5-12
(3) Condition of radiator fan exhaust duct	NA	NA
(4) Adequate coolant freeze protection	3-5	5-16
(5) Check pH	IB	5-16
j. Check combustion air cleaner	NA	IB
k. Examine fuel tanks for contamination	NA	5-56

SECTION 4. MOBILE POWERPLANTS (EXCLUDING GAS TURBINE UNITS) (Continued)

SUBSECTION 3. PERIODIC MAINTENANCE TASKS (Continued)

Maintenance Activities	Reference Paragraph: Standards and Tolerances	Reference Paragraph: Maintenance Procedures
l. Inspect and clean positive crankcase ventilation system filter valve and connecting lines and hoses.	NA	IB
* **m. Where load bank is available perform 2-hour load test with load bank or 30 minutes without load bank.**	NA	5-3 *
n. On gasoline engines, perform the following in conjunction with maintenance activities of steps 4-96a through m.		
(1) Inspect and service carburetor as required	NA	5-56; IB
(2) Check compression of all cylinders	IB	IB
(3) Inspect, clean, and gap spark plugs annually or after 100 hours, whichever occurs first.	IB	5-41
(4) Check complete ignition system	NA	5-41; IB
(5) Measure the following with the engine loaded and at operating temperature.		
(a) Intake manifold vacuum	IB	IB
(b) Fuel pump pressure and vacuum	IB	IB
o. On diesel engines, perform the following in conjunction with maintenance activities of steps 4-96a through m.		
(1) Clean and service fuel injectors, if required	NA	5-56; IB
(2) Clean or replace fuel filters as required	NA	5-56; IB
(3) Check turbocharger for proper operation	NA	5-58; IB
(4) Check starting air system (if applicable)	NA	IB
(a) Check the compressed air system for leaks.		
(b) Inspect air filters.		
(c) Check and clean moisture traps.		
4-97. BIENNIALLY.		
a. Drain and replace engine crankcase oil and filter(s) every 2 years or 200 hours, whichever comes first.	NA	IB

SECTION 4. MOBILE POWERPLANTS (EXCLUDING GAS TURBINE UNITS) (Continued)

SUBSECTION 3. PERIODIC MAINTENANCE TASKS (Continued)

Maintenance Activities	*Reference Paragraph*	
	Standards and Tolerances	*Maintenance Procedures*
b. Drain and replace oil in hydraulic governor sump every 2 years or after 200 hours of engine operation, whichever occurs first.	NA	IB
c. Drain coolant and flush system	NA	5-16
d. Drain and clean immersion heater element and housing	NA	IB
e. Clean radiator fins as required	NA	IB
f. Refill coolant system	NA	5-16; IB
g. Check trailer	NA	Order 6960.5A, paragraph 126
4-98. thru 4-118. RESERVED.		

SECTION 5. GAS TURBINE MOBILE POWERPLANTS

4-119. GENERAL. This section establishes all the maintenance activities required for gas turbine mobile powerplants on a periodic, recurring basis, and the schedules for their accomplishment. These activities include both performance checks (i.e., tests, measurements, and observations) of normal operating control and functions that are necessary to determine whether operation is within established tolerances or limits, and other tasks that are necessary to ensure a reliable operation. Refer to Order 6000.15 for additional general guidance. All references are to the Alturdyne instruction book, TI 6980.51.

4-120. PREPARATION FOR STORAGE. Prior to storage of the unit, make the required performance checks as listed in table V-l of instruction book, TI 6980.51. After performance checks are completed, check the powerplant trailer tires for proper inflation. Block up the axles and crank up the trailer jackstands for leveling if the unit is to remain in storage for an extended period. Provide an external power source, where feasible, to maintain the wet-cell starting battery voltage by using the powerplant battery charger. Ground the trailer if external power is connected. The breakaway electric braking dry-cell battery may be removed and stored to prevent its deterioration during extremely hot weather.

4-121. IN STORAGE.

a. General. The mobile powerplant must be maintained in a condition of readiness at all times to ensure satisfactory performance in an operational situation. Provide block-up supports, if feasible, for units remaining in storage longer than 3 months. Accomplish any maintenance tasks outlined in TI 6980.51, table V-2, when they become due.

b. Monthly.

(1) Accomplish all performance checks listed in TI 6980.51, table V-I.

(2) Perform the maintenance tasks outlined in TI 6980.51, table V-3, except the quarterly items.

(3) Perform scheduled battery maintenance.

c. **Bimonthly**.

(1) Check fuel for water condensation.

(2) Check tires for proper inflation.

d. Quarterly.

(1) Accomplish the quarterly tasks outlined in table V-3.

* (2) Perform a 30 minutes load test.

e. Annually.

(1) Check PR relays.

(2) Perform a 2-hour load test with load bank or 30 minutes without loadbank.. *

f. Biennially. Check wheel bearings, axles, and the frame's structural and paint condition.

4-122. UPON REMOVAL FROM STORAGE. Upon removal of a unit from storage, make the performance checks listed in table V- 1 of the instruction book. Accomplish any other performance check or maintenance task required to ensure that the unit is fully operational prior to transporting the mobile powerplant to the operation site. Check the tire pressure, and install a dry-cell battery for breakaway electric brake operation.

4-123. TRANSPORTING AND HANDLING. In transporting and handling the gas turbine mobile powerplant, ensure that the towing hitch and safety chains on the trailer mount are in good condition, working properly, and properly secured. Ensure that the towing vehicle and trailer brakes will provide effective stopping control; and that the running lights, turn indicator lights, and brake lights of the trailer are operating properly. Transport the unit with the minimum amount of fuel in the tank to facilitate handling, especially in movements to remote sites over rough roadways. Due to the unit's size and weight, a heavy-duty, four-wheel-drive vehicle and special towing hitch may be required to transport the unit, depending on climate and location.

4-124. INITIAL SETUP FOR OPERATION. Refer to the instruction book, and follow procedures prescribed for initial setup and operation checkout prior to putting the unit into operational standby/prime power service. Check all connections, terminals, and fittings subject to loosening from vibration in transporting the unit, to ensure correct tightness.

4-125. IN OPERATIONAL SITUATION. Refer to tables V-1, V-2, and V-3 of the instruction book and, accomplish the performance checks and maintenance tasks as applicable for mobile powerplants in prime power or standby operation situations.

4-126. PARALLEL OPERATIONS. Where two gas turbine units are needed to meet operational standby/prime power requirements, refer to TI 6980.51, appendix D, Paralleling Module, for guidance on setup and maintenance procedures in parallel operations.

4-127. thru 4-158. RESERVED.

CHAPTER 5. MAINTENANCE PROCEDURES

5-1. GENERAL. This chapter establishes the procedures for accomplishing the various essential maintenance activities which are required for engine generator plants on either a periodic or incidental basis. Refer to Order 6000.15, General Maintenance Handbook for Airway Facilities, for additional general guidance. Refer to instruction books for maintenance procedures for air-cooled engine generators.

SECTION 1. MAINTENANCE RECORDS AND LOAD TESTS

5-2. FAA FORMS AND ENGINE GENERATOR LOGBOOK.

a. Forms. FAA Form 6980-5, Technical Performance Record - Engine Generator (see figure 5-1), and 6000-8, Technical Performance Record - Continuation or Temporary Record/Report Form, shall be used to record the results of periodic performance checks. Because the entries become a permanent official record of equipment performance, all entries shall be made in either indelible pencil or ink and must be legible. A separate form shall be prepared for each engine generator. For gas turbine powerplants, modify and use the noted forms and reports, including FAA Form 6000-8; Continuation or Temporary/ Record report form, as applicable and appropriate for gas turbine units. In addition, fuel consumption data should be maintained and recorded along with maintenance record information.

(1) Entries. Line entries should be made as shown on sample form 6980-5 (figure 5-1). The line identified as NOMINAL should be used to record, as appropriate, the normal readings of the engine generator. FAA Form 6000-8 can be used to record any additional items of data deemed necessary by the regions.

(2) Documented Performance. The information recorded on FAA Forms 6980-5 and 6000-8 should represent equipment performance "as-found" rather than "as-corrected" values. If adjustment is required, the "as-found" reading should be recorded and encircled. The reading made following the corrective action shall be entered in the space directly below the encircled entry.

(3) FAA Form 6980-5, Technical Performance Record, Engine Generator. Check and record on FAA Form 6980-5 the items listed in the following subparagraphs.

(a) Nominal block entries.

1 Fuel storage level. Record the minimum fuel requirements, in gallons, established for the engine generator.

2 Crankcase oil used. Enter a check (√).

3 Coolant used (liquid-cooled). Enter a check (√).

4 Engine block temperature (standby). Enter a check (√).

5 Coolant temperature (operating). Record maximum liquid-coolant temperature after operating on facility load (or equal) for 45 minutes.

6 Battery cranking voltage. Record new battery cranking voltage, if known; otherwise leave blank.

7 Starting time. Record 15 seconds.

8 Oil pressure (operating). Record the manufacturer's recommended pressure at operating temperature.

9 Output voltage. Record generator output voltages established for the facility.

10 Output frequency. Record the frequency established for the facility.

11 Output current. Record the highest measured generator output line current with maximum facility load connected and essentially balanced.

12 Hours of operation. Record actual hours of operation or the last reading from the preceding sheet.

SECTION 1. MAINTENANCE RECORDS AND LOAD TESTS (Continued)

FIGURE 5-1. SAMPLE FAA FORM 6980-5

TECHNICAL PERFORMANCE RECORD — ENGINE GENERATOR

FACILITY (ATCT, FSS, ARTCC, VOR, LOC, ETC.) ARSR — DATES FROM 3/3/78 TO — SUPERVISOR'S SIGNATURE

LOCATION (CITY, STATE, AIRPORT, OTHER) Tinker AFB — EQUIPMENT 175KW ~~(KVA)~~ 3Ø E/G (MFGER) Holt Brothers — CONTRACT NO DOT-FA70AC10173H

DATE	TIME	FUEL STORAGE LEVEL*	CRANKCASE OIL USED*	COOLANT USED*	ENG BLOCK TEMP (STANDBY)**	COOLANT TEMP (OPERATING)*	BATTERY CRANKING VOLTAGE*	STARTING TIME*	OIL PRESSURE (OPERATING)*	OUTPUT VOLTAGE*	OUTPUT FREQUENCY*	OUTPUT CURRENT*	HOURS OF OPERATION*	PR RELAYS* PICK UP VOLTS PR1	PR2	PR3	PR4	DROP OUT VOLTS PR1	PR2	PR3	FREQ* SENSING RELAY OVER	UNDER	REMARKS *RECORD VALUES **CHECK WHEN NORMAL	INITIALS
NOMINAL		2000	✓	✓	✓	200	27.5	15	40-60	208	60.0	396	473	197	197	197	197	191	191	191	60.3	59.7		
3/3/78	1935	1339	✓	✓	✓	185	27.5	3	55	208	60.0	396	473	199	197	197	196	193	191	192	60.3	59.8	Facility load	
										208		392												
										208		400											Annual	DWB
4/1/78	1330	1323	✓	✓	✓	178	27.5	5	57	208	60.0	395	475	–	–	–	–	–	–	–	–	–	Load bank	
										208		393												
										208		398											Monthly	DWB

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SECTION 1. MAINTENANCE RECORDS AND LOAD TESTS (Continued)

13 PR devices. Record the pickup and dropout voltages established for each prime source PR device and for the generator source undervoltage relay (PR4) or device. Enter NA (not applicable) where PR devices are not installed.

14 Frequency sensing device. Record frequency established for the facility ±0.3Hz. Enter closer tolerance if required by the facility. Enter NA if the unit is not equipped with a frequency sensitive device.

(b) Routine Entries. Entries shall be made in conjunction with load tests of paragraph 5-3, and after resumption of service following a breakdown or major servicing.

1 Fuel storage level. Record the gallons of fuel on hand.

2 Crankcase oil used. Record the quarts of crankcase oil added. Enter a check if oil is not added.

3 Coolant used. Record the quarts of coolant added. Enter a check if coolant is not added.

4 Engine block temperature (standby). Check engine block temperature (by feel). Enter a check if satisfactory; otherwise, enter an (X). Continue to enter an (X) until corrected.

5 Coolant temperature (operating). Record coolant temperature after 45 minutes of operation.

6 Battery cranking voltage. Record the battery cranking voltage.

7 Starting time. Record the starting time after the cranking motor or air solenoid is engaged.

8 Oil pressure (operating). Record the engine oil pressure at operating temperature.

9 Output voltage. Record line-to-line or line-to-neutral output voltage at facility load.

10 Output current. Record the facility or load bank load current in sequence, starting with Phase I. Note in remarks column which load was used.

11 Hours of operation. Record the hourmeter reading.

12 PR devices. Record actual dropout and pickup values of the PR devices or undervoltage-sensing device(s); otherwise enter a dashmark.

13 Frequency sensing device. Record actual frequency for device operation; otherwise enter a dash-mark. Leave columns blank where not applicable.

14 Remarks. Enter type of load test being made. Add any other pertinent remarks.

b. Engine-Generator Logbook. A complete record of nonroutine maintenance activities shall be entered in the engine-generator logbook. This logbook also documents significant repairs, such as governors, fuel pumps, radiators, relays and oil pumps. Since this logbook provides a historical record of significant maintenance actions, it shall be forwarded with the powerplant if it is relocated.

5-3. LOAD TESTS.

a. General. Load tests are to be made as part of the scheduled maintenance activities required for standby engine generators. A load test must also be made following nonroutine maintenance. To be valid, a load test should be made by simulating a prime power loss, and by using the total facility as the engine generator load. A no-load test shall not be made prior to performing a load test. Load tests, other than those performed after nonroutine maintenance, should be conducted at a time reflecting the most severe environmental conditions experienced at each location for the various -seasons of the year. All facility equipment, including air-conditioners, heaters, and fans, should remain in an operational or an “as-found” condition immediately prior to and during the test. The unit shall be operated continuously for the specified test period. During

SECTION 1. MAINTENANCE RECORDS AND LOAD TESTS (Continued)

load tests, all building doors and/or cooling shroud doors and panels should be kept closed as they are normally when the facility is unattended. A technician shall be in attendance during all load tests. For engine generators that are instrumented remotely, the technician shall monitor monthly load tests from the remote site. Equipment performance should be checked at least every 30 minutes, and to the extent practicable, any readings that become a part of the facility records shall be made during the last 15-minute interval of the test.

NOTE: All load tests shall be performed by or with the cognizance of a technician qualified in the maintenance of FAA engine generators.

b. Types of Load Tests. Test duration times shown below are minimum, and should be lengthened to establish equipment operating temperatures in extremely cold weather. Frequency of load tests shown below are minimum. Load tests should be performed more frequently if a unit is operating marginally and in-depth maintenance cannot be performed immediately. Load tests are to be made as follows:

* (1) Scheduled Load Test. A load test of 30 minutes duration is to be performed monthly for engine generators of all sizes. A load test of a minimum 2-4-hour duration shall be performed annually for all engine generators. *

(2) Unscheduled Load Test. Upon completion of routine and nonroutine maintenance, test the repaired engine generator long enough to determine that the maintenance has not changed the operational characteristics of the engine generator.

c. Load Testing Methods. All load test must be coordinated with air traffic personnel. Observation of the complete sequence of transfer switch operation, normally made during the monthly load test, may be omitted if a load bank is used because the facility load is not available. However, the omission should not occur for two consecutive monthly load tests. Load tests may be performed by:

(1) Simulation of prime power loss with automatic transfer to facility load. Simulation may be made by:

(a) Opening the facility prime power service entrance switch or device, if rated for the required interrupting capacity under load.

(b) Coordination of the load test with a test of the engine generator remote control (start-stop) equipment, where installed. The latest edition of Order 6650.6, Maintenance of Radio Control Equipment for Plant Facilities, specifies operational checks for ground-to-ground radio remote control and monitoring equipment. Upon initiation of the remote "start" command, a remote control system usually starts the sequence of operation by opening the circuit to the TR device (or equal).

(2) Resistive Load Bank Test.

(a) Start the EIG using the no load test pushbutton or switch. In this test the facility will be powered by commercial power.

(b) When the E/G is up to frequency and voltage, place the loadbank on the engine generator. The minimum resistive load should match the facility load.

(3) Mobile Powerplants. Resistive load banks are used to test mobile powerplants under loaded conditions. The load bank shall not be connected to the engine generator during the start and stop cycle. The following procedures apply to the testing of all mobile powerplants.

(a) Locate the load bank outside in an area where the heat radiated from the load will not result in damage.

(b) Open the generator circuit breaker.

(c) Connect the load, through the test jacks, to the powerplant.

(d) Adjust the load switches for a load of 100 percent of the rated capacity of the mobile powerplant.

(e) Start the engine and close the circuit breaker after the engine is up to rated speed.

SECTION 1. MAINTENANCE RECORDS AND LOAD TESTS (Continued)

(f) Following the load test, open the generator circuit breaker, and allow the plant to run a few minutes to cool the engine.

(g) Disconnect the load, and place the plant in the desired status.

d. No-Load Operation. Operation of diesel engines without a load results in fouling of cylinders and injectors. Long-time operation of gasoline engines without a load may result in fouling of the sparkplugs. Therefore, no-load operation shall be held to an absolute minimum.

e. Load Testing During Power Failure. Standby engine generators at certain facilities may be started and put on facility load at least 30 minutes prior to the estimated arrival of a severe storm. This operational run may be substituted for a scheduled load test, providing the requirements of paragraph 5-3 a, b, and c are met. Observation by a technician (either onsite or by remote instrumentation) is required for detection of marginal conditions that could impair the reliability of the plant.

5-4. thru 5-9. RESERVED.

SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES
SUBSECTION 1. COOLING SYSTEMS

5-10. GENERAL. The efficiency and reliability of the cooling system is insured with adequate preventive maintenance. Good maintenance practices should detect impending failures so that corrective action may be taken before a failure occurs.

5-11. RADIATORS. Radiators are designed to dissipate excess heat developed by the engine, allowing it to operate at normal temperatures under full load and any normal ambient temperature. When a radiator becomes clogged, the engine may overheat. Certain minerals in water cause scale and sludge formation on the inner surfaces of the radiator hoses, water pump, immersion heater housing, and engine water jacket, resulting in poor heat transfer. A clean cooling system, especially the radiator, is necessary for the proper cooling of the engine. The cooling system should be cleaned with a suitable cleaner-conditioner, NSN 6850-00-965-2082, or a commercial equivalent. Not all cleaners are suitable for use with an aluminum radiator. If the radiator still remains clogged after use of the cleaner, it must be removed and cleaned by a radiator repair shop. If the radiator is removed, it should be repainted before it is reinstalled.

5-12. WATER PUMPS. Water pumps must circulate sufficient water through the system to keep the engine coolant temperature within the predetermined range under all operating conditions. Pumps are belt driven or gear driven and have packing gland or spring-loaded graphite shaft seals. Leaks are difficult to prevent with the packing gland type, as a slight seepage of water is necessary to lubricate and prevent overheating of the shaft. The spring-loaded seal is used extensively on units having pressurized water systems.

a. Packing Gland Type. If a leak develops in this type of water pump (figure 5-2), the pump gland nut should be checked for tightness, taking care not to tighten excessively. The most frequent failure is pitting and scoring of the pump shaft in the area of the packing. This generally results when a grease fitting has not been provided, where greasing has been neglected, or when the packing and gland have been too tightly compressed. When overhauling packing gland type pumps, remove old packing, and clean and reassemble, using new packing. Lubricate with grease. The pump shaft should be measured for wear; and if the clearance is greater than 0.002 inches, it should be replaced. The pump bushing should be checked; if the wear is in excess of 0.008 inches, the bushing should be replaced and refitted to the shaft. Examine the impeller for corrosion or wear, and replace if necessary.

b. Ball-Bearing Type, Graphite Seal. In disassembling this type of pump (figure 5-3), remove the fan hub or fan pulley from the forward end of the shaft. Then remove the internal snap ring that holds the forward bearing in place, after which the entire shaft and bearing assembly can be removed from the support housing. This pump is equipped with a carbon graphite seal that rides on a stainless steel bushing, the face of which is comparatively broad, permitting a wide area of contact with the seal. When reassembling a new seal, a light film of lubricant should be placed on the contact area to provide immediate

SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 1. COOLING SYSTEMS (Continued)

FIGURE 5-2. WATER PUMP WITH PACKING GLANDS

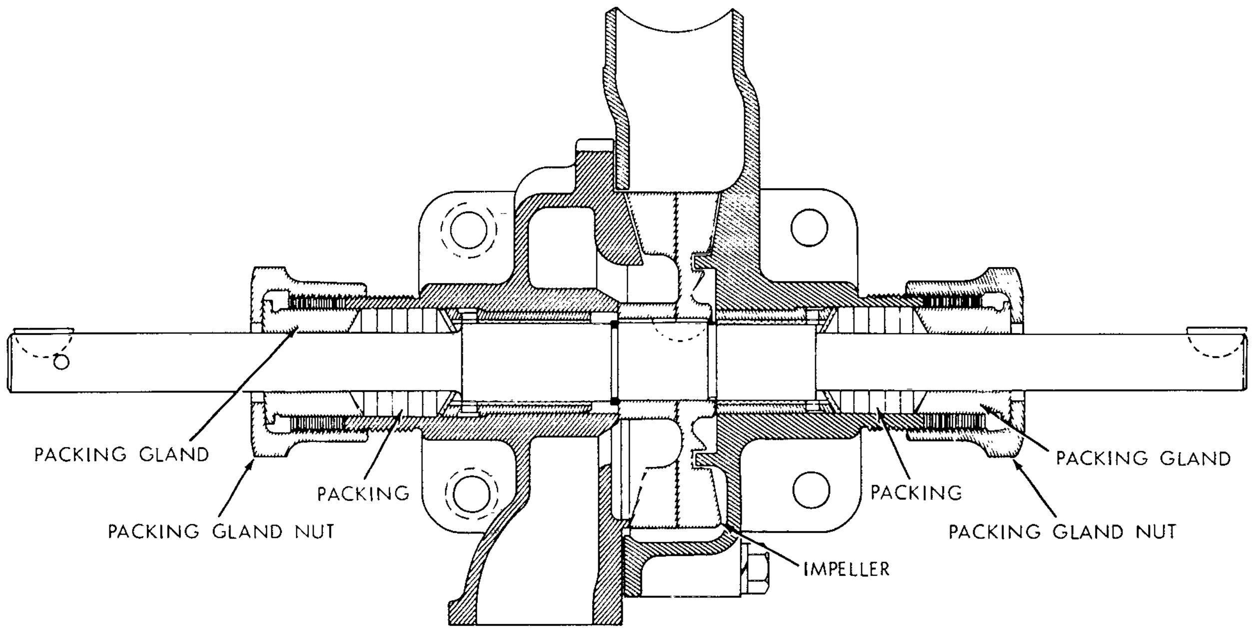
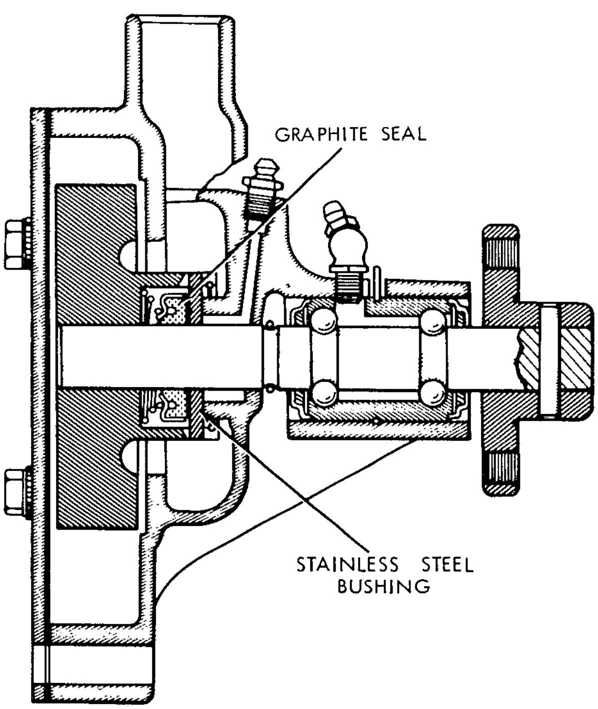


FIGURE 5-3. WATER PUMP WITH GRAPHITE SEALS

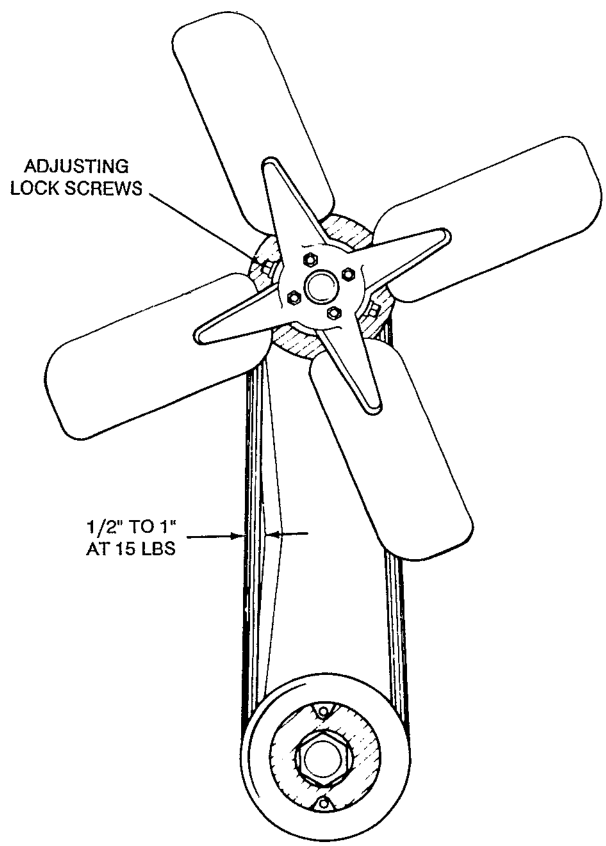


SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 1. COOLING SYSTEMS (Continued)

lubrication during starting. Ball bearings in this water pump operate free of water and require only a good grade of ball bearing lubricant. Do not use special water pump greases. A relief hole is provided through which water may drain if the pump seal starts to leak.

c. Fan and Fan Belts. The fan should be carefully inspected for cracks and loose or bent blades. If the fan is mounted on the water pump shaft, no further servicing is necessary. Some fans are mounted separately from the water pumps. On these it will be necessary to disassemble and inspect the shaft and bearings. A new fan belt should be installed during each complete overhaul and at other servicing periods when an inspection reveals defects such as breaks or fraying. Fan belt tension should be tight enough to prevent slippage, but not to the point where the fan or water pump bearings are overloaded. Follow the manufacturer's recommendations in making the necessary adjustments. Where no instructions are available, tighten the belt so that a force of 15 pounds will deflect the belt about one-half to one inch (figure 5-4).

FIGURE 5-4. FAN BELT TENSION



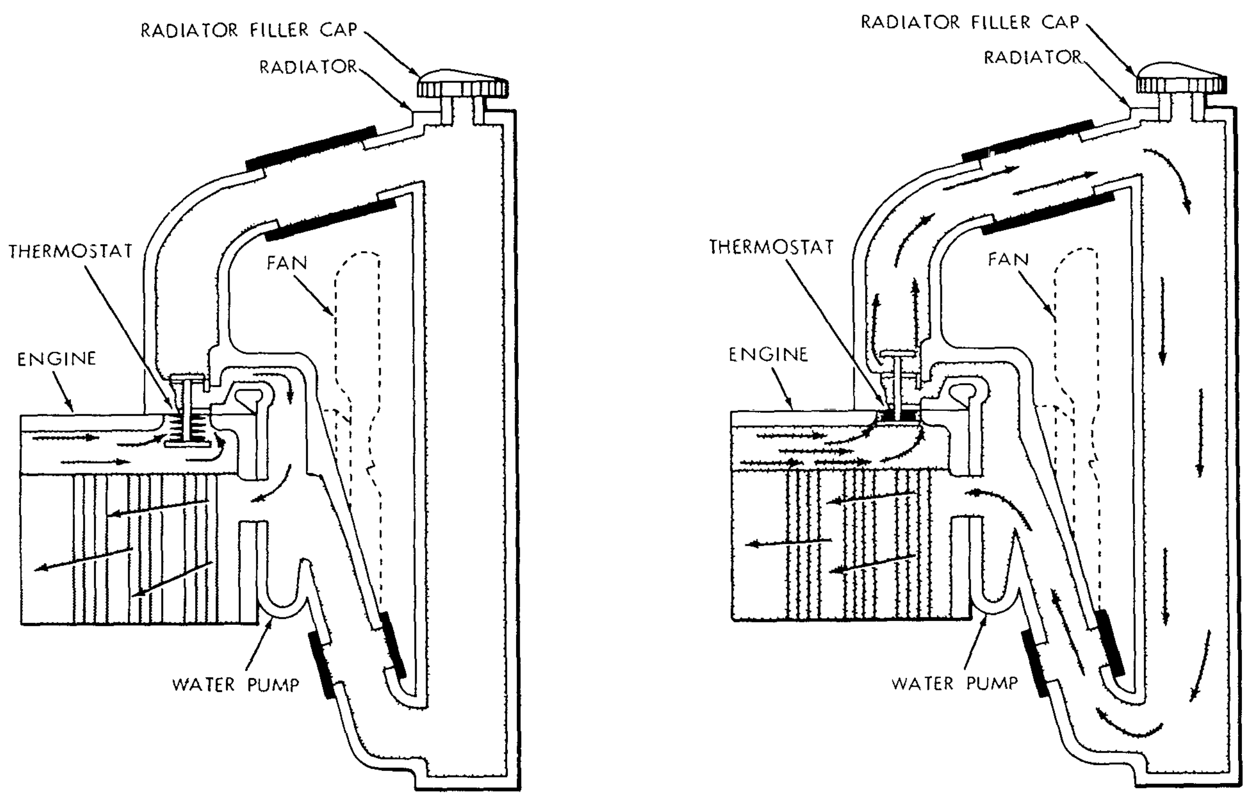
SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 1. COOLING SYSTEMS (Continued)

5-13. THERMOSTATS. The thermostat regulates the coolant flow from the engine to the radiator to maintain a predetermined engine operating temperature (figure 5-5). During the first portion of a test run, a rapid rise to normal operating temperature will indicate a thermostat operating normally. If a malfunction is suspected, the thermostat should be replaced. If the valve can be pulled or pushed from its seat with slight effort when the thermostat is cold, the thermostat is defective. When installing thermostats, place the thermal coil downward so it is immersed in the engine jacket water. A thermostat that becomes less sensitive to heat will not open its valve sufficiently and will allow the engine to overheat.

5-14. HOSES AND CONNECTIONS. Examine hose and connections periodically for cracks, breaks, softness, or deterioration. Replace with new hoses as required. When installing new hoses, do not over tighten the hose clamps. Excessive torque results in "cold-flow" of the hose material in the area of the clamp. This could cause early failure of the hose.

5-15. RADIATOR PRESSURE CAP. To improve cooling efficiency, practically all engine manufacturers use a pressure-type radiator filler cap (figure 5-6). The pressure cap raises the boiling point of the coolant in the system, and evaporation is reduced proportionally. (See table 5-1.) The cap has two springs: a large one to regulate pressure and a smaller one to prevent the formation of a vacuum in the system. These springs should be observed for indications of rust. The water gasket inside the cap should be replaced when defective. A cap having the pressure (pounds per square inch gauge) recommended by the plant manufacturer should be used.

FIGURE 5-5. THERMOSTAT OPERATION



Flow Control Thermostat Closed. Water Recirculating through engine *ONLY*.

Flow Control Thermostat open. Water Circulating through *BOTH* engine and radiator.

SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 1. COOLING SYSTEMS (Continued)

FIGURE 5-6. RADIATOR PRESSURE CAP

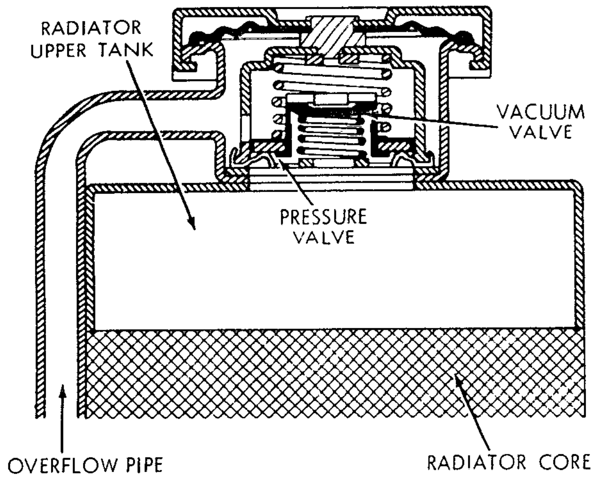


TABLE 5-1. BOILING POINT OF COOLANT (AS A FUNCTION OF SYSTEM PRESSURE AND PERMANENT-TYPE ANTIFREEZE PROTECTION LEVEL)

Freezing Protection (°F)	*COOLING SYSTEM PRESSURE PSIG (pounds per square inch, gauge)*							
	0	*2*	*4*	*6*	*8*	*10*	*12*	*14*
None	212°	219°	225°	230°	234°	238°	244°	247°
+20	216°	223°	228°	234°	237°	243°	247°	252°
0	221°	226°	234°	238°	244°	248°	253°	257°
-20	224°	229°	236°	242°	246°	252°	256°	260°
-40	226°	232°	239°	245°	250°	255°	259°	264°
-60	231°	236°	245°	250°	255°	260°	265°	268°

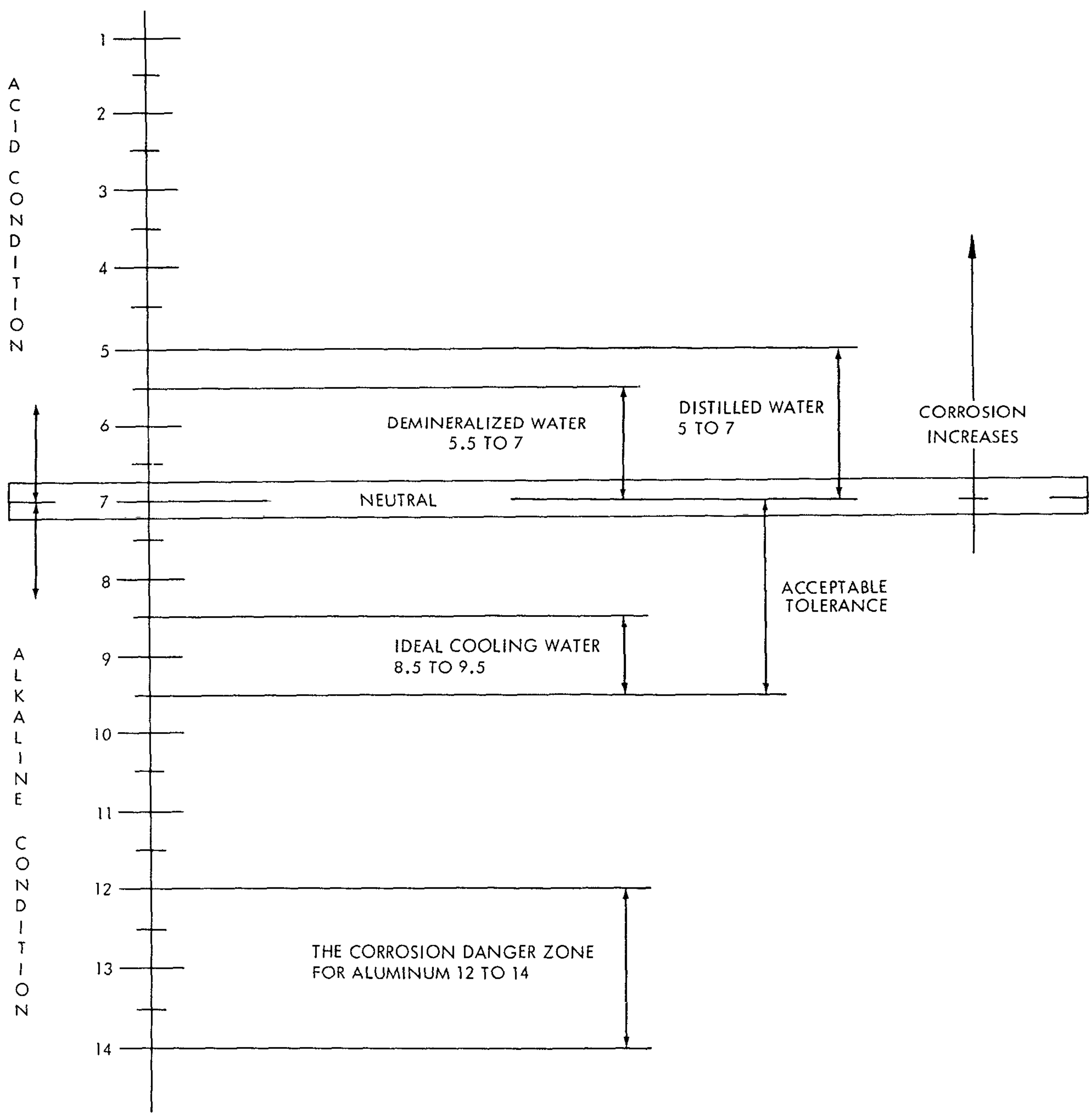
The above temperatures are for sea-level operation. Subtract 2° from these temperatures for each 1000 feet of elevation
.

SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 1. COOLING SYSTEMS (Continued)

5-16. COOLANT.

a. Water. Water used in the radiator and engine water jacket should have a neutral to slightly alkaline pH value of 7 to 9.5, as shown by the chart of figure 5-7. The pH value may be tested over a range of 4 to 9 with a colorimetric "indicator" paper (color comparison chart on the paper roll container), NSN 6640-00-434-5702. The test should be performed prior to mixing antifreeze with the water. When water meeting this specification is not obtainable in the area, distilled water may be used. To allow for thermal expansion, radiators should not be filled completely.

FIGURE 5-7. pH VALUE RANGE CHART

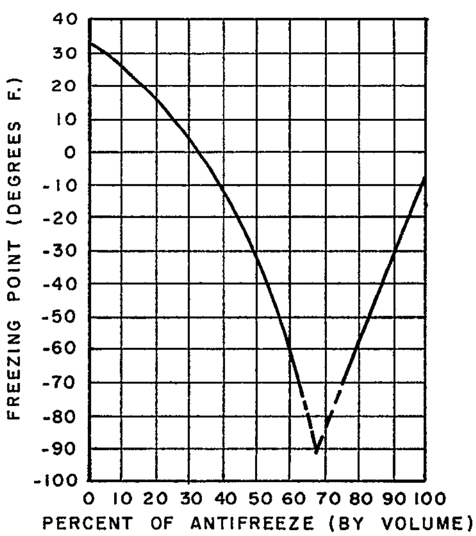


SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 1. COOLING SYSTEMS (Continued)

b. Antifreeze.

(1) Radiators and cooling systems must be protected from freezing. A permanent-type antifreeze should be used, one that may be left in the cooling system for 2 years before changing. Figure 5-8 shows the percent, by volume, of ethylene glycol required in the coolant solution to attain the desired freeze protection. This figure shows that when the ethylene glycol exceeds 68 percent, by volume, the freeze protection decreases.

FIGURE 5-8. PERMANENT ANTIFREEZE PROTECTION CHART



(2) Table 5-2 shows the quantity of ethylene glycol included in the total quantity of coolant for typical cooling systems. If the antifreeze is mixed with the water inside the cooling system, the engine should be run under load long enough for the thermostat to open, allowing the solution to be thoroughly mixed. Since the coolant solution has less surface tension than plain water, it will leak more readily through loose hose connections. Coolant freeze protection may be checked with a tester for permanent-type antifreeze, NSN 6630-00-247-2968.

NOTE: The antifreeze shall not contain any so-called “stop-leak” or “antileak” additives, except in certain circumstances. See paragraph 5-1 6e.

(3) An additive will coat the inside surfaces of the radiator and engine water jacket, as well as cause sludge formation in the immersion heater. Heat transfer and coolant flow will be retarded, which may cause the engine to operate at a higher than normal temperature.

c. Rust And Corrosion Inhibitor. Permanent antifreezes contain a corrosion inhibitor. This inhibitor loses its effectiveness with use and, therefore, its condition should be checked annually with an antifreeze corrosion tester, NSN 6630-01-011-5039. Add inhibitor when the need is indicated by the tester or annually if a tester is not used.

d. Water Pump Lubricant. Some brands of permanent antifreeze contain a water pump lubricant and others do not. Add a water pump lubricant if new antifreeze does not contain a lubricant. Add a water pump lubricant annually if the antifreeze is used more than 1 year.

e. Antileak Radiator Additives. Antileak additives shall not be used in an engine generator cooling system except in an emergency when immediate repairs cannot be made. If an antileak additive is used, permanent repairs must be made at the earliest opportunity and the complete cooling system drained, flushed, and filled with a new mixture of water and antifreeze in the proper proportions.

5-17. IMMERSION HEATERS. The immersion heater should be checked periodically and cleaned to maintain effective operation. A properly operating heater will improve starting, reduce condensation, and lessen the possibility of crankcase sludge formation. The immersion heater shall be energized at all times except during servicing. Some immersion heater housings are made of cast aluminum. These housings may be subject to electrolysis, which attacks the housing by eating away the aluminum from the inside out and causes early failure. Inspect the immersion heater housing for “pin holes” by looking for traces of antifreeze. Apply slight finger pressure to the housing walls to determine if the erosion has thinned the walls sufficiently to cause an untimely failure.

SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 1. COOLING SYSTEMS (Continued)

TABLE 5-2. FREEZE PROTECTION CHART (TEMPERATURE IN DEGREES FAHRENHEIT)

	Ethelyne Glycol Required in Gallons											
Cooling System Capacity in Gallons	*½*	*¾*	*1*	*1¼*	*1½*	*1¾*	*2*	*2¼*	*2½*	*2¾*	*3*	*3¼*
2¼	14	0	-21	-50								
2½	16	4	-12	-34	-62							
2¾	18	8	-6	-23	-47							
3	19	10	0	-15	-34	-57						
3¼	21	13	3	-9	-25	-45						
3½		15	6	-5	-18	-34	-54					
3¾		16	8	0	-12	-26	-43					
4		17	10	2	-8	-19	-34	-52				
4¼		18	12	5	-4	-14	-27	-42				
4½		19	14	7	0	-10	-21	-34	-50			
4¾		20	15	9	2	-7	-16	-28	-42			
5			16	10	4	-3	-12	-22	-34	-48		
5¼			17	12	6	0	-9	-17	-28	-41		
5½			18	13	8	2	-6	-14	-23	-34	-47	
5¾			19	14	9	4	-3	-10	-19	-29	-40	
6			19	15	10	5	0	-8	-15	-24	-34	-46

5-18. thru 5-20. RESERVED.

SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 1. COOLING SYSTEMS (Continued)

5-21. GAUGES. Observe water temperature and oil pressure gauges when the engine is operating. If they appear to register incorrectly, the temperature and pressure should be checked with an instrument of known accuracy.

5-22. OIL COOLERS. Oil coolers lower engine oil temperatures, resulting in a more efficient engine operation.

a. Water Type. Water-type oil coolers lose efficiency if the water in the system contains foreign materials such as calcium. Mineral deposits form on the walls of the cooler, resulting in a decrease in heat transfer. Accordingly, the cooling system must be kept clean, as recommended by the instruction book.

b. Air Type. Heat is transferred directly from the oil that circulates through a small radiator to the surrounding air. Oil, dirt, and other debris will collect on or between the cooling fins. This condition can be corrected by passing compressed air or water under pressure through the fins in the opposite direction to the normal flow of air.

5-23. ENGINE AIR SUPPLY. Inspect engine room ventilation grilles, louvers, and dampers. Clean and adjust if necessary. An adequate supply of air is required for engine cooling and combustion.

5-24 thru 5-25. RESERVED.

SUBSECTION 2. ELECTRIC STARTING SYSTEMS

5-26. GENERAL. All cranking motor mountings, wiring, and connections must be tight and in good condition. The magnetic switch or solenoid should be firmly mounted and operate freely. The cover band should be removed to check the commutator, brushes, and internal connections. Examine the cover band for thrown solder. This condition will result if the cranking motor is subjected to excessively long cranking periods. If the bars are not badly burned, the armature may be restored by resoldering the connections at the riser bars (use only rosin core solder), turning the commutator, and undercutting the mica between the bars. Some cranking motor armatures are of welded construction with the armature coil leads welded to the commutator bars. This type of armature should not be repaired with solder. Before inspecting or performing maintenance on starting systems, the negative battery lead shall be disconnected to prevent inadvertent starting of the engine.

5-27. CRANKING MOTOR BRUSHES. When checking brushes, make sure they are not binding and are resting on the commutator with sufficient tension. Brush leads and screws must be tight. If the brushes are worn to half their original length, they should be replaced.

5-28. CRANKING MOTOR ARMATURE AND FIELD COIL. The armature and field coils should not be cleaned with degreasing compounds, which may damage the insulation. However, brushing parts with an approved clean-ing solvent is satisfactory. Sealed ball bearings should not be cleaned as cleaning will remove the original lubricant. Other cranking motor parts shall be cleaned and inspected for wear and damage.

5-29. CRANKING MOTOR LUBRICATION. When the cranking motor is disassembled, lubricate as follows:

a. Oil wicks, if used, should be resaturated with medium grade engine oil.

b. The armature shaft and bushings should be coated with medium-grade engine oil.

c. The drive assembly should be wiped clean.

CAUTION: Do not clean in a degreasing tank or with grease-dissolving solvents. This will dissolve the lubricant in the clutch mechanism.

5-30. CENTRIFUGAL SWITCH. The purpose of the centrifugal switch is to remove the power from the starter contactor after the engine has started. When the engine attains approximately 500 rpm the switch opens. The actual opening speed is determined by the manufacturer. The switch may be checked by using a tachometer and a voltmeter connected across the centrifugal switch contacts. With the voltmeter connected, start the engine. At approximately 500 rpm the

SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 2. ELECTRIC STARTING SYSTEMS (Continued)

meter should indicate the dc control voltage. The tachometer will indicate the rpm at which the contacts opened. An alternate method to determine the operation of the centrifugal switch is to start the engine and observe the dropout of the starter contactor. For switch adjustment and correct dropout values, refer to the manufacturers instruction book.

5-31 thru 5-40. RESERVED.

SUBSECTION 3. IGNITION SYSTEMS

5-41. GENERAL. Spark and compression systems are used in FAA engine generators.

a. Spark Ignition. Spark ignition is provided by either a magneto or a battery.

(1) Magneto. When removing the magneto for servicing, it should be positioned to the firing point of cylinder number 1. To do this, rotate the engine in the direction of normal rotation until the piston in number I cylinder comes up on the compression stroke to the IGN location marker on the rim of the flywheel. Continue rotation until the impulse device trips. Reverse the engine rotation until the flywheel timing marks read the correct number of degrees before top dead center. (See engine manual for timing information.) In this position, the magneto can be removed with the impulse spring released. The engine now is also in position for replacing the magneto, if it is not rotated during the period the magneto is removed. Most modem magnetos are of the inductor type with permanent magnets on the armature. To disassemble the Bosch magneto, first remove the impulse coupling by taking off the holding nut and removing the part which retains the impulse spring. Next remove the trip plate and centrifugal weights, noting the marking “A” and “C” (counterclockwise or clockwise). Remove the drive mechanism or coupling and woodruff key. Use a puller to remove impulse coupling hub. Remove the distributor plate, breaker plate, and armature. (Disassembly of other type magnetos is similar to the above procedure.) Thoroughly clean all parts. Check bearings, seals, breaker points, condenser, wiring, etc. Components that transmit high voltages shall be checked for cracks or defects that can cause flashover, grounding of the system, or complete breakdown. Repack ball bearings with approved grease before assembly. The rotor bushing bearing in the distributor should be checked and properly lubricated before assembly.

(a) Grease Seals. Before assembling the magneto, observe the condition of the grease seals. If the seals have hardened or show signs of wear, they should be replaced. In an emergency, hardened grease seals may be softened by soaking in grease solvent; however, arrangements should be made for future replacement.

(b) Lubrication. One of the main difficulties in maintenance of magnetos is excessive lubrication. Only a film of lubricant is required on the magneto cam. Exercise extreme care to keep contact points free of oil and grease.

(c) Bearings. In the Bosch magneto, an insulating strip is placed between each outer bearing race ring and wall of the bearing seat, thereby insulating the rotor from the magneto frame. if the outer race on one of the main bearings requires shimming to remove excessive clearance, replace the insulating material on the race. Loose bearings in a magneto will cause the armature to drag on the pole shoe, which in turn will affect the contact opening point due to the instability of the cam rotation.

(d) Cam. Check the magneto cam for wear, grooves, and uneven wear of the lobes. Should it become necessary to replace a cam, insert the replacement on the keyway from which the defective cam was removed.

(e) Carbon Brush. If a carbon brush is used for contact between the distributor head and the coil contact, check its condition and freedom of operation, and deterioration of the spring. See that the brush slides easily in its recess and is in its proper place before attaching the distributor plate. The distributor gears should be examined for worn teeth and freedom of movement.

(f) Magnetizing. If magnetizing equipment is available, it is recommended that the magnets be remagnetized while the magneto is disassembled. Remagnetizing ensures a high utility spark under adverse operating conditions.

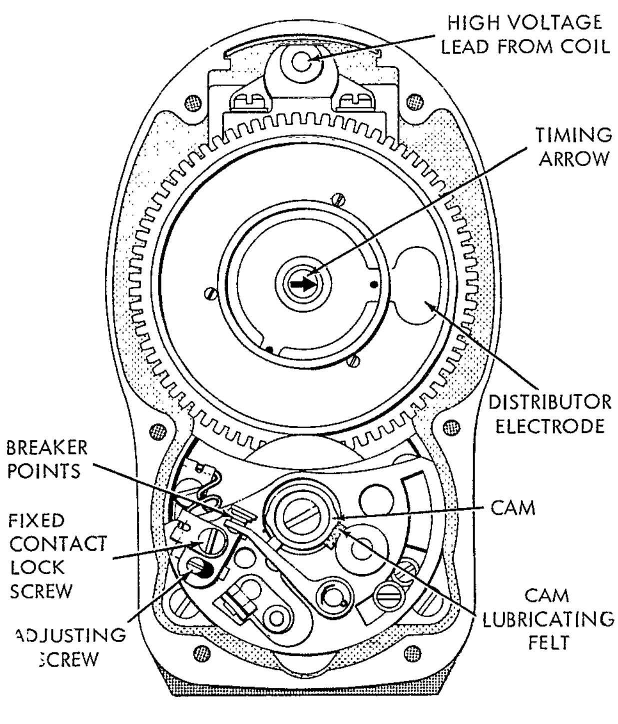
(g) Breaker Contacts. When the breaker contacts show signs of deterioration, they should be replaced. When

SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 3. IGNITION SYSTEMS (Continued)

replacing the points (figure 5-9), align them properly and adjust the point opening to 0.014 to 0.018 inch or as specified by the manufacturer. The condenser, which is located in this part of the assembly, should be tested if testing equipment is available. Replace the condenser if leakage is observed. When condenser testers are not available, replace the condenser and breaker points as a unit.

(h) "E" Gap. When the breaker plate assembly is installed on the magneto, position it so as to provide the correct "E" gap. The "E" gap (edge distance) is the number of degrees that the armature or rotating magnet turns past the neutral position before the contact points open. Consult the instruction book for "E" gap clearance.

FIGURE 5-9. MAGNETO WITH COVER REMOVED



(i) Testing. After the magneto is completely serviced and assembled, it should be tested. First rotate the armature to ensure no drag or unusual friction in the movement. Magnetos with impulse couplings must be rotated backward for the feel of rotation, or held upside down to prevent the impulse latches from engaging the impulse spring. If a test stand is not available, after servicing a magneto, the following method may be used for testing. Insert a conductor in one of the spark outlets of the distributor plate, and using the magneto as a base, form a spark gap of approximately three-eighth inch with the conductor. Clamp the magneto in a vise, rotate the rotor shaft with a suitable wrench, and observe the spark delivered at the spark gap. The spark should be very intense. No voltage or current output values have been established for magnetos.

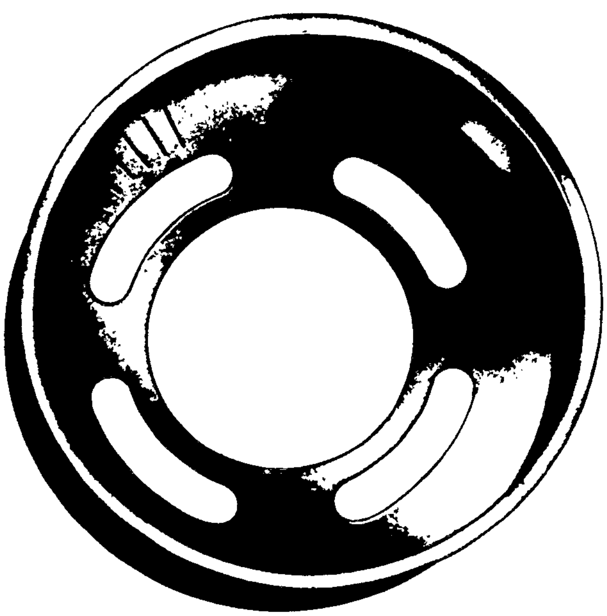
(j) Timing. If the engine has not been set to the firing point as mentioned in paragraph 5-41a(1), rotate the crankshaft in the direction of normal rotation until the compression begins building up in number 1 cylinder. Continue rotating until the IGN timing mark is lined up with the indicating pointer on the flywheel or vibration damper. Timing settings on engines with centrifugal or vacuum advance will be different from those without these devices. At the point indicated on the flywheel or vibration damper, ignition must occur. When the impulse coupling is engaged, as it is when starting to time the magneto, it must be released in order not to incorporate its lag angle in the timing procedure. Reverse rotation automatically disengages the impulse unit. With the breaker point cover open, rotate the magneto shaft in the direction it is to be driven, until the distributor rotor electrode is approximately opposite the distributor plate cable outlet for No. 1 cylinder. In this position, the breaker points should be wide open. Continue turning the magneto drive shaft until the breaker points just close. Install the magneto. Final timing is done after the mounting screws are almost tight. By using a low-range ohmmeter, determine the exact location where the points open. With the engine in firing position, move the magneto slowly to rotate it on the mounting flange. With careful movement, the exact point opening is readily determined. Securely tighten mounting screws and replace the breaker or distributor plate. These instructions cover the installation of flange-mounted magnetos. Base-mounted magnetos differ only in that they are driven from an accessory shaft. On this type, a slotted block (slots at 90° intervals) is used as a coupling device. To correct timing variations, loosen a nut behind the flange of the accessory shaft coupling, and tap the flange lightly to loosen it from the splined portion of the coupling. The magneto coupling may now be rotated to the desired timing position and the nut retightened. Complete the installation by connecting the remaining high tension cables of the magneto to the spark plugs in their proper

SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 3. IGNITION SYSTEMS (Continued)

firing order (generally marked on the engine block). The firing sequence on the distributor or high tension end of the magneto follow the opposite direction of rotation from that indicated by the arrow on the nameplate. This must be taken into consideration when the cables are connected to the spark plugs.

(k) Impulse Coupling. The impulse coupling facilitates starting the engine without the aid of an auxiliary ignition system. The coupling is designed to give the magneto rotor a short, quick turn regardless of how slowly the engine is cranked. It automatically disengages when the magneto attains a speed of approximately 180 rpm. To provide accurate setting of the impulse coupling, marks spaced 50 apart have been placed adjacent to the upper left-hand slot of the arrester plate (figure 5-10). When the heavy center mark lines up with the fastening hole in the magneto housing, the automatic retard or lag angle of the coupling is approximately 300. Turning the arrester plate in a clockwise direction increases the automatic retard angle, and turning it in a counterclockwise direction decreases the angle.

FIGURE 5-10. IMPULSE COUPLING ARRESTER PLATE



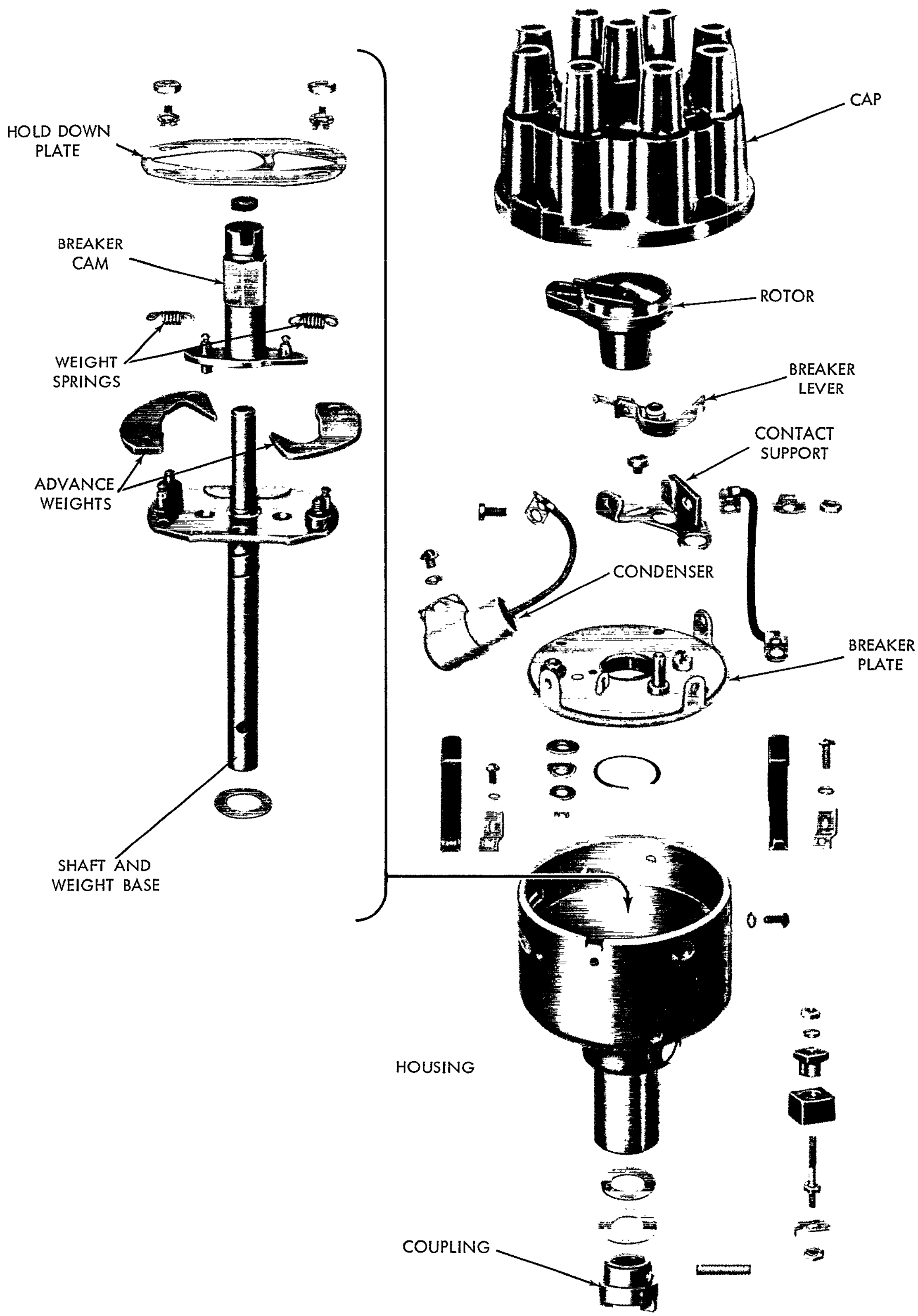
(2) Battery. All parts of the distributor (figure 5-11) should be cleaned and examined periodically. The cap, rotor, condenser, insulators, and housing (on units with built-in lubrication) must not be cleaned with any degreasing compound. Examine the centrifugal advance parts, weights, springs, and plate for signs of wear, and replace all parts that are worn or otherwise damaged. On units with dust seals, replace the seal washer if it is hard, worn, or otherwise damaged. Replace contact points that are worn or pitted. Also replace an excessively worn bushing or breaker level rubbing block. On units with cam lubricators, replace the lubricator if the felt lubricating wick is worn, hard, or dirty.

(a) Center Bearing Breaker Plates. It is necessary to replace the entire breaker plate assembly (figure 5-12) if any part becomes seriously damaged or worn. These breaker plates require very little servicing other than lubrication and an occasional adjustment of spring tension. Spring tension on type A plates may be increased by adding shim washers to the post; spring tension on type B plates may be increased by carefully stretching the spring or replacing it. To measure spring tension on either type, hold the breaker plate right side up in a horizontal position. Apply a spring scale at the stabilizing spring post, and note the force required to start vertical movement of the post. The force required for type A plates should not be less than 32 ounces or more than 56 ounces. For type B plates, the force should not be less than 18 ounces, or more the 24 ounces. Also check the friction between the plates (figure 5-13). Return the movable plate to the fully retarded position before making this check. The tension required to start the plate moving should not be more than 20 ounces for type A, or more than 15 ounces for type B. Excessive friction may be caused by insufficient lubrication, tight bearings, burrs, cupped, or distorted upper or lower plates, and dirt between the plates.

(b) Distributor shaft bushings. Bushings or bearings showing excessive wear should be replaced. Porous bushings are available as service replacement parts. The actual installation requires great care as well as use of a special arbor to prevent damage to the bearing surface. The lubrication of a porous bushing depends upon a uniform predictable seepage of oil through the structure of the bushing. The amount of oil which seeps through may be

SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 3. IGNITION SYSTEMS (Continued)

FIGURE 5-11. TYPICAL DISTRIBUTOR



SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 3. IGNITION SYSTEMS (Continued)

FIGURE 5-12. SPRING POST ASSEMBLY, TYPES A AND B

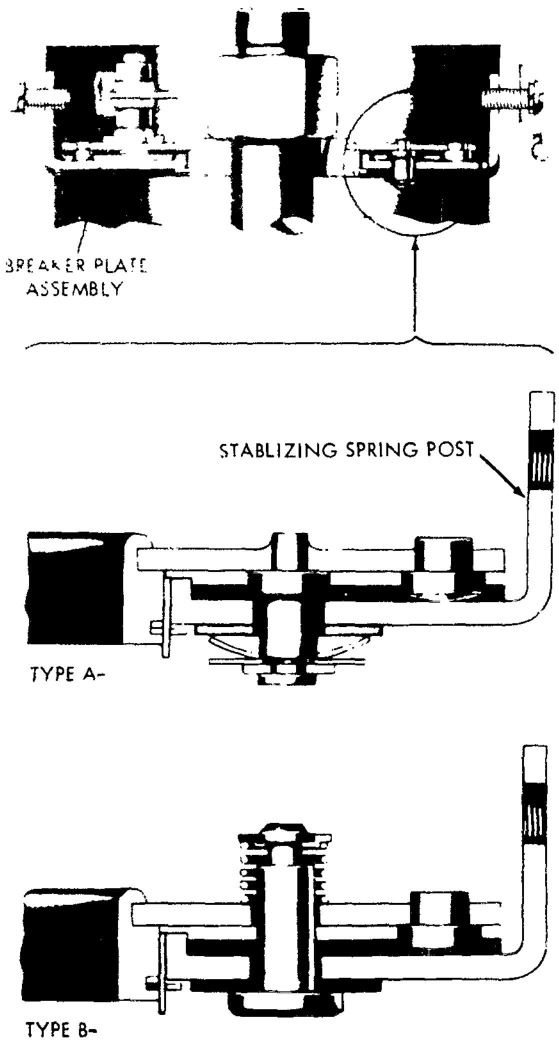


FIGURE 5-13. CENTER-BEARING PLATE SPRING TESTING

SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 3. IGNITION SYSTEMS (Continued)

seriously affected by scratches or scuffed areas on the bearing surfaces. Porous bushings are manufactured to an exact size and should not be reamed, scraped, or filed. Use only grade SAE 20 when adding oil to the reservoir. Under no circumstances shall grease be used in the oil reservoir.

(c) Centrifugal Advance Mechanism. The centrifugal advance mechanism can be checked for binding by turning the breaker cam in the direction of rotation and then releasing it. The advance springs should return the cam to its original position without sticking. This check provides information on the condition of the advanced mechanism, but does not supply data on the retard or advance operation of the mechanism. The retard and advance operation of the distributor must be checked in a distributor tester.

(d) Adjusting Contact Points. The setting of new points can be checked with a feeler gauge. The feeler gauge should not be used on rough or worn points as accurate gauging cannot be obtained (figure 5-14). Check the point opening of rough points with a dial indicator (figure 5-15). To adjust the point opening, loosen the lock screw, and turn the eccentric screw in the direction required until the desired point opening is obtained. Tighten the lock screw after adjustments are completed. A cam angle meter can be used in checking the cam angle. This angle is the number of degrees that the breaker cam rotates from the time the points close until they open again (figure 5-16). The cam angle is increased as the point opening is decreased, and reduced as the point opening is increased. Check the contact pressure (figure 5-17) with a spring scale. Hook a scale to the breaker lever, and exert the pull at an angle of 900 to the point surface. Readings should be taken just as the points separate. Contact pressure can be adjusted by bending the breaker lever spring. If the pressure is excessive, decrease it by pinching the spring carefully. If insufficient, remove the distributor and bend the spring away from the lever. Excessive spring distortion must be avoided. The spring tension of all new levers shall be checked when installed. Excessive pressure causes rapid wear of the rubbing block, cam, and contact points. Insufficient pressure will permit high-speed bounce, which will cause arcing and burning of the points.

FIGURE 5-14. GAUGING OF CONTACT POINTS

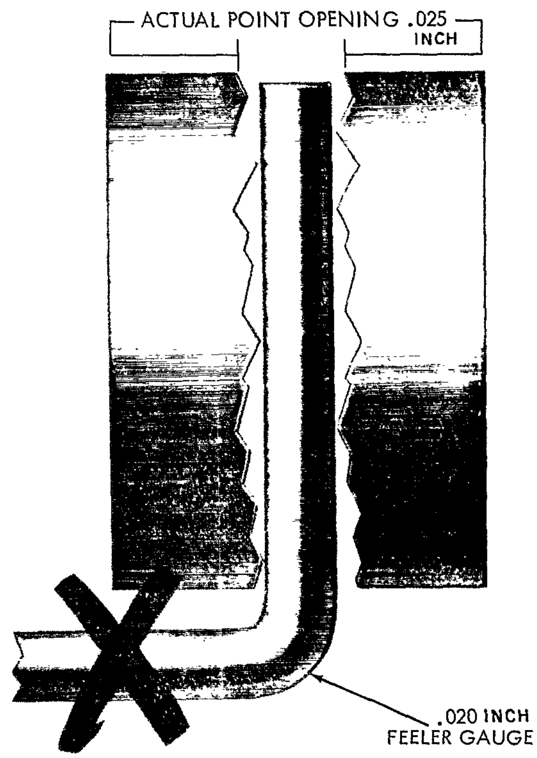
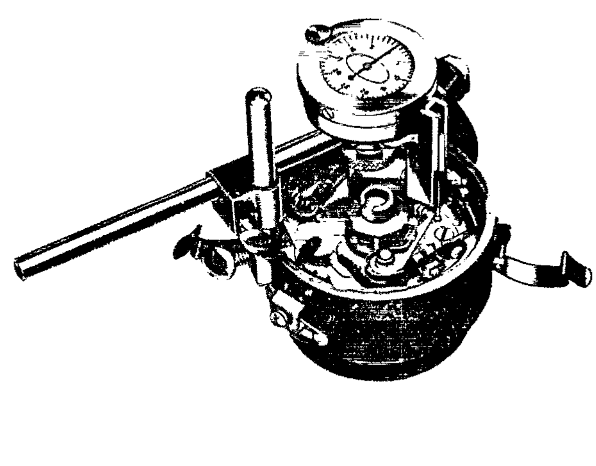
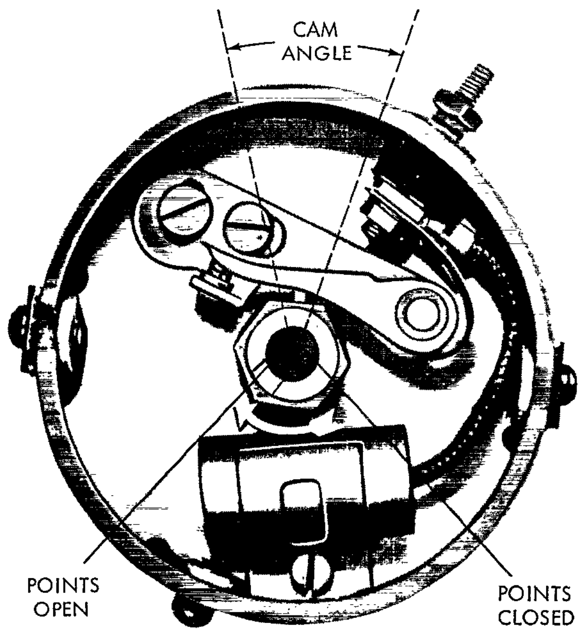


FIGURE 5-15. USING DIAL INDICATOR TO SET POINTS ADJUSTMENT



SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 3. IGNITION SYSTEMS (Continued)

FIGURE 5-16. CAM ANGLE



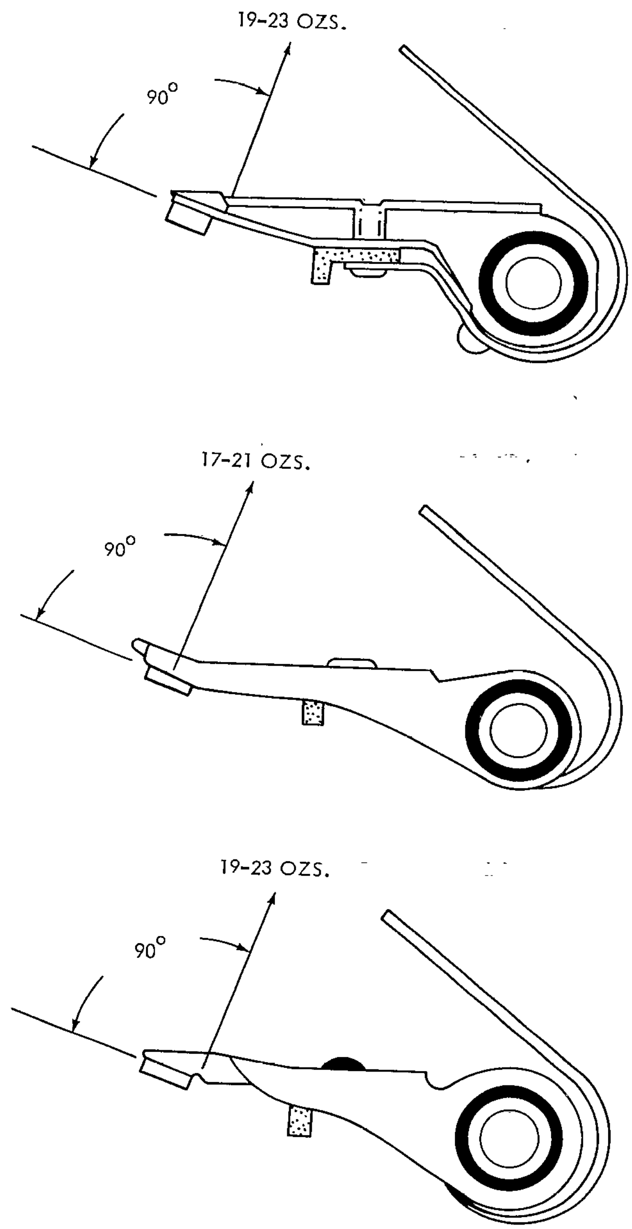
(e) Cleaning Contact Points. Clean the points with a few strokes of a clean, fine-cut file. Do not attempt to remove all roughness or dress the point surfaces down smoothly, but merely remove scale and dirt. Never use emery cloth or sandpaper to clean points, since particles may become embedded in the points and cause arcing or rapid burning.

(f) Normal Point Wear. Under normal operating conditions, contact points will provide many hours of service. Points that have undergone several hundred hours of operation will have a rough surface, but this should not be interpreted as meaning that the points are worn out. If the roughness between the points matches so that a large contact area is maintained, the points will continue to provide satisfactory service until most of the tungsten is worn away.

(g) Point Burning. Contact point burning will result from the presence of oil or other foreign material, defective condenser, or improper point adjustment. Oil or crankcase vapors that work up into the distributor and deposit on the point surface will cause them to burn rapidly. This may be readily observed as the oil produces a smudgy line under the contact points (figure 5-18). Obstructed engine breather pipes result in excessive crankcase pressures, and will force oil or vapors into the distributor. If the contact point opening is to small (cam angle to large), the points will remain closed for too long a period. The average current flow through the points will be high resulting in the rapid burning of the points. Series resistance in the condenser circuit will also cause the points to burn rapidly. This resistance may be caused by a loose condenser mounting or lead connection, or by a defective condenser. A condenser tester is required to test condensers for breakdown, low-insulation resistance, capacity, and excessive internal resistance.

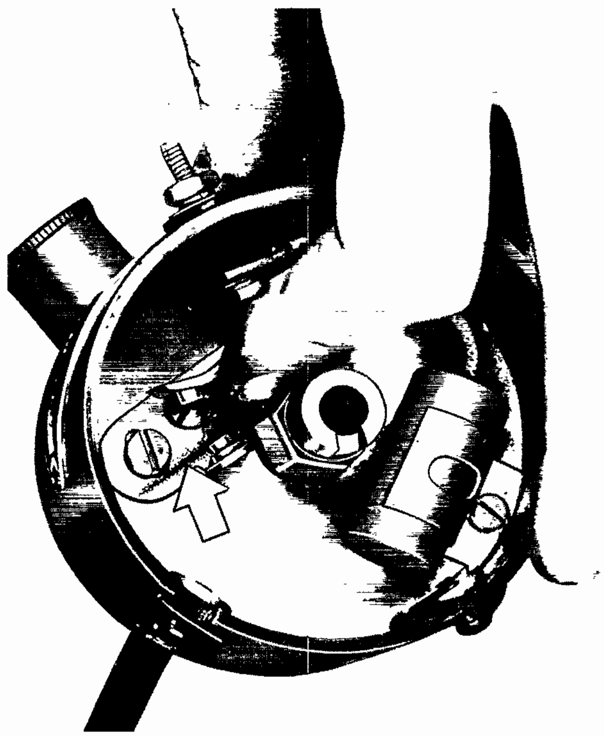
SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 3. IGNITION SYSTEMS (Continued)

FIGURE 5-17. CONTACT SPRING TENSION FOR VARIOUS SPRING ASSEMBLIES



SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 3. IGNITION SYSTEMS (Continued)

FIGURE 5-18. OIL SMUDGE UNDER CONTACT POINTS



(h) Point Pitting. Contact point pitting results from the out-of-balance characteristics of the electrical components in the ignition system. This causes a transfer of tungsten from one point to the other so that a tip builds up on one point while a pit forms in the other. The direction in which the tungsten transfers can be used as a basis for analysis and correction of pitting. If the material transfers from the negative to the positive point, one or more of these corrections may be made: increase condenser capacity, separate distributor-to-coil and high-tension lead, move these leads closer to ground (engine block frame), or remount coil directly to ground where coil depends on a lead for grounding. If the material transfers from the positive to the negative point, reduce the condenser capacity, move distributor-to-coil leads closer together, and move these leads away from ground.

(i) Cables. Carefully examine low- and high-tension cables for brittle or cracked insulation and broken wire strands. Defective insulation will cause missing or crossfiring of the engine. Connections should be clean and tight, and defective cable should be replaced.

(j) Distributor Cap. Examine the distributor cap for cracks, carbon deposit, and carbonized paths which will allow high-tension leakage to ground. Replace caps showing signs of defects.

(k) Sparkplugs.

1 Engine manufacturers usually recommend the sparkplug to be used in their engines based on normal operating conditions. The conditions under which an

SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 3. IGNITION SYSTEMS (Continued)

engine is actually operated, however, may reveal that a different type of plug is necessary for optimum performance. If too hot a plug is used, the electrodes will show excessive erosion. The insulator will be clean and probably have blisters or chips on its surface. A dull, black, soft carbon deposit is an indication of incomplete combustion, while a hard glossy carbon deposit is an indication of oil leaking into the combustion chamber. Satisfactory operation of a sparkplug is indicated by clean, gray-colored electrodes and a smooth, light-brown insulation tip, without ingrained carbon or evidence of heavy coating.

2 Sparkplugs are usually identified by number or letter, but identification differs among manufacturers. Due to varying load conditions and operating temperatures, the operator may desire to change to a different plug for better engine operation. Figure 5-19 shows the difference in sparkplug heat paths. The hot plug has a longer path in which to dissipate the heat of combustion to the surrounding metal and coolant. It operates at a higher temperature than a plug with a shorter heat path does. In battery ignition systems, incorrect polarity of the high voltage pulse requires 14 to 30 percent more voltage for proper ignition. If a meter is not available to make a polarity test of this high voltage pulse, a simple test my be made by disconnecting the ignition cable from the sparkplug. Hold the cable approximately three-eighths inch from the sparkplug terminal, and place an ordinary wood pencil point halfway between the cable terminal and the sparkplug terminal. When the high voltage is pulsed, if the arc is between the plug terminal and the pencil lead, the polarity is correct; if the arc is between the cable terminal and the pencil lead, the polarity is incorrect. To change the polarity, interchange the primary leads of the coil. Sparkplug gaps (figure 5-20) should be set according to the manufacturer's specifications. In some instances, a wider gap may be necessary in order to provide smoother combustion. This is true on engines equipped with magneto ignition systems as a polarity difference exists between cylinders. A wider gap increases the probability of regular firing on partial loads when stratification from exhaust gas dilution is present in the combustion chamber. The type of sparkplug which gives the best performance in an engine will vary with different operating conditions. The load at which an engine is operating will affect the electrode spacing for optimum operation. An engine operating under full load for long periods of time will require minimum sparkplug gap settings. For most engines the setting will range from 0.025 to 0.028 inch. An engine operating on light loads will require maximum sparkplug gap settings, and these will range from 0.030 to 0.037 inch. When using resistive-type spark plugs, the gap must be increased by approximately 0.010 inch. This type aids in reducing ignition noise in nearby radio communication facilities. Its resistance, coupled with the small capacitance, radically changes the initial resonating characteristics of the secondary circuit and, thereby, reduces the high frequency, high current capacity component. To prevent erosion of the electrodes, widen the gap of the resistive-type sparkplug.

b. Compression Ignition. The pressure developed by the compression stroke is much greater in a diesel engine than in a gasoline engine of comparable size. In a diesel engine, the pressure may be as high as 500 psig. For each pound of pressure exerted on the air, there will be a temperature increase of about 2 °F. At completion of the compression stroke, the temperature may be as high as 1,000 °F. This high temperature ignites the fuel spontaneously as it is injected into the cylinder. Good performance of a diesel engine is dependent upon the use of the clean fuel in high pressure precision pumps and properly adjusted injector nozzles. The fuel must be correctly metered upon delivery into the cylinder, and the correct spray pattern must be produced by the nozzle. Efficient operation of a diesel engine is dependent upon the maintenance of the component parts necessary for compression ignition. These components are discussed in paragraphs 5-56 and 5-57.

SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 3. IGNITION SYSTEMS (Continued)

FIGURE 5-19. SPARKPLUG HEAT PATH

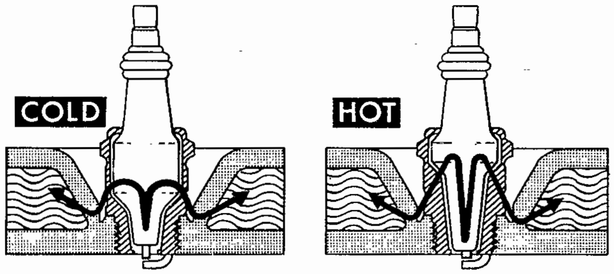
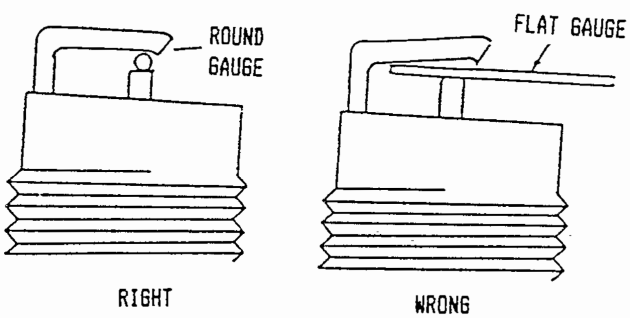


FIGURE 5-20. SPARKPLUG GAPS



5-42. thru 5-45. RESERVED.

SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 4. BATTERIES

5-46. GENERAL. Storage batteries are an important component of the engine generator assembly. It is necessary that they be properly installed and maintained and a record of their maintenance be kept. Refer to Order 6980.25, Maintenance of Batteries for Standby Power, for periodic maintenance schedules, required maintenance activities and the proper maintenance record forms. The maintenance record forms are to be completed as directed and shall be kept at the facility. The record will provide maintenance personnel with a case history of the battery.

5-47. REPLACEMENT/INSTALLATION.

a. Replacement batteries must be the size recommended by the engine generator manufacturer. Refer to the latest edition of Order 6980.24, Battery Theory and Selection Guidelines, for battery replacement data.

b. Follow the manufacturers instructions for preparing a new battery for service. These instructions shall be followed so that maximum battery life and efficiency can be obtained. If there are no instructions included with the battery, refer to Order 6980.25 for installation instructions.

5-48. BATTERY FREEZE PROTECTION.

a. Lead Acid Battery. When a battery is operated at temperatures below freezing, do not add water unless it will be charged immediately. The battery is protected against freezing by keeping it fully charged. The freezing point of the electrolyte in lead-acid batteries can be determined from table 5-3.

TABLE 5-3. ELECTROLYTE FREEZING POINT

Specific Gravity	*Freezing Point (°F)*
1.300	–95°
1.275	–80°
1.250	–62°
1.225	–35°
1.200	–16°
1.175	–4°
1.150	+5°
1.125	+13°
1.100	+19°

b. Nickel-Cadmium-Alkaline. The standard specific gravity of the electrolyte in a typical stationary nickel-cadmium-alkaline battery is 1.180, which is a safe condition down to -25 °F. For extremely low temperature a specific gravity of 1.225 can be used, providing safe operation down to -54 °F. Specific gravity does not change with state of charge in a nickel-cadmium-alkaline battery.

5-49. ELECTROLYTE.

a. Handling and Safety. While handling electrolyte, goggles and rubber gloves must be worn. Electrolytes stored at the facility shall be plainly marked. The electrolyte is injurious to eyes, skin, and clothing. If electrolyte comes in contact with eyes, skin, or clothing, flush with plenty of clean, cool water (it is recommended that flushing be continued for 15 minutes). Secure medical attention immediately. Inform medical personnel whether the electrolyte was acid or alkaline, as the treatment is different.

(1) Lead-acid battery general safety requirements.

(a) Promptly neutralize and remove any spilled electrolyte with a soda/water (1 pound of soda/per gallon of water) solution. If using the neutralizer solution on the top of a cell, take care to prevent the solution from getting into the cell. A prepared bottle of neutralizer solution should be kept readily available.

(b) If electrolyte comes into contact with the eyes, skin, or clothing, flush with water and then neutralize with a soda/water solution (1 pound of soda per gallon of water). Secure medical attention in case of eye or skin contact.

(c) When preparing electrolyte, pour the concentrated acid into the water. NEVER POUR WATER INTO CONCENTRATED ACID. Pouring water into acid releases heat which may be sufficient to cause localized boiling and splashing, resulting in personal injury. Use a plastic or rubber container. Allow the electrolyte to cool before adding to a cell.

(d) Never use hydrometers, thermometers, filler bulbs, or tools that have been used with alkaline cells

SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 4. BATTERIES (Continued)

as they may be contaminated with alkaline material, which could cause a chemical reaction and destroy the cell or result in injury.

(2) Nickel-cadmium-alkaline general safety requirements.

(a) Promptly neutralize and remove any spilled electrolyte with a 3 percent boric acid solution or household vinegar. When using on the top of a cell, take care to prevent the solution from getting into the cell. The boric acid solution or vinegar should be kept readily available.

(b) If electrolyte comes into contact with the eyes, skin, or clothing, flush immediately with clean cool water (it is recommended that flushing be continued for 15 minutes), and seek medical attention promptly. Inform medical personnel that the burn was due to an alkaline material rather than acidic, since the treatment is different.

(c) When preparing electrolyte, slowly pour the dry electrolyte into the water and mix slowly with a clean plastic paddle. Do not use a copper, zinc, galvanized steel, or aluminum container. Allow the electrolyte to cool before adding to a cell.

(d) Never use hydrometers, thermometers, filler bulbs, or tools that have been used with acid cells as they may be contaminated with acid, which could result in a chemical reaction and destroy the cell or cause injury.

b. Specific Gravity.

(1) Lead Acid Battery

(a) The specific gravity of the electrolyte contained in a lead acid battery gives useful information as to the state of charge of the battery. Hydrometer reading shall not be taken immediately after water has been added to the battery. When water is added, the battery should always be placed on charge to mix the electrolyte. In testing, be sure to empty the hydrometer back into the cell from which the electrolyte was taken. The glass parts of the hydrometer syringe should be washed as needed with warm water and soap to keep them clean and accurate. Where different types of batteries are installed at a facility, each battery shall have its own hydrometer. Refer to Order 6980.25 for testing procedures and maintenance requirements.

(b) The electrolyte contained in the lead-acid battery ranges from 1.170 to 1.300 specific gravity. As the acid in the electrolyte combines with the plates during discharging, the specific gravity of the electrolyte decreases. During charging, the current displaces the acid from the plates back into the solution, and the specific gravity rises. Generally speaking, the rise or fall of the specific gravity is proportional to the amount of current put into or taken from a battery. A measure of the specific gravity may be obtained with an accurate hydrometer. The actual volume of electrolyte in a cell changes with the temperature, which causes a change in the observed hydrometer reading. The normal or standard cell temperature is 77 °F or 25 °C. If the electrolyte temperature is above this point (specific gravity reading reduced), the observed hydrometer reading may be corrected to 77 °F by adding one point (0.001) for each 3 degrees above 77 °F. Conversely, if the electrolyte temperature is below 77 °F (specific gravity reading increased), the hydrometer reading may be corrected to 77 °F by subtracting one point (0.001) for each 3 degrees that the temperature is below 77 °F. Table 5-4 shows these corrections to be made if the hydrometer used does not have temperature correction scales.

(2) Nickel-Cadmium-Alkaline Battery. The electrolyte specific gravity of a nickel-cadmium-alkaline battery is normally 1.180 and normally does not need to be measured during the life of the battery. The specific gravity of the electrolyte in a nickel-cadmium-alkaline battery does not change with the state of charge of the battery. Small changes in specific gravity may occur due to water additions, cell gassing, variations in electrolyte temperature, and variations in electrolyte levels. These changes in specific gravity are normally small enough not to affect the performance of the battery.

SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 4. BATTERIES (Continued)

5-50. SULPHATION. A lead-acid battery may be discharged to the point where damage to the battery can occur. When a cell is being discharged, some of the hydrogen in the sulphuric acid of the electrolyte combines with the oxygen of the plate material to form water. The water dilutes the electrolyte to lower its specific gravity. Part of the sulphuric acid forms lead sulphate on both the negative and positive plates. When the plates are entirely sulphated, current will cease since they are then chemically identical. When a battery is discharged, recharge it immediately to prevent any further sulphation.

TABLE 5-4. SPECIFIC GRAVITY OF ELECTROLYTE, LEAD-ACID BATTERY

Electrolyte Temperature Degrees F.		*Specific Gravity Correction (points)*
140	Add to reading	21
130	Add to reading	18
120	Add to reading	15
110	Add to reading	11
100	Add to reading	8
90	No correction required.	
80	No correction required.	
70	No correction required.	
60	Subtract from reading	6
50	Subtract from reading	9
40	Subtract from reading	13
30	Subtract from reading	16
20	Subtract from reading	19
10	Subtract from reading	23
−10	Subtract from reading	29
−20	Subtract from reading	33
−30	Subtract from reading	36

5-51 thru 5-55. RESERVED.

SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 5. FUEL SYSTEMS AND TURBOCHARGERS

5-56. GENERAL. Fuel systems must be kept clean and free from impurities. The fuel tank's integrity shall be checked in accordance with Order 1050.15, Underground Storage Tanks at FAA Facilities, and any additional federal, state, and local requirements. The maintenance procedures listed are intended to supplement those in the equipment instruction books.

a. Gasoline. Fuel shall be kept clean and free of water and dirt. Impurities in the fuel are the major cause of trouble in the operation of internal combustion engines. Gasoline storage tanks shall be checked for water by applying water-indicating paste (NSN 6850-00-001-4194) to the bottom several inches of the fuel measuring stick when measuring fuel levels. Observe the treated portion of the measuring stick for change in color and for any contaminants.

(1) Carburetors. Before a carburetor is disassembled, wash its exterior with a solvent and dry with compressed air. After disassembly, the initial cleaning should involve soaking the various castings (such as the upper and lower body halves) and the small parts in a commercial solvent, after which all parts should be dried with compressed air. Clean all passages, and remove all carbon deposits. Clean the jets with a brass wire or a small wooden dowel, then blow out all passages with compressed air. Check float valves for leaks, and replace defective valves. Inspect the throttle valve for freedom of operation and worn parts.

(a) Float Level. The float level regulates and controls the movement of the fuel from the fuel pump into the carburetor float chamber. The float level must be set in accordance with manufacturer's specifications. Because of wear, the float level may rise, permitting flooding and excessively rich fuel mixtures. If the level is too low, the mixture will be too lean. The procedures for measuring and adjusting the float level will vary depending upon the carburetor involved. Consult the instruction book for detailed instructions for the type of carburetor used.

(b) Choke. The choke mechanism must be checked and cleaned as required to ensure proper operation. If it sticks or binds, the engine will be over- or under-choked, causing erratic operation. The choke thermostat must be positioned correctly. The electric solenoid portion of the choke should operate immediately upon being activated. Should the solenoid coil malfunction, check the mechanism and its electrical circuit. Refer to the instruction book for control circuits and voltage rating of the system. The Sisson automatic choke lever should be adjusted in the following manner. To prevent sticking of the butterfly valve in the closed position, a clearance of 0.015 to 0.020 inch shall be maintained between the valve and the throttle valve housing. This is accomplished by adjustment of the linkage. See that all linkages operate freely. The ground connection of the coil should be cleaned and soldered to provide a good electrical connection.

(c) Antidiesel Device. In order to prevent reverse rotation of the engine after shutdown, the antidiesel valve must close completely, stopping fuel from reaching the cylinders. See that the antidiesel solenoid closes its butterfly valve, and that the thermal timer delays the opening of the valve for several seconds after the engine comes to rest. All linkages and solenoids should be examined for binding or defects. Reference should be made to the instruction book for test and malfunctioning of the control circuit.

(2) Fuel Pump. A defective fuel pump should be replaced with a new or rebuilt pump.

b. Diesel. The importance of maintaining diesel fuel oil free of water and other contaminants cannot be overemphasized. Diesel fuel storage tanks shall be checked for water by applying water-indicating paste (NSN 6850-00-001-4194) to the bottom several inches of the fuel measuring stick when measuring fuel levels. Observe the treated portion of the measuring stick for change in color and for any contaminants.

(1) Fuel Injection Pumps. This pump is a precision device, and overhaul should be performed only by qualified mechanics. Use reliable local shops or FAA exchange and repair procedures. Extreme cleanliness is mandatory in servicing these pumps. Dirt, grit, water, or other foreign matter reaching the working parts of the injection pump will cause serious damage. Fuel injection equipment and accessories should be thoroughly washed with clean fuel oil to remove dirt or dust before dismantling. After removal of the unit from the engine, all openings (pumps, nozzle, tubing,

SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 5. FUEL SYSTEMS AND TURBOCHARGERS (Continued)

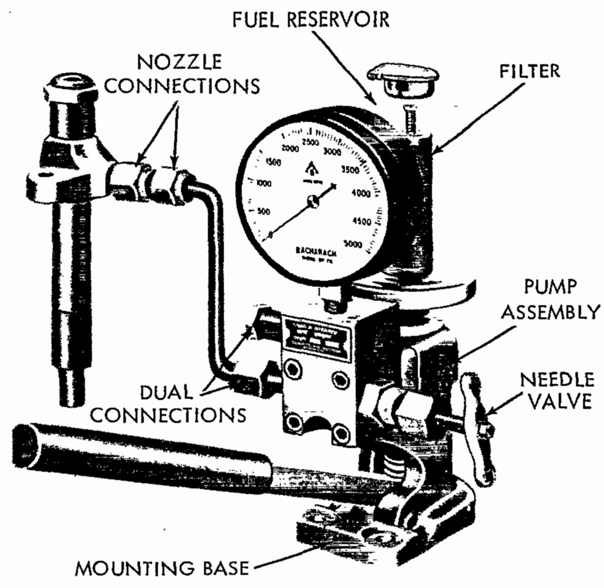
or injectors) should be covered. A clean working space is essential for the protection of parts during overhaul. The use of approved cleaning solvent and clean fuel oil will help ensure cleanliness. Rags or waste should never be used to clean injector parts. Many surfaces of the pump parts are lapped to extremely accurate finishes, and it is essential that they be *handled with care.* If the parts are dropped, they may be bent, nicked, dented, or otherwise damaged. Parts should not be left uncovered on the bench, but should be kept immersed in diesel fuel until reassembled. Lapped surfaces should never be handled when dry, as perspiration from the hands will cause corrosion. Before a lapped surface is handled, the hands should be rinsed in clean fuel oil. The mating parts of pumps and injectors are fitted in one another; such parts as plungers and barrels should never be interchanged. Water in the fuel, or improper storage of parts, will cause the parts to corrode.

(a) Cleaning. When work is done on any part of a fuel injection system, the procedure outlined in the instruction book should be followed. Proper test equipment must be available. Cleaning fluids should not be used on rubber gaskets. The specific procedures for cleaning fuel injection equipment will vary with manufacturer.

(b) Timing. Refer to the engine generator instruction book.

(2) Spray Nozzle. Refer to the engine generator instruction book. Normally, the nozzle valve can easily be withdrawn from the nozzle body. In some cases, it may be necessary to soak the nozzle in approved cleaner before removal is possible. To test the spray nozzle, attach it to a nozzle test fixture (figure 5-21), open the pressure gauge valve, and slowly raise the pressure by operating the pump handle. Note the pressure at which the nozzle opens. If the opening pressure is other than specified by the manufacturer, make the necessary adjustments. A properly functioning nozzle usually chatters. This indicates that the valve is free and its seating surface is good. The spray pattern of the nozzle should be noted by directing the spray from the nozzle onto a piece of paper. *CAUTION: Keep hands from nozzle spray as it may puncture the skin and cause injury.*

FIGURE 5-21. NOZZLE TESTING FIXTURE



c. LPG and Natural Gas.

(1) Fuel System. Refer to the manufacturer's instruction manual for maintenance requirements of the fuel system.

(2) Carburetors. One type of LPG/natural gas carburetor installed is manufactured by IMPCO Carburetion, Inc., and it provides two limited-range air-fuel mixture adjustments.

(a) Idle Air Bypass Adjustment. 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. The idle adjustment will not be used for an idle setting but may be screwed in for a richer starting mixture.

SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 5. FUEL SYSTEMS AND TURBOCHARGERS

(b) Power Mixture Adjustment This adjustment is effective only when the engine approaches full-load condition and may be set only with the engine loaded. The mixtures between idle 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 as load increases.

(c) Adjustment for Specific Carburetors. For the adjustment procedure of the specific carburetor installed on the engine, refer to the manufacturer's instruction manual.

(3) Timing. Refer to the manufacturer's instructions for the correct timing procedure. As a general rule, for high altitude engine operation, timing should be advanced approximately 4° for each 5000 feet.

5-57. FUEL SYSTEMS (100 TO 550 KW ENGINE GENERATORS). Fuel systems for large units are similar to those on other diesel engine units previously described. However, on some larger engine generators, external electric transfer pumps are used to pump fuel from underground storage to day tanks in the engine room. A second pump transfers fuel from the day tank and supplies the individual fuel injector pumps at pressures of approximately 25 psig. This pressure is necessary to provide uniform charging of fuel into each injector pump during its intake cycle. Fuel is fed through a duplex case filter assembly. A control valve directs the flow of fuel oil to either or both filter cases. The valve may also be used to cut one filter unit out of service for replacement of the element without a shutdown. A hand-operated pump is installed in the system so that the day tank may be filled manually should the electric fuel transfer pump malfunction. Some fuel systems are equipped with an electric fuel pump which operates continually during engine operation; excess fuel is bypassed back to the underground fuel tank.

5-58. TURBOCHARGERS. The impeller and diffuser of the turbocharger should be cleaned and inspected after 4000 hours. The total turbocharger assembly should be cleaned and inspected after 8000 hours. Normal operating temperature of the turbocharger should not exceed 1200 °F. Oil pressure to the turbocharger bearing should be kept at 35 psig (at the turbocharger). Journal bearings are used in this component, and it is imperative that these bearings be lubricated as soon as the engine starts. The turbocharger should be inspected occasionally for unusual noises or excessive vibration. This may be accomplished by observing the unit just after the engine has stopped, as the turbine will continue to operate on its own inertia for a short period of time. A jet of air should be felt upon termination of the engine operation when the plug in the bottom of the blower chamber is removed. This indicates a free operating unit. Preventive maintenance is very important in maintaining turbochargers. Water entering the high speed turbocharger may cause damage. Even a very small amount of water may break or warp turbine blades, causing excessive vibration due to unbalance. If noticeable vibration develops, the unit should be shut down and the cause determined. Vibration may be due to a damaged impeller, shaft, turbine wheel, or worn or loose bearings in the turbocharger. Any collection of foreign material on the impeller will also cause unbalance and vibration. Should oil collect in the turbocharger base, check for leakage between the shaft and oil seal. If leakage is noted, the unit should not be operated until the leak is corrected. Leakage, at this point, can cause engine overspeed.

5-59 thru 5-62. RESERVED.

SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 6. GOVERNORS

5-63. GENERAL. When servicing governors, all parts should be cleaned thoroughly. Bearings, weight pins, yokes, ball-weight toes, and thrust bearings should be checked for excess wear. It is important that control arm linkage and rods be adjusted to close tolerances without drag. Rod lengths should be checked, and parts indicating wear should be replaced. Lubricate all ball joints with graphite grease or powder as operating conditions warrant. When a governor is dismantled, the oil seals should be replaced to prevent oil leaks.

5-64. MECHANICAL GOVERNORS. Refer to the instruction book for maintenance procedures on the mechanical governor.

5-65. HYDRAULIC GOVERNORS. Refer to the instruction book for maintenance procedures on the hydraulic governor.

5-66. ELECTRIC GOVERNORS. Refer to the instruction book for maintenance procedures on the electric governor.

5-67. ELECTRONIC GOVERNORS. Refer to the manufacturer's instructions for maintenance procedures on the electronic governor.

5-68. thru 5-72. RESERVED.

SUBSECTION 7. ENGINE LUBRICATION

5-73. GENERAL. Engine design, the service it performs, and the prevailing atmospheric temperatures in which it operates are factors that determine the weight and type of lubricating oil to be used. Oil conforming to the manufacturer's recommendations or military specifications, should be used. Ambient temperature must be considered when selecting the proper grade, weight, and viscosity of oil. *Do not use a multiviscosity oil unless recommended by the manufacturer. Do not use detergent oil in an engine that was previously operated with nondetergent oil.* Changing to this type may release sludge and varnish deposits which may obstruct engine oil passages and cause subsequent engine failure. Sludge forms at low temperatures and will cause engine damage and excessive wear. It is formed by the combustion gases that blow by the piston and mix with the oil mist in the crankcase. This mist will condense on the cold surfaces of the crankcase. The condensate usually contains sulfuric and sulfurous acids which combine with the engine oil to form sludge. Fill the crankcase of new or rebuilt engines with oil as recommended by the manufacturer. Operate the unit at variable reduced loads (not to exceed 75 percent full load) for approximately 8 hours, or as recommended by the manufacturer. Drain the crankcase while the engine is still hot and refill with oil recommended by the manufacturer.

5-74. thru 5-77. RESERVED.

SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 8. ENGINES

5-78. GENERAL. Major engine overhaul may be accomplished by Logistics Center maintenance personnel, a field maintenance party, the engine manufacturer, a qualified local engine overhaul shop or by qualified FAA technicians. The method of overhaul is to be determined by existing conditions and on an individual basis. When servicing engines, care should be taken to keep the working area and engine parts clean. Refer to instruction book for specific maintenance instructions.

5-79. MANIFOLD AND CYLINDER HEADS. Remove carbon deposits from combustion chamber surfaces and interior passages of manifold system. Clean the cylinder head thoroughly and inspect it carefully for cracks. If hidden cracks are suspected, the casting should be taken to a local machine shop that has the capability to magniflux or dye check the casting for cracks. The machine shop can also check the casting for warpage and mill the surface flat, if required. The maximum permissible longitudinal deviation for six-cylinder head or block is 0.005 inch measured at the center. The transverse deviation should not exceed 0.004 inch. The cylinder head or block should be resurfaced if these limits are exceeded.

5-80. VALVE SERVICE. If valve service is required, the head should be taken to a local machine shop with the capability to disassemble the head, resurface valves and seats and replace those that are beyond grinding tolerances. When servicing the head avoid interchanging the valves. Each valve must be replaced in the cylinder valve port from which it was removed. A valve rack for storing valves with their parts in the proper order is recommended. Some engines are equipped with valve rotators. The rotator parts, as furnished, are made to be interchangeable when new and unused. However, the rotator clearance should be checked after assembly to ensure rotation. *When servicing, keep the rotator parts with their respective valves, as this will save unnecessary work in refitting the parts.* If no clearance exists after assembly, remove all parts and provide clearance by removing stock from the ends of the valve stem. If the clearance is too great, remove enough stock from the top of the cap to reduce it to the proper limits. To remove stock, either grind or lap on fine emery cloth or oil stone. The rotator clearance, when assembled, should not exceed 0.006 inch or be less than 0.002 inch. To check the clearance, rotate the crankshaft to raise the valve from its seat. The valve should turn freely and the clearance checked while it is in this position using a dial indicator or other measuring device. Various tools and removal procedures are used for valve maintenance. Refer to the associated engine generator instruction book for additional information. If the valve stems are worn or the seating faces badly cracked, pitted, or burned, new valves should be used. Slight pits, burns, or irregularities in the valve face can be removed by refacing or lapping. If the valve stem is bent, it should be discarded. The rocker arm assembly should be dismantled and inspected. Worn or defective parts must be replaced. It should be noted that rocker arms can be refaced on a valve refacing machine.

5-81. CAMSHAFT AND BEARINGS. Inspect camshaft alignment; examine bearings, journals, and cams for wear and defects. Alignment may be checked by placing the camshaft in "V" blocks and using a dial indicator to check runout of the journals. Journals should be checked with a micrometer and their dimensions compared to the bearing dimensions. Check the bearing dimensions with a micrometer or caliper. If measured clearance exceeds 0.003 inch, replace the bearing.

5-82. TIMING GEAR AND CHAIN. Check gear runout by mounting a dial indicator on the block with the indicating finger resting on the side of the gear. As the gear is rotated, the amount of runout will be indicated. Gear backlash shall not exceed 0.003 inch, and this should be checked by inserting a narrow feeler gauge between the meshing teeth. Inspect timing chains for excessive slack. Should the chain or sprocket wheels show excessive wear, they should be replaced.

5-83. CYLINDER WALLS. Cylinder walls should be wiped clean and examined carefully for scored places and spotty wear. These show up as dark, unpolished spots on the wall. Holding a light at the opposite end of the cylinder from the viewing point will assist in the examination. If scores or spots are found, refinish the cylinder walls. Measure the cylinders for taper and out-of-round wear. The permissible taper or out-of-roundness varies somewhat with different engines. Consult the applicable instruction book for acceptable tolerances. If the irregularity exceeds recommendations, the cylinders shall be honed or rebored.

SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 8. ENGINES (Continued)

CAUTION: If the main bearing caps have been removed, they should be replaced, and the cap bolts or nuts should be torqued down before cylinders are bored. With the caps in place, any distortion of the block will be held to a minimum during the boring operation.

a. Cylinder Sleeve (Dry). Scored cylinders and cylinders worn so badly that they cannot be bored to conform to the standard oversize can often be salvaged by installing cylinder sleeves. To use this method, the cylinder must be bored out to receive the cylinder sleeve, which is then installed and bored to the proper size. The sleeve should be coated on the outside with a mixture of glycerin and red lead before installation. This helps it slip into place and also provides an installation seal. Heating the block to 160 to 180 °F (71 to 82 °C), and cooling the sleeve with dry ice will facilitate installation.

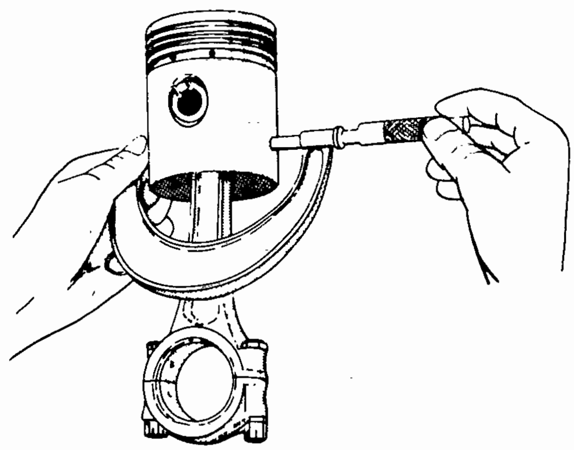
b. Cylinder Sleeve (Wet). When installing wet cylinder sleeve liners, use a new water seal gasket and attach it to the underside of the liner flange with a very thin layer of shellac. Do not use grease or soap on this gasket or on its seat in the cylinder block. Install new rubber sealing rings in the grooves at the lower end of the liner, using a thin film of cup grease or hydraulic brake fluid to make them slide freely over the liner. Make certain that the rubber rings are not twisted. Thoroughly lubricate the seal with either cup grease or hydraulic brake fluid, after which the sleeve may be dropped back into the bore to a point where it is resting on the seal. Press the sleeve in place with the palm of the hand. See the instruction book for any special procedures.

5-84. BLOCK EXPANSION PLUGS. If an expansion plug must be replaced, drill a 1/4-inch or 5/16-inch hole in the center of the plug, and pry it out with a punch or small pry bar. To install a replacement, clean the recess thoroughly, and coat the base and sides with red lead. Insert the new plug in the recess with convex side out. Place a drift or large punch against the convex surface of the plug, and apply sufficient force to flatten the surface slightly. This expands the plug, fitting it tightly into the recess.

5-85. PISTONS. When pistons are cleaned, a scraper should be used to remove the carbon from the head and inside of the piston. Do not scrape the wearing surface of the piston. Use a ring groove cleaning tool to remove carbon from the ring grooves, being careful not to remove any metal. Oil relief openings in the ring grooves should be cleaned. Install aluminum pistons in clockwise rotating engines with their split sides opposite the camshaft and facing the left side of the engine.

a. Piston Wear. After cleaning the pistons, take measurements at various points to determine the extent of wear. A piston that has "collapsed" has suffered an excessive reduction in diameter at the lower end of the skirt (piston is tapered.) Taper measurements are taken with a micrometer near the top, midpoint, bottom of the piston, and at right angles to the piston pin. (See figure 5-22.) Many engines use cam-ground pistons. This type is slightly elliptical in shape when cold.

FIGURE 5-22. PISTON TAPER MEASUREMENT



b. Piston Pins. Piston pin bushings that are worn excessively should be reamed or honed and fitted with oversize pins. Replace piston pins that are worn or pitted. The fit of a floating type piston pin is correct when it can be pushed through the pin bore with light thumb pressure at room temperature. When the pin is the stationary type, it is forced into place under pressure. When replacing this type, consult the instruction book for procedures and clearances. Oversized pins are available to ensure a proper fit. Connecting rod bushings are reamed or honed to obtain optimum clearance.

c. Piston Rings. When installing a new set of rings, the ridge at the top of the cylinder bore and all evidence of glaze must be removed. Piston rings must be sized to the cylinder and to the ring groove. All rings shall be fitted to their respective cylinder bores. When gauging the ring gap clearance, a piston inserted in the cylinder bore in the inverted position can be used to align the ring at right

SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 8. ENGINES (Continued)

angles to the cylinder bore. Standard and oversized rings shall be used in their respective cylinder bores. Refer to the engine specifications and instruction book for clearances and procedures.

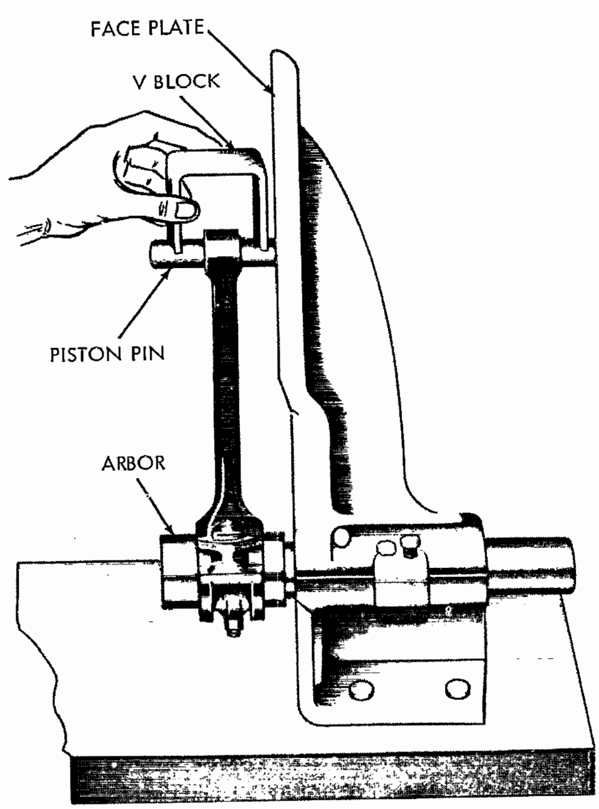
d. Rod and Piston Alignment. After assembling the connecting rod to the piston and before installing the rings, the rod and piston alignment should be checked with a rod alignment fixture (figure 5-23). If the "V" block does not align with the face plate as it is moved to various positions, the connecting rod is twisted and must be replaced.

5-86. CRANKSHAFT. Crankshaft journals may be measured without removal by using either a crankshaft gauge or a special micrometer. Take several measurements along each journal to check it for taper. Rotate the crankshaft by 1/4 or 1/8 turns, and check each journal for out-of-round condition. Journals exceeding taper or out-of-round measurements by more than 0.003 inch must be reground.

a. Main Bearing and Connecting Rod Service. If visual inspection of the crankshaft shows no indication of excessive wear or scoring, the clearance of the bearings should be checked using a piece of Plastigage. Plastigage is the trade name of a plastic material that is flattened under pressure. (See figure 5-24.) Follow the instructions furnished with this material. Check each bearing, one at a time, with the piece of Plastigage. Place it lengthwise in the bearing shell. Install the bearing cap and the screws or nuts, and torque them to specifications. Do not rotate the crankshaft. Remove the bearing cap. Compare the width of the crushed piece of Plastigage material with the Plastigage scale to determine bearing clearance. Consult the instruction book for bearing clearance. Replace the shell bearing if wear is excessive.

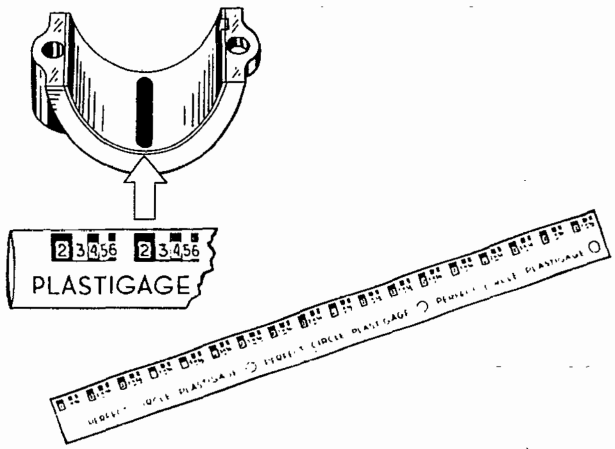
b. Crankshaft End Play. With crankshaft and main bearings installed, pry the crankshaft endwise and measure end play clearance. Refer to instruction books for specific clearances.

FIGURE 5-23. CONNECTING ROD ALIGNMENT



SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 8. ENGINES (Continued)

FIGURE 5-24. MEASURING BEARING CLEARANCE WITH PLASTIGAGE MATERIAL



5-87. ENGINE CRANKCASE VENTILATION. On those engines having positive crankcase ventilation, the filter restriction valve and connecting lines should be cleaned in accordance with the schedules in chapter 4.

5-88. thru 5-94. RESERVED.

SUBSECTION 9. GENERATORS

5-95. GENERAL. Good housekeeping will help to prevent the need for extensive generator maintenance. Refer to the equipment instruction book for additional guidance.

5-96. GENERATOR BEARINGS. Determining ball bearing wear by measuring the air gap of a generator is not practical, as a bearing worn to the point where it can be detected by this method would cause unsatisfactory generator operation. To determine the extent of wear in these bearings, periodically feel the bearing housing while the generator is running. Note any signs of overheating or excessive vibration, and listen for unusual noises. The indications thus obtained are comparative, and caution must be exercised in their analysis. Rapid heating of a bearing is indicative of danger. When testing for overheating, the normal running temperature of the bearing must be known. A normal operating bearing will take an hour or more to reach a stable operating temperature. Serious trouble can be expected if this same temperature is reached within the first 10 or 15 minutes of operation. Ball bearings are inherently noisier in normal operation than other type bearings. This fact must be kept in mind when testing for the presence of abnormal bearing operation.

5-97. LUBRICATION OF GENERATOR AND ACCESSORY SHAFT BEARINGS. Generators using grease-lubricated bearings are equipped with grease fittings attached to the bearing housing. When lubricating generator bearings, completely fill the grease cavity with a high melting point grease. Remove the lower plug from the bearing housing, operate the generator until grease ceases to flow from the opening, and replace the plug. This procedure is an effective means of preventing overgreasing. Permanently lubricated ball bearings require no additional lubrication throughout their life. Equipment furnished with this type bearing has no grease fittings or provision for installing them.

SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 9. GENERATORS (Continued)

5-98. FIELD COILS.

a. Testing. The insulation of field coils should be tested with an insulation tester or other suitable device to determine its condition. If a ground is detected in the field circuits of a dc generator, each circuit must be disconnected and tested separately to locate the ground circuit. Repair or replace the defective coil as conditions warrant. When a generator becomes saturated with water or is stored in a damp location for a long period of time, dry the coils, and measure the insulation resistance before placing it in service. The minimum safe insulation resistance at a temperature of 167 °F (75 °C), recommended by the Institute of Electrical and Electronics Engineers, is 1 megohm. The following procedure may be used for testing the insulation resistance of brush-type generator field windings, single or three-phase.

(1) Lock out the engine generator to prevent starting.

(2) The isolation switch should be in bypass mode.

(3) Isolate the control panel by tripping the generator circuit breaker.

(4) Isolate the field winding under test.

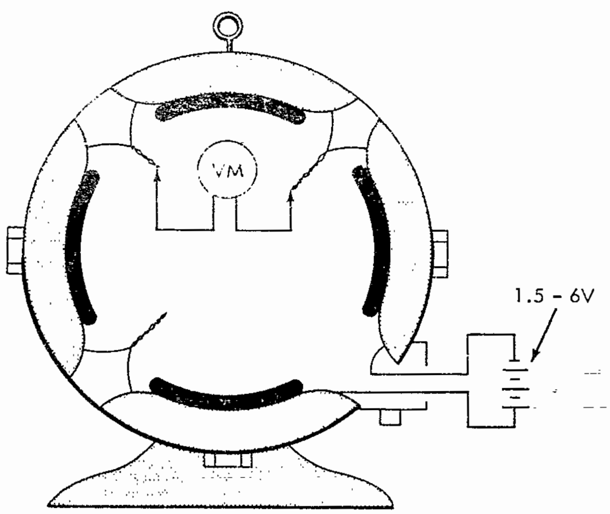
(5) Disconnect the neutral conductor from the neutral terminal of the control panel.

(6) Measure the insulation resistance of each winding to chassis ground using a 500-volt insulation tester.

b. Drying Out Generators. The most effective method is to pass a low-voltage current through the windings. Temperature of the windings during the drying out period should not exceed 194 °F (90 °C) (class A insulation). Applying heat internally drives out all moisture and is very effective where insulation is comparatively thick. Heat can also be applied externally by placing heating units around or in the generator housing and covering with a tarpaulin or other suitable cover. Provide a vent at the top to permit the escape of moisture-ladden air. Small fans may also be used to provide force ventilation drying. Equipment located in damp places may require heaters to prevent windings from being saturated with moisture when not in use.

c. Open Circuit Condition. Should an open circuit develop in the field windings of an operating ac or dc generator, it will be indicated by an immediate loss of output voltage. The open circuit will usually occur at the connections between the coils and may be detected by visual inspection. If an open circuit in a coil is not readily apparent, it can be located by applying a low-voltage source (dry cell batteries) to the terminals of the field windings. Then, using a low-range dc voltmeter, measure the difference in potential between the terminals of each coil. (See figure 5-25.) The open-circuit coil will develop the greatest difference in potential between its terminals. In a generator, a partially shorted field coil is indicated when it becomes necessary to increase the field current in order to maintain voltage with the generator running at normal speed. Stop a generator with a shorted field coil immediately. Locate the faulty coil by passing normal current through the field coil circuit and measuring the voltage drop across each coil. The coil indicating the lowest voltage drop will be the shorted coil.

FIGURE 5-25. TESTING FIELD COIL



d. Field Coil Removal. A field coil may be removed from most stationary field generators without removing the armature. Covering the armature with canvas or other suitable material will prevent any damage while the coil is being removed. To remove the coil, disconnect it from the adjacent coils and remove the bolts securing the pole piece to the generator frame. If shims are used, keep them with the pole piece. Before installing a new or repaired coil, test for short and open circuits. With the new or repaired

SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 9. GENERATORS (Continued)

coil in position, temporarily connect its leads to the adjacent coils. Connect a battery to the field leads (use polarity connections indicated on field lead terminal block), and check polarity of each field coil with a compass. Adjacent field coils must be of opposite polarity. If necessary, the polarity of the replaced coil can be changed by reversing its leads. If the polarity is correct, complete the coil connection, and secure the pole piece and coil to the generator frame. Check the armature air gap for uniformity. Finally, recheck the generator for grounded connections and open or short circuits.

e. Ventilation Ducts. The generator ventilation system should be checked for obstructions caused by dust, dirt, or lint.

5-99. AC STATOR WINDINGS. Ac stator coils require the same careful attention as other electrical windings. To function properly, the stator coils must be free from grounds, short circuits, and open circuits. Periodic inspections are necessary to determine the condition of the coils. Cleanliness is necessary to maintain high insulation values. A short circuit in the stator of an ac generator will produce smoke, flame, and an odor of charred insulation. When any of these conditions are noted, stop the operation immediately and locate the faulty coil. This should be done quickly and before it has time to cool. The shorted coil ends will feel warmer than those adjacent to them. Open circuits in ac stator coils can sometimes be found by visual inspection, as they are usually the result of damaged connections between stator coils or loose slip ring connections. Grounds in an ac stator winding can be detected with an insulation tester. New or repaired stator coils should be tested before and after installation for grounds, shorts, and open circuits. Check polarity of the coils after installation by employing a low dc voltage and a small compass. The compass needle will reverse itself at each adjacent pole if the stator coils are properly connected. If the same compass needle indication is obtained from two adjacent poles, the coils are incorrectly connected, and the polarity of one pole must be reversed.

5-100. COMMUTATOR AND SLIP RINGS. A commutator should maintain a good polish. Blackening (not to be mistaken with the normal dark glossy surface) or burning of the bars indicates poor commutation because of incorrect brush position. Blackening of bars at regular intervals may indicate a poor or open connection in the armature winding or commutator leads. Blackening at irregular intervals indicates a rough eccentric commutator. If blackening persists, the cause must be determined and removed. If out-of-round, the commutator must be removed and turned in a lathe. If it is apparent that enough copper will be removed by grinding so that the commutator undercutting will be too shallow, undercut the commutator again before grinding or turning on a lathe. After grinding, clean all commutator slots thoroughly and level the edges of the bars. Ordinarily, the commutator will require only an occasional wiping with a piece of dry canvas or lint-free material. Use no lubricant on the commutator. A roughened commutator may be polished with a piece of sandstone or sandpaper and woodblock curved to fit the commutator. Do not use emery or carborundum paper. All brushes should be lifted, the generator run at normal operating speed, and the polishing block moved back and forth parallel to the shaft. All grit should be carefully wiped off before lowering the brushes. Slip rings may be sanded and polished by using the same procedure.

5-101. BRUSHES AND BRUSH HOLDERS. The position of the brushes on a dc generator should be on or near the neutral point of the commutator. This neutral point on most standard, noncommutating pole generators is in line with the center of the pole. The brushes should be set slightly in advance of this neutral point. The exact position is that which gives the best commutation at normal voltage for all loads. In no case should the brushes be set far enough from the neutral point to cause dangerous sparking at no load. For commutating pole generators, it is essential that the brushes be located at the neutral point. The full load neutral brush position will be indicated by a point or chisel mark on the brush yoke and a companion mark on the frame. This mark is correct only for the rotation shown on the frame. The factory setting must not be tampered with unless direction of rotation is changed. If a change of rotation is necessary, consult the instruction book for the unit involved. Each brush must be adjusted to the tension specified in the appropriate manufacturer's instruction book. Check to see that the brush shunt clears the brush holder pressure finger and that the brush shunt terminal is securely connected to the brush holder.

5-102. BRUSHLESS GENERATORS AND EXCITERS. Paragraphs 5-100 and 5-101 are not applicable to brushless generators and exciters. The brushless generator armature windings are on the stator of the main machine, and the dc field windings are on the rotor. The dc field power is

SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 9. GENERATORS (Continued)

supplied by the rotating rectifiers mounted on one of the fans. The rectifiers that are on the rotor are supplied from the armature windings of the ac exciter. The exciter field windings are stationary. Exciter field power is obtained from the generator output that is rectified and controlled by the regulator or compensator. See the manufacturer's instruction book for operation and maintenance procedures.

CAUTION: Disconnect rectifiers if insulation resistance tests are made.

5-103. ENGINE GENERATOR COUPLINGS. There are several types of generator couplings in use. The one most widely used is the Falk coupling. This type uses a spring grid laced between splined hubs installed on the engine and generator shafts. It is built in two sections for easy removal. A cover is provided and has hub seals to prevent grease leaks. This coupling must be thoroughly packed with a fibrous grease before replacing the cover. Use a pressure gun to complete packing. Seals must be in good condition at all times to prevent grease from being thrown from the coupling. Two other type of couplings are in general use: a rubberoid and a steel flex disc type. These do not require lubrication.

5-104. GENERATOR ALIGNMENT. The alignment between the engine and generator is very critical. Misalignment causes an uneven rotation of the generator, which may affect the output waveform to the extent that malfunctioning of electronic equipment may occur. Where realignment is necessary, the generator holddown bolts and dowel pins must be removed. Alignment may be altered by a movement of the generator housing or by adding or removing shims under the generator base. After alignment, the generator holddown bolts must be tightened as securely as possible without dowel pins. Should difficulty arise in holding the alignment of the generator without dowel pins, the holes must be redrilled and correctly reamed. Most engines are equipped with Falk couplings. This coupling uses splined hubs with spring grids laced between the splines. The alignment tolerance shall be within 0.0045 inch when measured with a feeler gauge inserted between the coupling faces. This measurement must be taken at two positions 90° apart. The separation between the coupling faces shall be approximately one-eighth inch for couplings with bores ranging from 2-7/8 to 4 inches in diameter. (The coupling grid must be removed when measurements are taken.) If the alignment is out of tolerance, add or remove shims under the generator until the correct alignment is attained. *Do not use shims under the engine.* Misalignment between the engine and generator may be readily recognized, as the cover of the Falk coupling will not remain in concentric alignment while the unit is in operation. This condition will be evident by the formation of a black band around the hub cover edge. Falk couplings should be packed well with grease before the covers are put into place. Examine the seals for defects, as leaks will cause grease to be thrown from the housing. Grease a coupling of this type annually with a pressure gun. The grease should be as prescribed by the manufacturer. Single bearing generators usually are equipped with Thomas Airflax or Steelflex couplings. The bolts and studs attaching the coupling to the generator should be inspected for tightness. Should misalignment occur, consult the instruction book for alignment procedures.

5-105. thru 5-109. RESERVED.

SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 10. CONTROL PANEL

5-110. GENERAL. Before any maintenance that could cause injury is performed on control panels, one battery lead must be disconnected (ungrounded connection) and the plant isolated from the commercial power source. When a plant is locked out, the green indicating light on the engine control panel is deenergized. *After maintenance and before leaving the facility, the technician should make certain this light is on, indicating that the control panel is in normal operation.* All relays and other control devices must be adjusted and maintained properly. Control devices should be tested to determine that operation is normal. Inspect all electrical terminals for security of attachment, corrosion, and condition of conductor electrical insulation. Meters and gauges should be checked for correct reading, using a properly calibrated instrument as a standard. Fuses and holders should be kept clean and free of corrosion, as a slight resistance or loose connection may cause heating. Fuses should be checked for correct rating. When operating prime or standby power units under normal load conditions, observe panelboard instruments for indications of overload or unbalanced load conditions.

5-111. CONTROL RELAYS. Armature and coil equipped relays must be adjusted electrically and mechanically, and the correct gap provided between the armature and pole piece. When the relay is open, proper armature spring tension is very essential, especially if the relay is a close-differential voltage-sensing type. Relays should be checked for quietness of operation and absence of hum. If noisy, examine for loose parts which may be vibrating. If armature action is sluggish, check for corrosion or foreign matter on hinge pin or other bearing surface. If hum is present, align armature with pole piece and remove any foreign matter that may prevent the armature from closing. Check pole shading coils for condition and tightness. Examine relay contacts for proper alignment and pitted or burned contacts, and replace as required. Slightly rough or pitted copper contacts may be restored by using a fine file. Do not file or clean silver-plated contacts with a contact cleaner that may remove silver plating. Clean contacts with a lint-free cloth. Contact pressure must be sufficient to ensure positive contact. Examine relay terminal connections for tightness and electrical wiring for cracked or deteriorated insulation. Relays require little or no lubrication; however, a small amount of dry graphite powder may be used on hinge points of adjustable relays.

5-112. PRIMARY UNDERVOLTAGE DEVICES.

a. Electromechanical Device. FAA engine generators purchased before 1972 have one or more single-phase, prime-power, undervoltage devices. The device includes a close-differential relay that is voltage sensitive, and is mechanically and electrically adjustable. The relay coil is connected in series with a frequency and voltage sensitive circuit consisting of a rheostat, a capacitor, a tapped inductor, and a five- or seven-contact switch to select a tap on the inductor. It is referred to as an electromechanical type of prime-power, commercial-power, or primary undervoltage device to distinguish it from a solid-state device performing the same function. Both electromechanical and solid-state devices of this type are referred to as potential relays (PR), or more specifically, a 1PR, 2PR, or 3PR relay.

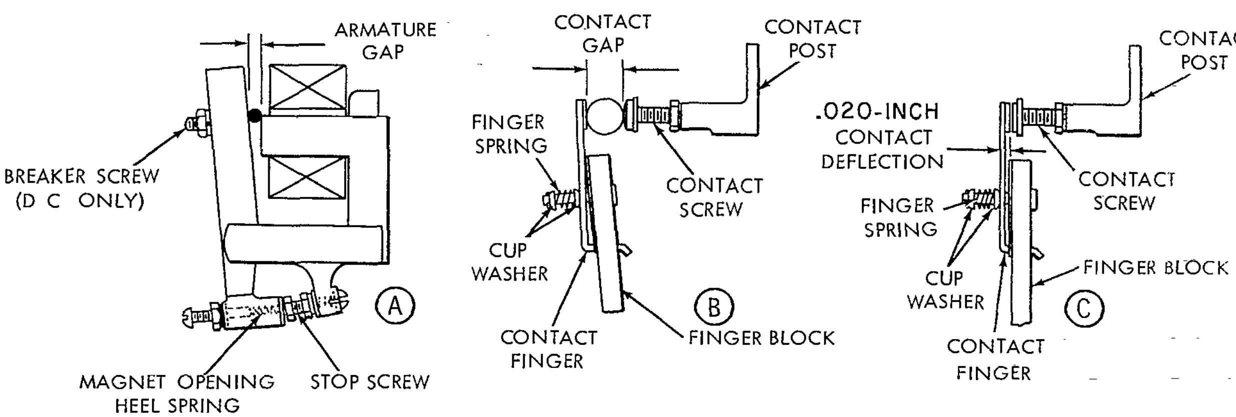
b. Solid-State Devices. Some engine generators purchased after 1972 have one or more single-phase, solid-state, prime-power, undervoltage devices. The undervoltage device includes an output relay that is nonadjustable. The relay is controlled by an adjustable solid-state circuit, within the device, that responds to ac voltage. The circuit is not responsive to changes in frequency within the range of 50 to 70Hz. Three of these single-phase devices are installed on three-phase units. Other units purchased after 1972 have a three-phase solid-state, prime-power, undervoltage device with one relay controlled by three separate solid-state circuits within the device. Each circuit is responsive to changes in levels in only one of the three-phase, prime-power voltages supplied to a facility. This device also in not responsive to changes in frequency within the range of 50 to 70Hz. These single-phase and three-phase devices are referred to as solid-state, prime-power, undervoltage devices or monitors.

SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 10. CONTROL PANEL (Continued)

c. Electromechanical Prime-Power, Undervoltage Device Adjustment.

(1) Mechanical Adjustment Procedures. To measure and adjust the armature gap, insert a 3/32-inch diameter drill or rod between the bottom of the armature and the top of the yoke. (See Figure 5-26, view A.) Adjust the armature stop screw at the back of the frame until both the armature and the yoke touch the drill or rod. Lock the armature stop screw and recheck the gap. To measure and adjust the contact gap, insert a 1/8-inch diameter drill or rod between the contacts. Adjust the stationary contact screw until both contacts touch the drill or rod. Lock the stationary contact screw in place and recheck the adjustment. (See figure 5-26, view B.) If the contact gap and armature gap are correct, the contact deflection will be correct. (See figure 5-26, view C.) Adjust the heel-spring tension with a gram gauge, if necessary. Armature movement should begin with 35 to 40 grams tension.

FIGURE 5-26. MECHANICAL ADJUSTMENTS FOR ELECTROMECHANICAL DEVICE CLOSE-DIFFERENTIAL RELAY



(2) Electrical Adjustment Procedures.

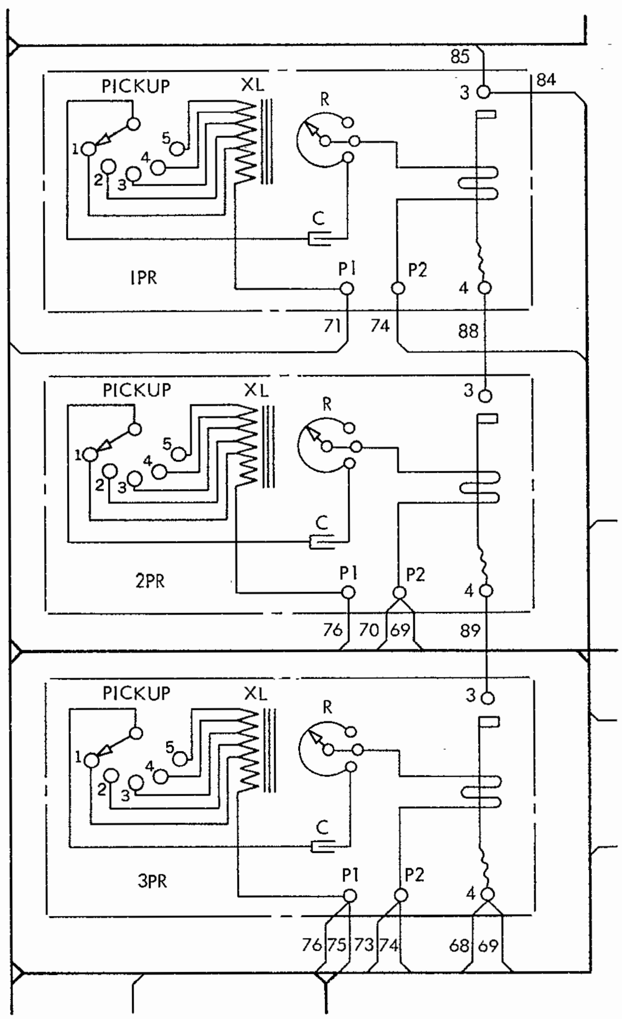
(a) General. A five- or seven-tap switch is provided to adjust the pickup value. (See figure 5-27.) Dropout is continuously variable through a range of 170 to 210 volts by adjusting a rheostat. If the rheostat is turned to a point where the dropout voltage exceeds the pickup voltage, the relay will pulse. Some units may have regular control relays that have not been replaced by single-phase, prime-power, undervoltage devices, each with a close-differential relay. The dropout and pull-in tolerances on these regular control relays can be controlled only by adjustment of the armature gap distance and heel-spring tension. The variable voltage source required for electrically adjusting a regular relay or a close-differential relay, can be obtained by using a single-phase variable transformer (autotransformer), Variac Transformer or equal.

(b) Prime Power Source. When using a single-phase, 0 to 240 V ac variable transformer to check and adjust an electromechanical undervoltage relay, either of two test procedures may be used after first locking out and isolating the engine generator. In the first procedure, open the generator output circuit breaker and disconnect the battery charger and immersion heater. Connect the power output from the autotransformer to one phase of the commercial (prime) power side of the transfer switch. Connect the input of the autotransformer to prime source

SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 10. CONTROL PANEL (Continued)

voltage in the facility. Slowly increase the autotransformer voltage to energize the device relay. When the relay armature pulls in, a voltage reading indicates the pickup setting. Increase the voltage to the nominal value, then slowly lower the voltage. The point at which the relay contacts open is the dropout voltage. An iron vane or true-rms digital voltmeter must be used when checking or adjusting the undervoltage devices, as powerline harmonics and/or radio frequencies transmitted by the facility can affect the reading of a rectifier type voltmeter. The second procedure is similar to the first except for the auto-transformer connections. The autotransformer output is connected to terminals P1 and P2 of the undervoltage device. If these terminals are not marked as shown on figure 5-27, use the coil and reactor terminals of the device connection points. Repeat either procedure for the two remaining undervoltage devices if the unit has a three-phase generator.

FIGURE 5-27. CONNECTION POINTS FOR CHECKING ELECTROMECHANICAL, PRIME-POWER, UNDERVOLTAGE DEVICES



SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 10. CONTROL PANEL (Continued)

CAUTION: An autotransformer does not provide electrical isolation against shock hazard. Disconnect it from its power source before connecting or disconnecting its output to or from the transfer switch or undervoltage device terminals.

d. Solid-State, Prime-Power, Undervoltage Device or Monitor Adjustment.

(1) General. These devices shall be checked and adjusted by using prime-power source voltage. This is required because the output voltage waveform of some engine generators is distorted. Measurement of pickup and dropout voltages, made when using the generator distorted output voltage, may result in erroneous rms voltage readings even when measured by an iron vane or true-rms digital voltmeter. Some digital voltmeters revert to average voltage reading when the sine wave of the measured rms voltage to be measured is distorted appreciatively.

(2) Single-Phase Monitor Adjustment. Follow the procedure furnished with the engine generator instruction book to check or to adjust the Asco monitor (Catalog 214A69). Lock out and isolate the unit. Disconnect both line-input connections to the monitor to avoid accidental voltage feedback from the autotransformer to ground. Reconnect the line-input connections after checking and/or adjusting. Isolate and check or adjust the remaining two monitors if the unit has a three-phase generator.

(3) Three-Phase Monitor Adjustment.

(a) Procedure for 120/208-Volt Monitor. An Asco monitor (Catalog 214A249 or Catalog 214A293) may be furnished as part of a 120/208-volt, three-phase, four-wire, wye-connected unit. These devices may be checked or adjusted by using a potential relay tester, NSN 6625-01-172-6511. Use the procedure included with the tester for connecting it to the input-power terminals of the monitor. Use the engine generator instruction book procedure for adjusting the monitor pickup and dropout voltage adjustment potentiometers. Repeat the pickup and dropout checks and adjustments at least twice, since there is some interaction of adjustments. If the desired pickup or dropout voltage cannot be made by adjustment of either potentiometer, check the balance potentiometer adjustment before completing the procedure. Refer to paragraph (c) below.

(b) Procedure for 240-Volt Monitor. The tester also includes a procedure for checking or adjusting either Asco monitor when used with a 240-volt, three-phase, three- or four-wire generator. However, the following procedure is recommended for checking or adjusting both the 214A249 and 214A293 monitors by using a single-phase variable transformer. The following procedure may also be used in lieu of using the potential relay tester to check and adjust the monitor on a three-phase, 120/208-volt, four-wire, wye-connected unit, as previously described in paragraph (3)(a). Refer to figure 5-28, view A, and perform the following.

1 Lock out and isolate the engine generator.

2 Remove the conductor from the phase A terminal of the monitor.

3 Connect a 0- to 240-volt variable autotransformer as shown, with the adjustable arm of the transformer supplying phase A of the monitor.

4 Set the autotransformer to its maximum position (not over 240 volts).

5 Energize the transfer switch. The monitor relay should now be energized.

6 Slowly reduce the autotransformer output voltage until the monitor output relay just deenergizes. Record this dropout voltage for phase A. Note that the 214A293 monitor has a time delay, which should allow the output relay to remain energized for approximately 1 second after the phase A input voltage has been reduced to the desired dropout voltage.

SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 10. CONTROL PANEL (Continued)

7 Slowly increase the autotransformer output voltage until the monitor output relay just energizes. Record this pickup voltage for phase A.

8 If pickup and dropout voltage adjustments require change to meet chapter 3 standards, make the adjustments in accordance with the Asco procedure in the engine generator instruction book. Repeat both adjustments at least twice because of interaction between adjustments.

9 Deenergize the transfer switch with the facility isolation switch.

10 Disconnect the autotransformer and reconnect the monitor phase A conductors.

11 Repeat steps 2 through 7 to check and record phase B pickup and dropout voltages, using the connections shown by figure 5-28, view B. These voltages should normally remain the same as for phase A. If they are not within the initial tolerances required by chapter 3, do not readjust the pickup and dropout potentiometers. Adjust the phase B balance potentiometer using the following procedure.

12 Repeat steps 2 through 7 to check and record phase C pickup and dropout voltages, using the connections shown by figure 5-28, view C. These voltages should normally remain the same as for phase A. If they are not within the initial tolerances required by chapter 3, do not readjust the pickup and dropout potentiometers. Adjust the phase C balance potentiometer using the procedure of paragraph (c).

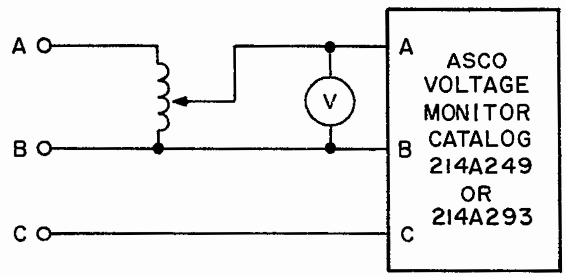
13 Place the isolation switch in standby position and unlock the unit for service if balance potentiometer adjustment is not required.

(c) Balance Potentiometer Adjustment.

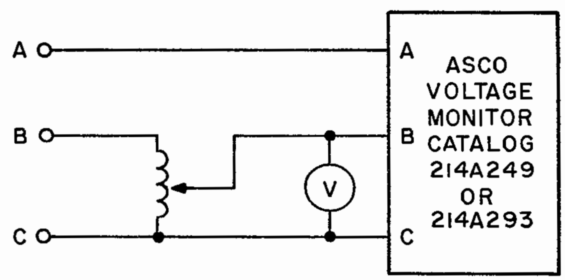
1 General. The Asco monitors have one (single-phase device) or three (three-phase device) balance potentiometers mounted internally. These normally do not require adjustment unless certain components are replaced. These devices have an input transformer for each line-to-line phase voltage to be monitored. Each phase voltage is separately transformed and rectified to originate two dc voltage sources. One dc voltage is used for monitor output relay operation and for a reference voltage. The second dc voltage is connected to the balance potentiometer. When nominal line-to-line voltage is present at the phase input transformer, the balance potentiometer is adjusted until the dc voltage at its wiper contact is equal to the reference voltage. When the line-to-line voltage of a phase becomes lower than the monitor dropout voltage setting, the dc voltage at the potentiometer wiper arm is no longer in balance with the reference dc voltage, and the output relay is deenergized. In three-phase monitors, the balance potentiometer wiper arm dc voltages have to be equal in order for the pickup and dropout voltage values of the three phases to be identical with just one adjustment of the pickup and dropout potentiometers. The following procedures may be used for balance potentiometer adjustments.

SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 10. CONTROL PANEL (Continued)

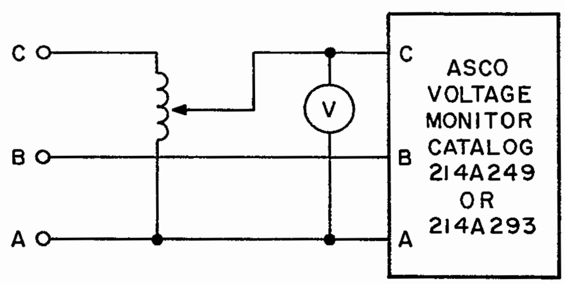
FIGURE 5-28. CONNECTION DIAGRAMS FOR ADJUSTMENT OF SOLID-STATE, PRIME POWER, UNDERVOLTAGE MONITOR



A. VOLTAGE CHECK PHASE A TO B



B. VOLTAGE CHECK PHASE B TO C



C. VOLTAGE CHECK PHASE A TO C

SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 10. CONTROL PANEL (Continued)

2 Asco Catalog 214A69, Single-Phase Undervoltage Monitor.

a Lock out and isolate the engine generator.

b Mark conductors and remove monitor from the unit.

c Locate the balance potentiometer on the printed-circuit board. Locate the balance diode connected to the potentiometer center terminal. Observe the polarity of the diode. Detach the printed-circuit board for access to the potentiometer.

d Locate the center tap of the monitor input transformer secondary winding and its connection to the printed-circuit board. This is the "common" point (negative polarity) of the circuit for voltage measurements.

e Connect the variable autotransformer to the monitor input terminals and to facility power. Adjust for nominal line voltage to the monitor. The output relay may not be energized if a component has been replaced, causing the balance, pickup, and dropout potentiometers to be out of adjustment.

f From the "common" point, measure and record the positive voltage on both the anode and cathode of the balance diode. If the circuit is balanced (diode not conducting), these should be approximately 12 volts on each end of the diode, and the voltages should be nearly equal, or the voltage at the cathode may be slightly higher (diode reverse biased).

g If the voltages are low to "common" (diode conducting), adjust the balance potentiometer until they are equal (12 volts to "common"). To measure more accurately, connect the voltmeter between the anode and cathode of the diode, then adjust the balance potentiometer for zero volts.

h Reduce the monitor input voltage to the desired rms pickup voltage, and adjust the pickup potentiometer just enough to cause the output relay to energize. The voltage across the diode should be zero.

i Reduce the monitor input voltage to the desired rms dropout voltage. Adjust the dropout potentiometer just enough to deenergize the output relay. The diode anode and cathode voltages to "common" should be low and approximately equal.

j Repeat both pickup and dropout voltage adjustments because of interaction between adjustments.

k Remove monitor input voltage and autotransformer. Reattach the printed-circuit board; mount and connect the monitor in the control cabinet. Restore the unit to service.

3 Asco Catalog 214A249, Three-Phase, Undervoltage Monitor.

a Lock out and isolate the engine generator.

b Mark conductors and remove the monitor from the control cabinet.

c Detach the monitor printed-circuit board for access to components.

d Locate test points 1, 2, and 3 (wiper arm of phase A, phase B, and phase C balance potentiometers, respectively) on the foil side of the printed-circuit board. Locate the circuit common (negative polarity) foil conductor where the secondary winding center tap of the three line input transformers are connected.

e Locate balance potentiometers P1, P2, and P3.

f Refer to figure 5-28, and connect the output terminals of the variable autotransformer to the monitor input terminals. Connect to the phase that requires balance potentiometer adjustment.

g Connect the other two monitor phases to facility source voltage with jumper conductors. Connect the input terminals of the autotransformer to facility source voltage, and adjust its output to equal the facility voltage. The monitor output relay should be energized. Test point 4 should measure approximately 12 volts positive.

SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 10. CONTROL PANEL (Continued)

h Measure and record the voltage from test point 4 to the test point (1, 2, or 3) of the phase to be balanced. This voltage should be zero. Adjust the balance potentiometer if necessary.

i Lower the autotransformer voltage to the desired pickup voltage. Test point 4 should be 12 volts positive with the output relay energized. Voltage from the test point (1, 2, or 3) of the phase to be balanced should be zero. If the output relay has deenergized, adjust the balance potentiometer just enough to energize the relay.

j Lower the autotransformer voltage to the desired dropout voltage. This voltage should be in tolerance just as the output relay deenergizes.

k Repeat the procedure for the other phase that requires balance.

l Disconnect autotransformer and jumpers. Assemble and mount monitor in control cabinet. Restore unit to service.

4 Asco Catalog 214A293, Three-Phase, undervoltage Monitor.

a Lock out and isolate the engine generator.

b Mark conductors and remove the monitor from the control cabinet.

c Detach the monitor printed-circuit board for access to components.

d Locate test points TP1, TP2, and TP3 on the printed-circuit foil pattern. Locate TP4.

e Locate balance potentiometers P1, P2, and P3. These are not marked, but notice that TP1 is connected to the center (slider) terminal of P3. TP2 is connected to the center terminal of P2, and TP3 is connected to the center terminal of P1.

f Locate the circuit "common" (negative) conductor. This is located on the edge of the board and is marked CT1, CT2, and CT3.

g Refer to figure 5-28, and connect the output terminals of the variable autotransformer to the monitor input terminals of the phase that requires balance potentiometer adjustment. Note that input terminals 7 and 8 are for phase A, 8 and 9 are for phase B, and 9 and 10 are for phase C.

h Connect the other two phases to facility source voltage with jumper conductors. Connect the input terminals of the autotransformer to facility source voltage, and adjust its output voltage to equal the nominal facility voltage. The monitor output relay should be energized.

i Measure the voltage (from common) at TP1, TP2, and TP3. These should be approximately 4 volts dc. Adjust only the balance potentiometer of the phase requiring balance until its test point voltage is equal to the other test point voltage.

j Reduce the autotransformer output to the desired pickup voltage. Do not adjust the pickup potentiometer. If the output relay has energized, readjust the balance potentiometer, adjusted in step i, until the relay energizes.

k Connect the voltmeter between TP4 (+12 volts dc) and "common." Reduce the autotransformer output to the desired dropout voltage. Do not adjust the dropout potentiometer. After the voltage at TP4 suddenly decreases to approximately 0.6 volt, the output relay will deenergize after a time delay. If the voltage decreases at TP4 before the autotransformer voltage is reduced to the desired dropout voltage, slightly adjust the balance potentiometer until the relay is energized, then continue to reduce the autotransformer voltage.

l Repeat steps j and k because of interaction between pickup and dropout potentiometer adjustments. When performing step k, listen for output relay dropout after TP4 voltage decreases to 0.6 volt. Adjust the time-delay potentiometer, if necessary, for a 1- to 2-second time delay.

m Deenergize the monitor and fasten the printed-circuit board. Install the monitor in the power plant control cabinet and connect. Restore the unit to service.

n Repeat steps g through l for each phase requiring adjustment.

5-113. GENERATOR UNDERVOLTAGE/UNDER-FREQUENCY DEVICES.

a. Electromechanical Device. Single- and three-phase FAA engine generators purchased before 1972 have an electromechanical, generator-power, undervoltage device. The device includes a close-differential relay that is voltage sensitive, and is mechanically and electrically adjustable. The relay coil is connected in series with a frequency- and voltage-sensitive circuit consisting of a capacitor and resistor mounted on the device. This electromechanical device is referred to as a generator power sensing relay and is shown on wiring diagrams as a 4PR device or lockout relay.

b. Solid-State Device. Single- and three-phase FAA units purchased since 1972 may have a solid-state, generator-power, undervoltage device or lockout relay. This device includes an output relay that is nonadjustable. The relay is controlled by an adjustable solid-state circuit, within the device, that responds to ac voltage and to frequency near 60Hz.

c. Electromechanical, Generator-Power, Under-Voltage Device Adjustment.

(1) Mechanical Adjustment Procedures. To measure and adjust the armature gap, insert a 1/8 (± 1/64) -inch-diameter drill or rod between the bottom of the armature and the top of the yoke. (See figure 5-26, view A.) Adjust the armature stop screw at the back of the frame until the armature and the yoke both make contact with the drill or rod. Lock the armature stop screw and recheck the gap. To measure and adjust the contact gap, insert a 5/32 (± 1/64) inch-diameter drill or rod between the contacts. Adjust the stationary contact screw until both contacts touch the drill or rod. Lock the stationary contact screw in place and recheck the adjustment. (See figure 5-26, view B.) If the armature gap and contact gap are both correct, the contact deflection will be correct. (See figure 5-26, view C.)

(2) Electrical Adjustment Procedure. The only electrical adjustment required for this device is an adjustment for pickup voltage at 60Hz. Pickup voltage is adjusted by heel-spring tension. The pickup voltage may also be checked with a variable autotransformer, using the facility source voltage. With 60Hz pickup voltage applied, the relay armature should barely overcome heel-spring tension and should move against the yoke.

d. Solid-State, Generator-Power, Undervoltage Device Adjustment. The Asco lockout relay device (Catalog 214A284) has an output relay which is nonadjustable. Replace the relay if its contacts are too pitted to be dressed. This device has a potentiometer to adjust pickup voltage only. There is no dropout voltage adjustment. Voltage from a variable transformer can be used for adjusting the pickup voltage potentiometer. Starting with voltage below the pickup voltage required, increase the voltage until the desired pickup voltage value is reached. With proper setting of the potentiometer, the device relay should energize. If adjustment is required to energize the relay, turn the potentiometer counterclockwise. If the relay is energized below the desired pickup voltage, deenergize the device to electrically unlatch the relay and turn the potentiometer fully clockwise. Apply the desired pickup voltage and turn the potentiometer counterclockwise until the relay is just energized. Refer to the instruction book for additional adjustment procedures.

e. Undervoltage and underfrequency monitors (types UVE and UFE, respectively) are used to control the generator 4PR relay. The UVE (ASCO pn 214A304) and UFE (ASCO pn 214A262) monitors are used on engine generators that have an uninterrupted power transfer (UPT) system (or closed transition system) installed. The UVE and UFE monitor the generator output and control the 4PR relay. The UVE monitor has an adjustable pickup and dropout voltage adjustment. The UFE monitor has an adjustable frequency pickup, trip, and trip time delay. The calibration procedures for the UVE and UFE monitors follow.

(1) Equipment Required for Calibration.

SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 10. CONTROL PANEL (Continued)

(a) Fluke 8060A series digital multimeter.

(b) 208-volt Variable Transformer.

(2) UVE Monitor Calibration Procedure.

(a) Lock the engine generator out by placing the emergency stop and control cutout switch (ESCCS) to OFF.

(b) Place the facility bypass switch to BYPASS.

(c) Disconnect the wires from terminals 1 and 2 of the UVE monitor.

(d) Connect the output of the variable transformer to terminals 1 and 2 of the UVE monitor.

(e) Remove the two screws holding the nameplate on the UVE monitor, and remove the nameplate to expose the adjustment potentiometers.

(f) Rotate the pickup (PU) control to its maximum clockwise position.

(g) Rotate the dropout (DO) control to its maximum counterclockwise position.

(h) Turn on the variable transformer, and adjust its output to the desired pickup value as measured by the 8060A multimeter.

(i) Carefully rotate the PU control counterclockwise until UVE contact 5/6 picks up. Pickup is indicated when the UVE contact 5/6 resistance drops to zero ohms.

(j) Adjust the variable transformer to the desired dropout voltage.

(k) Carefully rotate the DO control clockwise until the UVE contact 5/6 just opens.

(l) Check the pickup and dropout settings by varying the variable transformer voltage output through the pickup and dropout voltage points.

(m) Turn off the variable transformer, and remove its output wires from terminals 1 and 2 of the UVE monitor.

(n) Replace the wires on terminals 1 and 2 of the UVE monitor that were removed in step (c).

(o) Restore the facility to its normal operating configuration.

(3) UFE Monitor Calibration Procedure.

(a) Place the ESCCS switch to the OFF position, and remove the wires from UFE terminals 4 and 5.

(b) Remove the two screws holding the nameplate, and remove the nameplate to expose the adjustment potentiometers.

(c) Rotate the PU control to its maximum clockwise position.

(d) Mark the position of the time-delay control, then rotate the DO control to its maximum counterclockwise position.

(e) Rotate the time-delay control to its maximum counterclockwise position.

(f) Press the Hz button on the 8060A multimeter, and connect it to terminals 7 and 8 of the UFE monitor.

(g) Place the facility bypass switch to the BYPASS position and the ESCCS switch to the ON position. The engine should start.

(h) Adjust the governor speed control until the generator frequency indicates the desired pickup frequency. Slowly rotate the PU control until the UFE monitor just picks up. Pickup is indicated by the resistance across UFE contact 4/5 dropping to 0 ohms.

(i) Adjust the governor speed control until the generator frequency is at the dropout value. Slowly rotate the DO control clockwise until the UFE monitor relay just drops out, contacts 4/5 open.

(j) Check the pickup and dropout settings by varying the generator frequency.

(k) Return the time delay control to its original setting. Adjust the generator frequency to the UFE drop frequency, verify that the UFE drop out time is within the tolerance specified in paragraph 3-26. If the dropout time delay is not within tolerance, adjust as required.

(l) Shut down the engine by placing the ESCCS to the OFF position. Replace the wires that were removed in step (a), and replace the nameplate.

(m) Restore the engine generator control switches to their normal operating configuration.

5-114. FERMONT OVERVOLTAGE DETECTOR ADJUSTMENT PROCEDURE. Use the following procedure to test and adjust the generator overvoltage detector associated with the Fermont engine generator.

a. Operate the engine generator in the no-load test condition.

b. Place the voltage regulator switch in the manual position.

c. Slowly increase the manual voltage adjust until the system is disabled. System shutdown should occur at 135 ±2 V ac.

d. If out of tolerance, reset the RTS switch and restart the engine generator. The manual voltage adjust control may require adjustment to reduce the output voltage to allow RTS to initialize the relay circuits.

e. Readjust the manual voltage adjust for 135 V ac output.

f. Adjust R-76 on the overvoltage detector until the system is disabled.

g. Repeat steps c through f as necessary so that the system shutdown occurs at 135 ±2 V ac.

h. With the engine in operation, adjust the manual voltage control to provide a normal 120 V ac output.

i. Place the voltage regulator switch in the auto position.

j. Return the engine generator to the standby condition.

5-115. FREQUENCY SENSING DEVICE ADJUSTMENT. An Asco frequency-sensitive relay device (Catalog 214A89) is installed on some engine generators to immediately initiate a transfer of the facility load to commercial power when the engine fails. Wiring diagrams refer to this device as a frequency-sensing device (FSD). It will operate on both 208 V and 240 V units. If a failure occurs that allows the engine to coast to a stop, the generator voltage may remain high enough for several seconds before the 4PR device deenergizes to initiate the transfer of facility load to the prime-power source. This device initiates the transfer when the generator frequency drops to 57Hz. Another set of its normally-open relay contacts is connected in series with the 4PR device coil. One set of its normally-open relay contacts is connected in series with the extended load test relay coil. Both sets are closed when FSD is energized at 60Hz. The device is factory adjusted for both overfrequency (OF) and underfrequency (UF) trip.

5-116. TRANSFER SWITCH DELAY RELAY (CR) AND TRANSFER RELAY (TR) ADJUSTMENTS. Maintenance instructions for these relays are contained in the appropriate engine generator instruction books.

5-117. ADJUSTMENT PROCEDURE FOR DUAL SOURCE PRIME POWER. Installations with more than one source should have the power sources identified as prime power No. 1 and prime power No. 2. The prime-power undervoltage devices (PR relays) and transfer switch should be sequenced to permit the facility to operate on the No. 1 power source until it fails or drifts out of tolerance. Where the dual source of prime power is backed up with standby generators, the prime power should be sequenced to permit the facility to operate on the No. 1 source until it fails, and then switch to the No. 2 prime power source until it fails. Only after the failure of both prime sources of power should the facility load be connected to the standby generators. This procedure will allow momentary power interruptions without the disruption associated with starting and transferring the facility load to the standby generators. This mode of operation should be accomplished by adjusting the prime-power undervoltage devices. The prime-power, undervoltage-device voltage dropout setting of the No. 2 prime power should be adjusted to operate at the upper limit of the

SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 10. CONTROL PANEL (Continued)

operating tolerance. The standby generator prime-power undervoltage devices should be adjusted to drop out at the lowest voltage (within the range of the device) that will satisfy the connected load requirements. The pickup voltage of the PR devices should be adjusted to the same value for prime and for standby power.

5-118. TRANSFER SWITCH. Asco switch bulletins are missing from many engine generator instruction books. For this reason detailed instruction are provided in this handbook. Other manufacturers' equipment is adequately covered in the appropriate instruction books.

a. Transfer Switch (75 to 100 Ampere).

(1) Before any maintenance may be performed on the transfer switch assembly, the engine generator must be locked out, the power disconnected by the isolation switch or main power switch, and the ungrounded battery lead disconnected. Most transfer switches are of the double-throw type, pivoted on a single shaft, and electrically operated. Action is provided by a solenoid operating a counterweight, which provides sufficient force to rotate the switch operating shaft assembly, completely closing the contacts, and mechanically locking them into place. Auxiliary contacts are installed on the main shaft to initiate the opening and closing of the circuit to the transfer switch solenoid through the control circuit. The control circuit for the transfer switch is provided by the primary sensing relays (1PR, 2PR, and 3PR), transfer relay (TR), and the time-delay relay (TD). When any or all primary relays sense a power failure or a voltage drop in any phase, the transfer relay is deenergized. A pair of contacts of the transfer relay provides a starting circuit for the engine and sets up a circuit for operation of the transfer switch. This is done through the auxiliary contacts of the transfer switch and contacts of the generator power sensing relay (4PR). When the generator comes up to frequency and voltage, the generator power sensing relay closes and energizes the transfer switch coil through the upper auxiliary contacts of the transfer switch. Upon transferring, the upper auxiliary contacts open and deenergize the transfer switch solenoid, thus completing the operation. When commercial power returns, the sequence of operation is reversed; the primary power sensing relay(s) pulls in and energizes the TD relay. After a preset time interval, a contact in the TD relay closes and completes a circuit to the transfer relay. This, in turn, completes a circuit through the lower auxiliary contacts of the transfer switch and causes it to transfer back to the commercial power side. A partial typical schematic drawing (figure 5-29) is shown with the transfer switch contacts closed in the normal position (commercial power position). Newer transfer switches may also switch the neutral conductor. This is a make-before-break operation so that the neutral is not disconnected during the transfer. This is accomplished at those facilities that use the engine generator as a separately derived source.

(2) When maintenance is performed on the transfer switch, the bearings and moving parts of the solenoid mechanism must be lubricated. The solenoid must not be overlubricated, and no oil should be used on the plunger. Powdered graphite or molybdenum disulfide powder may be used on this part. Inspect the mechanism for freedom of operation. Any malfunctioning shall be corrected. All contacts in the control circuit must be clean and adjusted so that the contacts open simultaneously. Adjust the 4PR device pickup value to conform to standard tolerances. Set the adjustment of the transfer switch main and arcing contacts according to the limits indicated for the size switch in use. In addition, the travel limit of the solenoid plunger must be adjusted as required. The following instructions cover the majority of switches in use. For detailed maintenance instruction consult the instruction book.

(a) Lubrication. Where coil replacement or repair of any kind requires removal of lubrication, relubricate in accordance with manufacturer's instructions. Lubricate 75- to 100-ampere transfer switches in accordance with the following procedures. (See figure 5-30.)

1 Disassemble the mechanism and remove the core weight assembly (2), core spring (3), core tube (4), and pivot pin (5) from frame (1).

2 Wipe or wash the parts clean with solvent.

3 At points indicated by curved arrows, apply a light coat of Dow Corning No. 44 silicone grease, and dust with molybdenum disulfide powder. *Apply only enough grease to retain the powder film.*

SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 10. CONTROL PANEL (Continued)

FIGURE 5-29. SCHEMATIC OF TRANSFER SWITCH

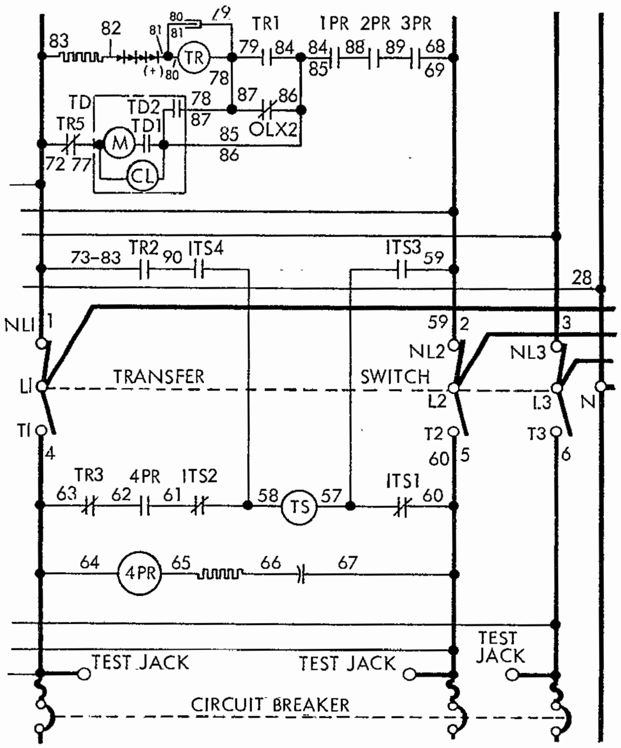
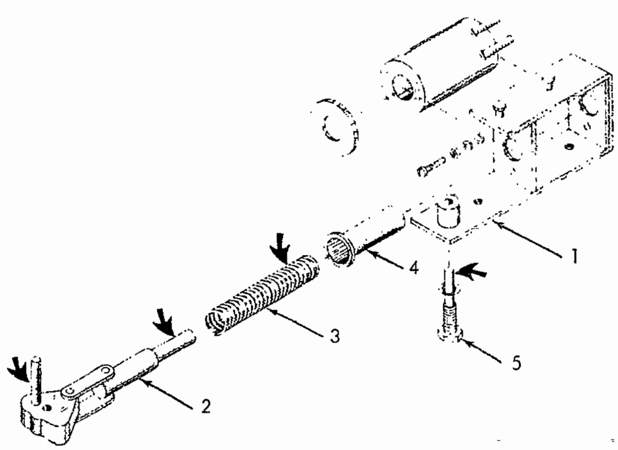


FIGURE 5-30. LUBRICATION OF 75- TO 100-AMPERE TRANSFER SWITCH



SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 10. CONTROL PANEL (Continued)

(b) Contact Service.

1 Replacement. Remove the nuts and lock-washers above the movable contact spring and back finger pin. The stationary contact is easily removed with a socket or open-end wrench. Inspect contacts periodically. Operation is not affected if contacts are discolored; they should be changed only when excessively pitted.

2 Adjustment.

a With the contacts in the open position, adjust the nuts above the spring until the spring height is eleven-sixteenths of an inch. (See figure 5-31.)

b Adjust the back finger pin until the gap at point "A" is one-eighth of an inch.

c With the contacts in the closed position, adjust the stationary contact screw until the gap at point "B" is one-eighth of an inch.

d Lock all adjustments. Operate switch manually and recheck.

b. Transfer Switch (125- to 200-Ampere). Figure 5-32 shows a typical mechanism used in operating the contact assembly on the 125- to 200-ampere capacity transfer switches. The same mechanical movement governs the operation of both the automatic transfer switch and the remote control switch. Essentially, the movement consists of a rotating weight controlled by a solenoid coil connected through a three-way control contact arrangement to the control line. Circuit control contacts are mounted either on the weight or on the operating shaft; the operating principle remains the same. Once the solenoid coil is energized, the core will move into the coil against a compression spring. The connecting link sets the weight in motion. The motion will not stop until completed. In the case of the transfer switch, completion means opening the contacts to the normal supply and closing those to emergency, or vice versa.

(1) Movement. There are five different movements depending on the amperage and number of poles. These movements are basically the same, but they differ in size. To determine the type of movement, measure the width of the frame (dimension "W" figure 5-32). Refer this measurement to table 5-5 to determine the type of movement, maximum stroke and contact adjustment dimensions.

(2) Coil Replacement (With Cover Plate). Disconnect the power from the switch; remove stop nut, flat washer, and threaded leather washer; remove screws holding the cover plate on the top frame (figure 5-32).

CAUTION: Care should be exercised when removing the plate, as it is under spring pressure.

The main core spring and core tube can now be removed by pulling out the top frame. Remove the core link pin and lift the core out of the frame. Loosen the screws holding the coil in the frame, remove coil leads from the panel stud, and lift the coil from the frame. Install the new coil and parts in reverse order to that listed above. After the type of movement is determined from table 5-5, the corresponding maximum stroke (dimension "A" figure 5-32) is set by adjusting the stop nut on the core stem.

(3) Coil Replacement (Without Cover Plate). On switches without cover plates, the coil is removed from the bottom of the frame rather than the top. To remove the coil, disconnect the power from the switch and remove the stop nut, flat washer, and threaded leather washer. Remove the weight pivot pin. This will allow the weight, core assembly, and spring to be removed from the frame. Remove the screw holding the core tube in place and lift out the core tube. Loosen the screws holding the coil in the frame, remove coil leads from the panel studs, and lift the coil from frame. Install the new coil in the frame, remove coil leads from the panel studs, and lift the coil from frame. Install new coil and parts in reverse order to that listed above. After the type of movement is determined, the corresponding maximum stroke (dimension "A" figure 5-32) is set by adjusting the stop nut on the core stem.

SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 10. CONTROL PANEL (Continued)

FIGURE 5-31. ADJUSTMENT OF 75- TO 100-AMPERE TRANSFER SWITCH

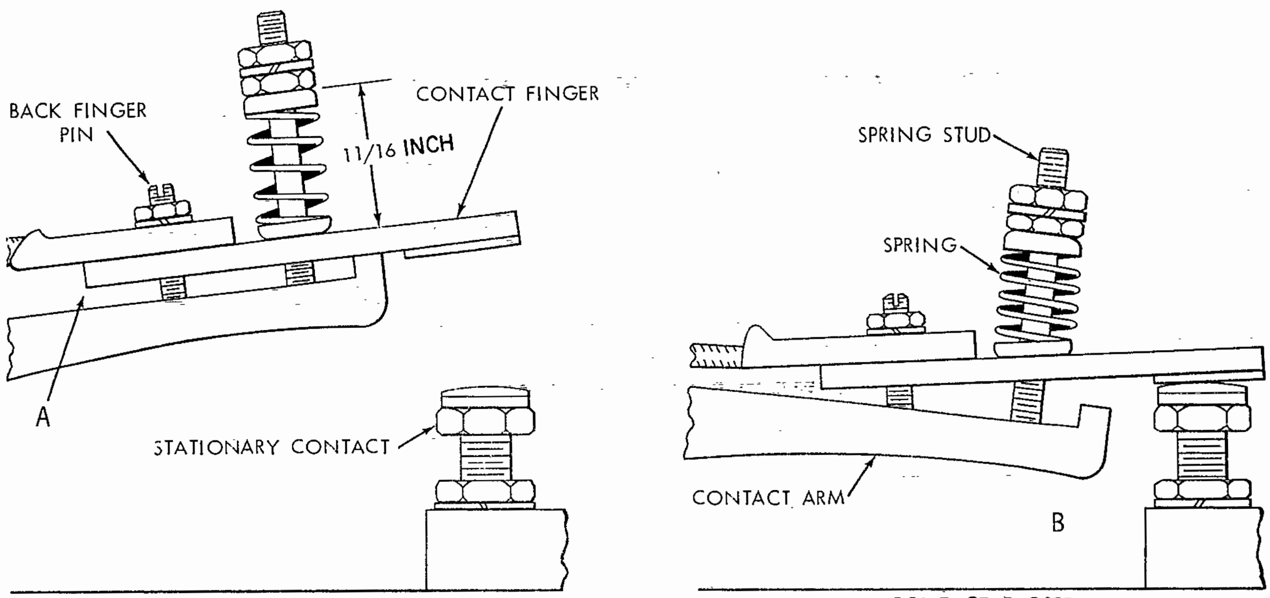
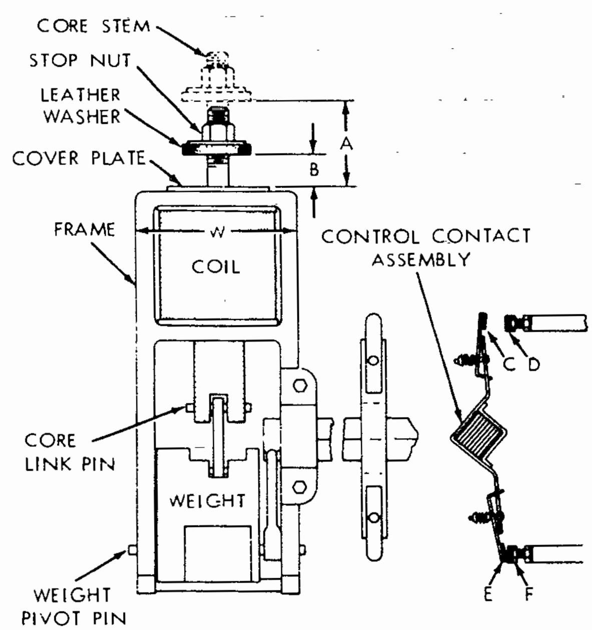


FIGURE 5-32. TRANSFER SWITCH COIL REPLACEMENT



SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 10. CONTROL PANEL (Continued)

TABLE 5-5. TRANSFER SWITCH ADJUSTMENT DATA

Dimension	Type of Movement	Maximum Stroke Dimension (A)	Contact Adjustment Dimension (B)
2 7/8 inch	V #2	1 7/32 inch	7/8 inch to 1 inch
3 5/8 inch	V #3	1 1/2 inch	1 1/4 inch to 1 3/8 inch
4 1/4 inch	II #1	1 I/2 inch	1 1/4 inch to 1 3/8 inch
4 3/4 inch	II #2	2 1/2 inch	1 7/8 inch to 2 1/8 inch

(4) Control Contact Adjustment. When the control contacts are located on the weight, no adjustment is required. If the control contacts are located on the shaft (figure 5-32), adjust as follows.

(a) After the correct movement is determined from table 5-5, the corresponding "Contact Adjustment, Dimension (B)" is used in setting the control contacts.

(b) Manually pull up the core stem, and insert a block between the leather washer and the top of the cover plate. On units without a cover plate, insert block between the leather washer and the frame. The size of the block must be the same as the "Contact Adjustment, Dimension(B)."

(c) In this position, the control contacts C and D or E and F should just make contact. Adjustable contact screws D and F obtain this setting.

(d) Adjust the opposite set of contacts by lifting the core stem to its extended stroke, and let the weight fall in the opposite direction. Adjust this set of contacts, following the procedure outlined above.

(e) Tighten all lock nuts and remove the block.

CAUTION: The stop nut (figure 5-32) must not be used to adjust the control contacts.

(5) Contact Service. A typical transfer switch contact assembly is shown in figure 5-33. The stationary contact structure consists of a main laminated brush and graphalloy contact. The latter contact protects the current carrying brush contact against pitting due to arcing.

(a) Replacement. Disconnect the pigtail from the brush contact plate, and remove the lock nuts above bushing (C of figure 5-33), allowing the brush and graphalloy contact plates to be removed as an assembly. Install new parts as required. Remove the bolt holding the laminated brush contact, and replace worn or damaged parts. The graphalloy contact is held in a clamp-type holder and is easily replaced by loosening the single clamping screw. Contact operation is not affected if contacts are discolored; however, they should be changed when excessively pitted or broken.

(b) Adjustment of Contact. With the contact arm in the closed position (figure 5-33), adjust bushings C until point A is in contact and point B is not in contact by one-sixteenth to three thirty-seconds of an inch. Advance brush contact plate by turning bushings C equal amounts until point B is in contact. Continue adjustment to a point where the brush contact is not touching the brush side plate D by one sixty-fourth to one thirty-second of an inch. Lock this adjustment. Operate the switch manually and recheck the adjustment.

(c) Lubrication. Critical points requiring lubrication on the 125- to 200-ampere transfer switches are identified in figure 5-34. Clean the shaft ball bearing (1) with solvent and apply a light coat of Dow Corning No. 44 silicone grease. Apply dry molybdenum disulfide powder to shaft sleeve bearing (2) and link pins and weight shaft (3). Alcohol my be used as a vehicle. Clean drive lever and cam (4); apply a light film of Dow Corning No. 44 grease, and dust with molybdenum disulfide powder. Remove the bright chrome-plated core (5); clean it and the core bore with solvent; apply a light coat of Dow Corning No. 44 grease, and dust with molybdenum disulfide

SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 10. CONTROL PANEL (Continued)

FIGURE 5-33. TYPICAL TRANSFER SWITCH CONTACT ASSEMBLY

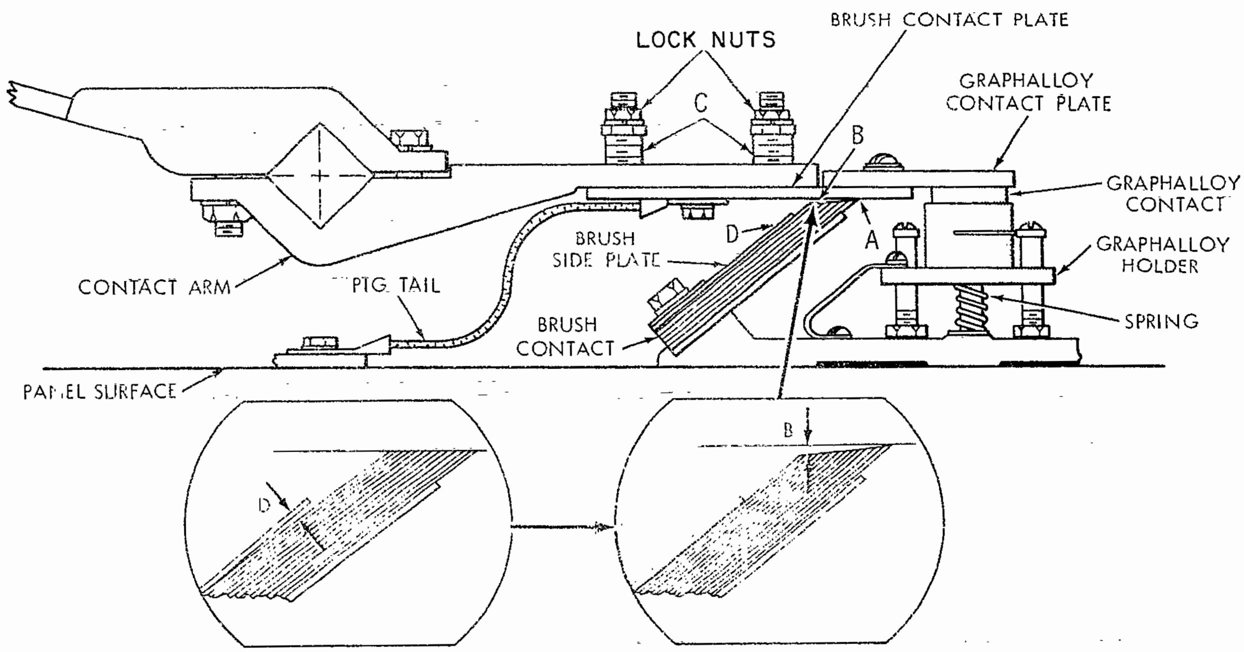
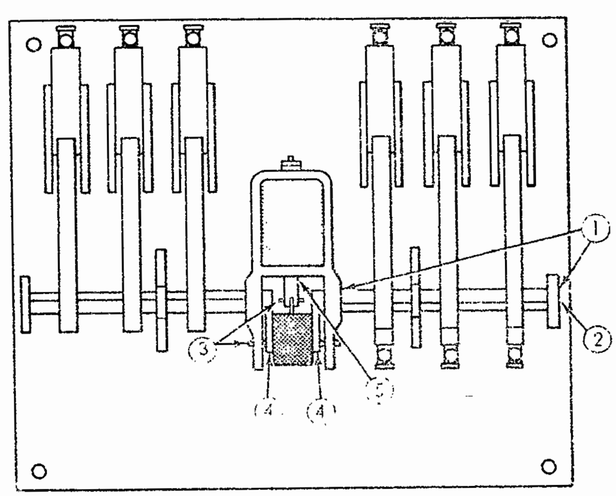


FIGURE 5-34. LUBRICATION OF 125- TO 200-AMPERE TRANSFER SWITCHES



powder. When cleaning parts, trichloroethylene should be used. Kerosene or alcohol may be used; however, they are volatile and require handling with care. *Do not use carbon tetrachloride.* Lubrication is provided by a thin film separation; therefore, apply only enough grease to retain the powder film. Excessive lubrication is harmful as it will gather dirt and dust. Any visible excess should be wiped off. All sintered bronze (Oilite) bearings are permanently lubricated. No petroleum derivative grease should be used to lubricate transfer switches.

5-119. UNINTERRUPTED POWER TRANSFER (UPT) CONTACT SEQUENCE AND ADJUSTMENT.

a. Sequence.

(1) The UPT system incorporates paralleling contactors (CE and CN) and time-delay relays (2TDR and 3TDR) not found on other engine generators. In addition to the main paralleling contacts, contactors CN and CE each have three sets of auxiliary transfer switches. The function of the auxiliary transfer switches is to direct the sequence and timing of the paralleling contacts. The sequence of operation of the auxiliary contacts is critical to the function of the UPT. Improper adjustment will result in failure to transfer or may cause burning of the power contacts of the paralleling contactors.

(2) The adjustable time-delay relay contacts, 3TDR in series with CN and 2TDR in series with CE, open the coil circuit of CN and CE after the transfer switch has moved from one power source to the alternate power source. Contacts 2TDR and 3TDR must open only after the transfer switch has made contact with the contacts of the source to which power is being transferred.

b. Adjustment of Contacts. Some CN and CE contactors are not adjustable. If the contactors are adjustable, first adjust the three main paralleling contacts of CN and CE and then adjust the auxiliary contactors.

(1) Main Contacts. Connect two ohmmeters across any two of the three main contacts. Slowly push contactor towards the closed (energized) position. Adjust the two stationary contacts so that both contacts close simultaneously as indicated by the ohmmeters. Move one ohmmeter to the third stationary contact. Follow the same procedure and adjust the third stationary contact so that both contacts close simultaneously.

(2) Auxiliary Contacts.

(a) Contact P7/P8. Connect an ohmmeter across P7/P8. Slowly push the contactor towards the closed position. Adjust the P7/P8 stationary contact so that when the ohmmeter indicates that P7/P8 is closed, the three main contacts are still open approximately one sixty-fourth of an inch. A 0.015-inch feeler gauge can be used to measure this opening.

(b) Contact P3/P4. Connect one ohmmeter across any one of the three main contacts. Slowly push the contactor towards the closed position. Adjust the P3/P4 stationary contact so that when the ohmmeter indicates closure of the main contact, the P3/P4 contact is still open one sixty-fourth of an inch.

(c) Contact P5/P6. Adjust the P5/P6 stationary contact so that when the main contacts are fully closed (contactor held in the fully closed position) the P5/P6 contact is still approximately open one sixty-fourth of an inch.

c. Adjustment of Relays. If the time-delay relays 2TDR and 3TDR are adjustable, adjust the relays for a setting of 2 (200 milliseconds) for the ASCO transfer switches and 7 (700 milliseconds) for the Russell Electric transfer switches. Nonadjustable time-delay relays 2TDR and 3TDR are preset at 1 second. Verify correct operation as follows.

(1) Lock out the engine generator by placing the emergency stop control cutout switch (ESCCS) to OFF. Select the battery charger and immersion heater to OFF.

(2) Place the bypass switch to BYPASS.

(3) Jumper power from the facility main breaker or bypass switch to terminals NL1, NL2, and NL3 of the engine generator, using a 10-ampere fused disconnect. Make sure that the phases of the engine generator match those of the commercial power.

(4) Turn the ESCCS switch to ON and start the engine generator on the NOLOAD test. When the engine

generator is up and running, depress the LOAD test pushbutton (ELS). Observe the transfer switch main contacts and the CE paralleling contacts for arcing during transfer to the engine-generator position. If arcing occurs, raise the setting of the 2TDR relay to 2-1/2. Depress the extended load stop pushbutton (ELSS) and observe the transfer switch main contacts and CN paralleling contacts for arcing during transfer to the commercial power position. If arcing occurs, raise the setting of the 3TDR relay to 7-1/2. Repeat the transfer sequence to verify correct operation (no arcing) during transfer.

(5) Return the engine generator to standby statue.

d. Load Test. Perform the facility load test. Exercise the LTS and ELSS pushbuttons to transfer the facility load to and from the engine generator to verify correct operation (no arcing).

5-120. INPHASE MONITOR CALIBRATION PROCEDURE.

a. Preparation.

(1) Before calibrating the inphase monitor (IM), monitor the commercial voltage supply in order to determine the high and low voltage supplied to the facility.

(2) Calculate the center voltage of the commercial supply by adding the high and low voltage readings and dividing by two.

Example: $\frac{203\text{ V} + 218\text{ V}}{2} = 210.5\text{ V}$

(3) Calculate the upper end-point voltage by taking 5 percent of the center voltage and adding it to the center voltage. Calculate the lower end-point voltage by taking 5 percent of the center voltage and subtracting it from the center voltage.

Example: 210.5 X 0.05 = 10.5 V
high end point = 210.5 + 10.5 = 221.0 V
low end point = 210.5 - 10.5 = 200.0 V

(4) To calculate voltage width, find the difference between the high end point and the low end point.

Example: 221 V – 200 V = 21 V

b. Test Equipment.

(1) One 208-volt variable transformer.

(2) Two digital voltmeters.

(3) Two voltmeters (moving-coil type).

(4) Recording voltmeter.

(5) A 10-ampere fused disconnect.

c. Delay Test.

(1) Lock the engine generator out by placing the emergency stop control cutout switch (ESCCS) to OFF. Select the battery charger and immersion heater to OFF.

(2) Place the facility bypass switch to BYPASS.

(3) Disconnect the wires attached to pins 11 and 12 of the IM.

(4) Set the output of the variable transformer to 208 volts. Select the Variable Transformer on-off switch to OFF.

(5) Attach the output leads of the variable transformer to pins 11 and 12 of the IM.

(6) Select the Variable Transformer on-off switch to ON, and listen for a faint click, which will occur approximately 2 seconds after the Variable Transformer is selected to ON.

(7) Repeat the procedure in step (6) several times to ensure that the 2-second time delay is operating properly.

(8) Remove the Variable Transformer wires from pins 11 and 12, and reinstall the wires removed in step (3).

d. IM Adjustment.

(1) Jumper power from the facility main breaker or bypass switch to terminals NL1, NL2, and NL3 of the engine generator, using a 10-ampere fused disconnect. Make sure that the phases of the E/G match those of the commercial power.

SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 10. CONTROL PANEL (Continued)

(2) Perform IM adjustment when the commercial power is within ±1 V ac of the center voltage calculated in step a(2).

(3) Connect a moving-coil type voltmeter between phase 1 of the normal power bus and phase 1 of the engine-generator bus. Connect one digital voltmeter to the commercial source and the other to the engine generator.

(4) Select the ESCCS switch to ON. Operate the engine generator on no-load test.

(5) Set the engine generator output voltage below the low end-point voltage calculated in step a(3). Attempt to transfer the power source by depressing the load transfer switch (LTS) and, in sequence, the extended load stop switch (ELSS). Continue this procedure by increasing the engine-generator output voltage in increments, and attempting to transfer and retransfer the power source until the transfer begins and then ceases when the voltage becomes too high to permit the transfer. The difference between the readings of where the transfer begins and where it ends is the voltage width (VW).

(6) Adjust the VW potentiometer to obtain the proper VW calculated in step a(4). Repeat the test in step (5) to verify that the VW is properly set.

(7) Adjust the voltage centering (VC) potentiometer to cause the VW to be centered at the voltage determined in step a(2).

NOTE: The VC and VW increase with a counterclockwise rotation of the potentiometers.

(8) The IM will signal a transfer when the voltages of both sources are within the parameters of the VW and VC. In addition, the transfer is signaled when the two sources are within ±5 electrical degrees and approaching zero volts differential. The transfer signal point may be calculated by the relation:

$$\frac{2 \text{ X center voltage X } 0.0872}{1.732} = \text{WW.}$$

This is the window width (WW). The window width (transfer point) is approximately 20 volts.

(9) Observe the moving-coil voltmeter, and note that it reads 21 volts or less when the transfer occurs. Adjust the WW potentiometer to obtain the proper WW. The frequency difference of the two sources may need to be closely matched to slow the voltmeter excursions in order to observe the voltage differential at the transfer point.

e. Return To Service.

(1) Place the engine-generator ESCCS switch to OFF.

(2) Remove the jumpers between the facility main breaker and terminals NL1, NL2, and NL3.

(3) Place the bypass switch to normal.

(4) Remove all test equipment, and return the engine generator to service.

5-121. ISOLATION OR BYPASS SWITCHES.

a. General. Although an isolation switch is not a component of the control panel, it is considered an auxiliary item. Under normal conditions, commercial (prime) power is supplied to the control panel through the transfer switch and then out to the facility load. This fact makes it very difficult to perform maintenance or repair on the transfer switch and some of the other relays in the control panel without working the circuits "hot."

b. Purpose. The isolation switch removes all commercial power from the control panel without breaking the circuit to the facility load in the process. On some installations, a secondary switching arrangement can keep a potential on certain components even though the isolation switch is in the bypass position. Caution should be observed at all times when working on the control panel.

c. Operation. All isolation switches used by the FAA are manually activated. Internally, they consist of a series of make-before-break blades or contacts. Isolation switch operation is as follows.

(1) Normal Position, Normal to Bypass Operation. When the transfer switch is in its normal (prime) power position, commercial power is fed into the isolation switch

SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 10. CONTROL PANEL (Continued)

and then to the facility distribution panel. Figure 5-35, part A, depicts this arrangement with the isolation switch in the normal position. Contact 1 is open, and contacts 2 and 3 are closed.

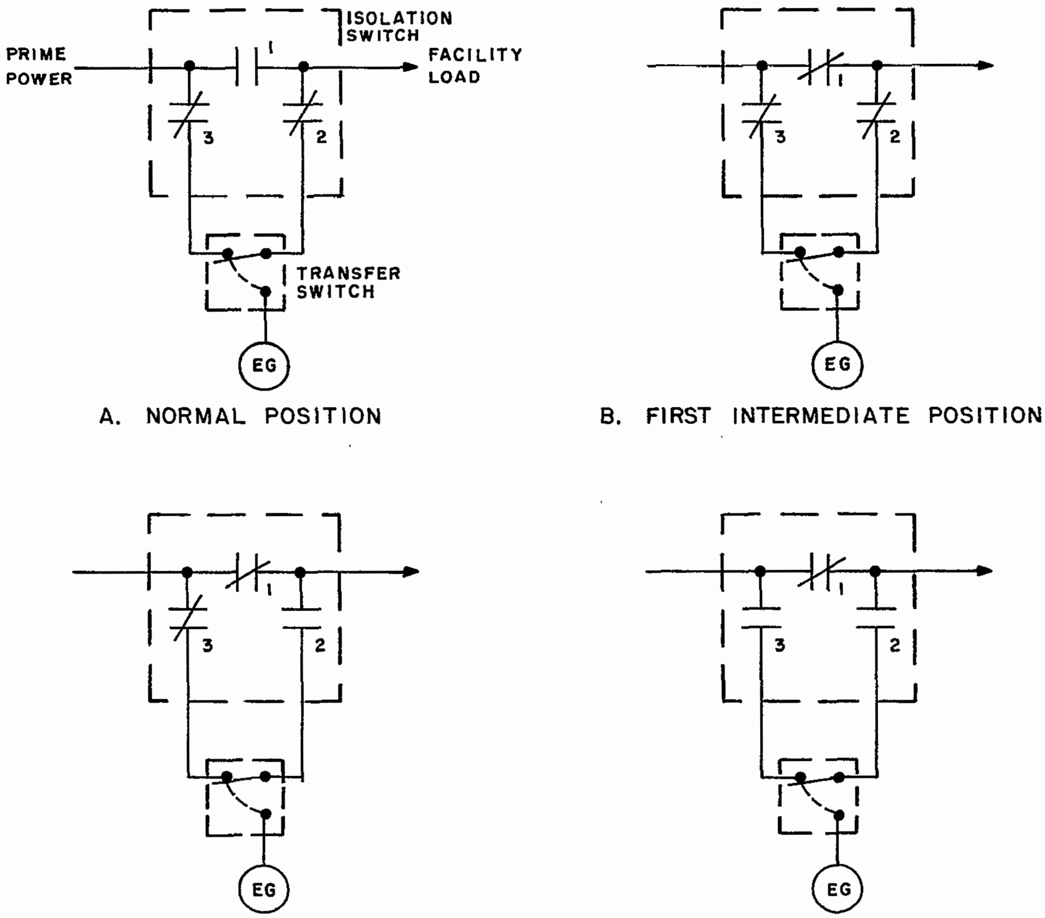
(2) Intermediate Positions, Normal to Bypass Operation. In order to accomplish the isolation of the control panel without interrupting the power to the facility load, all isolation switches use a make-before-break contact arrangement. Figure 5-35, part B, shows the sequence of contact operation as the isolation switch handle is moved to the first of two intermediate positions between the normal and bypass positions. In part B of the figure, contact 1 has closed to start the sequence, with contact 2 and 3 still closed. In part C of the figure, further movement of the handle has caused contact 2 to open, with contacts 1 and 3 remaining closed.

(3) Bypass Position, Normal to Bypass Operation. Figure 5-35, part D, shows that further movement of the isolation switch handle opens contact 3 to completely remove prime power from the transfer switch. No break in power has occurred during this switching operation from normal to bypass.

(4) Bypass Position, Bypass to Normal Operation. At the start of manual operation of the isolation switch, the transfer switch may be in the standby power position, shown by figure 5-36, part A. As the isolation switch handle is moved further, contact 3 will close, shown by figure 5-36, part B. If further movement of the isolating switch handle should occur, contact 2 would close and the generator would be connected in parallel with prime power as shown by part C. Arc damage to the isolation switch, damage to the generator, and facility outage would occur. To prevent the parallel operation, some isolation switches have a pin or other mechanism to momentarily stop further movement of the isolation switch handle when contact 3 closes. Closure of contact 3 causes the transfer switch to move to its normal (prime) position. The isolation switch contact arrangements and transfer switch position at this time are shown by figure 5-36, part D. After transfer switch operation has occurred, the isolation switch handle can be moved further to close contact 2, as shown by part E of the figure. The isolation switch operation is complete when contact 1 opens, and the switch is in the normal position, as shown by figure 5-35, part A. Operation of switches with a mechanical stop on return from bypass to normal should be firm but unhurried. Hurried operation may shear or force the stop mechanism, allowing contact 2 to close before the transfer switch has time to operate when contact 3 closes. (Refer to figure 5-36, part C.) Some isolation switches have a solenoid to stop movement of the isolation switch handle when contact 3 is closed on return from bypass to normal, with the transfer switch in the standby position. The solenoid will not allow further movement of the isolation switch handle (to close contact 2) until the solenoid is energized by auxiliary contacts on the transfer switch. The contacts close when the switch has moved to its normal (prime) position.

SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 10. CONTROL PANEL (Continued)

FIGURE 5-35. ISOLATION SWITCH, NORMAL TO BYPASS OPERATION



A. NORMAL POSITION

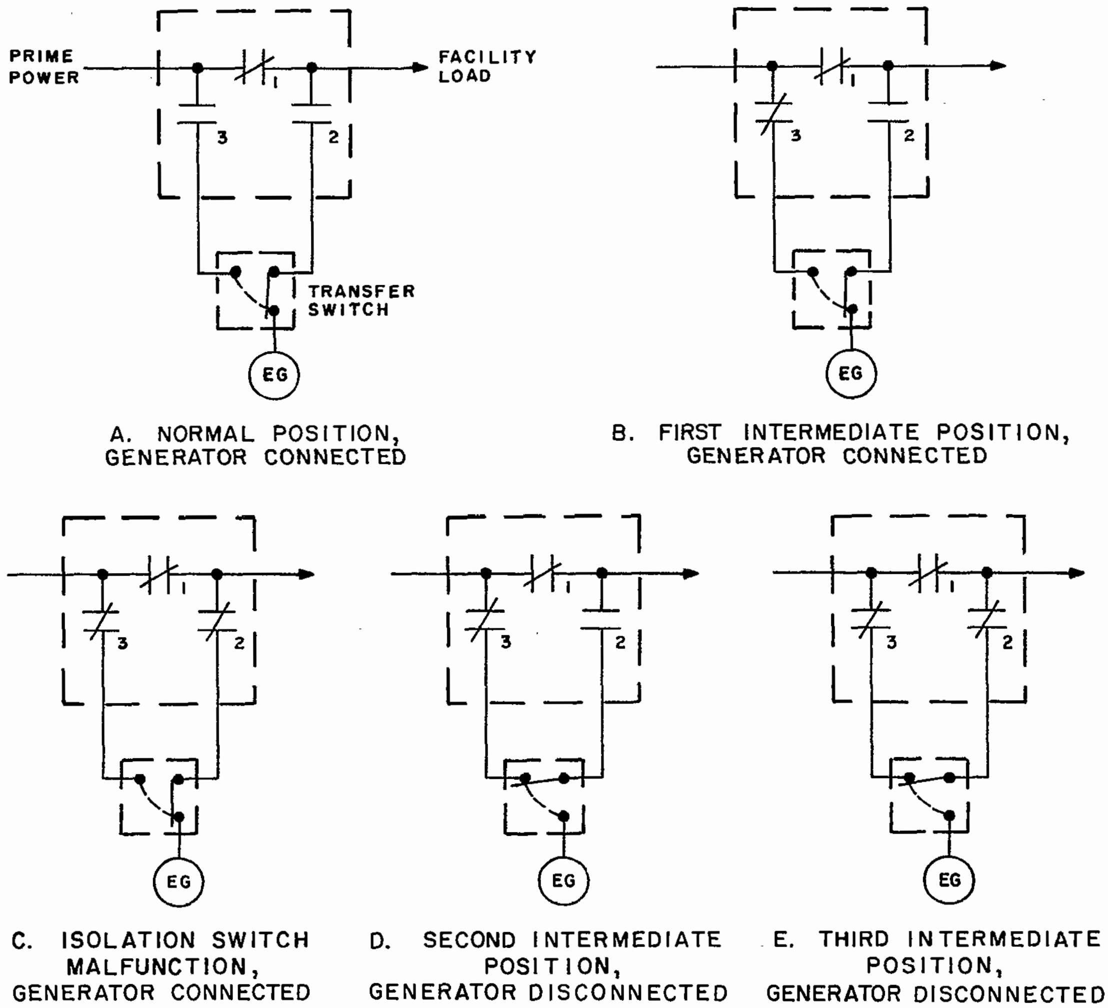
B. FIRST INTERMEDIATE POSITION

C. SECOND INTERMEDIATE POSITION

D. BYPASS POSITION

SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 10. CONTROL PANEL (Continued)

FIGURE 5-36. ISOLATION SWITCH, BYPASS TO NORMAL OPERATION



5-122. CONTROL SWITCHES. Several control switches are mounted on the engine generator control panel. Among these are switches controlling battery charging, lockout, meter selection, voltage regulator, and exciter manual control. It is imperative that the switches listed be left in their normal operating position when the facility is unattended. When maintenance is performed, the proper functioning and position of these controls shall be checked.

5-123. 550 KW ENGINE GENERATOR AND CONTROL EQUIPMENT. For a description of the 550 kW and 750 kW engine generator and associated control equipment and for maintenance procedures and parameters, refer to Order 6470.5, Appendix 2, Maintenance of Air Route Traffic Control Center Environmental Systems. If the facility is not an ARTCC, use that portion of the order that is applicable to the system being maintained.

5-124. thru 5-130. RESERVED.

SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 11. SAFETY DEVICES

5-131. GENERAL. Engine safety devices must be periodically maintained to protect the equipment from dangerous malfunctions. These safety devices are for overtemperature, low oil pressure, overspeed, overcrank, and starter engagement.

5-132. OVERTEMPERATURE. It is generally not practicable to check the cutoff temperature of the coolant overtemperature device with a conventional thermometer. This is because the pressurized system must be opened to measure the coolant temperature with a thermometer, and the overtemperature device may normally be adjusted for a boiling temperature of the system when under pressure. Rather than subject the engine to overheating to test the overtemperature device, the calibration of the device should be checked against the known coolant temperature under normal operating conditions. With the pressure cap removed and a thermometer placed in the coolant in the radiator, operate the engine until the coolant reaches engine thermostat temperature as evidenced by a stabilized radiator temperature approximately equal to the engine thermostat temperature. Slowly reduce the setting of the overtemperature control until the engine cuts off, and compare the indicated temperature on the control with the measured temperature of the coolant. Note the difference, if any, between the two devices for adjusting the overtemperature device to the desired shutdown temperature. Restore the engine to normal and return the overtemperature control to the proper setting for the conditions at that facility.

5-133. LOW OIL PRESSURE DEVICE. The low oil pressure safety switch should be checked to ensure that it will terminate the operation of the engine if the oil pressure falls below a predetermined point. On the conventional type oil switch, connect a voltmeter across the contact with the engine in operation, and observe the pressure at which the contacts close as the engine comes to rest after termination of a test run. In testing this device, it should be noted that some plants have a relay which bypasses the low oil pressure circuit during starting periods to ensure a rapid engine start.

5-134. OVERSPEED DEVICE. An engine may be damaged if excessive overspeed occurs for only a few seconds. In testing overspeed devices, carefully note the point at which the overspeed device terminates the operation of the engine. Most overspeed governors are of a mechanical centrifugal type. They actuate a microswitch, initiating an electrical circuit that terminates the operation of the engine should its speed exceed the specific setting of the overspeed device. Linkage and other parts of this device should be inspected for proper operation and excessive wear. All moving parts should be lubricated as required. When checking the overspeed device on diesels not equipped with a positive air shutoff device, the air cleaners should be removed while the test is in progress.

> **NOTE:** *A piece of flat material must be available to place over the air intake to terminate the operation of the engine should an uncontrolled speed condition develop.*

Overspeed governors are mounted in different locations on engine generator units. Some have the overspeed devices installed on the extended shaft of the exciter. Adjustment is provided by moving a collar which increases or decreases pressure on a spring that controls a set of centrifugal weights. In other cases, these devices are a separate unit driven from an accessory drive, or driven directly from the camshaft. Most units have an adjusting screw for setting the overspeed device to a specific value. In some cases, it is necessary to move the microswitch to obtain the required setting. A few units have two switches mounted on the extended shaft of the exciter: one to control the starting switch cutout and the other for overspeed control. All later model plants have a time delay in the overspeed control circuit, which prevents locking out the plant during the inherent overspeed of the governor during the initial starting period. Whenever excessive overspeed has occurred to an engine generator, examine the engine generator, ascertain the damage sustained by the unit, and take the necessary corrective action discussed below.

a. Connecting rod bolts shall be checked for tightness. When more than 10 percent of the bolts are found loose, it is an indication that the bolts have been stretched excessively. A more accurate check of the bolt stretch may be made by torque measurement of the rod bolts and by comparing readings with the manufacturer's recommendations. If more than 10 percent of the bolts are stretched, all bolts should be replaced.

b. Measure crankshaft deflection with a strain or deflection gauge.

SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 11. SAFETY DEVICES (Continued)

c. Examine main bearing nuts or jackscrews for tightness.

d. Thoroughly inspect the crankcase for loose metal particles or other foreign matter.

e. Take compression readings to ascertain if there are any cracked pistons or broken rings.

f. Examine generators for cracked fan blades, loose or thrown windings, loose or raised commutator bars, and bearing misalignment.

5-135. OVERCRANKING RELAY. Two types of devices control the cranking time of an engine. The Agastat, a pneumatic type, predominates. The timing period may be changed by limiting the amount of air passing through an orifice. The other type is a thermal unit. This thermal unit has a current-limiting resistor incorporated into the circuit that determines the heating time limit of the thermal element. Some plants have a plug-in type thermal element for timing the cranking period. Elements having various timing ranges are available if it becomes necessary to shorten or lengthen the cranking period. Another control (cycle cranking) provides cranking for 15 seconds then resting for 15 seconds, repeating this cycle four times. After the first cycle, the time delay mechanism of the automatic choke should deactivate the choke to eliminate flooding of the carburetor. When making this check, the magneto must be grounded or the coil lead disconnected. The starting sequence of the engine may then be initiated.

5-136. STARTER BUTT TOOTH ENGAGEMENT DEVICE. To check this mechanism, use a bar or rod placed in such a manner as to prevent the solenoid pinion lever from engaging the ring gear. Initiate the no-load starting sequence. After a 1-second delay, the circuit should interrupt and then reclose. Several attempts of opening and closing should occur before the cranking timer locks the main cranking circuit open.

5-137. thru 5-140. RESERVED.

SUBSECTION 12. VOLTAGE REGULATORS

5-141. GENERAL. The exciter field rheostat must be manually adjusted to the normal operating voltage of the plant, and the stability of the voltage must be observed. Set rheostat for proper automatic voltage requirements. With the automatic voltage regulator switch turned on, its rheostat should be adjusted to the rating of the plant or to match the commercial power source. If voltage regulation is not satisfactory, refer to the instruction book for the particular voltage regulator in question. Voltage regulators in use are of the electronic, magnetic amplifier, or rheostat types.

5-142. ELECTRONIC. The electronic regulator controls and provides separate excitation from the output of the main ac generator for the exciter shunt field. The regulator becomes effective when the exciter field rheostat is turned toward the maximum resistance position. The regulator becomes inoperative and the ac generator voltage is under manual control when the exciter field rheostat is turned toward the minimum resistance position. The functions of the adjustments on the regulator are indicated in the instruction book.

5-143. RHEOSTAT. Rheostat regulators control voltage by automatically cutting resistance in and out of the exciter field. The exciter in turn controls the generator field current, thereby controlling the output of the generator. The opening and closing of the contacts to increase or decrease the exciter field resistance is controlled by a solenoid or armature. Its coil is energized by a rectified voltage from the output of the generator. Although there is some variation in the design of regulators, all designs are basically similar and maintenance is practically the same. Some operation problems exist on older type regulators when the contacts of the resistance banks get dirty. Clean these only by air pressure because the contacts or fingers can easily be damaged or misaligned. Clean the regulator control arm rheostat, and properly secure all terminal connections. Cases have been known where reverse polarity of the exciter has affected the voltage regulator. This condition may occur if the antidiesel device fails to operate and the engine diesels in the reverse rotation for several seconds. When reverse polarity is suspected, the polarity of the damping transformer should be checked before reversing the exciter polarity. Some of the older

SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 12. VOLTAGE REGULATORS (Continued)

types had transformers for damping oscillations; however, newer models use a dashpot to perform this function. The rectifiers which furnish direct current to the control arm of the regulator should be checked if operation is erratic.

5-144. MAGNETIC AMPLIFIER. For maintenance of magnetic amplifier type voltage regulators, consult the applicable instruction book.

5-145. thru 5-150. RESERVED.

SUBSECTION 13. CIRCUIT BREAKERS

5-151. GENERAL. The information in this subsection applies in general to all engine generator plants. However, for circuit breakers located in ARTCC's, refer to Order 6470.5A, Maintenance of Air Route Traffic Control Center Environmental Systems. For additional guidance and instructions, refer to the manufacturer's instruction manual.

5-152. CONTROL EQUIPMENT. The generator and control equipment circuit breakers shall be operated periodically. Breakers are designed to open if the circuit load exceeds 125 percent of its nameplate rating at a temperature rise not exceeding 104 °F (40 °C) above an ambient temperature of 104 °F (40 °C). If there is any doubt as to proper breaker operation, it should be tested at its rated output or be replaced.

5-153. MAIN GENERATOR. The two types of main generator circuit breakers are adjustable and fixed breakers.

a. Adjustable Breakers. Most engine generator main circuit breakers have instantaneous trip ranges which are externally adjustable, usually with three intermediate settings between minimum (low) and maximum (high) trip points. The appropriate breaker bulletin should be referred to for details regarding trip settings and precise adjustment procedures.

(1) Minimum Trip Settings. To ensure positive operation, set the instantaneous trip at the lowest value possible without spurious tripping; but in no case shall it be set lower than three times the full load current rating of the generator.

(2) Maximum Trip Setting. The maximum instantaneous trip setting should not exceed six times the full load current rating of the generator.

b. Fixed Breakers. Nonadjustable breakers are selected with a capacity rating suitable for the short circuit characteristics of the generator and the characteristics of the load. The instantaneous trip is factory set and sealed against field adjustment. If there is any doubt as to the proper circuit breaker operation, replace it.

5-154. thru 5-159. RESERVED.

SUBSECTION 14. RESISTIVE LOAD BANKS

5-160. GENERAL. Resistive load banks (portable and fixed) are used to test engine generators under loaded conditions without interfering with facility operations.

NOTE: The load bank shall not be connected to the engine generator during the start or stop cycle.

The following procedures apply to load testing all engine generator.

a. Portable. The portable units usually do not exceed 21 kW and are equipped with switches for varying the applied load from 0.25 to 21 kW.

(1) Locate the load outside the building in an area where the heat radiated from the load will not result in damage.

(2) Lock out the engine generator, and isolate it from the commercial power.

SECTION 2. MAINTENANCE ACTIVITIES PROCEDURES (Continued)
SUBSECTION 14. RESISTIVE LOAD BANKS (Continued)

(3) Open the generator circuit breaker.

(4) Connect the load into the test jacks, and ground the load to a facility ground.

(5) Adjust the load switches for a load approximately equal to the full rated capacity of the engine generator.

(6) Start the engine and close the circuit breaker after the engine is up to rated speed.

(7) Following load testing, open the generator circuit breaker, and allow the plant to run for a few minutes to cool the engine.

(8) Disconnect the load and restore the engine generator to normal service.

b. Fixed. The permanently installed load banks vary in size according to the capacity of the engine generator at the site. The load banks are connected to the engine generator either by the use of plugs and jacks or through automatic load dropping relays that permit load testing without isolating the plant from commercial power.

(1) When load testing using fixed loads that have plug and jack connections to the plant, use paragraph 5-160a as outlined for portable load banks.

(2) When load testing units that have automatic load dropping relays, follow the procedures outlined in the appropriate instruction book.

5-161.-thru 5-165. RESERVED.

SECTION 3. SPECIAL MAINTENANCE PROCEDURES

5-166. MOBILE SHOP. Properly scheduled maintenance of standby engine generator units is a field responsibility. However, in cases where extensive repairs or major overhaul makes such action technically and economically feasible, a mobile engine generator repair shop should be set up and scheduled to perform the necessary work. Overhaul of engine generators shall be scheduled to comply with paragraphs 4-6, 4-36, and 4-58. Equipment of mobile shops shall be the prerogative of the regions depending upon the justification and need. Some regions require rather complete units due to the unavailability of adequate local shops, and some have a number of units where it is more economical and feasible to perform the overhaul on a scheduled basis. Other regions may only require a one- or two-man crew with a small vehicle to perform the same functions due to the limited number of power facilities or a lack of isolated facilities to warrant a full-sized shop. These mobile units will, however, be equipped with load banks of sufficient capacity for use on both single- or three-phase systems. They should also be equipped with recording meters for frequency and voltage. Other recording instruments may be added as required.

5-167. REPAIR BY LOCAL SHOP. Where overhaul of engine generator is done on a contract basis by a local shop, the standards, tolerances, and criteria in this order as well as applicable portions of the instruction book shall be followed. After a unit has been overhauled either by the region or a local shop, data of the type included in, but not limited to, the following list should be logged. The complete log should be inserted in an 8-1/2-inch by 11-inch loose-leaf 3-ring binder. This binder along with the engine generator log book should be kept with the unit.

Date
Manufacturer
Serial Number
KW
Work Order No.
Date of Previous Overhaul
Elapsed Time Meter Reading
Starter Centrifugal Switch Opens (rpm)
Overcrank Relay Operation
Starter Contactor Overhauled
Potential Relay Setting
  1PR - Pickup volts
  2PR - Pickup volts
  3PR - Pickup volts
  4PR - Pickup volts
  1PR - Dropout volts
  2PR - Dropout volts
  3PR - Dropout volts
Transfer Relay (TR) Time Delay (Sec.)
Over Temp. Switch Opens (Deg.)
Low Oil Press. Switch Opens (psig)

SECTION 3. SPECIAL MAINTENANCE PROCEDURES (Continued)

Overspeed Switch Setting (rpm)
Generator and Exciter
Armature Reinsulated (Varnish)
Field Coil Reinsulated (Varnish)
Brush Seating Percent
Commutator Mica Undercut
Commutator Turned
Slip Rings True
Brushes Staggered
Bearings Replaced
Volt. Reg. Range
Engine
Cylinder Rebored
Cylinder Honed
Cylinder Sleeves Replaced
Cylinder Size
Piston Ring Size
Piston Size
Piston Pin Size
Connecting Rod Bearing Size
Gasoline Fuel Pumps Press.
Timing Degrees (BTC)
Sparkplug Type
Sparkplug Gap
Magneto Overhauled
Distributor Overhauled
Exact size to 0.001 inch
Inject Pump Overhauled
Injector Nozzle Press (Each Cyl.)
Diesel Fuel Pump (psig)
Valve Setting; Exhaust
Oil Pressure (psig)
Water Pump Overhauled
Compression (Each Cyl.)
Cylinder Temperature (Each Cyl.)
Firing Press. (Each Cyl.)
(At Specific Facility Load)

5-168. ENGINE GENERATOR STORAGE.

a. General. The following description covers the requirements for preparing a liquid-cooled, diesel or gasoline engine generator for storage.

(1) All Engine Generators.

(a) Drain the cooling system of liquid-cooled engines, including all low points of the engine block, water pumps, and hoses. Refill the cooling system with a mixture of 60 percent ethylene glycol antifreeze and 40 percent water. Add rust inhibitor and water pump lubricant (see paragraph 5-16) if not contained in the antifreeze. Run the engine long enough to open the thermostat and to circulate the cooling solution.

(b) Shut down the engine, and while it is hot, drain the lubricating oil system, including all sumps and oil filter housings. Remove and discard the used oil filter(s). Fill the crankcase to the low level mark on the dipstick with preservative oil. Add extra preservative oil to equal the quantity required by the oil filter housing(s). The preservative oil shall conform to MIL-L-21260, Grade 2, and may be ordered by NSN 9150-00-111-0210 (SAE No. 30W in 55 gallon quantity). The preservative oil can be purchased in various quantities and SAE viscosities from most local commercial distributors.

(2) Diesel Engine Generators. After the cooling system and the crankcase have been filled:

(a) Run the plant for 10 minutes, then shut down the engine.

(b) After the engine has been shut down, remove the injectors, and spray a small amount of preservative oil in each cylinder. While spraying oil into the cylinders, turn the engine over for at least five complete revolutions. Do not spray preservative oil into the intake manifold with the engine running because this can cause engine overspeed if the speed governor should fail.

(c) Coat tip and threads of each injector with preservative oil and reinstall. Torque injectors to specifications and connect fuel lines. Leave fuel in the lines, injectors, and pumps for protection during storage.

(d) On valve-in-head engines, remove valve cover(s), and spray the interior side of the valve cover(s). Spray surfaces within the valve compartment, including rocker mechanism, valve stems, springs, guides, and push rods. On engines with the valves in the block, remove the valve compartment cover plate, and spray the entire interior of the compartment including valve mechanisms. Spray the interior side of the valve compartment cover plate(s) before installing.

(e) Spray the interior of the air cleaner housing and crankcase ventilator pipes with preservative oil. Clean the oil-wetted or oil-saturated types of air cleaner filter elements and wet with preservative oil.

SECTION 3. SPECIAL MAINTENANCE PROCEDURES (Continued)

(f) Coat all exterior machined surfaces that have not been painted (fan pulleys, flywheel, etc.) with preservative oil.

(g) Seal all engine openings with masking or sealing tape, including air intakes and breather openings. Tag lube oil filter housing(s) with a tag to indicate that the filter element(s) has been removed.

(h) Remove the tension on all fan belts.

(i) Seal all generator ventilation openings and control cabinet openings with masking or sealing tape.

(3) Gasoline Engine Generator. After the cooling system and the crankcase have been filled:

(a) Start and run the engine for 10 minutes. During the last 2 minutes, spray preservative oil into the carburetor air intake.

(b) Shut down the engine, and drain gasoline from the fuel system, making certain that all reservoirs, carburetor float bowl, sumps, and other low points are drained. If the engine has an auxiliary fuel circulating tank, drain the gasoline and seal the tank.

(c) After the engine has thoroughly cooled, remove the sparkplugs and spray a small amount of preservative oil into the combustion chambers. While spraying oil into the sparkplug holes, turn the engine over for at least five complete revolutions.

(d) Coat the threads of the spark plugs with preservative oil and reinstall. Torque to specifications.

(e) Repeat steps (2)(d), (e), (f), (g), (h), and (i).

b. Preoperation Instructions. After completing the above procedure, attach an envelope type tag on the engine instrument panel containing preoperation instructions, which shall include:

(1) Necessary data for preparing the engine generator for operation.

(2) Items such as clearing all openings of tape, cleaning relay contacts and commutators, filling oil bath air cleaner, installing oil filter(s), draining and filling the crankcase, etc.

(3) Marking the envelope on both sides with large bold print: "Preoperative Instructions."

APPENDIX 1. METRIC CONVERSION TABLE

LENGTH

1 millimeter	= 0.03937 inch	1 inch	= 25.4 millimeters (mm)
1 centimeter	= 0.3937 inch	1 inch	= 2.54 centimeters (cm)
1 meter	= 3.2808 feet	1 foot	= 0.3048 meter
1 meter	= 1.0936 yards	1 yard	= 0.9144 meter

CAPACITY

1 liter	= 0.2642 gallon (U.S.)	1 gallon	= 3.7853 liters
1 liter	= 1.056 quarts (liquid)	1 liter	= 0.9081 quart (dry)

WEIGHT

1 gram	= 0.0353 ounce (avdp.)	1 ounce	= 28.3495 grams
1 kg	= 2.2046 pounds (avdp.)	1 pound	= 0.4536 kg.

PRESSURE

1 kg per sq. cm	= 14.223 lbs. per sq. inch
1 lb per sq. inch	= 0.0703 kg. per sq. cm

APPENDIX 2. DEFINITIONS AND ACRONYMS

Ampere-hour rating	A battery capacity rating which is the product of discharge current in amperes multiplied by the time in hours that the current exists before the cell voltage decreases to the cutoff voltage.
ATC	Air Traffic Control
CR	Transfer switch delay relay
FSD	Frequency-sensing device
IM	Inphase monitor
LPG	Liquid petroleum gas
Mobile powerplant	A powerplant which is officially categorized and used as a temporary or emergency powerplant.
NEC	National electrical code
NFPA	National Fire Protection Association
pH	Degree of acidity or alkalinity
PR	Potential relay
Prime power	That source of electrical energy utilized by the user which is normally available continuously and usually supplied by an electrical utility company (also referred to as commercial power). Prime power can be generated onsite where commercial power is unavailable.
RMM	Remote maintenance monitor
RMS	Root mean square
SAE	Society of Automotive Engineers
SCR	Silicon controlled rectifier
Standby power	An alternative electrical energy source that can be switched to perform the function of the preferred source (i.e., prime power), routinely or when the preferred source has failed or is inoperative.
TD	Time delay
TR	Transfer relay
TVR	Temperature-compensated voltage relay
UFE	Underfrequency monitor
UVE	Undervoltage monitor

APPENDIX 3. PROPANE AND NATURAL GAS E/G FUEL SYSTEM TROUBLESHOOTING DRAWINGS

This Appendix contains the following troubleshooting drawings for propane and natural gas fuel systems for FAA engine generators.

LIST OF FIGURES

Figure A3-1. Normal operating parameters and troubleshooting information for a propane fuel system that withdraws liquid propane from the storage tanks and uses a coolant heated vaporizer (Impco Model PE) that is mounted outside of the E/G room. This configuration uses an Impco or Nolff's brand of carburetor. This is the most common propane fuel configuration used in the FAA. This configuration is used to fuel both legacy and Kohler E/Gs. This type of fuel system was called out in the original propane modification AF P 6980.3, Change 289, Chapter 249, "Conversion of Engine Generators from Gasoline-Fueled to Propane-Fueled," dated 01/04/1990.

Figure A3-2. Normal operating parameters and troubleshooting information for a propane fuel system that withdraws propane vapor from the storage tanks. This configuration uses an Impco or Nolff's brand of carburetor. This configuration is used to fuel both legacy and Kohler E/Gs. This configuration is used primarily in the Southern Region of the FAA.

Figure A3-3. Normal operating parameters and troubleshooting information for a propane fuel system that withdraws liquid propane from the storage tanks and uses a coolant heated vaporizer (Impco Model EB) that is mounted inside the E/G room at the inlet to the engine carburetor. This configuration uses an Impco or Nolff's brand of carburetor. This configuration is used to fuel both legacy and Kohler E/Gs. This configuration is used primarily in the Central Region of the FAA.

Figure A3-4. Normal operating parameters and troubleshooting information for a propane fuel system that withdraws liquid propane from the storage tanks and uses an electric heated vaporizer (manufactured by Sam Dick Industries) that is mounted outside of the E/G room. This configuration uses an Impco or Nolff's brand of carburetor. This configuration is used only on Kohler E/Gs. The Sam Dick Industries electric vaporizer was provided with each Kohler E/G during the early years of the Kohler contract. During the later years of the Kohler contract, the electric vaporizer was an option that had to be selected.

Figure A3-5. Normal operating parameters and troubleshooting information for a typical natural gas fuel system. This configuration uses an Impco or Nolff's brand of carburetor. This configuration is used to fuel both legacy and Kohler E/Gs.

Figure A3-6. Normal operating parameters and troubleshooting information for Kohler Propane or Natural Gas E/G Equipped with Woodward LC-50 carburetor and Maxitrol R600Z Regulator. Beginning in May 2002, Kohler changed over to a new Woodward carburetor and governor control system. This configuration is used only on Kohler E/Gs delivered after May of 2002.

NOTES:

1. "w.c. pressure" stands for water column pressure. Inches of water column are used to measure low pressure. There are 27.70 inches of water column in one psi. Or one inch of water column pressure is approximately 1/28th of a psi.
2. The Carburetor Test Fitting, 3/16" ID hose, Magnehelic pressure gauges, and the 1/8" NPT by 3/16" hose barb fittings are included in the NSN 5180-01-483-1236 Propane and Natural Gas E/G Test Kit.
3. The NSN 5180-01-483-1236 Propane and Natural Gas E/G Test Kit has the drill bits and 1/8" NPT tap to add fuel pressure test ports to the regulator.
4. The Magnehelic pressure gauges measure the differential pressure between the two ports on the gauge housing. To measure a negative pressure (vacuum) connect the 3/16" hose to the lower port. To measure a positive pressure, connect the 3/16" hose to the upper port.

Normal Operation

-5 to -6" w.c. pressure (vacuum) during cranking.
-5 to -14" w.c. pressure (vacuum) from no load to full load operation.

Troubleshooting

0 to -5" w.c. pressure (vacuum) during cranking indicates the air/gas valve is stuck open or a low intake manifold vacuum.
-6" w.c. pressure (vacuum) or higher during cranking indicates a ruptured air/gas valve diaphragm or the air/gas valve is stuck closed.
-14" w.c. pressure (vacuum) or higher during engine operation indicates one of the following:
- the air/gas valve diaphragm is ruptured.
- the air/gas valve assembly is binding/sticking.
- the air filter is dirty or restricted.
- the carburetor is too small for the engine.

Normal Operation

-0.7 to -1.7" w.c. pressure (vacuum) at all times.

Troubleshooting

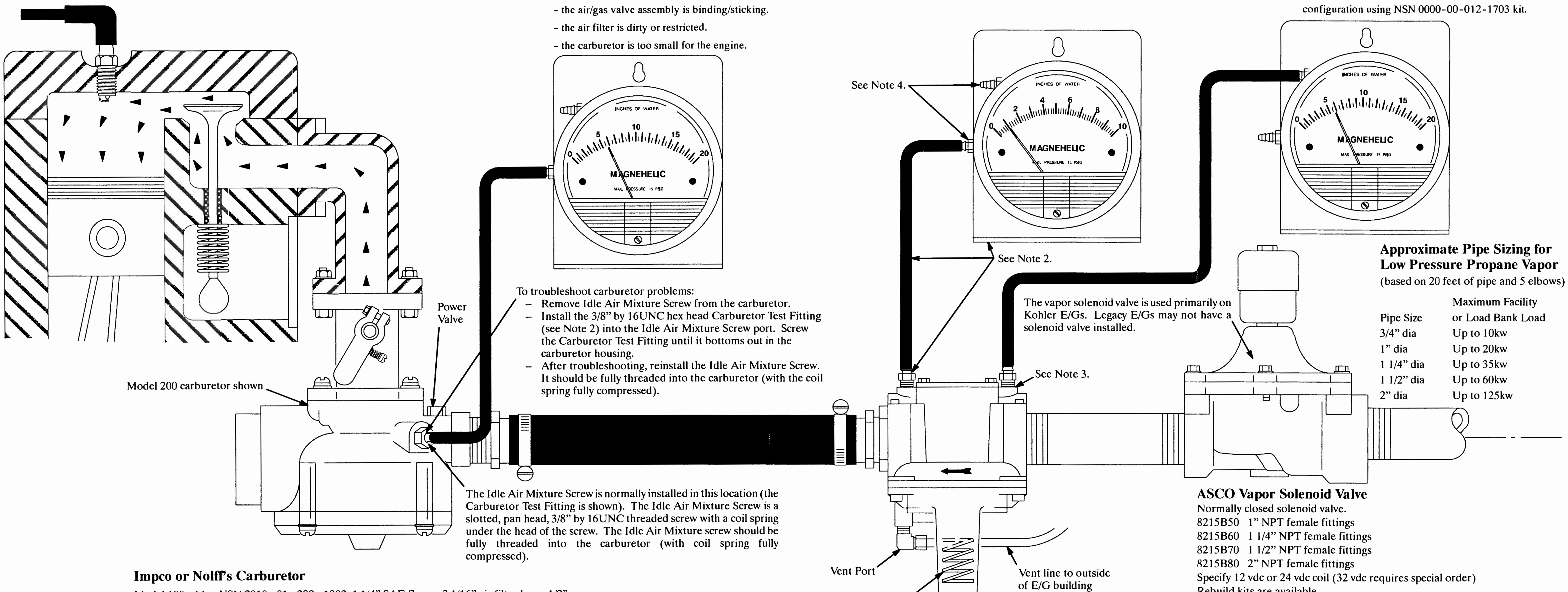
-5 to -6" w.c. pressure (vacuum) during cranking indicates no fuel flow.
+3 to +6" w.c. pressure during engine operation indicates the regulating spring is still installed inside the regulator. Remove the regulating spring (see below).
-2 to -6" w.c. pressure (vacuum) during cranking indicates regulator is binding (replace regulator) or vent line is clogged (clear out debris).

Normal Operation

+4 to +11" w.c. pressure at all times.

Troubleshooting

-5 to -6" w.c. pressure (vacuum) during cranking indicates no fuel flow.
0 to +11" w.c. pressure during engine operation. If pressure drops as load increases, there is a fuel flow restriction (faulty solenoid, piping too small).
-1 to -2" w.c. pressure (vacuum) during engine operation indicates an Impco Model EB vaporizer is installed instead of the correct Model PE vaporizer. Convert to a Model PE configuration using NSN 0000-00-012-1703 kit.



To troubleshoot carburetor problems:
- Remove Idle Air Mixture Screw from the carburetor.
- Install the 3/8" by 16UNC hex head Carburetor Test Fitting (see Note 2) into the Idle Air Mixture Screw port. Screw the Carburetor Test Fitting until it bottoms out in the carburetor housing.
- After troubleshooting, reinstall the Idle Air Mixture Screw. It should be fully threaded into the carburetor (with the coil spring fully compressed).

The vapor solenoid valve is used primarily on Kohler E/Gs. Legacy E/Gs may not have a solenoid valve installed.

The Idle Air Mixture Screw is normally installed in this location (the Carburetor Test Fitting is shown). The Idle Air Mixture Screw is a slotted, pan head, 3/8" by 16UNC threaded screw with a coil spring under the head of the screw. The Idle Air Mixture screw should be fully threaded into the carburetor (with coil spring fully compressed).

Remove the regulating spring and install the regulator upside down (as shown) for propane fuel. Remove slot head cap and nylon adjusting screw to gain access to regulating spring. Reinstall slot head cap and nylon adjusting screw. Regulating spring is used for natural gas fuel only.

Approximate Pipe Sizing for Low Pressure Propane Vapor
(based on 20 feet of pipe and 5 elbows)

Pipe Size	Maximum Facility or Load Bank Load
3/4" dia	Up to 10kw
1" dia	Up to 20kw
1 1/4" dia	Up to 35kw
1 1/2" dia	Up to 60kw
2" dia	Up to 125kw

ASCO Vapor Solenoid Valve
Normally closed solenoid valve.
8215B50 1" NPT female fittings
8215B60 1 1/4" NPT female fittings
8215B70 1 1/2" NPT female fittings
8215B80 2" NPT female fittings
Specify 12 vdc or 24 vdc coil (32 vdc requires special order)
Rebuild kits are available.

Impco or Nolff's Carburetor

Model 100-64	NSN 2910-01-299-1802, 1 1/4" SAE flange, 2 1/16" air filter horn, 1/2" NPT female fuel inlet, D1-17-2 replacement diaphragm.
Model 125	not stocklisted, 1/2" NPT female inlet, D1-17-2 replacement diaphragm.
Model 200-4	NSN 2910-01-299-2713, 1 3/4" SAE flange, 2 5/8" air filter horn, 3/4" NPT female fuel inlet, D1-16-2 replacement diaphragm.
Model 200-6	NSN 2910-01-299-1803, 2" SAE flange, 3 1/16" air filter horn, 3/4" NPT female fuel inlet, D1-16-2 replacement diaphragm.
Model 225	not stocklisted, 3/4" NPT female fuel inlet, D1-16-2 replacement diaphragm.
Model 425	not stocklisted, 1" NPT female fuel inlet, D1-25 replacement diaphragm. (The Carburetor Test Fitting cannot be used on the Model 425 carburetor)

Impco/Maxitrol Secondary Regulator
IMP-52 3/4" NPT female fittings
IMP-53 NSN 4820-01-299-0215, 1" NPT female fittings
IMP-61 1 1/4" NPT female fittings
No repair parts available.

FEDERAL AVIATION ADMINISTRATION

System Configuration:	**Propane Liquid from Storage Tank**
For Carburetor Type:	**Impco or Nolff's brand**
Propane Vaporizer:	**Impco Model PE (coolant heated) Mounted Outside the E/G Building**
For E/G Type:	**Legacy E/G's and Kohler E/G's**
For FAA Regions:	**All Regions. Most Common Configuration in FAA**

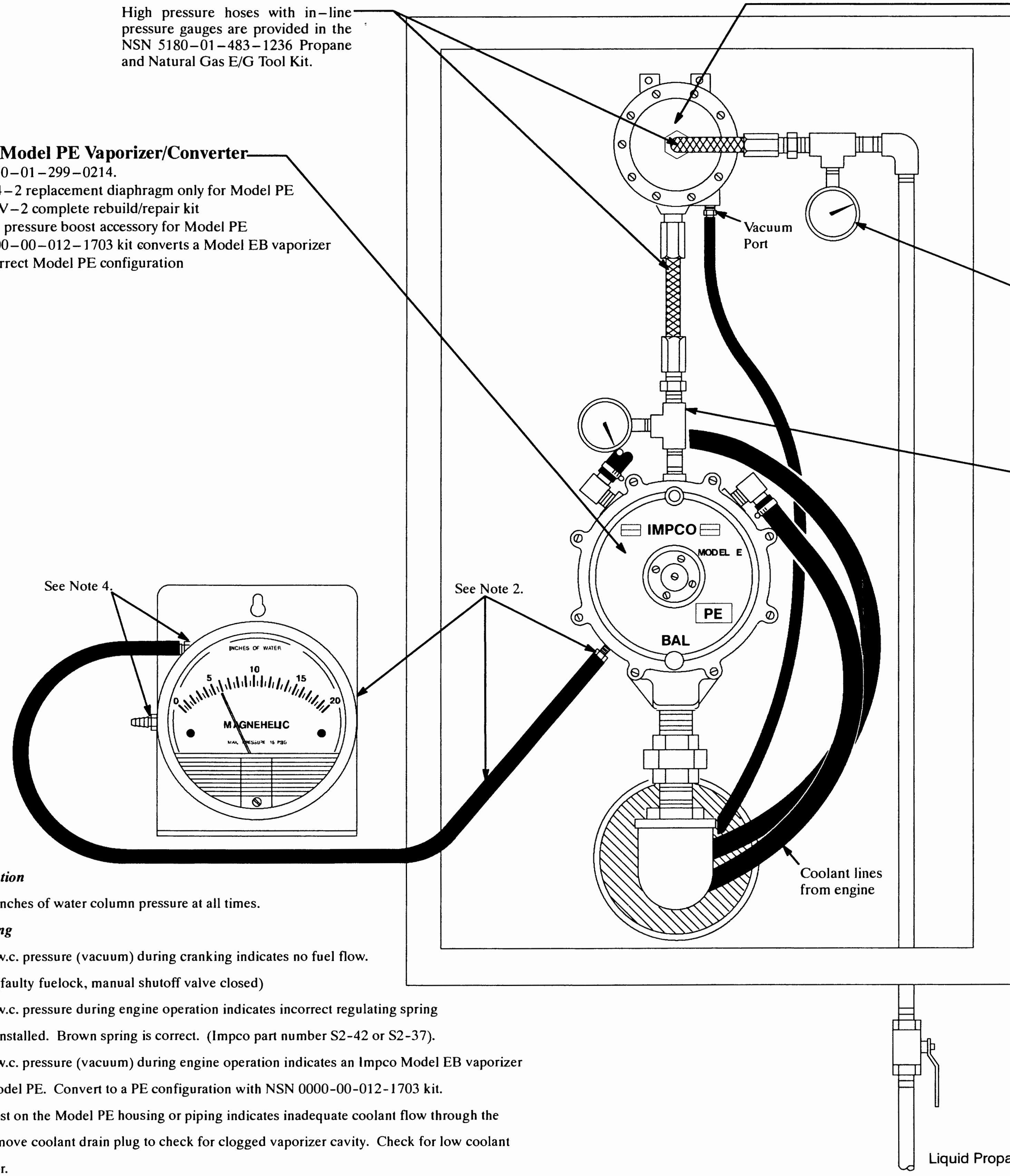
SUBMITTED BY **Tim Riley**
DRAWN BY **Ron Perkins**

Figure A3-1.

SHEET 1 OF 2 — REV. **D**

High pressure hoses with in-line pressure gauges are provided in the NSN 5180-01-483-1236 Propane and Natural Gas E/G Tool Kit.

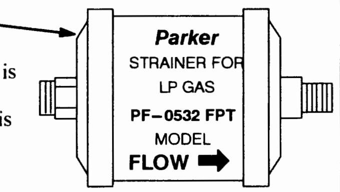
Impco Model PE Vaporizer/Converter
NSN 4810-01-299-0214.
AD1-14-2 replacement diaphragm only for Model PE
RK-PEV-2 complete rebuild/repair kit
AC1-74 pressure boost accessory for Model PE
NSN 0000-00-012-1703 kit converts a Model EB vaporizer to the correct Model PE configuration



Impco VFF-30 Vacuum Fuelock Filter OR
(used on legacy E/Gs only)
NSN 5915-01-298-9831
RK-VFF30-2 repair kit
AF1-10 replacement filter assembly

Normal Operation
-2" of w.c. pressure or greater (a vacuum) from the engine intake manifold or carburetor is needed at the vacuum port to open the fuelock filter and allow fuel to flow.
Troubleshooting
If -2" w.c. pressure or greater (a vacuum) is present at the vacuum port and the fuelock does not open, then rebuild or replace the VFF-30 unit. If frost appears on the VFF-30 housing, the filter is clogged and should be replaced.

Parker #PF-0532 Strainer
(used on Kohler E/Gs only)
On Kohler E/Gs the Parker strainer is used in place of the Impco Vff-30 Fuelock Filter. The Parker strainer is a filter only, it does not provide any fuel shutoff function.



Normal Operation
See Liquid Propane Pressure chart for correct pressure.
Troubleshooting
0 psi indicates no fuel flow. Manual shutoff valve closed. If the pressure is significantly less than the pressure given in the Liquid Propane Pressure chart, then a poor quality propane fuel is likely present (not HD-5 grade propane).

Normal Operation
See Liquid Propane Pressure chart for correct pressure.
Troubleshooting
0 psi indicates no fuel flow. Possible causes are loss of manifold vacuum, internal fuelock filter failure, or manual shutoff valve is closed. Pressure above 0 psi but below Liquid Propane chart value indicates possible clogged filter element.

LIQUID PROPANE PRESSURE

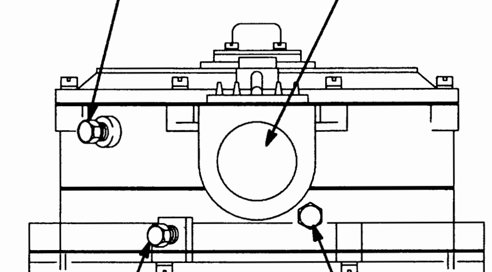
Propane pressure (tank pressure) varies with temperature. See below.

Temperature °F	Tank Pressure HD-5 Propane
-44	0 psi
-40	1.3 psi
-30	5.5 psi
-20	11.0 psi
-10	17 psi
0	24 psi
10	32 psi
20	41 psi
30	52 psi
40	63 psi
50	77 psi
60	93 psi
70	109 psi
80	128 psi
90	149 psi
100	172 psi
110	197 psi
120	224 psi
130	253 psi

* HD-5 Commercial grade propane per specification ASTM D 1835, "Standard Specification for Liquefied Petroleum (LP) Gases." HD-5 propane is at least 90% pure propane and a maximum 5% of propylene. If butane is mixed into the fuel, the above pressure s are reduced.

1/8" NPT Output Pressure Test Port (Magnehelic pressure gauge is connected to this port)

1" NPT Outlet



1/8" NPT Coolant Drain Plug

1/8" NPT Internal Pressure Test Port (not used).

Bottom View of Model PE Vaporizer

Normal Operation
+4 to +11" inches of water column pressure at all times.
Troubleshooting
-5 to -6" w.c. pressure (vacuum) during cranking indicates no fuel flow. (faulty fuelock, manual shutoff valve closed)
0 to +4" w.c. pressure during engine operation indicates incorrect regulating spring installed. Brown spring is correct. (Impco part number S2-42 or S2-37).
-1 to -2" w.c. pressure (vacuum) during engine operation indicates an Impco Model EB vaporizer instead of a Model PE. Convert to a PE configuration with NSN 0000-00-012-1703 kit.
Freezing or frost on the Model PE housing or piping indicates inadequate coolant flow through the vaporizer. Remove coolant drain plug to check for clogged vaporizer cavity. Check for low coolant level in radiator.
Propane odor from "BAL" port during operation indicates a ruptured diaphragm. Check for a ruptured diaphragm by removing the round, perforated brass cover from the "BAL" port. Operate the engine at no load. Seal off the "BAL" port with your finger. If the output pressure goes significantly higher (beyond 11 inches of w.c.), then the diaphragm is faulty. Replace the diaphragm.

FEDERAL AVIATION ADMINISTRATION

System Configuration:	Propane Liquid from Storage Tank
For Carburetor Type:	Impco or Nolff's brand
Propane Vaporizer:	Impco Model PE (coolant heated) Mounted Outside the E/G Building
For E/G Type:	Legacy E/G's and Kohler E/G's
For FAA Regions:	All Regions. Most Common Configuration in FAA

SUBMITTED BY Tim Riley / DRAWN BY Ron Perkins	Figure A3-1.	SHEET 2 OF 2	REV. D

NOTES:

1. "w.c. pressure" stands for water column pressure. Inches of water column are used to measure low pressure. There are 27.70 inches of water column in one psi. Or one inch of water column pressure is approximately 1/28th of a psi.
2. The Carburetor Test Fitting, 3/16" ID hose, Magnehelic pressure gauges, and the 1/8" NPT by 3/16" hose barb fittings are included in the NSN 5180–01–483–1236 Propane and Natural Gas E/G Test Kit.
3. The NSN 5180–01–483–1236 Propane and Natural Gas E/G Test Kit has the drill bits and 1/8" NPT tap to add fuel pressure test ports to the regulator.
4. The Magnehelic pressure gauges measure the differential pressure between the two ports on the gauge housing. To measure a negative pressure (vacuum) connect the 3/16" hose to the lower port. To measure a positive pressure, connect the 3/16" hose to the upper port.

Normal Operation

-5 to -6"	w.c. pressure (vacuum) during cranking.
-5 to -14"	w.c. pressure (vacuum) from no load to full load operation.

Troubleshooting

0 to -5"	w.c. pressure (vacuum) during cranking indicates the air/gas valve is stuck open or a low intake manifold vacuum.
-6"	w.c. pressure (vacuum) or higher during cranking indicates a ruptured air/gas valve diaphragm or the air/gas valve is stuck closed.
-14"	w.c. pressure (vacuum) or higher during engine operation indicates one of the following: - the air/gas valve diaphragm is ruptured. - the air/gas valve assembly is binding/sticking. - the air filter is dirty or restricted. - the carburetor is too small for the engine.

Normal Operation

-0.7 to -1.7"	w.c. pressure (vacuum) at all times.

Troubleshooting

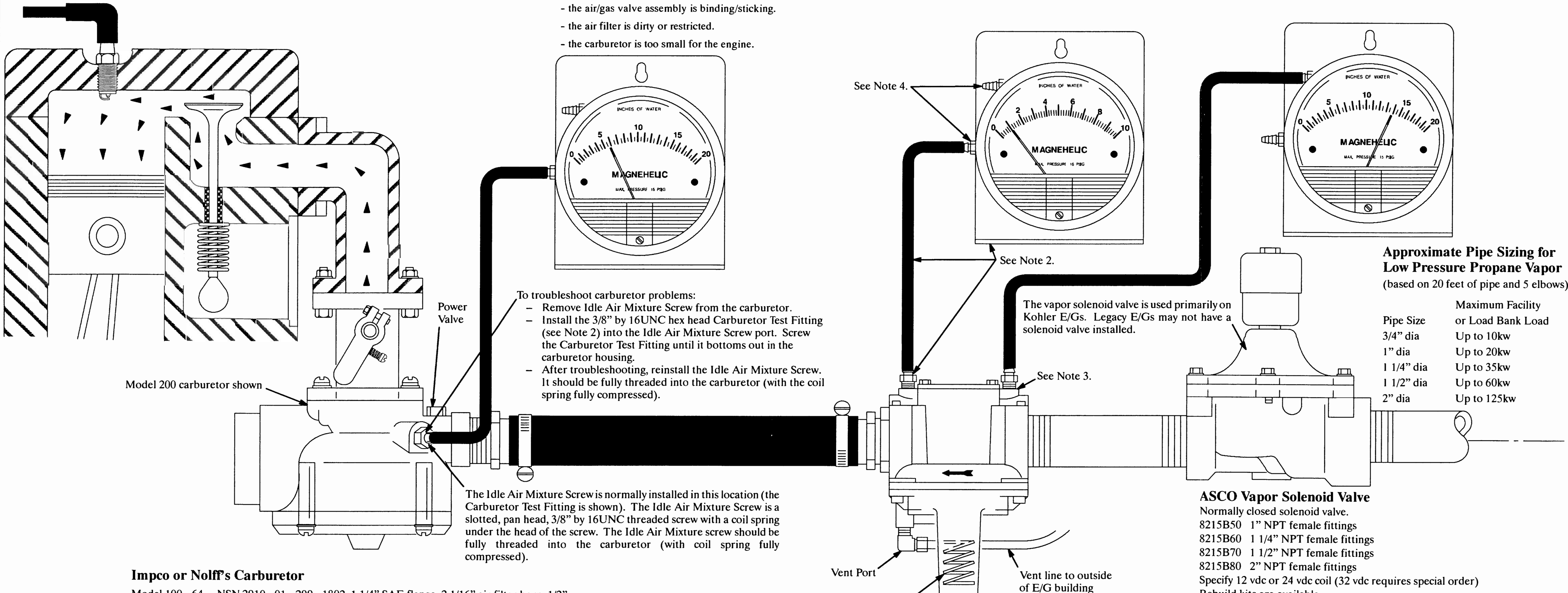
-5 to -6"	w.c. pressure (vacuum) during cranking indicates no fuel flow.
+3 to +6"	w.c. pressure during engine operation indicates the regulating spring is still installed inside the regulator. Remove the regulating spring (see below).
-2 to -6"	w.c. pressure (vacuum) during cranking indicates regulator is binding (replace regulator) or vent line is clogged (clear out debris).

Normal Operation

+11 to +14"	w.c. pressure at all times.

Troubleshooting

-5 to -6"	w.c. pressure (vacuum) during cranking indicates no fuel flow. (failed solenoid valve or manual shutoff valve is closed).
Less than +11"	w.c. pressure during engine operation. If pressure drops as load increases, there is a fuel flow restriction (faulty solenoid valve or piping is too small for engine fuel requirements).



Approximate Pipe Sizing for Low Pressure Propane Vapor
(based on 20 feet of pipe and 5 elbows)

Pipe Size	Maximum Facility or Load Bank Load
3/4" dia	Up to 10kw
1" dia	Up to 20kw
1 1/4" dia	Up to 35kw
1 1/2" dia	Up to 60kw
2" dia	Up to 125kw

ASCO Vapor Solenoid Valve
Normally closed solenoid valve.
8215B50 1" NPT female fittings
8215B60 1 1/4" NPT female fittings
8215B70 1 1/2" NPT female fittings
8215B80 2" NPT female fittings
Specify 12 vdc or 24 vdc coil (32 vdc requires special order)
Rebuild kits are available.

Impco or Nolff's Carburetor

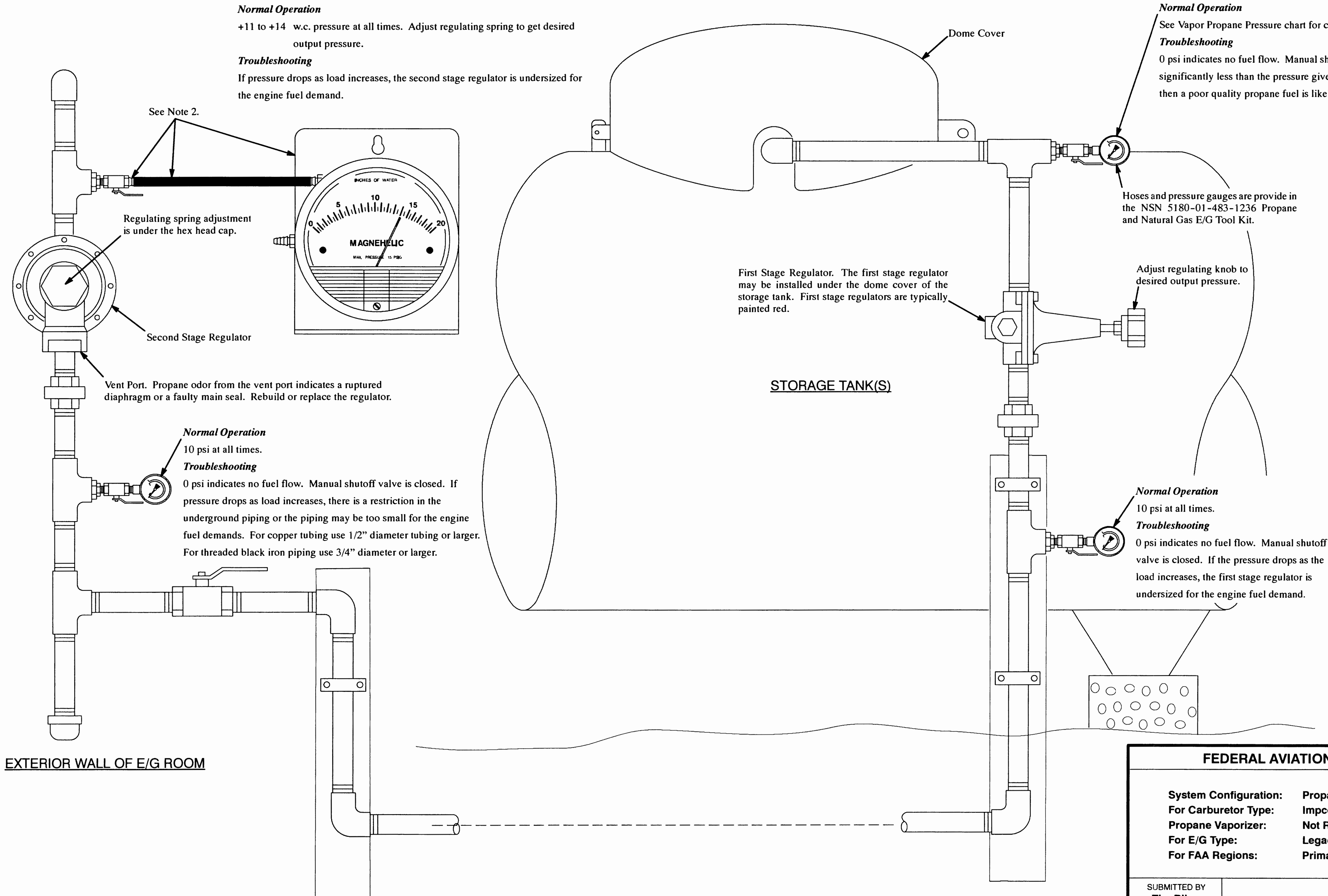
Model 100–64	NSN 2910–01–299–1802, 1 1/4" SAE flange, 2 1/16" air filter horn, 1/2" NPT female fuel inlet, D1–17–2 replacement diaphragm.
Model 125	not stocklisted, 1/2" NPT female inlet, D1–17–2 replacement diaphragm.
Model 200–4	NSN 2910–01–299–2713, 1 3/4" SAE flange, 2 5/8" air filter horn, 3/4" NPT female fuel inlet, D1–16–2 replacement diaphragm.
Model 200–6	NSN 2910–01–299–1803, 2" SAE flange, 3 1/16" air filter horn, 3/4" NPT female fuel inlet, D1–16–2 replacement diaphragm.
Model 225	not stocklisted, 3/4" NPT female fuel inlet, D1–16–2 replacement diaphragm.
Model 425	not stocklisted, 1" NPT female fuel inlet, D1–25 replacement diaphragm. (The Carburetor Test Fitting cannot be used on the Model 425 carburetor)

Impco/Maxitrol Secondary Regulator
IMP–52 3/4" NPT female fittings
IMP–53 NSN 4820–01–299–0215, 1" NPT female fittings
IMP–61 1 1/4" NPT female fittings
No repair parts available.

FEDERAL AVIATION ADMINISTRATION

System Configuration:	**Propane Vapor from Storage Tank**
For Carburetor Type:	**Impco or Nolff's brand**
Propane Vaporizer:	**Not Required**
For E/G Type:	**Legacy E/G's and Kohler E/G's**
For FAA Regions:	**Primarily Southern Region (ASO)**

SUBMITTED BY / DRAWN BY		SHEET	REV.
Tim Riley / Ron Perkins	**Figure A3–2.**	1 OF 2	E



VAPOR PROPANE PRESSURE

Propane pressure (tank pressure) varies with temperature. See below.

Temperature °F	Tank Pressure HD-5 Propane
-44	0 psi
-40	1.3 psi
-30	5.5 psi
-20	11.0 psi
-10	17 psi
0	24 psi
10	32 psi
20	41 psi
30	52 psi
40	63 psi
50	77 psi
60	93 psi
70	109 psi
80	128 psi
90	149 psi
100	172 psi
110	197 psi
120	224 psi
130	253 psi

* HD-5 Commercial grade propane per specification ASTM D 1835, "Standard Specification for Liquefied Petroleum (LP) Gases." HD-5 propane is at least 90% pure propane and a maximum 5% of propylene. If butane is mixed into the fuel, the above pressure s are reduced.

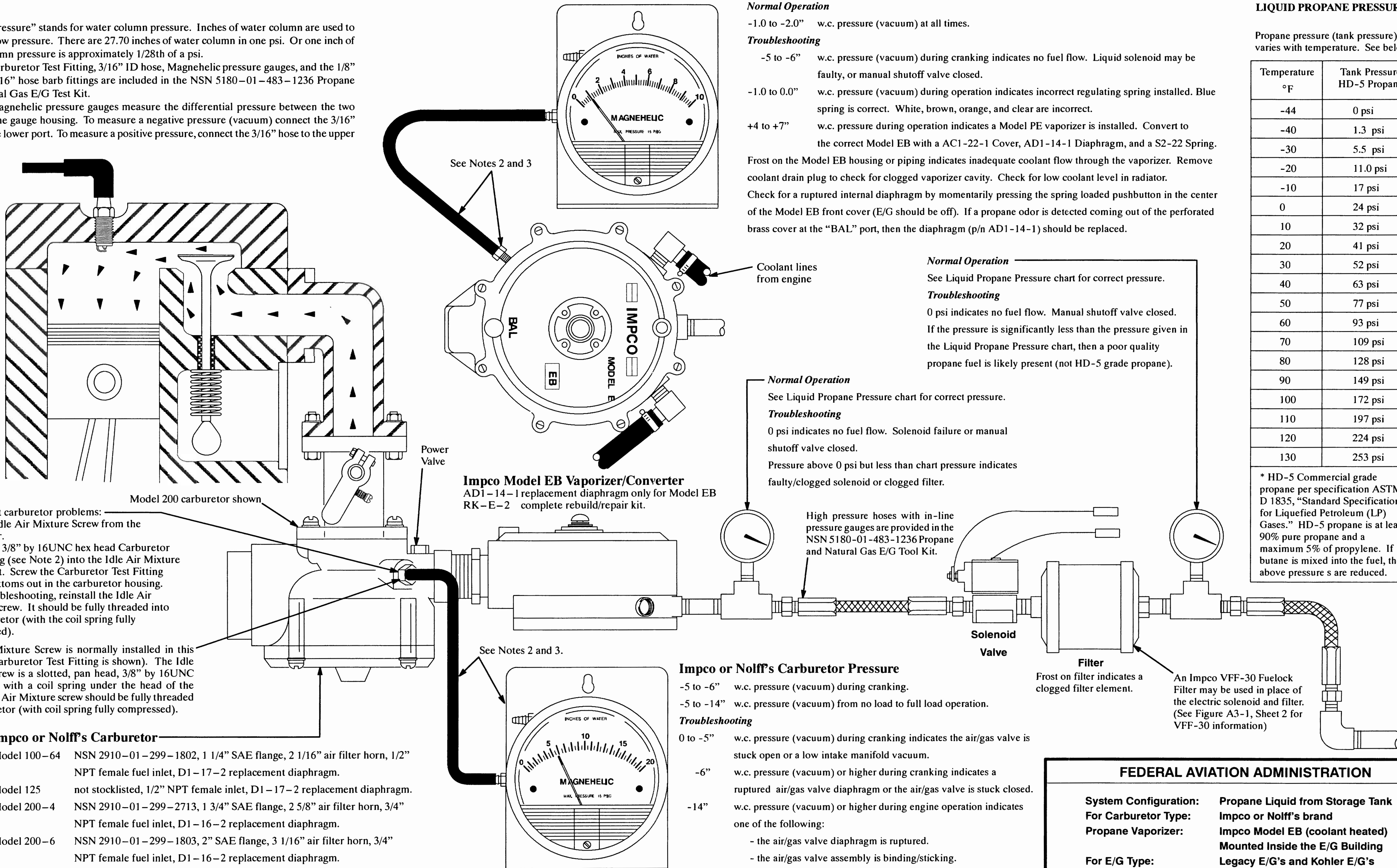
FEDERAL AVIATION ADMINISTRATION

System Configuration:	**Propane Vapor from Storage Tank**
For Carburetor Type:	**Impco or Nolff's brand**
Propane Vaporizer:	**Not Required**
For E/G Type:	**Legacy E/G's and Kohler E/G's**
For FAA Regions:	**Primarily Southern Region (ASO)**

SUBMITTED BY **Tim Riley** / DRAWN BY **Ron Perkins**	**Figure A3–2.**	SHEET 2 OF 2	REV. **C**

NOTES:

1. "w.c. pressure" stands for water column pressure. Inches of water column are used to measure low pressure. There are 27.70 inches of water column in one psi. Or one inch of water column pressure is approximately 1/28th of a psi.
2. The Carburetor Test Fitting, 3/16" ID hose, Magnehelic pressure gauges, and the 1/8" NPT by 3/16" hose barb fittings are included in the NSN 5180-01-483-1236 Propane and Natural Gas E/G Test Kit.
3. The Magnehelic pressure gauges measure the differential pressure between the two ports on the gauge housing. To measure a negative pressure (vacuum) connect the 3/16" hose to the lower port. To measure a positive pressure, connect the 3/16" hose to the upper port.



Normal Operation

-1.0 to -2.0" w.c. pressure (vacuum) at all times.

Troubleshooting

-5 to -6" w.c. pressure (vacuum) during cranking indicates no fuel flow. Liquid solenoid may be faulty, or manual shutoff valve closed.

-1.0 to 0.0" w.c. pressure (vacuum) during operation indicates incorrect regulating spring installed. Blue spring is correct. White, brown, orange, and clear are incorrect.

+4 to +7" w.c. pressure during operation indicates a Model PE vaporizer is installed. Convert to the correct Model EB with a AC1-22-1 Cover, AD1-14-1 Diaphragm, and a S2-22 Spring.

Frost on the Model EB housing or piping indicates inadequate coolant flow through the vaporizer. Remove coolant drain plug to check for clogged vaporizer cavity. Check for low coolant level in radiator.

Check for a ruptured internal diaphragm by momentarily pressing the spring loaded pushbutton in the center of the Model EB front cover (E/G should be off). If a propane odor is detected coming out of the perforated brass cover at the "BAL" port, then the diaphragm (p/n AD1-14-1) should be replaced.

LIQUID PROPANE PRESSURE

Propane pressure (tank pressure) varies with temperature. See below.

Temperature °F	Tank Pressure HD-5 Propane
-44	0 psi
-40	1.3 psi
-30	5.5 psi
-20	11.0 psi
-10	17 psi
0	24 psi
10	32 psi
20	41 psi
30	52 psi
40	63 psi
50	77 psi
60	93 psi
70	109 psi
80	128 psi
90	149 psi
100	172 psi
110	197 psi
120	224 psi
130	253 psi

* HD-5 Commercial grade propane per specification ASTM D 1835, "Standard Specification for Liquefied Petroleum (LP) Gases." HD-5 propane is at least 90% pure propane and a maximum 5% of propylene. If butane is mixed into the fuel, the above pressure s are reduced.

Normal Operation

See Liquid Propane Pressure chart for correct pressure.

Troubleshooting

0 psi indicates no fuel flow. Manual shutoff valve closed.

If the pressure is significantly less than the pressure given in the Liquid Propane Pressure chart, then a poor quality propane fuel is likely present (not HD-5 grade propane).

Normal Operation

See Liquid Propane Pressure chart for correct pressure.

Troubleshooting

0 psi indicates no fuel flow. Solenoid failure or manual shutoff valve closed.

Pressure above 0 psi but less than chart pressure indicates faulty/clogged solenoid or clogged filter.

Impco Model EB Vaporizer/Converter

AD1-14-1 replacement diaphragm only for Model EB

RK-E-2 complete rebuild/repair kit.

To troubleshoot carburetor problems:
- Remove Idle Air Mixture Screw from the carburetor.
- Install the 3/8" by 16UNC hex head Carburetor Test Fitting (see Note 2) into the Idle Air Mixture Screw port. Screw the Carburetor Test Fitting until it bottoms out in the carburetor housing.
- After troubleshooting, reinstall the Idle Air Mixture Screw. It should be fully threaded into the carburetor (with the coil spring fully compressed).

The Idle Air Mixture Screw is normally installed in this location (the Carburetor Test Fitting is shown). The Idle Air Mixture Screw is a slotted, pan head, 3/8" by 16UNC threaded screw with a coil spring under the head of the screw. The Idle Air Mixture screw should be fully threaded into the carburetor (with coil spring fully compressed).

Impco or Nolff's Carburetor

Model 100-64	NSN 2910-01-299-1802, 1 1/4" SAE flange, 2 1/16" air filter horn, 1/2" NPT female fuel inlet, D1-17-2 replacement diaphragm.
Model 125	not stocklisted, 1/2" NPT female inlet, D1-17-2 replacement diaphragm.
Model 200-4	NSN 2910-01-299-2713, 1 3/4" SAE flange, 2 5/8" air filter horn, 3/4" NPT female fuel inlet, D1-16-2 replacement diaphragm.
Model 200-6	NSN 2910-01-299-1803, 2" SAE flange, 3 1/16" air filter horn, 3/4" NPT female fuel inlet, D1-16-2 replacement diaphragm.
Model 225	not stocklisted, 3/4" NPT female fuel inlet, D1-16-2 replacement diaphragm.
Model 425	not stocklisted, 1" NPT female fuel inlet, D1-25 replacement diaphragm. (The Carburetor Test Fitting cannot be used on the Model 425 carburetor)

Impco or Nolff's Carburetor Pressure

-5 to -6" w.c. pressure (vacuum) during cranking.

-5 to -14" w.c. pressure (vacuum) from no load to full load operation.

Troubleshooting

0 to -5" w.c. pressure (vacuum) during cranking indicates the air/gas valve is stuck open or a low intake manifold vacuum.

-6" w.c. pressure (vacuum) or higher during cranking indicates a ruptured air/gas valve diaphragm or the air/gas valve is stuck closed.

-14" w.c. pressure (vacuum) or higher during engine operation indicates one of the following:
- the air/gas valve diaphragm is ruptured.
- the air/gas valve assembly is binding/sticking.
- the air filter is dirty or restricted.
- the carburetor is too small for the engine.

FEDERAL AVIATION ADMINISTRATION

System Configuration:	Propane Liquid from Storage Tank
For Carburetor Type:	Impco or Nolff's brand
Propane Vaporizer:	Impco Model EB (coolant heated) Mounted Inside the E/G Building
For E/G Type:	Legacy E/G's and Kohler E/G's
For FAA Regions:	Primarily Central Region (ACE)

SUBMITTED BY Tim Riley / DRAWN BY Ron Perkins	Figure A3-3.	SHEET 1 OF 1	REV. C

NOTES:

1. "w.c. pressure" stands for water column pressure. Inches of water column are used to measure low pressure. There are 27.70 inches of water column in one psi. Or one inch of water column pressure is approximately 1/28th of a psi.
2. The Carburetor Test Fitting, 3/16" ID hose, Magnehelic pressure gauges, and the 1/8" NPT by 3/16" hose barb fittings are included in the NSN 5180-01-483-1236 Propane and Natural Gas E/G Test Kit.
3. The NSN 5180-01-483-1236 Propane and Natural Gas E/G Test Kit has the drill bits and 1/8" NPT tap to add fuel pressure test ports to the regulator.
4. The Magnehelic pressure gauges measure the differential pressure between the two ports on the gauge housing. To measure a negative pressure (vacuum) connect the 3/16" hose to the lower port. To measure a positive pressure, connect the 3/16" hose to the upper port.

Normal Operation

-5 to -6" w.c. pressure (vacuum) during cranking.

-5 to -14" w.c. pressure (vacuum) from no load to full load operation.

Troubleshooting

0 to -5" w.c. pressure (vacuum) during cranking indicates the air/gas valve is stuck open or a low intake manifold vacuum.

-6" w.c. pressure (vacuum) or higher during cranking indicates a ruptured air/gas valve diaphragm or the air/gas valve is stuck closed.

-14" w.c. pressure (vacuum) or higher during engine operation indicates one of the following:

- the air/gas valve diaphragm is ruptured.
- the air/gas valve assembly is binding/sticking.
- the air filter is dirty or restricted.
- the carburetor is too small for the engine.

Normal Operation

-0.7 to -1.7" w.c. pressure (vacuum) at all times.

Troubleshooting

-5 to -6" w.c. pressure (vacuum) during cranking indicates no fuel flow.

+3 to +6" w.c. pressure during engine operation indicates the regulating spring is still installed inside the regulator. Remove the regulating spring (see below).

-2 to -6" w.c. pressure (vacuum) during cranking indicates regulator is binding (replace regulator) or vent line is clogged (clear out debris).

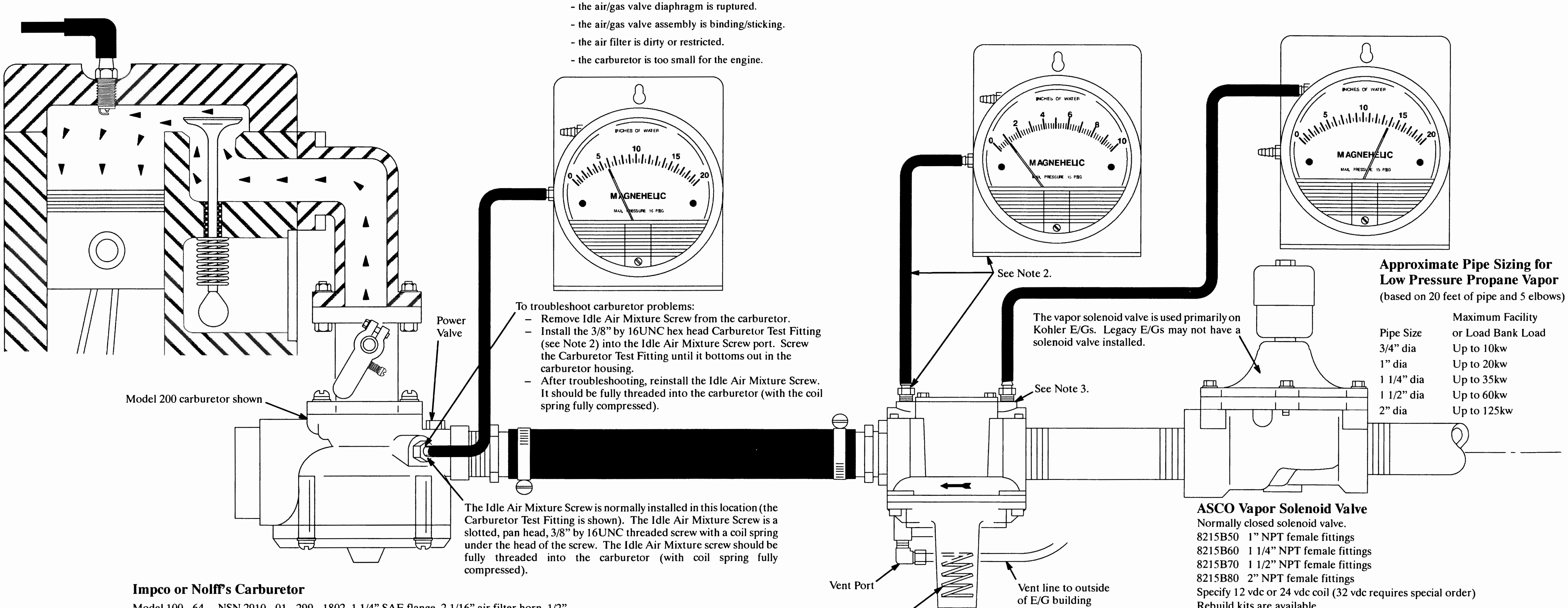
Normal Operation

+11 to +14" w.c. pressure at all times.

Troubleshooting

-5 to -6" w.c. pressure (vacuum) during cranking indicates no fuel flow. (failed solenoid valve or manual shutoff valve is closed).

Less than +11" w.c. presure during engine operation. If pressure drops as load increases, there is a fuel flow restriction (faulty solenoid valve or piping is too small for engine fuel requirements).



To troubleshoot carburetor problems:
- Remove Idle Air Mixture Screw from the carburetor.
- Install the 3/8" by 16UNC hex head Carburetor Test Fitting (see Note 2) into the Idle Air Mixture Screw port. Screw the Carburetor Test Fitting until it bottoms out in the carburetor housing.
- After troubleshooting, reinstall the Idle Air Mixture Screw. It should be fully threaded into the carburetor (with the coil spring fully compressed).

The vapor solenoid valve is used primarily on Kohler E/Gs. Legacy E/Gs may not have a solenoid valve installed.

The Idle Air Mixture Screw is normally installed in this location (the Carburetor Test Fitting is shown). The Idle Air Mixture Screw is a slotted, pan head, 3/8" by 16UNC threaded screw with a coil spring under the head of the screw. The Idle Air Mixture screw should be fully threaded into the carburetor (with coil spring fully compressed).

Remove the regulating spring and install the regulator upside down (as shown) for propane fuel. Remove slot head cap and nylon adjusting screw to gain access to regulating spring. Reinstall slot head cap and nylon adjusting screw. Regulating spring is used for natural gas fuel only.

Approximate Pipe Sizing for Low Pressure Propane Vapor
(based on 20 feet of pipe and 5 elbows)

Pipe Size	Maximum Facility or Load Bank Load
3/4" dia	Up to 10kw
1" dia	Up to 20kw
1 1/4" dia	Up to 35kw
1 1/2" dia	Up to 60kw
2" dia	Up to 125kw

ASCO Vapor Solenoid Valve
Normally closed solenoid valve.
8215B50 1" NPT female fittings
8215B60 1 1/4" NPT female fittings
8215B70 1 1/2" NPT female fittings
8215B80 2" NPT female fittings
Specify 12 vdc or 24 vdc coil (32 vdc requires special order)
Rebuild kits are available.

Impco or Nolff's Carburetor

Model 100-64	NSN 2910-01-299-1802, 1 1/4" SAE flange, 2 1/16" air filter horn, 1/2" NPT female fuel inlet, D1-17-2 replacement diaphragm.
Model 125	not stocklisted, 1/2" NPT female inlet, D1-17-2 replacement diaphragm.
Model 200-4	NSN 2910-01-299-2713, 1 3/4" SAE flange, 2 5/8" air filter horn, 3/4" NPT female fuel inlet, D1-16-2 replacement diaphragm.
Model 200-6	NSN 2910-01-299-1803, 2" SAE flange, 3 1/16" air filter horn, 3/4" NPT female fuel inlet, D1-16-2 replacement diaphragm.
Model 225	not stocklisted, 3/4" NPT female fuel inlet, D1-16-2 replacement diaphragm.
Model 425	not stocklisted, 1" NPT female fuel inlet, D1-25 replacement diaphragm. (The Carburetor Test Fitting cannot be used on the Model 425 carburetor)

Impco/Maxitrol Secondary Regulator
IMP-52 3/4" NPT female fittings
IMP-53 NSN 4820-01-299-0215, 1" NPT female fittings
IMP-61 1 1/4" NPT female fittings
No repair parts available.

FEDERAL AVIATION ADMINISTRATION

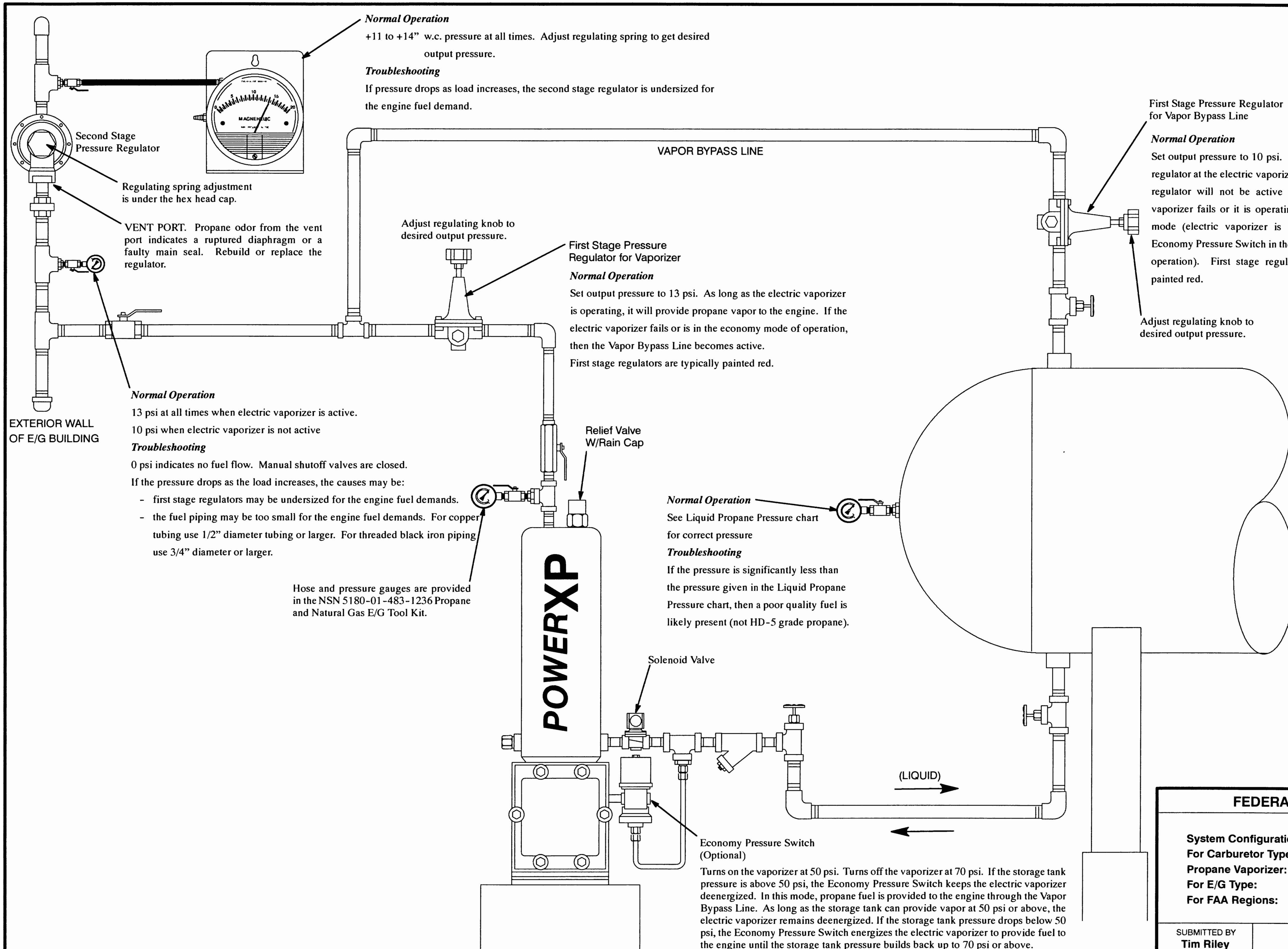
System Configuration:	Propane Liquid from Storage Tank
For Carburetor Type:	Impco or Nolff's brand
Propane Vaporizer:	Sam Dick Industries Electric Vaporizer
For E/G Type:	Kohler E/G's
For FAA Regions:	All Regions

SUBMITTED BY Tim Riley
DRAWN BY Ron Perkins

Figure A3-4.

SHEET 1 OF 2

REV. D



LIQUID PROPANE PRESSURE

Propane pressure (tank pressure) varies with temperature. See below.

Temperature °F	Tank Pressure HD-5 Propane
-44	0 psi
-40	1.3 psi
-30	5.5 psi
-20	11.0 psi
-10	17 psi
0	24 psi
10	32 psi
20	41 psi
30	52 psi
40	63 psi
50	77 psi
60	93 psi
70	109 psi
80	128 psi
90	149 psi
100	172 psi
110	197 psi
120	224 psi
130	253 psi

* HD-5 Commercial grade propane per specification ASTM D 1835, "Standard Specification for Liquefied Petroleum (LP) Gases." HD-5 propane is at least 90% pure propane and a maximum 5% of propylene. If butane is mixed into the fuel, the above pressure s are reduced.

FEDERAL AVIATION ADMINISTRATION

System Configuration:	**Propane Liquid from Storage Tank**
For Carburetor Type:	**Impco or Nolff's brand**
Propane Vaporizer:	**Sam Dick Industries Electric Vaporizer**
For E/G Type:	**Kohler E/G's**
For FAA Regions:	**All Regions**

SUBMITTED BY **Tim Riley**	**Figure A3-4.**	SHEET	REV.
DRAWN BY **Ron Perkins**		2 OF 2	**C**

NOTES:

1. "w.c. pressure" stands for water column pressure. Inches of water column are used to measure low pressure. There are 27.70 inches of water column in one psi. Or one inch of water column pressure is approximately 1/28th of a psi.
2. The Carburetor Test Fitting, 3/16" ID hose, Magnehelic pressure gauges, and the 1/8" NPT by 3/16" hose barb fittings are included in the NSN 5180–01–483–1236 Propane and Natural Gas E/G Test Kit.
3. The NSN 5180–01–483–1236 Propane and Natural Gas E/G Test Kit has the drill bits and 1/8" NPT tap to add fuel pressure test ports to the regulator.
4. The Magnehelic pressure gauges measure the differential pressure between the two ports on the gauge housing. To measure a negative pressure (vacuum) connect the 3/16" hose to the lower port. To measure a positive pressure, connect the 3/16" hose to the upper port.

Normal Operation

-5 to -6" w.c. pressure (vacuum) during cranking.

-5 to -14" w.c. pressure (vacuum) from no load to full load operation.

Troubleshooting

0 to -5" w.c. pressure (vacuum) during cranking indicates the air/gas valve is stuck open or a low intake manifold vacuum.

-6" w.c. pressure (vacuum) or higher during cranking indicates a ruptured air/gas valve diaphragm or the air/gas valve is stuck closed.

-14" w.c. pressure (vacuum) or higher during engine operation indicates one of the following:

- the air/gas valve diaphragm is ruptured.
- the air/gas valve assembly is binding/sticking.
- the air filter is dirty or restricted.
- the carburetor is too small for the engine.

Normal Operation

+3 to +5" w.c. pressure at all times. Adjust regulating spring to get desired output pressure.

Troubleshooting

-5 to -6" w.c. pressure (vacuum) during cranking indicates no fuel flow.

+6" w.c. pressure or above indicates regulator is binding (replace regulator) or vent line is clogged (clear out debris).

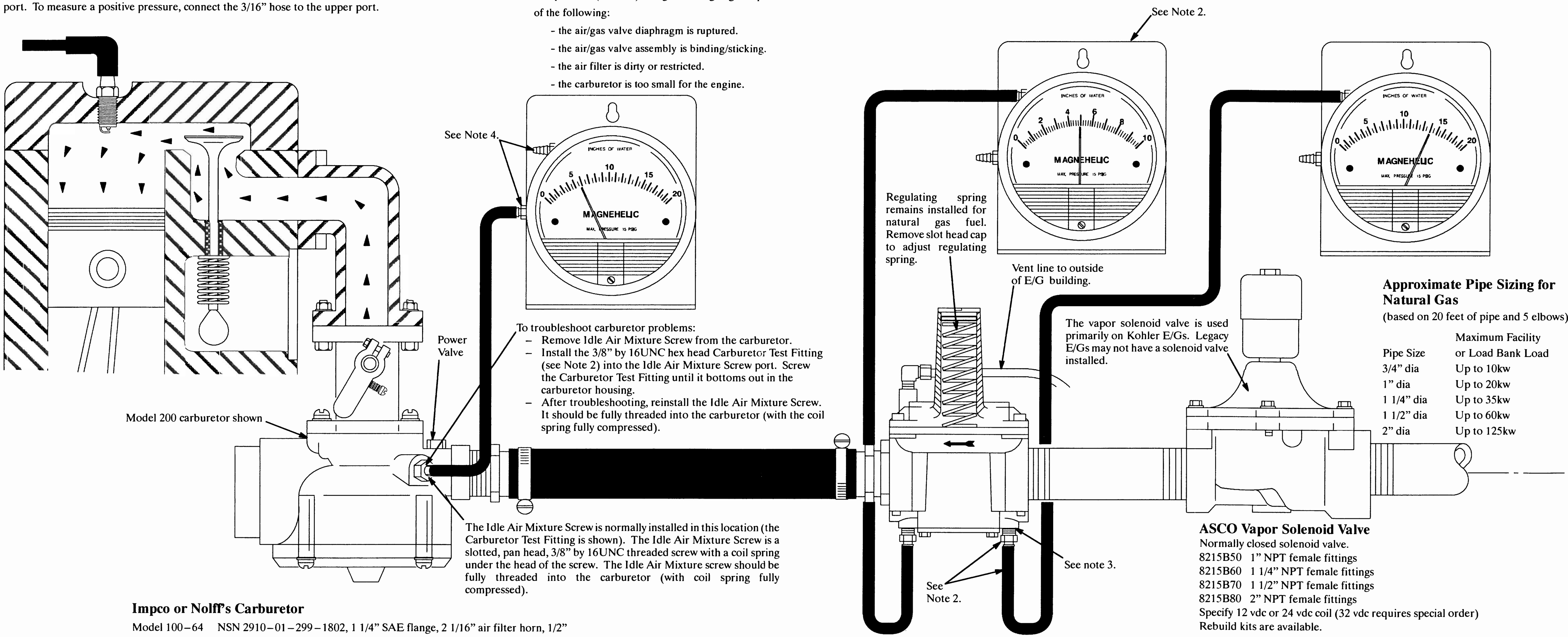
Normal Operation

+11 to +14" w.c. pressure at all times.

Troubleshooting

-5 to -6" w.c. pressure (vacuum) during cranking indicates no fuel flow.

If pressure drops as load increases, there is a fuel flow restriction (faulty solenoid, or piping is too small).



To troubleshoot carburetor problems:
- Remove Idle Air Mixture Screw from the carburetor.
- Install the 3/8" by 16UNC hex head Carburetor Test Fitting (see Note 2) into the Idle Air Mixture Screw port. Screw the Carburetor Test Fitting until it bottoms out in the carburetor housing.
- After troubleshooting, reinstall the Idle Air Mixture Screw. It should be fully threaded into the carburetor (with the coil spring fully compressed).

The Idle Air Mixture Screw is normally installed in this location (the Carburetor Test Fitting is shown). The Idle Air Mixture Screw is a slotted, pan head, 3/8" by 16UNC threaded screw with a coil spring under the head of the screw. The Idle Air Mixture screw should be fully threaded into the carburetor (with coil spring fully compressed).

Approximate Pipe Sizing for Natural Gas

(based on 20 feet of pipe and 5 elbows)

Pipe Size	Maximum Facility or Load Bank Load
3/4" dia	Up to 10kw
1" dia	Up to 20kw
1 1/4" dia	Up to 35kw
1 1/2" dia	Up to 60kw
2" dia	Up to 125kw

ASCO Vapor Solenoid Valve

Normally closed solenoid valve.
8215B50 1" NPT female fittings
8215B60 1 1/4" NPT female fittings
8215B70 1 1/2" NPT female fittings
8215B80 2" NPT female fittings
Specify 12 vdc or 24 vdc coil (32 vdc requires special order)
Rebuild kits are available.

Impco or Nolff's Carburetor

Model 100–64	NSN 2910–01–299–1802, 1 1/4" SAE flange, 2 1/16" air filter horn, 1/2" NPT female fuel inlet, D1–17–2 replacement diaphragm.
Model 125	not stocklisted, 1/2" NPT female inlet, D1–17–2 replacement diaphragm.
Model 200–4	NSN 2910–01–299–2713, 1 3/4" SAE flange, 2 5/8" air filter horn, 3/4" NPT female fuel inlet, D1–16–2 replacement diaphragm.
Model 200–6	NSN 2910–01–299–1803, 2" SAE flange, 3 1/16" air filter horn, 3/4" NPT female fuel inlet, D1–16–2 replacement diaphragm.
Model 225	not stocklisted, 3/4" NPT female fuel inlet, D1–16–2 replacement diaphragm.
Model 425	not stocklisted, 1" NPT female fuel inlet, D1–25 replacement diaphragm. (The Carburetor Test Fitting cannot be used on the Model 425 carburetor)

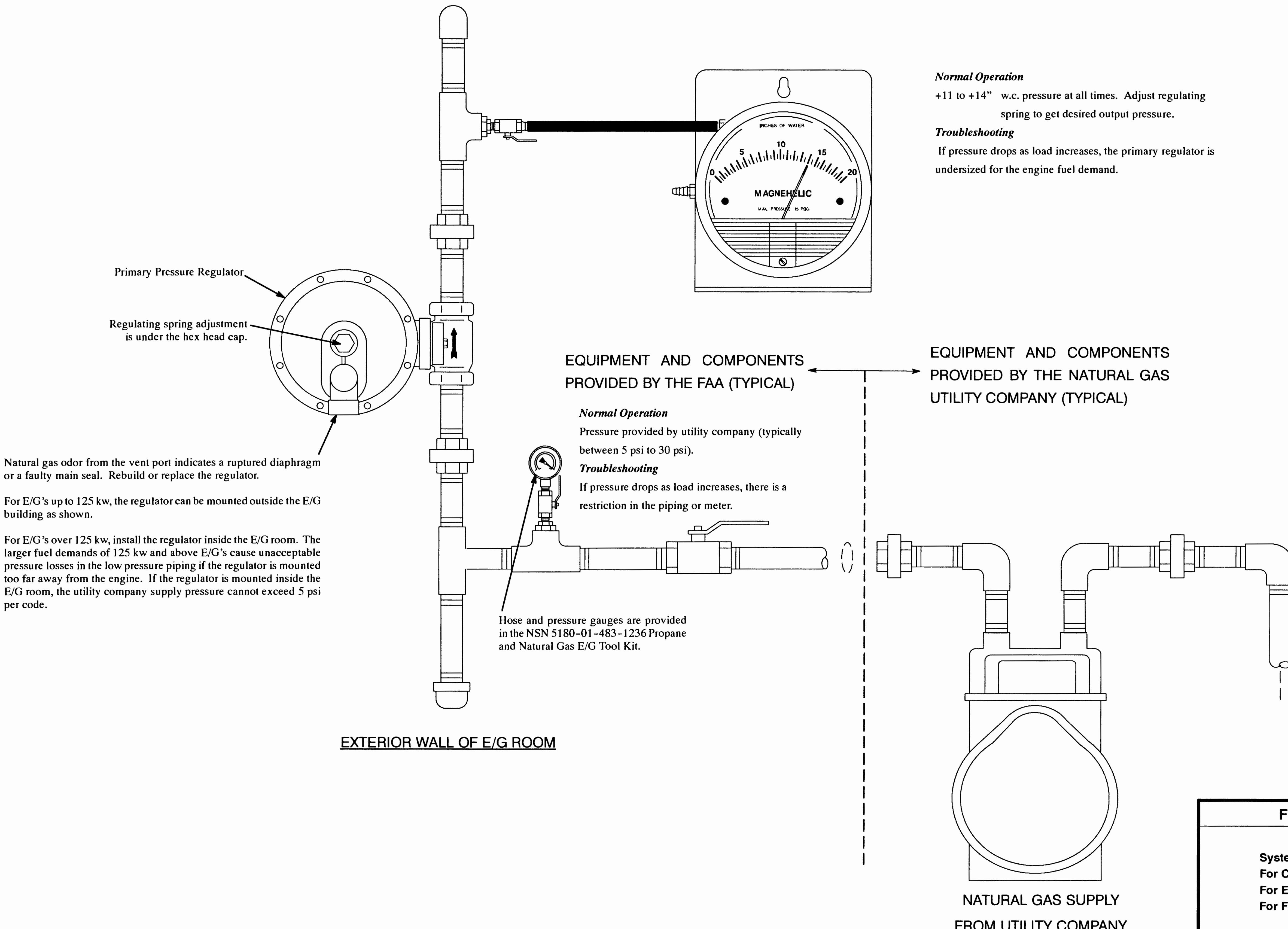
Impco/Maxitrol Secondary Regulator

IMP–52 3/4" NPT female fittings
IMP–53 NSN 4820–01–299–0215, 1" NPT female fittings
IMP–61 1 1/4" NPT female fittings
No repair parts available.

FEDERAL AVIATION ADMINISTRATION

System Configuration:	**Natural Gas Fuel**
For Carburetor Type:	**Impco or Nolff's brand**
For E/G Type:	**Legacy E/G's and Kohler E/G's**
For FAA Regions:	**All Regions**

SUBMITTED BY **Tim Riley**	**Figure A3–5.**	SHEET 1 OF 2	REV. **E**
DRAWN BY **Ron Perkins**			



FEDERAL AVIATION ADMINISTRATION

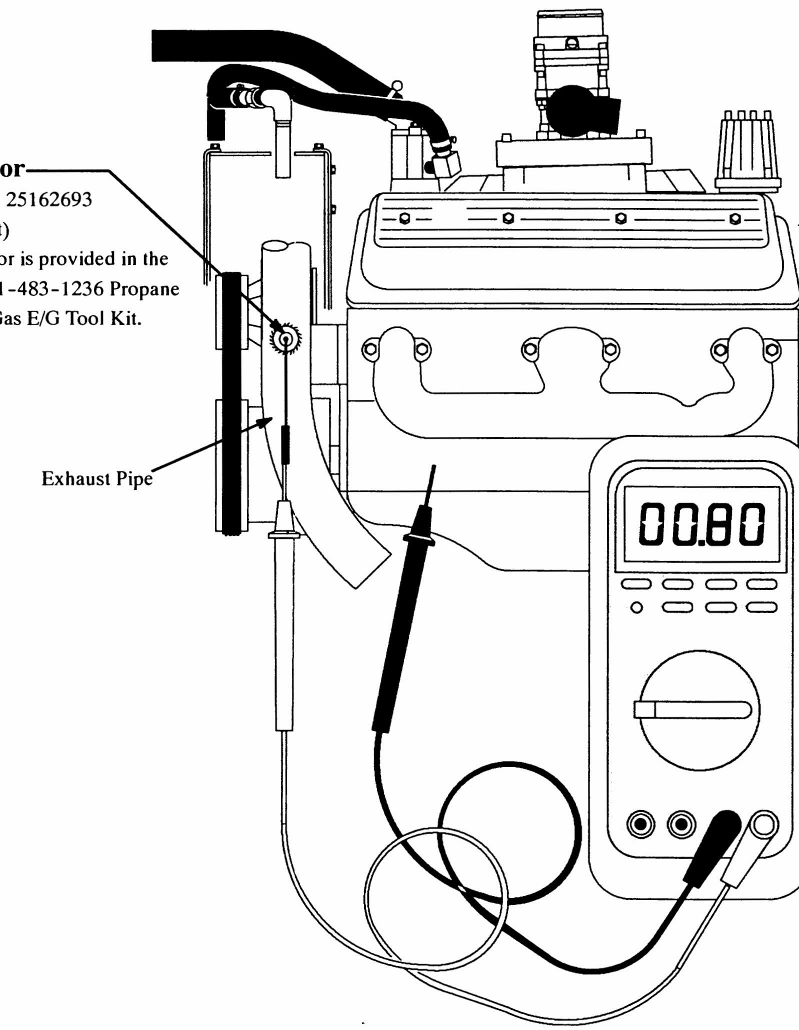
System Configuration:	**Natural Gas Fuel**
For Carburetor Type:	**Impco or Nolff's brand**
For E/G Type:	**Legacy E/G's and Kohler E/G's**
For FAA Regions:	**All Regions**

SUBMITTED BY **Tim Riley**	**Figure A3–5.**	SHEET	REV.
DRAWN BY **Ron Perkins**		2 OF 2	**D**

Fuel System Adjustment Procedures for Woodward LC-50 Carburetor

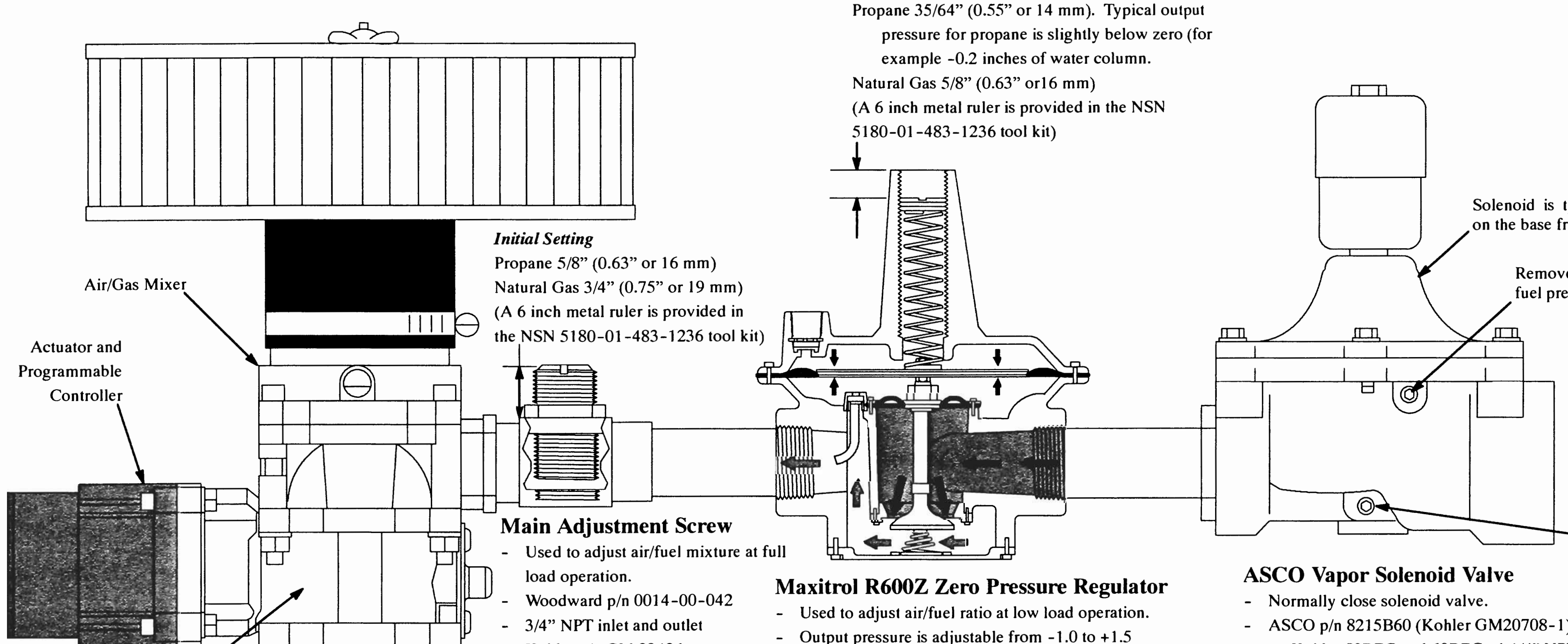
1. Remove the plug from the exhaust pipe and install the oxygen sensor. Remove the slotted cap from the top of the Maxitrol R600Z regulator. Loosen the jamnut on the Main adjustment Screw. Verify that the Maxitrol Zero Pressure Regulator and the Main Adjustment Screw are set up near their initial settings listed below.
2. Connect the positive (red) lead from the digital multimeter to the terminal on the oxygen sensor. Connect the negative (black) lead to the engine block. Set the multimeter to DC voltage.
3. Start the engine and, step by step, apply the full load bank capacity. Run the engine for approximately three minutes to allow the oxygen sensor to warm up.
4. At 10kw (or the smallest load element above 10kw), adjust the Maxitrol R600Z pressure regulator to center the oxygen sensor output voltage in the 0.75 to 0.85 vdc range. The output voltage of the oxygen sensor will fluctuate rapidly. This indicates active oxygen sensor operation.
   a. Lower than 0.75 Vdc indicates a lean mixture. On the Maxitrol R600Z regulator, turn the nylon adjusting screw clockwise to increase the fuel pressure and richen the air/fuel mixture.
   b. Greater than 0.85 Vdc indicates a rich mixture. On the Maxitrol R600Z regulator, turn the nylon adjusting screw counter clockwise to decrease the fuel pressure and lean out the air/fuel mixture..
5. Apply full load bank capacity to the engine. Adjust the Main Adjustment Screw to center the oxygen sensor output in the 0.75 to 0.85 Vdc range.
   a. Lower than 0.75 volts indicates a lean mixture. On the Main Adjustment Screw, turn the brass adjusting screw counter clockwise to increase fuel flow into the Woodward LC-50 carburetor and richen the air/fuel mixture.
   b. Greater than 0.85 volts indicates a rich mixture. On the Main Adjustment Screw, turn the brass adjusting screw clockwise to decrease fuel flow into the Woodward LC-50 carburetor and lean out the air/fuel mixture.
6. Recheck the output of the oxygen sensor at 10kw load (or the smallest load element above 10kw). The above two steps may have to be repeated several times until the 0.75 to 0.85 range is achieved at both low load and full load operation of the engine.
7. After testing, tighten the jamnut on the Main Adjustment Screw. Reinstall the slotted cap on the Maxitrol R600Z regulator. Disconnect the multimeter. Reinstall the plug in the exhaust pipe.

Oxygen Sensor
- AC Delco p/n 25162693 (or equivalent)
- Oxygen Sensor is provided in the NSN 5180-01-483-1236 Propane and Natural Gas E/G Tool Kit.



Digital Multimeter
- Set to DC voltage

0.75 to 0.85 Vdc at 10 kW load and full load operation.



Initial Setting
Propane 35/64" (0.55" or 14 mm). Typical output pressure for propane is slightly below zero (for example -0.2 inches of water column.
Natural Gas 5/8" (0.63" or16 mm)
(A 6 inch metal ruler is provided in the NSN 5180-01-483-1236 tool kit)

Initial Setting
Propane 5/8" (0.63" or 16 mm)
Natural Gas 3/4" (0.75" or 19 mm)
(A 6 inch metal ruler is provided in the NSN 5180-01-483-1236 tool kit)

Main Adjustment Screw
- Used to adjust air/fuel mixture at full load operation.
- Woodward p/n 0014-00-042
- 3/4" NPT inlet and outlet
- Kohler p/n GM 29426

Woodward Model LC-50
- The LC-50 is an integrated air/gas mixer, throttle body, actuator, and programmable controller.
- Woodward p/n 0055-01-000
- 3/4" NPT inlet

Maxitrol R600Z Zero Pressure Regulator
- Used to adjust air/fuel ratio at low load operation.
- Output pressure is adjustable from -1.0 to +1.5 inches of water column.
- Regulating spring remains installed for both propane and natural gas fuel.
- Install regulator with the spring tower pointed up (as shown) for both propane and natural gas fuel.
- 3/4" NPT inlet and outlet.
- Kohler p/n GM 28832

ASCO Vapor Solenoid Valve
- Normally close solenoid valve.
- ASCO p/n 8215B60 (Kohler GM20708-1) used on Kohler 50RZG and 60RZG. 1 1/4" NPT inlet and outlet.
- ASCO p/n 8215G30 (Kohler GM 20707-1) used on Kohler 35RZG. 3/4" NPT inlet and outlet.
- 12 Vdc coil.

The fuel piping configuration installed by the Remove FAA up to the solenoid valve did not change. See sheet 2 of Figures A3-1, A3-2, A3-4 or A3-5 for troubleshooting information.

NOTE

Beginning in May 2002, Kohler changed carburetors and regulators on some of their spark-ignited General Motors engines. They switched from Impco or Nolff's brand carburetors to the Woodward LC-50 carburetor. This change applies to the Kohler 35RZG, 50RZG, 60RZG, and 80/100RZG models. New fuel system adjustment procedures are needed for the Woodward LC-50 configuration.

FEDERAL AVIATION ADMINISTRATION

System Configuration:	**Propane or Natural Gas**
For Carburetor Type:	**Woodward LC-50 (part number 0055-01-000) With a Maxitrol R600Z Regulator**
For E/G Type:	**Kohler E/G's after May 2002**
For FAA Regions:	**All Regions**

SUBMITTED BY **Tim Riley** / DRAWN BY **Ron Perkins**	**Figure A3-6.**	SHEET 1 OF 1	REV. **G**

APPENDIX 4. PROPANE AND NATURAL GAS E/G CONFIGURATION TABLES

This Appendix contains the following configuration tables for propane and natural gas engine generators: In a future update to Order 6980.11C, these tables will be referenced in the new periodic maintenance requirements for propane and natural gas E/Gs.

LIST OF TABLES AND FIGURES

E/G Model No.	Year Quantity	Engine Information	Ignition Timing [1] Propane Fuel	Natural Gas Fuel	Ignition Type	Airflow & Carburetor	Points Gap	Plug Gap [3,4]	Valve Clearances [4]	Typical Governor Controls
Kohler 20RZ	1995-2000 5 each	Ford LRG-423, 4 cyl, 140 cu. in., in-line, CR 9.4 to 1	26 degrees BTDC total advance at 1800 RPM [2]	34 degrees BTDC total advance at 1800 RPM [2]	Electronic with no distributor. 12vdc	60 cfm Model 125	N/A	0.031 - 0.034" Motorcraft AWSF 52C	No adjustment. Hydraulic valve lifters.	Barber Colman 12vdc: Actuator DYNC 10202 Controller DYN1 10724 (Gain from 10 to 60)
Onan 20ES	1991-94 62 each (Southern Region)	Ford LSG-423, 4 cyl, 140 cu. in., in-line, CR 9.4 to 1	25 degrees BTDC total advance at 1800 RPM	30 degrees BTDC total advance at 1800 RPM	Electronic with distributor and no points. 12vdc	60 cfm Model 100	N/A	0.031 - 0.034" Motorcraft AWSF 52C	No adjustment. Hydraulic valve lifters.	Barber Colman 12vdc: Actuator DYNC 10202 Controller DYN1 10840. SW1 (down, down, up) SW2 Gain at 9. SW3 (down, up, down)
Kohler 20RZ	2001 and on	Ford LRG-425, 4 cyl, 153 cu. in., in-line, CR 9.0 to 1	24 degrees BTDC total advance at 1800 RPM [2]	29 degrees BTDC total advance at 1800 RPM [2]	Electronic with no distributor. 12vdc	65 cfm Model 125	N/A	0.031 - 0.034" Motorcraft AWSF 52C	No adjustment. Hydraulic valve lifters.	Barber Colman 12vdc: Actuator DYNC 10202 Controller DYN1 10724.
Kohler 35RZ	1995-2000 13 each	Ford CSG-649, 6 cyl, 300 cu. in., in-line, CR 8.0 to 1	20 degrees BTDC total advance at 1800 RPM	28 degrees BTDC total advance at 1800 RPM	Electronic with distributor and no points. 12vdc	126 cfm Model 125	N/A	0.031 - 0.034"	No adjustment. Hydraulic valve lifters.	Barber Colman 12vdc: Actuator DYNC 10502 Controller DYN1 10724.
Onan 35EK Onan 45EM	1991-93 12 each (Southern Region)	Ford CSG-649, 6 cyl, 300 cu. in., in-line, CR 8.0 to 1	20 degrees BTDC total advance at 1800 RPM	28 degrees BTDC total advance at 1800 RPM	Electronic with distributor and no points. 12vdc	126 cfm	N/A	0.031 - 0.034"	No adjustment. Hydraulic valve lifters.	Barber Colman 12vdc: Actuator DYNC 10502 Controller DYN1 10840.
Kohler 40RZ & 50RZ	1995-2000 118 each	Ford LSG-875, 8 cyl, 460 cu. in., V-8, natural aspiration, CR 8.0 to 1	36 degrees BTDC total advance at 1800 RPM.	36 degrees BTDC total advance at 1800 RPM.	Electronic with distributor and no points. 12vdc	194 cfm Model 225	N/A	0.031 - 0.034" Autolite 23	No adjustment. Hydraulic valve lifters.	Barber Colman 12vdc: Actuator DYNC 10502 Controller DYN1 10726 or 10724 (Gain at10 to 60) Magnetic pickup signal at 5400hz
Kohler 80RZ & 100RZ	1993-2000 49 each	Ford LSG-875, 8 cyl, 460 cu. in., V-8, turbocharged, CR 8.0 to 1	22 degrees BTDC total advance at 1800 RPM.	34 degrees BTDC total advance at 1800 RPM.	Electronic with distributor and no points. 12vdc	431 cfm Model 225	N/A	0.031 - 0.034" Autolite 23	No adjustment. Hydraulic valve lifters.	TDWR facilities have Woodward Controls 12vdc: Actuator 8256-017 (linkage 4th hole up from shaft). Controller 8290-141 (Start Limit at 65%, Gain at 25%, Stability at 25%) National E/G Contract has Barber Colman 12vdc: Actuator DYNC 10502 Controller DYN1 10726 or 10724 (Gain at 10 to 60) Magnetic pickup signal at 5400hz
Kohler 135RZ	1995-2000 10 each	Cummins G855, 6 cyl, 855 cu in, in-line, CR 10.0 to 1	18 to 23 degrees BTDC total advance at 1800 RPM	26 to 30 degrees BTDC total advance at 1800 RPM	Altronic Ignition Generator. 24vdc	360 cfm Model 425	N/A	0.019 - 0.021" Champion N2C	Intake 0.014" Exhaust 0.033" Cold engine	Barber Colman 24vdc: Actuator DYNC 8000 Controller DYN1 10684 (Gain at 25, I at 20, DER at 75, Droop at zero, S1 On, S2 Off)
Kohler 35RZG	2001 thru April 2002 8 each	General Motors 4.3L, 6 cyl, 262 cu. in., V-6, CR 9.4 to 1	28 degrees BTDC total advance at 1800 RPM	36 degrees BTDC total advance at 1800 RPM	Electronic with distributor and no points. 12vdc	112 cfm Model 125	N/A	0.034 - 0.036" AC 41-932	No adjustment. Hydraulic valve lifters.	Barber Colman 12vdc: Actuator Power Flow 42 Controller DPG 2105
Kohler 35RZG	May 2002 and on	General Motors 4.3L, 6 cyl, 262 cu. in., V-6, CR 9.4 to 1	28 degrees BTDC total advance at 1800 RPM	36 degrees BTDC total advance at 1800 RPM	Electronic with distributor and no points. 12vdc	112 cfm Woodward LC-50	N/A	0.034 - 0.036" AC 41-932	No adjustment. Hydraulic valve lifters.	Woodward LC-50 12vdc. The LC-50 controller and actuator are integrated into the throttle body of the carburetor. The controller is software controlled and has no external adjustments (such as speed or gain)

Notes.
1. Effects of Altitude on Ignition Timing. For altitudes of 5000 - 7000 feet advance timing by 3 degrees. For altitudes of 7000 - 9000 feet advance timing by 5 degrees. For altitudes of 9000 feet and above advance timing by 7 degrees. An ignition timing light is provided in the NSN 5180-01-483-1236 Propane and Natural Gas E/G Tool Kit. Refer to Figure A4-1 for location of #1 cylinder.
2. Refer to Kohler Service Bulletin SB-595 for changing the ignition timing. Timing is changed by the wire connections to the electronic spark control module.
3. Plug gap listed in the table is for propane or natural gas operation. The gap will typically be smaller than the gasoline specification that is listed in most of the manuals supplied with the engines.
4. An all-purpose feeler gauge is provided in the NSN 5180-01-483-1236 Propane and Natural Gas E/G Tool Kit.

Table A4-1. Configurations for Kohler and Onan Propane and Natural Gas Engine Generators (sheet 1 of 2).

E/G Model No.	Year Quantity	Engine Information	Ignition Timing [1] Propane Fuel	Natural Gas Fuel	Ignition Type	Airflow & Carburetor	Points Gap	Plug Gap [3,4]	Valve Clearances [4]	Typical Governor Controls
Kohler 50RZG Kohler 60RZG	2001 thru April 2002 28 each	General Motors 5.7L, 8 cyl, 350 cu. in., V-8, CR 9.4 to 1	28 degrees BTDC total advance at 1800 RPM	36 degrees BTDC total advance at 1800 RPM	Electronic with distributor and no points. 12vdc	146 cfm Model 225	N/A	0.034 - 0.036" AC 41-932	1 turn down from zero lash. Hydraulic valve lifters.	Barber Colman 12vdc: Actuator Power Flow 42 Controller DPG 2105
Kohler 50RZG Kohler 60RZG	May 2002 and on	General Motors 5.7L, 8 cyl, 350 cu. in., V-8, CR 9.4 to 1	28 degrees BTDC total advance at 1800 RPM	36 degrees BTDC total advance at 1800 RPM	Electronic with distributor and no points. 12vdc	146 cfm Woodward LC-50	N/A	0.034 - 0.036" AC 41-932	1 turn down from zero lash. Hydraulic valve lifters.	Woodward LC-50 12vdc. The LC-50 controller and actuator are integrated into the throttle body of the carburetor. The controller is software controlled and has no external adjustments (such as speed or gain)
Kohler 50RZGB	2003 and on	General Motors 5.0L, 8 cyl, 305 cu. in., V-8, CR 9.4 to 1	28 degrees BTDC total advance at 1800 RPM	36 degrees BTDC total advance at 1800 RPM	Electronic with distributor and no points. 12vdc	127 cfm Woodward LC-50	N/A	0.034 - 0.036" AC 41-932	1 turn down from zero lash. Hydraulic valve lifters.	Woodward LC-50 12vdc. The LC-50 controller and actuator are integrated into the throttle body of the carburetor. The controller is software controlled and has no external adjustments (such as speed or gain)
Kohler 80RZG Kohler 100RZG	2001 and on 2 each	General Motors 8.1L, 8 cyl, 496 cu. in., V-8, CR 9.1 to 1	Factory set. Not adjustable.	Factory set. Not adjustable.	Electronic with no distributor. 12vdc	208 cfm Model 225	N/A	0.034 - 0.036"	No adjustment. Hydraulic valve lifters.	Barber Colman 12vdc: Actuator Power Flow 50 Controller DPG 2105

Notes.
1. Effects of Altitude on Ignition Timing. For altitudes of 5000 - 7000 feet advance timing by 3 degrees. For altitudes of 7000 - 9000 feet advance timing by 5 degrees. For altitudes of 9000 feet and above advance timing by 7 degrees. An ignition timing light is provided in the NSN 5180-01-483-1236 Propane and Natural Gas E/G Tool Kit. Refer to Figure A4-1 for location of #1 cylinder.
2. Refer to Kohler Service Bulletin SB-595 for changing the ignition timing. Timing is changed by the wire connections to the electronic spark control module.
3. Plug gap listed in the table is for propane or natural gas operation. The gap will typically be smaller than the gasoline specification that is listed in most of the manuals supplied with the engines.
4. An all-purpose feeler gauge is provided in the NSN 5180-01-483-1236 Propane and Natural Gas E/G Tool Kit.

Table A4-1. Configurations for Kohler and Onan Propane and Natural Gas Engine Generators (sheet 2 of 2).

E/G Manufacturer, Contract Number, E/G Size	Year / Quantity	Engine Information	Ignition Timing for Propane Fuel [1,2]	Ignition Type and Voltage	Airflow & Impco Carb	Distributor Points Gap[4]	Plug Gap Plug Type [4]	Valve Clearances [4]	Typical Governor Controls
Fermont, FA72AC1443-3F, 15kw	1972 / 90	International Harvester UC221, 6 cyl, 221 cu in	31 to 33 degrees BTDC total advance at 1800 RPM	Distributor/Points 32vdc	60 cfm Model 100-8	0.019 - 0.021"	0.025 - 0.028" Champion RD-15Y	Intake 0.030" Exhaust 0.030" Cold engine	American Bosch 32vdc: Controller CU671C-7 Actuator AGB130
U.S. Motors, CCA 32614, 30kw	1957 / 4	Waukesha 140GKB, 6 cyl, 525 cu in	23 to 25 degrees BTDC total advance at 1200 RPM	Distributor/Points 24vdc	84 cfm	0.018 - 0.020"	0.025 - 0.028"	Intake 0.015" Exhaust 0.029" Cold engine	
U.S. Motors, CCA 32614, 50kw	1957 / 5	Waukesha 145GKB, 6 cyl, 779 cu in	23 to 25 degrees BTDC total advance at 1200 RPM	Distributor/Points 24vdc	98 cfm	0.018 - 0.020"	0.025 - 0.028"	Intake 0.015" Exhaust 0.026" Cold engine	
Warner & Swasey, CCA 31894, 8kw	1956 / 8	Continental F186, 6 cyl. 186 cu in, CR 6.4 to 1	13 to 15 degrees BTDC total advance at 1200 RPM	Distributor/Points 32vdc	56 cfm Model 100-8	0.019 - 0.021"	0.025 - 0.028"	Intake 0.014" Exhaust 0.014" Hot engine	
Warner & Swasey, CCA 31894, 10kw	1956 / 4	Continental F244, 6 cyl, 244 cu in, CR 6.4 to 1	16 to 18 degrees BTDC total advance at 1200 RPM	Distributor/Points 32vdc	70 cfm Model 100-8	0.019 - 0.021"	0.025 - 0.028"	Intake 0.014" Exhaust 0.014" Hot engine	
Warner & Swasey, CCA34258, 15kw Warner & Swasey, FA520, 15kw	1958 / 51 1960 / 116	Continental M330, 6 cyl, 330 cu in, CR 6.7 to 1	23 to 25 degrees BTDC total advance at 1200 RPM	Distributor/Points 32vdc	98 cfm Model 100-8 or 100-12	0.019 - 0.021"	0.025 - 0.028" Champion 516	Intake 0.017" Exhaust 0.020" Hot engine	American Bosch 32vdc: Actuator AGB130D3 or AGB200A1 Controller CU673C-7.
Warner & Swasey, FA 1078, 15kw	1961 / 110	Continental F226, 6 cyl, 226 cu in, CR 6.7 to 1	25 to 27 degrees BTDC total advance at 1800 RPM	Distributor/Points 32vdc	100 cfm Model 100-8	0.019 - 0.021"	0.025 - 0.028" Champion 516	Intake 0.014" Exhaust 0.014" Hot engine	
Warner & Swasey, FA 718, 20kw Warner & Swasey, CCA 31894, 20kw	1960 / 48 1956 / 15	Continental M363, 6 cyl, 363 cu in, CR 7 to 1,	23 to 25 degrees BTDC total advance at 1200 RPM	Distributor/Points 32vdc	105 cfm Model 200-4	0.019 - 0.021"	0.025 - 0.028" Champion 516	Intake 0.017" Exhaust 0.020" Hot engine	American Bosch 32vdc: Actuator AGB130D4 or AGB200A1 Controller CU671C-7 or CU673C-7.
Warner & Swasey, CCA 33140, 30kw Warner & Swasey, CCA 33948, 30kw Warner & Swasey, CCA 31894, 30kw Warner & Swasey, FA 449, 30kw	1958 / 160 1959 / 230 1956 / 10 1960 / 9	Continental R602, 6 cyl, 602 cu in, CR 5.9 to 1, 57hp	31 to 33 degrees BTDC total advance at 1200 RPM	Distributor/Points 32vdc	166 cfm Model 200-6	0.019 - 0.021"	0.025 - 0.028" Champion 516	Intake 0.020" Exhaust 0.024" Hot engine. See Note 3.	American Bosch 32vdc: Actuator AGB200A1 Controller CU671C-7 or CU673C-7 (Gain at 5 or 6 and Stability at 5 or 6) Magnetic pickup signal at 2060hz
Warner & Swasey, FA2970, 30kw Warner & Swasey, FA 1993, 30kw	1962 / 5 1961 / 9	Continental M363, 6 cyl, 363 cu in, CR 7 to 1	25 to 27 degrees BTDC total advance at 1800 RPM	Distributor/Points 32vdc	146 cfm Model 200-4	0.019 - 0.021"	0.025 - 0.028" Champion 516	Intake 0.017" Exhaust 0.020" Hot engine	American Bosch 32vdc: Actuator AGB200A1 Controller CU671C-7 or CU673C-7.
Warner & Swasey, CCA 34640, 50kw	1959 / 3	Continental S820, 6 cyl, 820 cu in, CR 6.4 to 1	31 to 33 degrees BTDC total advance at 1200 RPM	Distributor/Points 32vdc	258 cfm Model 200-6	0.019 - 0.021"	0.025 - 0.028"	Intake 0.020" Exhaust 0.024" Hot engine	
Winpower, CCA 34639, 20kw	1959 / 4	Continental M363, 6 cyl, 363 cu in, CR 7 to 1	23 to 25 degrees BTDC total advance at 1200 RPM	Distributor/Points 24vdc	105 cfm Model 200-4	0.019 - 0.021"	0.025 - 0.028" Champion 516	Intake 0.017" Exhaust 0.020" Hot engine	
Winpower, CCA 34639, 30kw	1959 / 3	Continental R602, 6 cyl, 602 cu in, CR 5.9 to 1	31 to 33 degrees BTDC total advance at 1200 RPM	Distributor/Points 24vdc	166 cfm Model 200-6	0.019 - 0.021"	0.025 - 0.028" Champion 516	Intake 0.019" Exhaust 0.024" Hot engine	

Notes.

1. Effects of Altitude on Ignition Timing. For altitudes of 5000 - 7000 feet advance timing by 3 degrees. For altitudes of 7000 - 9000 feet advance timing by 5 degrees. For altitudes of 9000 and above advance timing by 7 degrees. An ignition timing light is provided in the NSN 5180-01-483-1236 Propane and Natural Gas E/G Tool Kit. Refer to Figure A4-1 for location of #1 cylinder.
2. If the engine does not run smoothly at these settings, adjust the ignition timing to obtain smooth operation at typical facility loads. For engines not listed in this chart that do not have any specific ignition timing settings from the engine manufacturer for propane fuel, use the following guidelines. For engines running at 1200 rpm, ignition timing should be in the range of 23-25 degrees BTDC total advance at 1200 rpm. For engines running at 1800 rpm, ignition timing should be in the range of 25-27 degrees BTDC total advance at 1800 rpm.
3. A decal on the valve cover of some Continental R602 engines may call for a 0.030" exhaust valve clearance. Use 0.024" clearance for the exhaust valve on the Continental R602 engine. The Technical Instruction books for the Warner and Swasey E/G call for a 0.024" exhaust valve clearance. The R602 Engine Service Manual No. IMX-6130 from Continental Motors Corporation also calls for a 0.024" exhaust valve clearance.
4. An all-purpose feeler gauge and tungsten ignition points file are provided in the NSN 5180-01-483-1236 Propane and Natural Gas E/G Tool Kit.

Table A4-2. Configurations for Legacy Engine Generators Converted To Propane Fuel With Distributor/Points Ignition Systems.

E/G Manufacturer, Contract Number, E/G Size	Year / Quantity	Engine Information	Ignition Timing for Propane Fuel [1,2]	Ignition Type and Voltage	Airflow & Impco Carb	Magneto Points Gap [4]	Plug Gap Plug Type [4]	Valve Clearances [4]	Typical Governor Controls
Consolidated, CCA 33141, 10kw	1958 / 16	Hercules QXB, 6 cyl, 205 cu in, CR 5.85 to 1	23 to 25 degrees BTDC total advance at 1200 rpm	Magneto 24vdc	60 cfm Model 100-8	0.014 - 0.018"	0.025 - 0.028"	Refer to engine nameplate data. Hot engine.	
Consolidated, CCA 32274, 15kw Consolidated, CCA 33141, 15kw	1957 / 56 1958 / 11	Hercules JXC, 6 cyl, 282 cu in, CR 6 to 1	23 to 25 degrees BTDC total advance at 1200 rpm	Magneto 24vdc	84 cfm Model 100-8	0.014 - 0.018"	0.025 - 0.028" Autolite 308	Intake 0.008" Exhaust 0.010" Hot engine.	
Consolidated, CCA 33141, 20kw Consolidated, CCA 32274, 20kw	1958 / 22 1957 / 144	Hercules JXLD, 6 cyl, 339 cu in, CR 6.5 to 1	23 to 25 degrees BTDC total advance at 1200 rpm	Magneto 24vdc	98 cfm Model 200-4	0.014 - 0.018"	0.025 - 0.028" Autolite 308	Intake 0.010" Exhaust 0.010" Hot engine.	American Bosch 24vdc: Actuator AGB130D1 or AGB200A1 Controller CU671C-7 Barber Colman 24vdc: Actuator DYNC 50000 and Controller DYN1 10604 Magnetic pickup signal at 1980hz
Consolidated, CCA 32511, 30kw Consolidated, CCA 32274, 30kw	1957 / 208 1957 / 16	Hercules RXLD, 6 cyl, 558 cu in, CR 5.4 to 1	23 to 25 degrees BTDC total advance at 1200 rpm	Magneto 24vdc	155 cfm Model 200-4	0.014 - 0.018"	0.025 - 0.028" Autolite 308	Intake 0.010" Exhaust 0.016" Hot engine.	American Bosch 24vdc: Actuator AGB130D1 or AGB200A1 Controller CU671C-7 Barber Colman 24vdc: Actuator DYNC 50000 and Controller DYN1 10604
Fermont, CCA 31248, 8kva	1955 / 2	Continental F186, 6 cyl. 186 cu in, CR 6.4 to 1	13 to 15 degrees BTDC total advance at 1200 rpm	Magneto 32vdc	56 cfm Model 100-8	0.014 -0.018"	0.025 - 0.028"	Intake 0.014" Exhaust 0.014" Hot engine	
Fermont, CCA 31248, 10kw	1955 / 2	Continental F244, 6 cyl, 244 cu in, CR 6.4 to 1	16 to 18 degrees BTDC total advance at 1200 rpm	Magneto 32vdc	70 cfm Model 100-8	0.014 - 0.018"	0.025 - 0.028"	Intake 0.014" Exhaust 0.014" Hot engine	
Hollingsworth, FAWA 4219, 15kw	1963 / 28	Hercules QXLD, 6 cyl, 236 cu in, CR 6.59 to 1	25 to 27 degrees BTDC total advance at 1800 rpm	Magneto 32vdc	105 cfm Model 100-8	0.014 - 0.018"	0.025 - 0.028"	Refer to engine nameplate data. Hot engine.	American Bosch 32vdc: Actuator AGB100C1, AGB130D1, or AGB200A1 Controller CU671C-7
Hollingsworth, FA 2694, 20kw	1962 / 10	Hercules QXLD, 6 cyl, 236 cu in, CR 6.59 to 1	25 to 27 degrees BTDC total advance at 1800 rpm	Magneto 24vdc	105 cfm Model 100-8	0.014 - 0.018"	0.025 - 0.028"	Refer to engine nameplate data. Hot engine.	American Bosch 24vdc: Actuator AGB130D1 or AGB200A1 Controller CU671C-7 Barber Colman 24vdc: Actuator DYNC 50000 and Controller DYN1 10604
Hollingsworth, FA 2715, 30kw	1962 / 3	Hercules JXLD, 6 cyl, 339 cu in, CR 6.5 to 1	25 to 27 degrees BTDC total advance at 1800 rpm	Magneto 32vdc	143 cfm Model 200-4	0.014 - 0.018"	0.025 - 0.028" Autolite 308	Intake 0.010" Exhaust 0.010" Hot engine.	
Warner & Swasey, CCA 31247, 30kw	1955 / 4	Continental R602, 6 cyl, 602 cu in, CR 5.9 to 1	31 to 33 degrees BTDC total advance at 1200 rpm	Magneto 32vdc	166 cfm Model 200-6	0.014 - 0.018"	0.025 - 0.028" Champion 516	Intake 0.020" Exhaust 0.024" Hot engine See Note 3.	
Warner & Swasey, CCA 31247, 50kw	1955 / 3	Hercules HXE, 6 cyl, 935 cu in, CR 5.5 to 1	23 to 25 degrees BTDC total advance at 1200 rpm	Magneto 32vdc	258 cfm Model 200-6	0.014 - 0.018"	0.025 - 0.028"	Refer to engine nameplate data. Hot engine.	

Notes.

1. Effects of Altitude on Ignition Timing. For altitudes of 5000 - 7000 feet advance timing by 3 degrees. For altitudes of 7000 - 9000 feet advance timing by 5 degrees. For altitudes of 9000 and above advance timing by 7 degrees. An ignition timing light is provided in the NSN 5180-01-483-1236 Propane and Natural Gas E/G Tool Kit. Refer to Figure A4-1 for location of #1 cylinder.
2. If the engine does not run smoothly at these settings, adjust the ignition timing to obtain smooth operation at typical facility loads. For engines not listed in this chart that do not have any specific ignition timing settings from the engine manufacturer for propane fuel, use the following guidelines. For engines running at 1200 rpm, ignition timing should be in the range of 23-25 degrees BTDC total advance at 1200 rpm. For engines running at 1800 rpm, ignition timing should be in the range of 25-27 degrees BTDC total advance at 1800 rpm.
3. A decal on the valve cover of some Continental R602 engines may call for a 0.030" exhaust valve clearance. Use 0.024" clearance for the exhaust valve on the Continental R602 engine. The Technical Instruction books for the Warner and Swasey E/G call for a 0.024" exhaust valve clearance. The R602 Engine Service Manual No. IMX-6130 from Continental Motors Corporation also calls for a 0.024" exhaust valve clearance.
4. An all-purpose feeler gauge and tungsten ignition points file are provided in the NSN 5180-01-483-1236 Propane and Natural Gas E/G Tool Kit.

Table A4-3. Configurations for Legacy Engine Generators Converted To Propane Fuel With Magneto Ignition Systems

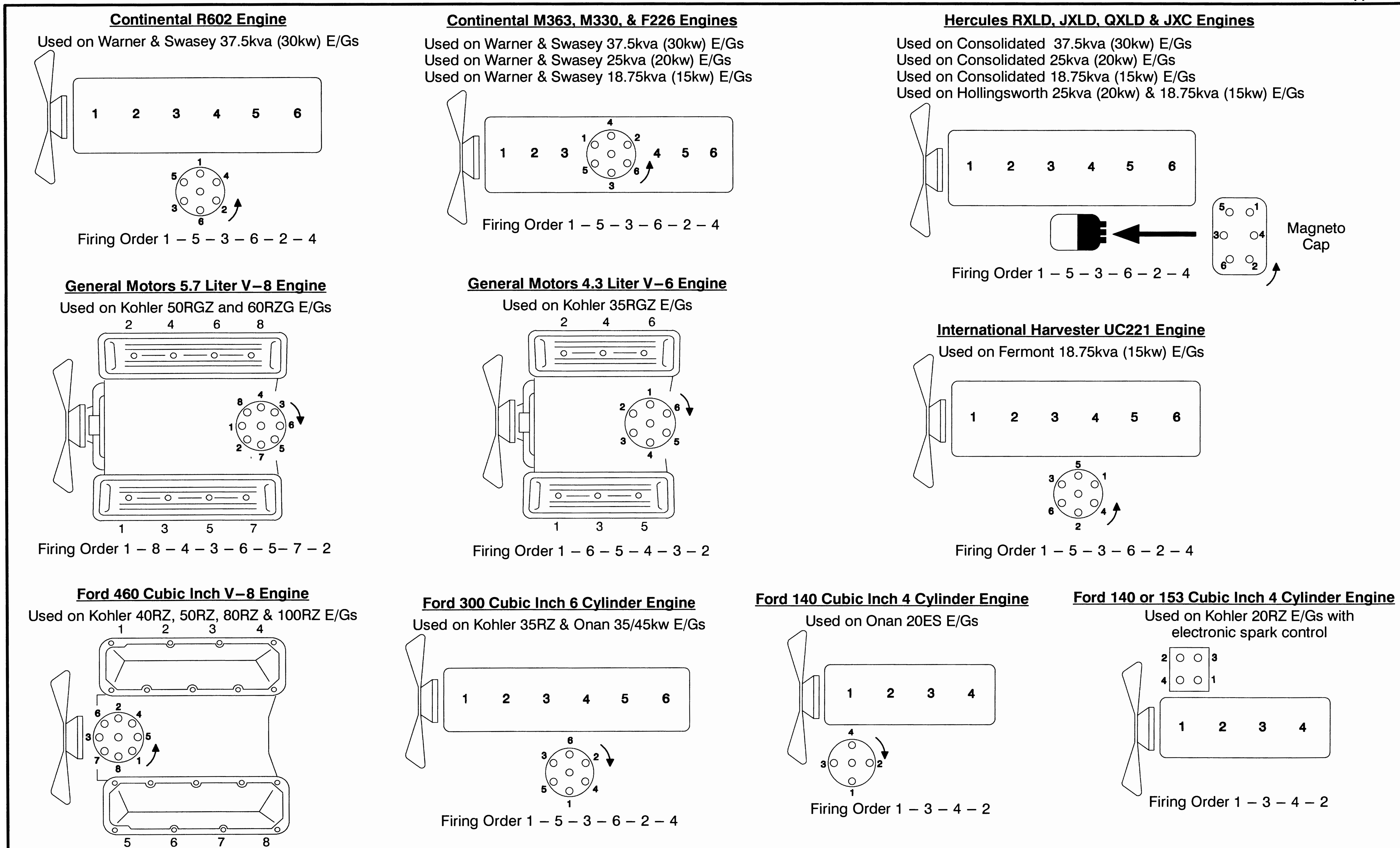


Figure A4–1. Engine Cylinder Layout and Ignition System Information

APPENDIX 5. PROPANE AND NATURAL GAS E/G TOOL KIT INFORMATION

FAA drawing AE-B-1588 outlines the tools and test equipment provided in the NSN 5180-01-483-1236 Propane and Natural Gas E/G Tool Kit.

In the original tool kits delivered to the field in 2002 and 2003, there was an 11 by 17 drawing package included in each kit. The 11 by 17 drawing package contained troubleshooting drawings (Figures 2-2 through 2-7) and an earlier revision of the tool kit drawing AE-B-1588. Figures 2-2 through 2-7 have been superceded by Figures A3-1 through A3-6 in Appendix 3 of this Order. This Appendix provides the latest revision of drawing AE-B-1588.

ITEM NO.	TOOL KIT COMPONENT DESCRIPTION	PART NO. (or equivalent)
1	Dwyer Magnehelic Low Pressure Gage, 0-10 inches of water column (1 each)	Grainger 3T319
2	Dwyer Magnehelic Low Pressure Gage, 0-20 inches of water column (3 each)	Grainger 1W479
3	Dwyer Magnehelic Low Pressure Gage portable kit (4 each)	Grainger 2T648
4	Ashcroft 0-30 psi pressure gauge	Grainger 2C506
5	Ashcroft 0-60 psi pressure gauge	Grainger 2C510
6	Ashcroft 0-300 psi pressure gauge	Grainger 2C508
7	Manifold Vacuum/Fuel Pressure Gage, 0 to 30" hg vacuum and 0 to 10 psi	Grainger 2T553
8	Cylinder compression test gage	Grainger 2T554
9	Inductive ignition timing light with advance adjustment	Grainger 4A651
10	1/4" NPT male by 3/8" male flare brass fitting (4 each)	Grainger 2P180
11	1/4" NPT female by 3/8" male flare brass fitting (2 each)	Grainger 2P187
12	1/8" NPT plugs, brass (5 each)	Grainger 6MN91
13	1/4" NPT brass coupler (2 each) (preferred) or 1/4"NPT black iron coupling (2 each) (alternate)	Grainger 6MN54 or Grainger 5P550
14	1/4" NPT female to 1/8" NPT male brass fitting (2 each)	Grainger 6MN88
15	1/4" NPT male to 1/8" NPT female brass reducer bushing (2 each) (preferred) or 1/4" NPT male to 1/8" NPT female black iron reducer bushing (2 each) (alternate)	Grainger 6MN59 or Grainger 5P507
16	3/8" NPT male to 1/4" NPT female brass reducer bushing (2 each) (preferred) or 3/8" NPT male to 1/4" NPT female black iron reducer bushing (2 each) (alternate)	Grainger 6MN60 or Grainger 5P509
17	1/2" NPT male to 1/4" NPT female brass reducer bushing (2 each) (preferred) or 1/2" NPT male to 1/4" NPT female black iron reducer bushing (2 each) (alternate)	Grainger 6MN61 or Grainger 5P511
18	3/4" NPT male to 1/4" NPT female reducer bushing (2 each)	Grainger 5P513
19	1/8" by 27 NPT pipe thread tap	Grainger 4AKL1
20	Pipe tap T handle	Grainger 4AKL9
21	"Q" drill bit	Grainger 1F721
22	3/32" drill bit	Grainger 1F751
23	Teflon pipe tape. 1/2" wide by 520" long	Grainger 4X543
24	Pipe dope	Grainger 4UK03
25	10 ft of 14/2 all-purpose service cord	Grainger 3V937
26	14-16 insulated butt splice (4 each)	Grainger 3KF23
27	Tool Box	Grainger 2H180
28	Plastic organizer for fittings	Grainger 2W782
29	Minigrip Reclosable Polyethylene Bag, 9" by 12" (2 each)	Grainger 5ZW37
30	1/8" NPT male to 3/16" hose male brass fitting (6 each)	McMaster-Carr 5346K11
31	Bubble Forming Leak Detector Liquid, Military Spec, 8 oz bottle with dauber.	McMaster-Carr 10875T16
32	(not used)	
33	High Pressure Hose Assembly (see Detail A). Consists of a. 5/16" high pressure steel braided hose, 18" long, 350 psi, suitable for liquid propane. b. High pressure, reusable, non-mandrel, hose coupling, 3/8" flare fitting female. c. High pressure, reusable, non-mandrel, hose coupling, 3/8" flare fitting female with 1/4"NPT female hydrostatic relief valve fitting. d. 0-300 psi pressure gage, 2" diameter face, 1/4" NPT male bottom connection.	American Propane Co. 1509 Exchange Ave Oklahoma City, OK 405-235-8401
34	High Pressure Hose Assembly (see Detail B). Consists of a. 5/16" high pressure steel braided hose, 12" long, 350 psi, suitable for liquid propane. b. High pressure, reusable, non-mandrel, hose coupling, 1/4" NPT male fitting (2 each). c. 1/4" NPT brass coupler. d. 1/4" NPT female by 1/8" NPT male brass fitting.	American Propane Co. 1509 Exchange Ave Oklahoma City, OK 405-235-8401
35	Adhesive-backed, plastic engraved nameplate, black with white letters.	See Detail C
36	Carburetor test fitting	See Detail F
37	All purpose feeler gauge set, 25-blade	Grainger 1AC11
38	Tungsten ignition point file	Grainger 1G780
39	Propane & Natural Gas E/G Tool Kit drawing, AE-B-1588 (2 sheets).	FAA AOS-1040
40	Propane & Natural Gas Troubleshooting Drawings.(10 sheets)	FAA AOS-1040
41	Oxygen Sensor, single wire	AC Delco 25162693
42	Stainless Steel Pocket Ruler, 1/2" wide by 6" long, 1/64th graduations, pocket clip	McMaster Carr 6813A61
43	Anti-Seize lubricant, 1 oz tube	Permatex 133AR
44	White Out Correction Fluid, 20ml bottle with applicator.	Any office supply store

Propane and Natural Gas E/G Tool Kit Assembly Instructions

1. Assemble each of the four Dwyer pressure gages (items 1 and 2) and the Dwyer portable gage kits (item 3) as follows:
   a. Install the two each recessed hex head 1/8" NPT plugs in the "HIGH PRESSURE" and "LOW PRESSURE" ports on the back of each Dwyer pressure gage prior to mounting the gage on the portable bracket.
   b. Install the two 1/8" NPT male by 3/16" hose barb brass fittings into the "HIGH PRESSURE" and "LOW PRESSURE" ports on the side of each Dwyer pressure gage.
   c. Use the three #6-32 slot head machine screws provided with each Dwyer pressure gage to attach the gage to the angle bracket in the portable kit.
   d. Place the gage/bracket, the black 3/16" dia hose and the 1/4" dia aluminum tube in the plastic carrying case.
   e. Discard the three each #8 sheet metal screws (2" long) and the four black plastic mounting adapters that are provided with each Dwyer gage. Discard the plastic bag containing 2 springs and 3 small #6-32 machine screws provided with each portable kit.
2. Install the 0-30 psi pressure gage (item 4) finger tight on the end of the 12 inch long hose assembly (item 34).
3. Places items 10, 11, 12, 13, 14, 15, 16, 17, 18, 30, and 36 in the plastic organizer box (item 28).
4. Place items 19, 20, 21, and 22 in a ziplock bag (item 29). Photocopy and insert one of the "ADDING PRESSURE ACCESS PORTS" instruction notes (see Detail E) inside the ziplock bag.
5. Use butt splices (item 26) and the 10 feet of 14/2 all purpose wire (item 25) to lengthen the battery cables on the ignition timing light (item 9). Be sure to maintain the polarity of the battery cables when adding the additional wire.
6. Stick the tool box nameplate (item 35) to the side of the tool box (item 27).
7. Photocopy the 11" by 17" tool kit drawing (item 39) and the Troubleshooting Drawings (item 40). Staple the 12 sheets together.
8. Place items 1, 2, 3, 7, 8, and 9 in the bottom level of the tool box (item 27). Place the ziplock bag from step 4 above in the bottom level of the tool box. Place the 11" by 17" drawing package (items 39 and 40 from the step above) in the bottom level of the tool box. Place the plastic organizer box and its contents (from step 3 above) in the bottom level of the tool box.
9. Place items 5, 6, 23, 24, 31, 37, 38, 41, 42, 43, and 44 in the second level of the tool box (the 5 1/2" deep open tray with handle). Place the two hose assemblies (items 33 and 34) in the second level of the tool box.
10. The top level of the tool box (the 2 1/2" deep plastic tray with multiple compartments) will remain empty.
11. Photocopy and insert a "TIMING LIGHT CONNECTIONS" note from Detail G inside the timing light box.
12. Photocopy and insert a "PLUGGED PRESSURE FITTINGS" note from Detail H inside each of the plastic Dwyer pressure gage carrying cases.

TIMING LIGHT CONNECTIONS

The timing light is designed for 12vdc systems. For 24vdc or 32vdc systems, connect the timing light battery leads across 8vdc or 12vdc on the E/G batteries. Do not connect across the entire 24vdc or 32vdc capacity.

DETAIL G.

PLUGGED PRESSURE FITTINGS

The brass hose barb fittings can rub through the plastic wall of the carrying case and become plugged. If the pressure gage is not reading accurately, insure that the gray plastic material has not plugged the end of the brass hose barb fitting

DETAIL H.

REV LTR	DATE	DESCRIPTION	CHECKED	APPROVED
H	4/20/04	Revise Assembly Notes 3 and 9	RP	TLR
G	4/14/04	Revised the assembly instructions. Deleted item 32 training videos from the tool kit	RP	TLR
F	3/12/04	Added items 43 and 44 to parts list	RP	TLR
E	10/7/03	Revised Items 39 and 40. Revised assembly instructions. Deleted timing light note	RP	TLR
D	7/29/02	Added oxygen sensor, ruler, & Figure 2-7 to kit	RP	TLR
C	3/1/02	Replaced item 32 hose with video series	RP	TLR
B	2/26/02	Updated Grainger part numbers	RP	TLR
A	2/12/02	Deleted AOS-220 as source for carb fitting. Added Details G & H. Deleted dielectric grease.	RP	TLR

FEDERAL AVIATION ADMINISTRATION
MIKE MONRONEY AERONAUTICAL CENTER OKLAHOMA CITY, OKLAHOMA 73125

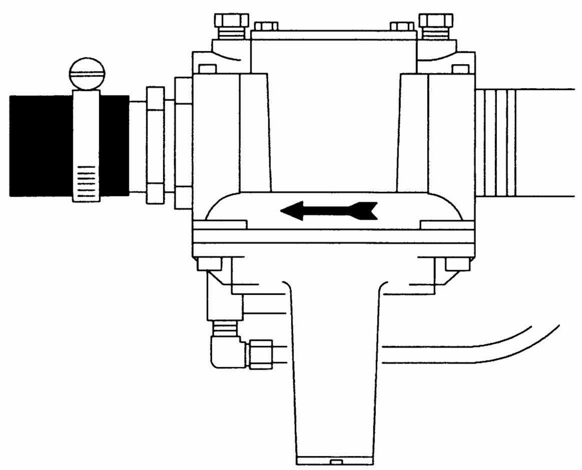
Propane & Natural Gas E/G Tool Kit

REVIEWED BY	DATE REVIEWED	SUBMITTED BY		APPROVED BY	
Tim Riley	12/20/00	Tim Riley		RHONDA WATKINS	
		DRAWN BY Ron Perkins	DATE: 01/15/01	PROJECT NO. 221-2001D019A	REV LTR
			ISSUED BY AOS-220	DRAWING NO.	
		CHKED BY Tim Riley	SHEET 1 OF 2	AE-B-1588-1	H
		Scale: None			

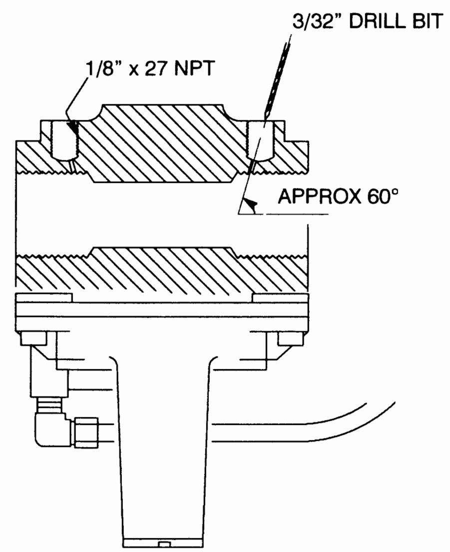
ADDING PRESSURE ACCESS PORTS

The items in this bag are used to create 1/8" NPT pressure access ports in the fuel delivery components in order to measure fuel system pressures. The "Q" size drill bit is used to drill the holes for the 1/8" – 27 thread NPT tap. Pressure access ports can be added to most regulator housings in order to measure input and output pressures.

Special instructions for Impco/Maxitrol IMP–53 Regulator Pressure Access Ports. Most propane and natural gas engines in the FAA use an Impco/Maxitrol IMP–53 regulator at the engine. On the base of the IMP–53 regulator housing, there is usually a 1/8" NPT access plug already threaded into the regulator housing. This access port is used to measure the output pressure of the IMP–53 regulator. The input pressure to the IMP–53 regulator can also be measured by threading the access port on the input side. See the drawing below for adding threaded access ports to the base of the IMP–53 regulators.

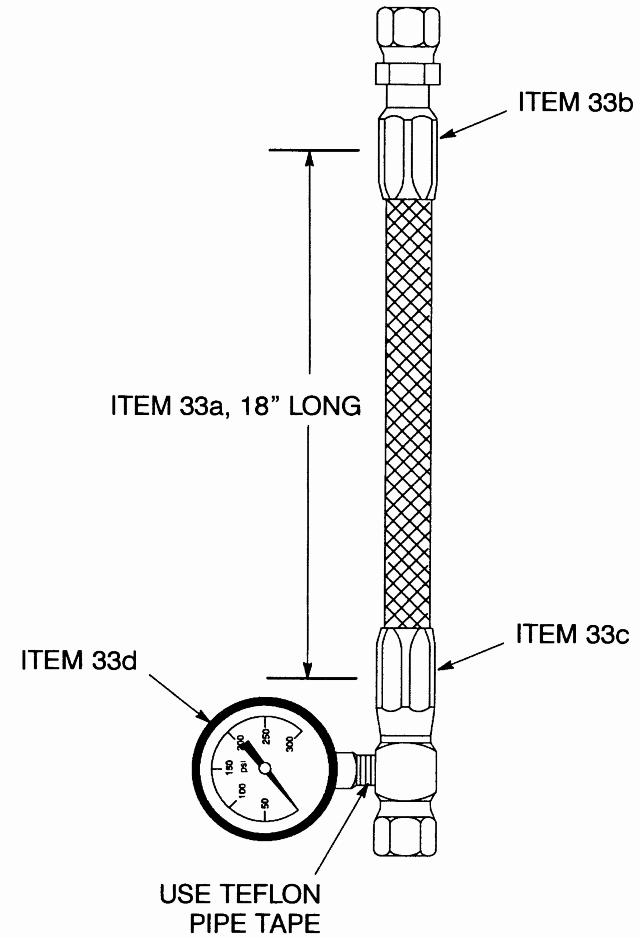


Impco/Maxitrol IMP–53 Pressure Regulator

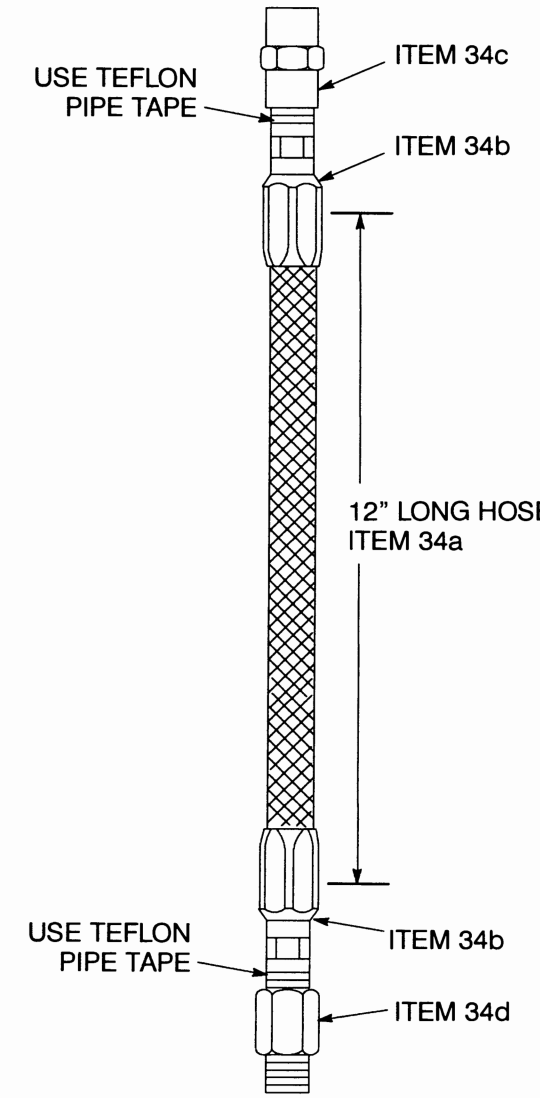


Cross section view of the Impco/Maxitrol IMP–53 pressure regulator housing showing threaded access ports for fuel pressure measurement.

DETAIL E. Instruction Notes for Access Ports

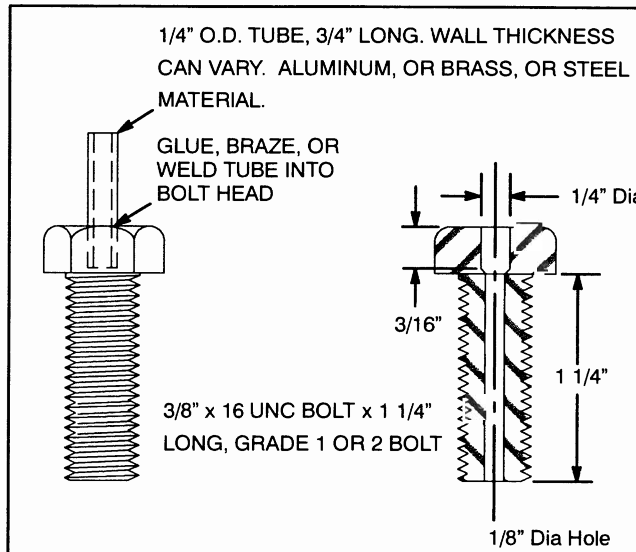


DETAIL A. High Pressure Hose Assembly



Detail B. High Pressure Hose Assembly

DETAIL C. Tool Box Nameplate
(Overall size and lettering style can vary slightly from above, if needed)



DETAIL F. Carburetor Test Fitting

Rev. LTR.	DATE	DESCRIPTION	CHECKED	APPROVED
C	8-09-02	ADDED BRASS MATERIAL FOR CARB TUBE	RP	TR
B	3-01-02	DELETED ITEM 32 FROM DETAIL A	RP	TR
A	2-12-02	CHANGED CARB FITTING FROM NYLON TO METAL	RP	TR

FEDERAL AVIATION ADMINISTRATION
MIKE MONRONEY AERONAUTICAL CENTER OKLAHOMA CITY, OKLAHOMA 73125

Propane & Natural Gas E/G Tool Kit

REVIEWED BY	DATE REVIEWED	SUBMITTED BY		APPROVED BY	
Tim Riley	12/20/00	Tim Riley		RHONDA WATKINS	
		DRAWN BY Ron Perkins	DATE: 01/15/01	PROJECT NO. 221-2001D019A	REV. LTR.
			ISSUED BY AOS–220	DRAWING NO.	
		CHECKED BY Tim Riley	SHEET 2 OF 2	AE-B-1588-2	C
		SCALE: NONE			

APPENDIX 6. PROPANE E/G FUEL SYSTEM INSTALLATION DRAWINGS - LIQUID WITHDRAWAL

FAA drawing AE-B-1479 outlines the recommended configuration for installing a new liquid propane fuel system for a Kohler E/G. This configuration uses a coolant heated vaporizer (Impco Model PE or equivalent) that is mounted on the outside wall of the E/G building. This is the most common propane fuel system used in the FAA. This type of fuel system was used in the original propane modification AF P 6980.3, change 289, chapter 249, Conversion of Engine Generators from Gasoline-Fueled to Propane-Fueled, dated 01/04/1990.

LIST OF DRAWINGS

Drawing AE-B-1479 is available in the original 11 by 17 size from the AOS-1040 website at http://aos-ext.amc.faa.gov/aos_1040/. At the AOS-1040 website, select "Propane and Natural Gas E/G Information" from the left hand menu. From the Propane and Natural Gas E/G Information home page, select "Fuel System Installation Drawings." Electronic copies (in Adobe Acrobat *.pdf format) of each drawing package can also be downloaded from the website.

Drawing AE-B-1479 should not be used by the Central Region of the FAA. The Central Region uses a different type of liquid propane system than what is outlined in drawing AE-B-1479. The Central Region configuration brings liquid propane inside the E/G building. A coolant heated vaporizer (Impco Model EB or equivalent) is used to convert the liquid to vapor. FAA drawing AE-B-1481 was originally developed for this type of liquid propane fuel system. However, in May 2002, the Kohler Company changed to a Woodward brand carburetor and governor control system. The new Woodward configuration is not compatible with an Impco Model EB vaporizer outlined in AE-B-1481. Therefore, drawing AE-B-1481 can no longer be used for Woodward-equipped Kohler E/Gs in the Central Region. Contact AOS-1040 for the fuel system modifications needed to make the Woodward-equipped Kohler E/Gs compatible with an Impco Model EB vaporizer.

Click on the following link to view drawings:

http://aos-ext.amc.faa.gov/user_documents/aos_1040/1044/eg/docs/install_propane_pe.pdf

APPENDIX 7. PROPANE E/G FUEL SYSTEM INSTALLATION DRAWINGS - VAPOR WITHDRAWAL

FAA drawing AE-B-1485 outlines the recommended configuration for installing a new vapor propane fuel system for a Kohler E/G. This configuration withdraws propane vapor (not liquid) from the top of the storage tank. This configuration is used primarily in the Southern Region of the FAA. It is intended for warm climates where the natural vaporization of the propane inside the storage tank can support the fuel demand of the engine. Refer to drawing AE-B-1485, sheet 20 of 21, for temperature guidelines.

LIST OF DRAWINGS

Drawing AE-B-1485 is available in the original 11 by 17 size from the AOS-1040 website at http://aos-ext.amc.faa.gov/aos_1040/. At the AOS-1040 website, select "Propane and Natural Gas E/G Information" from the left hand menu. From the Propane and Natural Gas E/G Information home page, select "Fuel System Installation Drawings." Electronic copies (in Adobe Acrobat *.pdf format) of each drawing package can also be downloaded from the website.

Click on the following link to view drawings:

http://aos-ext.amc.faa.gov/user_documents/aos_1040/1044/eg/docs/install_propane_vapor.pdf

APPENDIX 8. NATURAL GAS E/G FUEL SYSTEM INSTALLATION DRAWINGS

FAA drawing AE-B-1486 outlines the recommended configuration for installing a new natural gas fuel system for a Kohler E/G. This configuration uses a natural gas supply provided by a utility company.

LIST OF DRAWINGS

Drawing AE-B-1486 is available in the original 11 by 17 size from the AOS-1040 website at http://aos-ext.amc.faa.gov/aos_1040/. At the AOS-1040 website, select "Propane and Natural Gas E/G Information" from the left hand menu. From the Propane and Natural Gas E/G Information home page, select "Fuel System Installation Drawings." Electronic copies (in Adobe Acrobat *.pdf format) of each drawing package can also be downloaded from the website.

Click on the following link to view the drawings:

http://aos-ext.amc.faa.gov/user_documents/aos_1040/1044/eg/docs/install_natural_gas.pdf

U.S. Department of Transportation
Federal Aviation Administration

Memorandum

Subject: <u>INFORMATION:</u> Suggested improvements to Order 6980.11C, Maintenance of Engine Generators

Date:

From: ______________________________
Signature and title

Reply to Attn of: ______________________________
Facility Identifier
AF Address

To: Manager, National Airway Engineering Systems Division, AOS-200

Problems with present handbook:

Recommended improvements:

☆ U.S. GPO: 1997-568-016/60174

CHANGE U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

6980.11C
CHG 1

3/6/2002

SUBJ: MAINTENANCE OF ENGINE GENERATORS

1. PURPOSE. This change transmits revised maintenance interval pages to the stationary or mobile, standby or prime power engine generators. This directive implements Configuration Control Decision (CCD) No. N23824, Administrative Update to Maintenance of Engine Generators.

2. DISTRIBUTION.

a. This directive is distributed to selected offices and services within Washington headquarters, the William J. Hughes Technical Center, the Mike Monroney Aeronautical Center, regional Airway Facilities divisions, and Airway Facilities field offices having the following facilities/equipment: All Engine Generators facilities except air route traffic control centers (ARTCC).

b. An electronic version and distribution report of this directive is available on an Intranet site located at **http://aos-ext.amc.faa.gov/** under the "Technical Documentation" heading.

c. To obtain additional hard copies of this publication, contact Printing & Distribution Team, AMI-700B, at (405) 954-3771.

3. DISPOSITION OF TRANSMITTAL. Retain this transmittal.

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		28	3/6/2002
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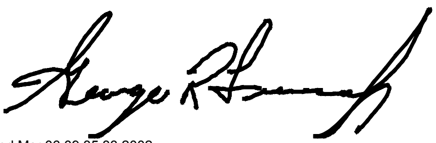

Wed Mar 06 09:35:33 2002

Gregg W. Dvorak
Program Director for Operational Support

CHANGE

U.S. DEPARTMENT OF TRANSPORTATION
FEDERAL AVIATION ADMINISTRATION

6980.11C
CHG 2

08/03/2004

SUBJ: MAINTENANCE OF ENGINE GENERATORS

1. PURPOSE. This change adds troubleshooting, maintenance, and installation information for propane and natural gas engine generators to the maintenance handbook.

2. DISTRIBUTION.

a. This directive is distributed to selected offices and services within Washington headquarters, the William J. Hughes Technical Center, the Mike Monroney Aeronautical Center, regional Airway Facilities divisions, and Airway Facilities field offices having the following facilities/equipment: SX.

b. An electronic version and distribution report of this directive are available on an Intranet site located at **http://aos-ext.amc.faa.gov/** under the "Technical Documentation" heading.

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		1 thru 21 (and 22)	08/03/2004
		Appendix 4	
		1 thru 11 (and 12)	08/03/2004
		Appendix 5	
		1 thru 5 (and 6)	08/03/2004
		Appendix 6	
		1 (and 2)	08/03/2004
		Appendix 7	
		1 (and 2)	08/03/2004
		Appendix 8	
		1 (and 2)	08/03/2004

Robert J. Morgan Jr.

for Jack Nager
Director for Technical Operations ATC Facilities

Distribution: 833 **Initiated By:** Operations Engineering Branch