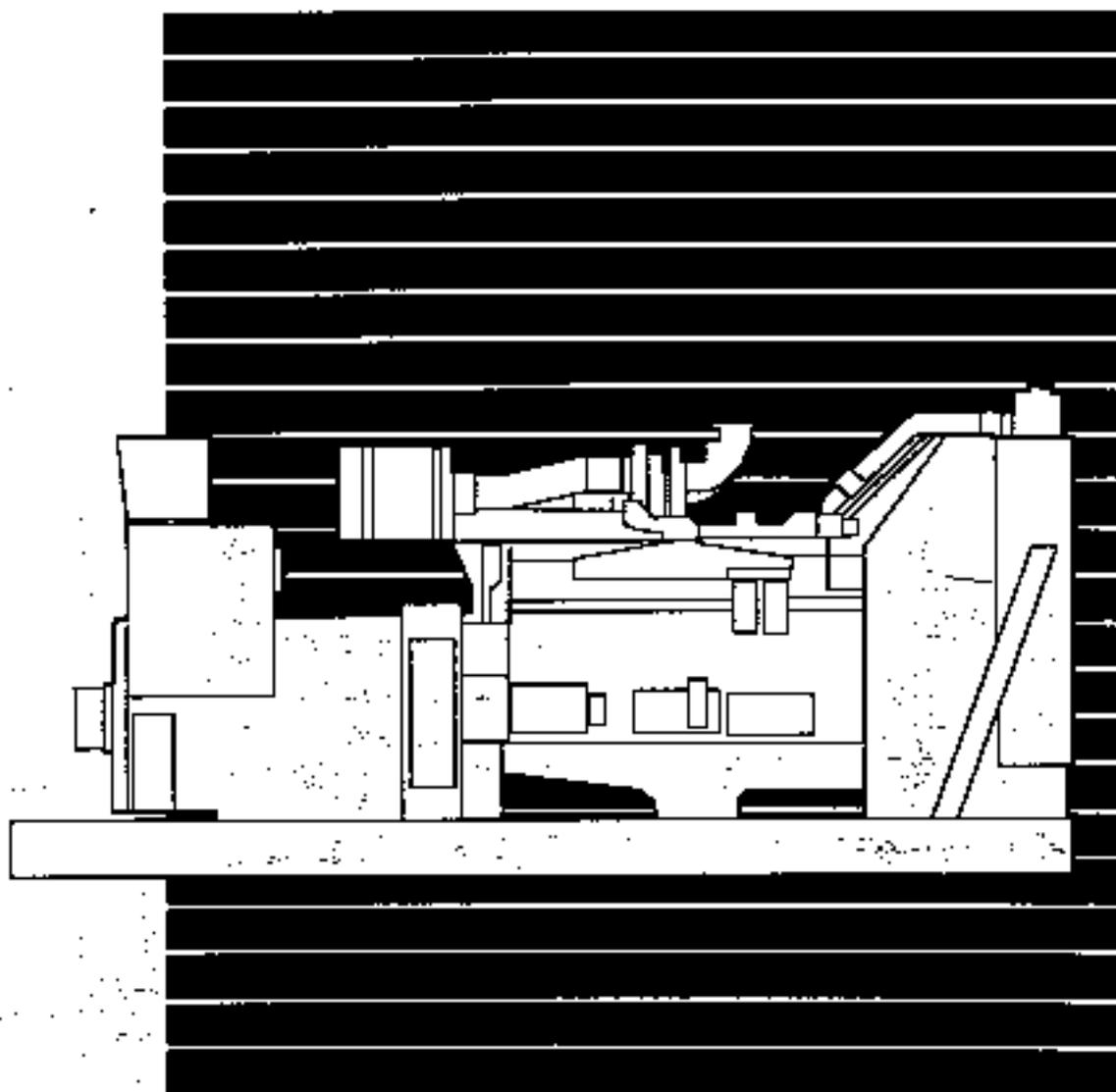




**Cummins
Power
Systems**

**Operation and
Maintenance
Manual**

**VTA-28-GS/GC
Generator Sets**



Important Safety Precautions

Read and observe these safety precautions when using or working on electric generators, engines and related equipment. Also read and follow the literature provided with the equipment.

Proper operation and maintenance are critical to performance and safety. Electricity, fuel, exhaust, moving parts and batteries present hazards that can cause severe personal injury or death.

FUEL, ENGINE OIL, AND FUMES ARE FLAMMABLE AND TOXIC

Fire, explosion, and personal injury can result from improper practices.

- Used engine oil, and benzene and lead, found in some gasoline, have been identified by government agencies as causing cancer or reproductive toxicity. When checking, draining or adding fuel or oil, do not ingest, breathe the fumes, or contact gasoline or used oil.
- Do not fill tanks with engine running. Do not smoke around the area. Wipe up oil or fuel spills. Do not leave rags in engine compartment or on equipment. Keep this and surrounding area clean.
- Inspect fuel system before each operation and periodically while running.
- Equip fuel supply with a positive fuel shutoff.
- Do not store or transport equipment with fuel in tank.
- Keep an ABC-rated fire extinguisher available near equipment and adjacent areas for use on all types of fires except alcohol.
- Unless provided with equipment or noted otherwise in installation manual, fuel lines must be copper or steel, secured, free of leaks and separated or shielded from electrical wiring.
- Use approved, non-conductive flexible fuel hose for fuel connections. Do not use copper tubing as a flexible connection. It will work-harden and break.

EXHAUST GAS IS DEADLY

- Engine exhaust contains carbon monoxide (CO), an odorless, invisible, poisonous gas. Learn the symptoms of CO poisoning.
- Never sleep in a vessel, vehicle, or room with a genset or engine running unless the area is equipped with an operating CO detector with an audible alarm.
- Each time the engine or genset is started, or at least every day, thoroughly inspect the exhaust system. Shut down the unit and repair leaks immediately.

- **Warning:** Engine exhaust is known to the State of California to cause cancer, birth defects and other reproductive harm.

Make sure exhaust is properly ventilated.

- Vessel bilge must have an operating power exhaust.
- Vehicle exhaust system must extend beyond vehicle perimeter and not near windows, doors or vents.
- Do not use engine or genset cooling air to heat an area.
- Do not operate engine/genset in enclosed area without ample fresh air ventilation.
- Expel exhaust away from enclosed, sheltered, or occupied areas.
- Make sure exhaust system components are securely fastened and not warped.

MOVING PARTS CAN CAUSE SEVERE PERSONAL INJURY OR DEATH

- Do not remove any guards or covers with the equipment running.
- Keep hands, clothing, hair, and jewelry away from moving parts.
- Before performing any maintenance, disconnect battery (negative [-] cable first) to prevent accidental starting.
- Make sure fasteners and joints are secure. Tighten supports and clamps, keep guards in position over fans, drive belts, etc.
- If adjustments must be made while equipment is running, use extreme caution around hot manifolds and moving parts, etc. Wear safety glasses and protective clothing.

BATTERY GAS IS EXPLOSIVE

- Wear safety glasses and do not smoke while servicing batteries.
- Always disconnect battery negative (-) lead first and reconnect it last. Make sure you connect battery correctly. A direct short across battery terminals can cause an explosion. Do not smoke while servicing batteries. Hydrogen gas given off during charging is explosive.
- Do not disconnect or connect battery cables if fuel vapors are present. Ventilate the area thoroughly.

DO NOT OPERATE IN FLAMMABLE AND EXPLOSIVE ENVIRONMENTS

Flammable vapor can be ignited by equipment operation or cause a diesel engine to overspeed and become difficult to stop, resulting in possible fire, explosion, severe personal injury and death. **Do not operate diesel equipment where a flammable vapor environment can be created by fuel spill, leak, etc., unless equipped with an automatic safety device to block the air intake and stop the engine.**

HOT COOLANT CAN CAUSE SEVERE PERSONAL INJURY

- Hot coolant is under pressure. Do not loosen the coolant pressure cap while the engine is hot. Let the engine cool before opening the pressure cap.

ELECTRICAL SHOCK CAN CAUSE SEVERE PERSONAL INJURY OR DEATH

- Do not service control panel or engine with unit running. High voltages are present. Work that must be done while unit is running should be done only by qualified service personnel.
- Do not connect the generator set to the public utility or to any other electrical power system. Electrocutation can occur at a remote site where line or equipment repairs are being made. An approved transfer switch must be used if more than one power source is connected.
- Disconnect starting battery (negative [-] cable first) before removing protective shields or touching electrical equipment. Use insulative mats placed on dry wood platforms. Do not wear jewelry, damp clothing or a low skin surface to be damp when handling electrical equipment.
- Use insulated tools. Do not tamper with interlocks.
- Follow all applicable state and local electrical codes. Have all electrical installations performed by a qualified licensed electrician. Tag open switches to avoid accidental closure.
- With transfer switches, keep cabinet closed and locked. Only authorized personnel should have cabinet or operational keys. Due to serious shock hazard from high voltages within cabinet, all service and adjustments must be performed by an electrician or authorized service representative.

If the cabinet must be opened for any reason:

1. Move genset operation switch or Stop/Auto/Handcrank switch (whichever applies) to Stop.
2. Disconnect genset batteries (negative [-] lead first).
3. Remove AC power to automatic transfer switch. If instructions require otherwise, use extreme caution due to shock hazard.

MEDIUM VOLTAGE GENERATOR SETS (601V TO 15KV)

- Medium voltage acts differently than low voltage. Special equipment and training are required to work on or around medium voltage equipment. Operation and maintenance must be done only by persons trained and qualified to work on such devices. Improper use or procedures will result in severe personal injury or death.
- Do not work on energized equipment. Unauthorized personnel must not be permitted near energized equipment. Induced voltage remains even after equipment is disconnected from the power source. Plan maintenance with authorized personnel so equipment can be de-energized and safely grounded.

GENERAL SAFETY PRECAUTIONS

- Do not work on equipment when mentally or physically fatigued or after consuming alcohol or drugs.
- Carefully follow all applicable local, state and federal codes.
- Never step on equipment (as when entering or leaving the engine compartment). It can stress and break unit components, possibly resulting in dangerous operating conditions from leaking fuel, leaking exhaust fumes, etc.
- Keep equipment and area clean. Oil, grease, dirt, or stored gear can cause fire or damage equipment by restricting airflow.
- Equipment owners and operators are solely responsible for operating equipment safely. Contact your authorized Onan/Cummins dealer or distributor for more information.

KEEP THIS DOCUMENT NEAR EQUIPMENT FOR EASY REFERENCE.

Table Of Contents

SECTION	TITLE	PAGE
	SAFETY PRECAUTIONS	ii
1	INTRODUCTION	1-1
	About This Manual	1-1
	How to Use This Manual	1-1
	How to Obtain Service	1-1
	Generator Set Overview	1-2
	Control Panel	1-4
	Control Panel Interior	1-8
	Voltage Regulator and Excitation Switch	1-10
	Engine Sensors	1-10
2	OPERATION	2-1
	General	2-1
	Prestart Checks	2-1
	Starting	2-4
	Operating Checks	2-5
	Stopping	2-5
	No-Load Operation	2-5
	Exercise Period	2-6
	Low Operating Temperatures	2-6
3	TROUBLESHOOTING	3-1
4	MAINTENANCE	4-1
	Generator Set Inspection	4-2
	Lubrication System	4-4
	Crankcase Breathers	4-7
	Cooling System	4-7
	Fuel System	4-11
	Air Cleaner	4-12
	AC Generator	4-13
	Batteries	4-13
5	INSTALLATION	5-1
	General	5-1
	Specifications	5-3
	Mounting the Generator Set	5-4
	Mechanical Connections	5-5
	Electrical Connections	5-11
	Wiring Diagrams	5-16

Table Of Contents

SECTION	TITLE	PAGE
6	PRESTART PREPARATIONS	6-1
	Ventilation	6-1
	Exhaust System	6-1
	Mechanical	6-1
	Electrical System	6-1
	Coolant	6-2
	Lubrication	6-2
	Fuel System	6-3
7	INITIAL START AND CHECKS	7-1
	Prestart Control Checks	7-1
	Starting	7-2
	Engine Gauges	7-2
	AC Checks	7-3
	Exhaust System	7-4
	Fuel System	7-4
	Mechanical	7-4
	Stopping	7-4
	Break-In Procedure	7-4
8	ADJUSTMENTS	8-1
.....	Electric Governor Adjustment	8-1
	Voltage Regulator Adjustment	8-3

Section 1. Introduction

ABOUT THIS MANUAL

This manual provides general information for installing, operating, and maintaining your generator set. Study this manual carefully and observe all warnings and cautions. Be sure to thoroughly review *Safety Precautions*, pages i and ii. Using the generator set properly and following a regular maintenance schedule is important to obtain longer unit life, better performance, and safer operation.

Included with the generator set literature package is a copy of the Cummins Engine Operation and Maintenance Manual. In case of conflicting information, this Generator Set Operation and Maintenance Manual takes precedence over the engine manual.

HOW TO USE THIS MANUAL

Personnel responsible for operating and maintaining this generator set should read this manual completely.

Installation, prestart preparations, and initial start-up information is provided in this manual, Sections 5 through 7, to assist in personnel training and future facility changes that may require relocating the generator set. During generator set installation, initial prestart preparations and start-up, the operating and maintenance personnel should review Sections 5 through 7 of this manual and make notes about the location and function of all ancillary equipment specific to your installation. Upon completion of installation and satisfactory performance of site equipment, normally performed by consulting engineer, the operation and maintenance sections of the manual, Sections 2 through 4, should then be followed.

For any operation, maintenance, or troubleshooting information beyond the scope of this manual, refer to other manuals received with unit, or contact your distributor.

HOW TO OBTAIN SERVICE

When the generator set requires servicing, contact your distributor for assistance. Factory trained Parts and Service representatives are ready to handle your service needs.

When contacting your distributor, always supply the complete Model, ID, and Serial numbers of your generator set as shown on the Generator Set Data Tag (see Figure 1-1), located on the side of the generator control box (see Figure 1-3). Also provide the engine serial number from the Engine Data Tag, located at generator end of engine (see Figure 1-3).

WARNING *Incorrect service or replacement of parts can result in severe personal injury or death, and equipment damage. Service personnel must be qualified to perform electrical and mechanical service. Read and follow Safety Precautions, pages i and ii.*

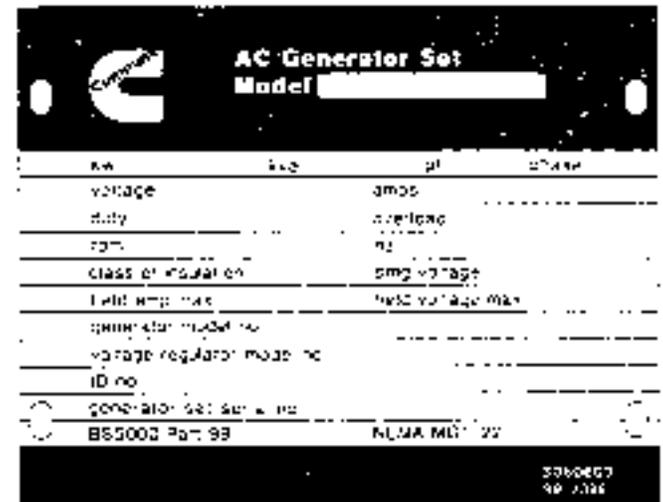


FIGURE 1-1. GENERATOR SET DATA TAG

GENERATOR SET OVERVIEW

Study the following outline drawings of the generator set and become familiar where these components are located. A more in-depth description of the control components follow in this section. Read this information

well and understand the function of each control component. You will want to become efficient at operating the generator set in order to be effective troubleshooting a fault condition, if one occurs.

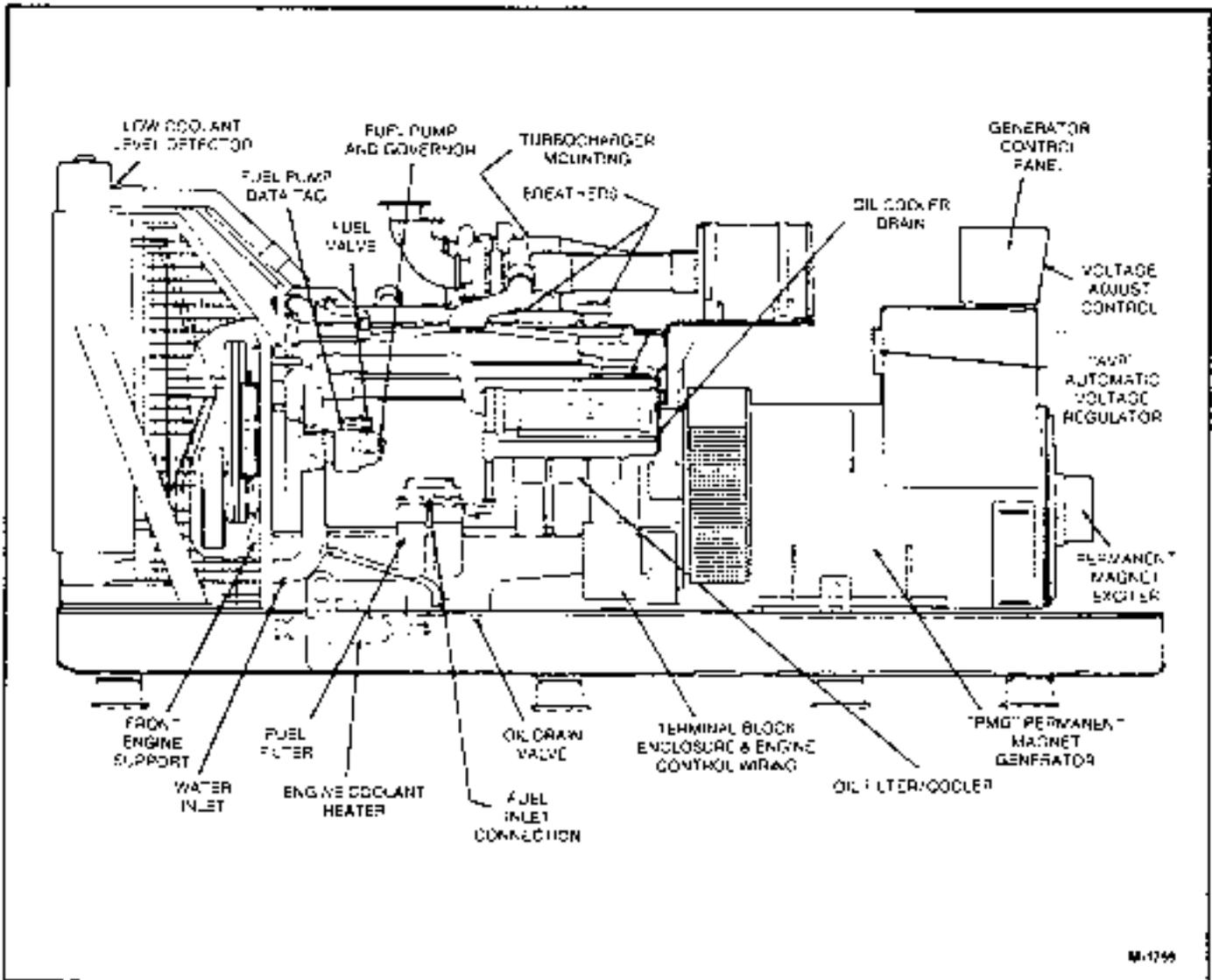
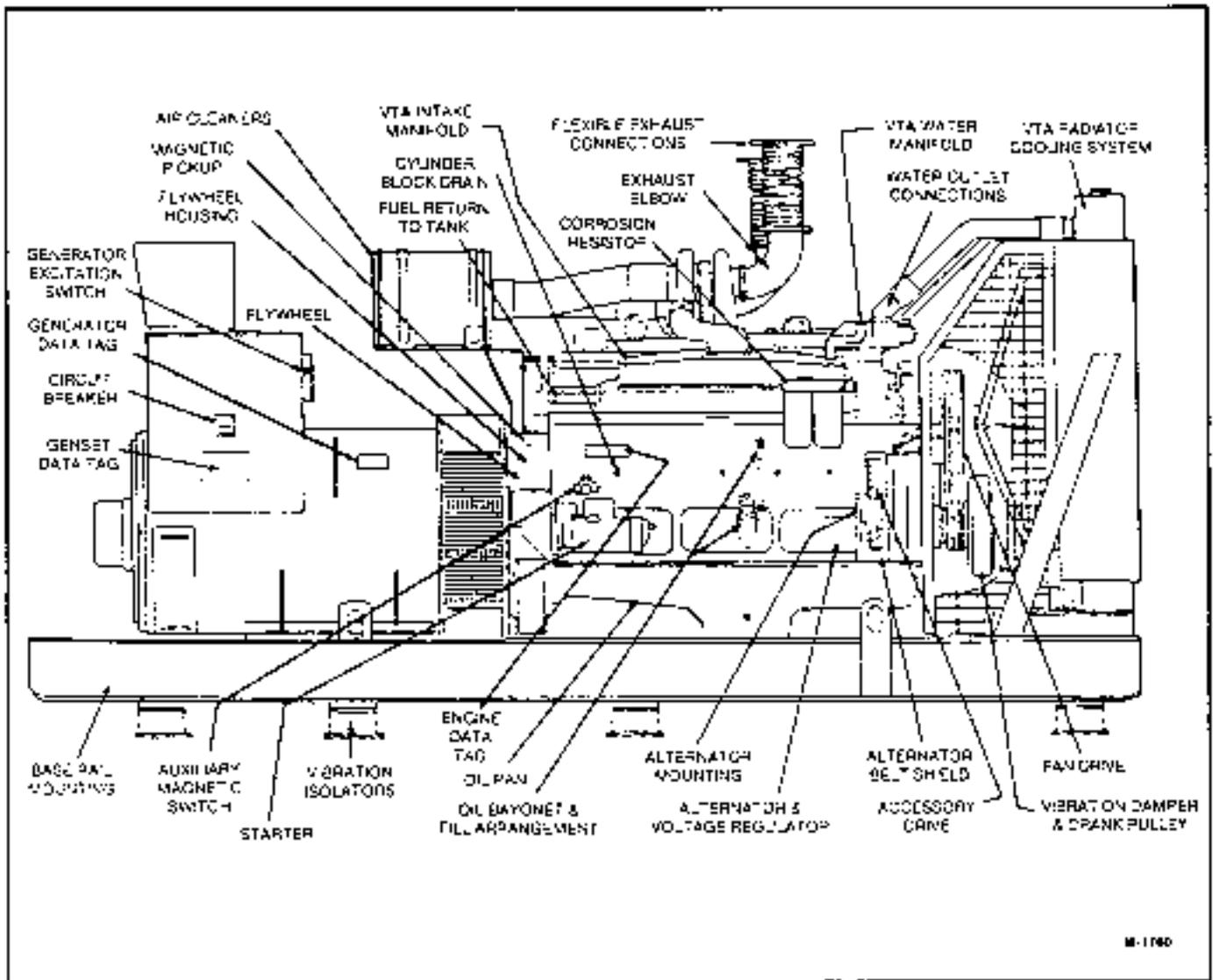


FIGURE 1-2. TYPICAL VTA-28 GENERATOR SET OUTLINE DRAWING (LEFT SIDE)



M-1760

FIGURE 1-3. TYPICAL VTA-28 GENERATOR SET OUTLINE DRAWING (RIGHT SIDE)

CONTROL PANEL

The following describes the function and operation of a generator set control with options included. All instruments and control switches are located on the face of the control panel. Except for a few system fault indicators, the generator set control panel is separated into two parts; an engine panel on the left for monitoring the engine (see Figure 1-4), and a generator panel on the right for monitoring the generator (see Figure 1-5).

Depending on customer order, your control configuration may differ from that described here. Review the following component descriptions and illustrations to identify your specific control options.

Engine Panel

SHUT-DOWN — Indicator Lamps

- **OVERSPEED** (red) indicates engine has shut down because of excessive speed.
- **LOW OIL PRESSURE** (red) indicates engine has shut down because of critically low oil pressure.
- **COOLANT** (red) indicates engine has shut down because of critically high coolant temperature, or low coolant level (option a).
- **REMOTE STOP** (red) indicates engine has shut down because of remote signal (customer dedicated).

EARLY WARNING — Indicator Lamps

- **LOW OIL PRESSURE** (yellow) indicates engine oil pressure is marginally low.
- **HIGH COOLANT TEMP** (yellow) indicates engine coolant temperature is marginally high.
- **LOW COOLANT TEMP** (yellow) indicates engine coolant temperature is marginally low for starting. Indicates inoperative coolant heater. (Lamp lights when engine water jacket temperature is 70°F (21°C) or lower. The lamp may stay on during initial generator set operation, but should extinguish after the engine warms up.)
- **LAMP TEST** (yellow) will illuminate when the Lamp Test switch is depressed. Depressing the Lamp Test switch will illuminate all indicator lamps.

Instruments

Oil Pressure Gauge: Indicates pressure of lubricating oil in engine (wired to a sensor unit located on the engine).

Oil Temperature Gauge: Indicates temperature of lubricating oil in engine (wired to a sensor unit located on the engine).

Water (Engine Coolant) Temperature Gauge: Indicates temperature of circulating coolant in engine (wired to a sensor unit located on the engine).

Battery Voltmeter: Indicates the battery condition. Proper reading should be approximately 26 to 28 volts. A lower reading indicates maintenance required.

Hour Meter: Registers the total number of hours the unit has run. Use it to keep a record of periodic servicing. Time is cumulative, meter cannot be reset.

Tachometer: Provides monitoring of engine r/min.

Speed Adjust: Potentiometer providing engine speed adjustment to achieve proper AC frequency.

Run/Idle Switch: Switch to allow engine to operate at lower idle speed during certain maintenance procedures; normally in RUN position.

Circuit Breaker: Protects 24-volt engine control wiring and components from overloads.

Manual Start Switches: The CRANK and START-RUN-OFF switch are used together to manually start the generator set. Upon start-up, the CRANK switch returns to the upward position, and the START-RUN-OFF switch returns to RUN position. Placing the START-RUN-OFF switch to OFF position shuts down the generator set.

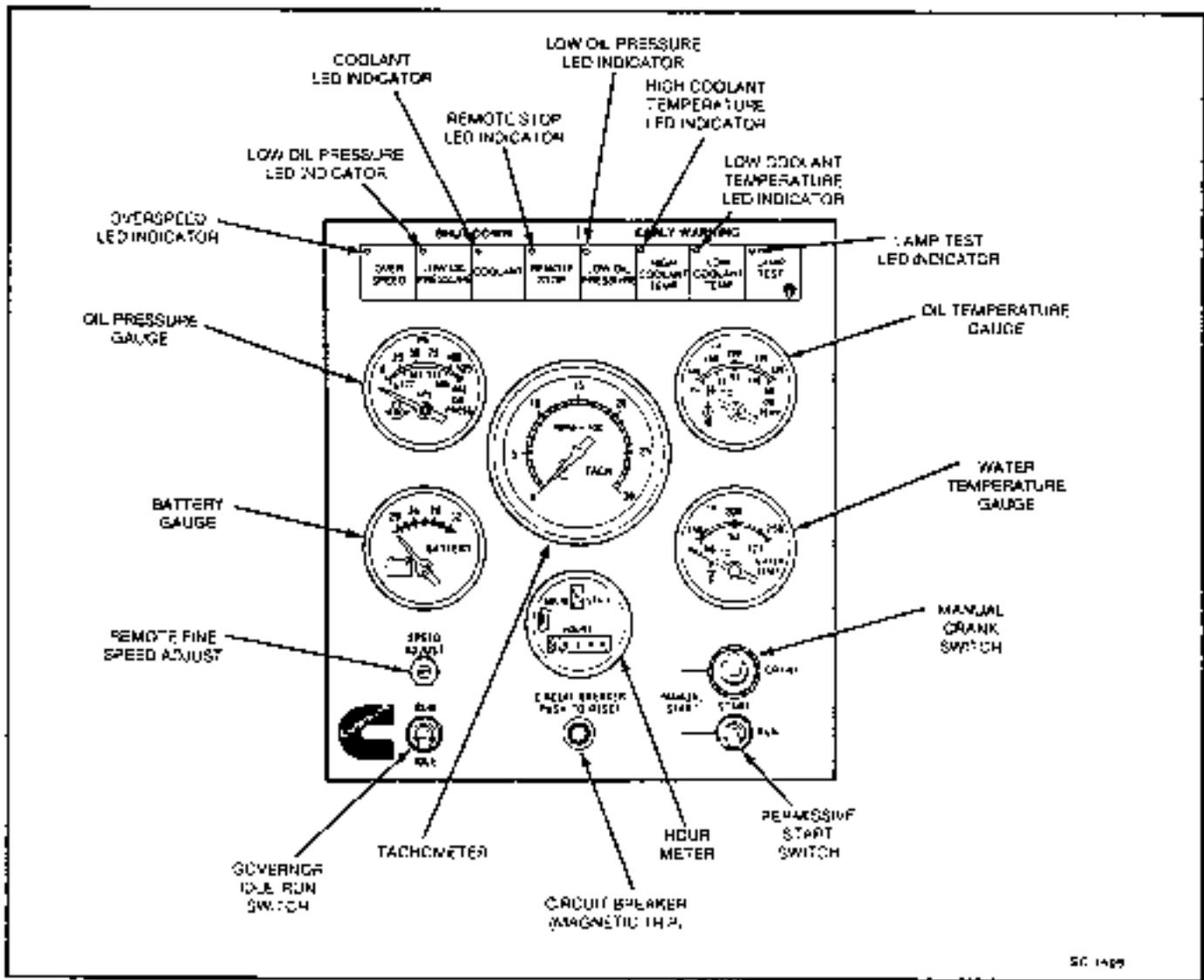


FIGURE 1-4. ENGINE PANEL

The following describes the function and operation of the generator panel, with options included. (See Figure 1-5).

Generator Panel

AUTO START — Indicator Lamps

- **CONTROL NOT IN AUTO** (flashing red) indicates generator set is not in automatic start operation mode.
- **OVERCRANK** (red) indicates the starter has been locked out because of excessive cranking time.

METER SCALE — Indicator Lamps

- **READ UPPER/LOWER METER SCALES** (red) provides a reminder when monitoring dual scale AC Ammeter and Voltmeter.

NFPA 110 — Indicator Lamps

- **ALARM** (yellow) provides a visual alarm indication should the ALARM switch be at SILENCE position; lamp will remain illuminated until control is reset.
- **LOW FUEL** (yellow) indicates fuel supply is low
- **GEN SET UNDER LOAD** (yellow) indicates that generator set is attempting to start under a load condition.
- **LOW BATTERY VOLTAGE** (yellow) indicates that starting batteries are at low voltage condition.
- **BATTERY CHARGER FAILURE** (yellow) indicates a fault condition of on-site battery charger

Instruments

AC Voltmeter: Dual range instrument indicating generator AC voltage.

AC Amperes: Dual range instrument indicates AC generator line current.

Hertz/RPM Meter: Indicates generator output frequency in hertz, and engine speed.

Voltage Adjust: Rheostat providing approximately plus or minus three percent adjustment of the rated output voltage.

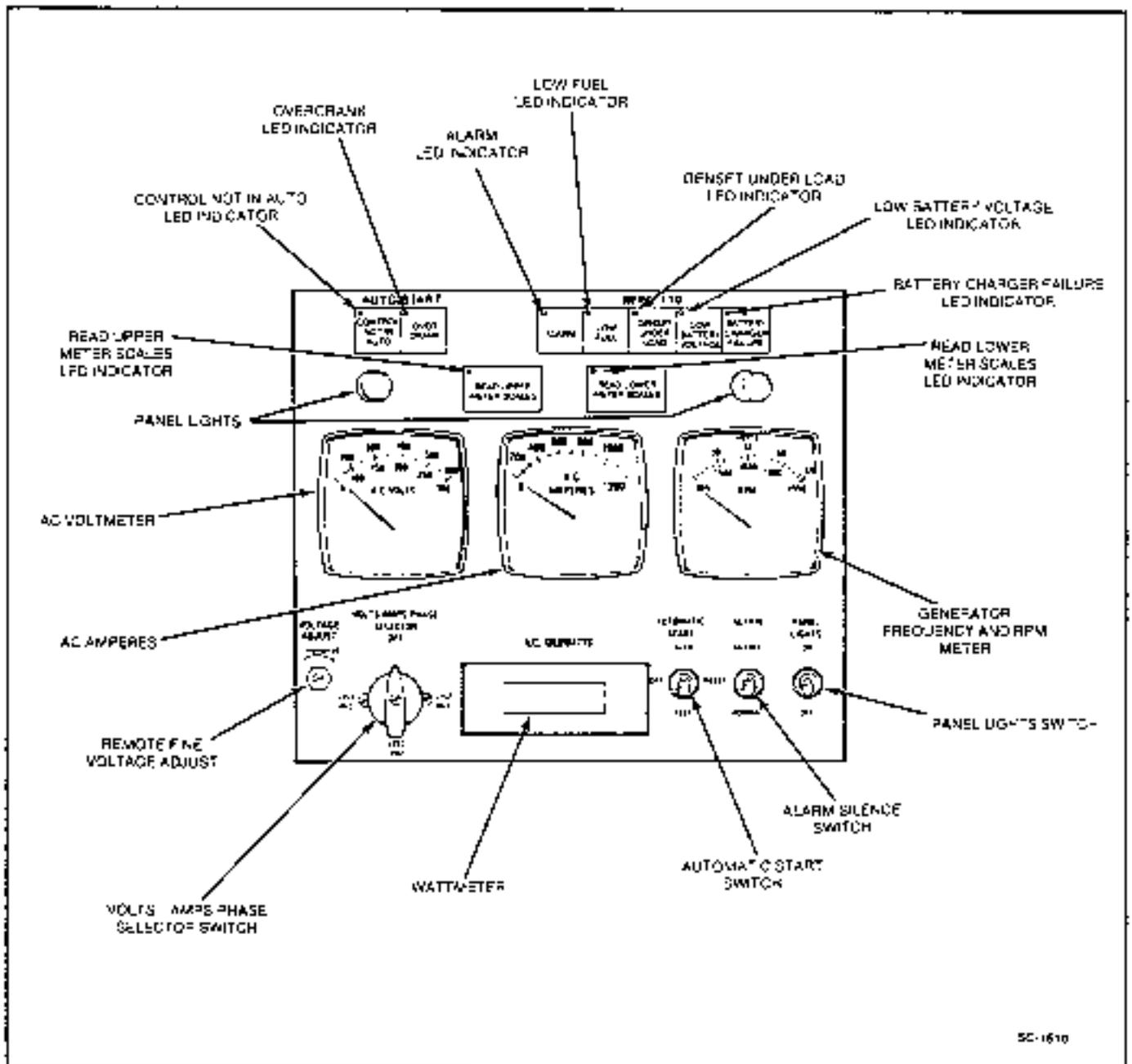
Phase Selector Switch: Selects phases of generator output to be measured by AC voltmeter and AC ammeter.

Wattmeter: Continuously gives reading of the generator output in kilowatts.

Automatic Start Switch: With the switch at AUTO position, the generator set may be started from a remote location (manual remote start switch, or automatic start switch at transfer switch equipment). The OFF/RESET position is used to reset the control after a fault condition. Depressing the switch down to TEST position simulates a remote start signal.

Alarm Switch: Placing the switch to SILENCE position will silence the horn alarm during a fault condition. This switch should always spring-return to the NORMAL position.

Panel Lights Switch: Illuminates control panel lights.



SC-1610

FIGURE 1-5. GENERATOR PANEL

CONTROL PANEL INTERIOR

Review the following description of the Generator Set Control Circuit Boards to better understand the operation of the generator set should a fault condition occur. For more information regarding the components in your control box, refer to specific wiring diagrams for your generator set. The Adjustments section of this manual contains adjustments for the governor and voltage regulator. Contact your distributor for further assistance.

Engine/Generator Control Circuit Boards

These circuit boards contain the basic components for normal engine start-up and shutdown, terminals for remote control interconnect, plug-in connectors for option modules and engine sensor inputs, etc. (see Figure 1-8). The control circuit boards provide the following functions of unit protection:

- **Overcrank** - The cyclic cranking circuit provides for alternate 15-second cranking periods with 15-second rest periods, and limits an engine cranking cycle to 80 seconds. If the engine fails to start, the control lights a fault lamp and opens the cranking circuit.
- **Overspeed** - Shuts down the engine immediately if overspeed occurs and lights a fault lamp. The sensor is a frequency detection module connected to the generator PMG output. The module is mounted in the generator output box. It is factory adjusted to shut down 60 Hz units at approximately 2100 r/min, 50 Hz units at approximately 1850 r/min.
- **Low Oil Pressure** - Shuts down the engine immediately if oil pressure drops below 12 psi (83 kPa) and lights a fault lamp. The fault is time delayed about 10 seconds following starter disconnect and inhibited during cranking. The delay allows oil pressure to rise to normal before the electronic control monitors this system.

A pre-low oil pressure sensor and lamp provides an alarm that oil pressure is marginally low, 18 psi (124 kPa) or less. The cause should be found and corrected as soon as possible.

- **High Coolant Temperature** - Shuts down the engine immediately if coolant temperature rises above 223° F (106° C) and lights a fault lamp. The fault is time delayed about 10 seconds following starter disconnect and inhibited during cranking. This delay allows coolant in a hot engine time to circulate and return the water jacket to normal before the electronic control resumes monitoring this system.

A pre-high engine temperature sensor and lamp provides an alarm that engine temperature is marginally high, 215° F (102° C) or higher. The cause should be found and corrected as soon as possible.

CAUTION *The high engine coolant temperature shutdown system will not operate if the coolant level is too low. The high engine coolant temperature sensor monitors coolant temperature. Loss of coolant will prevent sensor operation and allow the engine to overheat causing severe damage to the engine. Maintain adequate coolant level so the high engine coolant temperature shutdown system can function properly.*

- **Low Coolant Level Shutdown** - A fluid level sensing switch provides engine shutdown if coolant level falls too low. It also lights the high engine coolant temperature fault lamp.

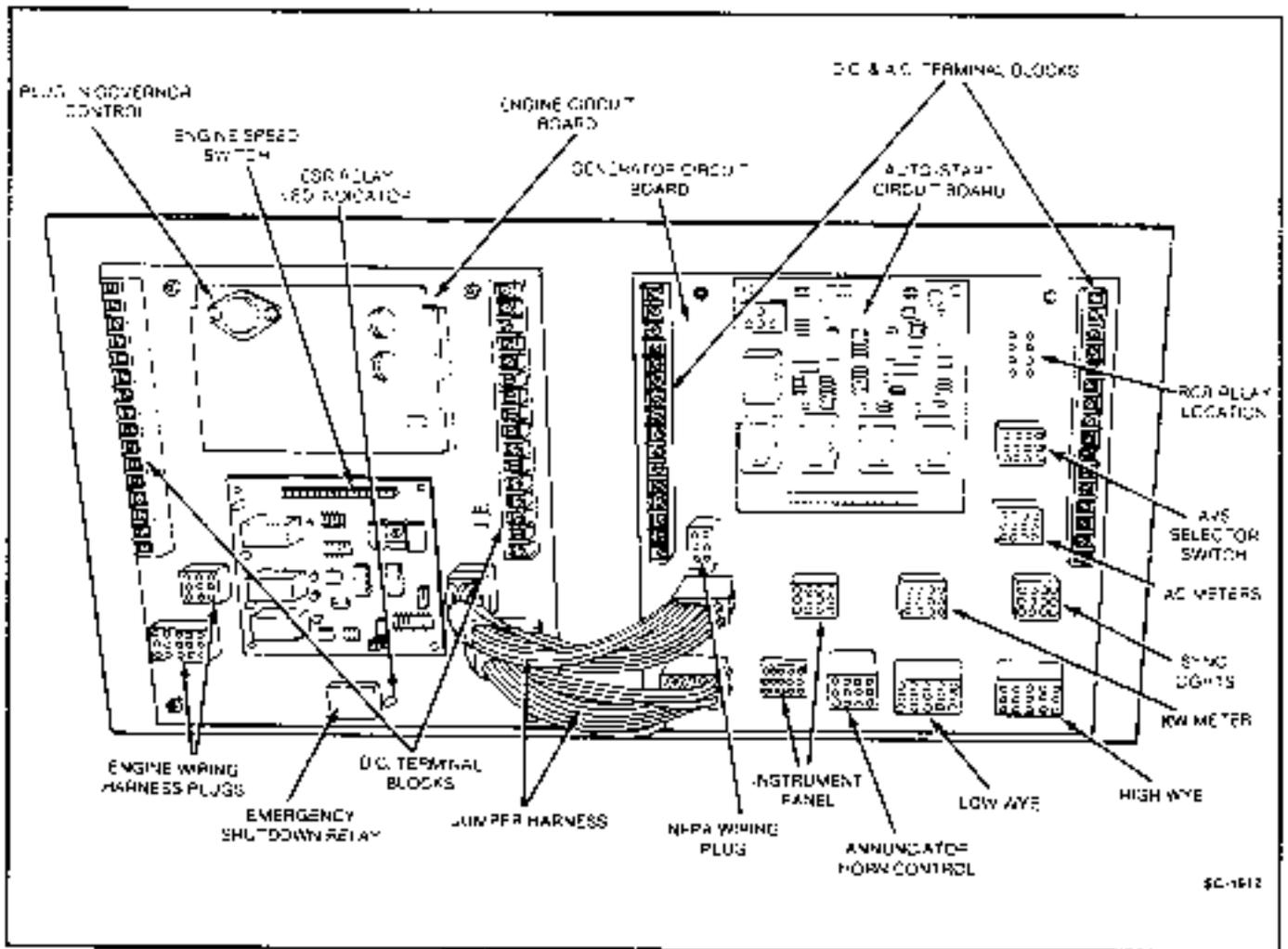


FIGURE 1-6. ENGINE/GENERATOR CONTROL CIRCUIT BOARDS

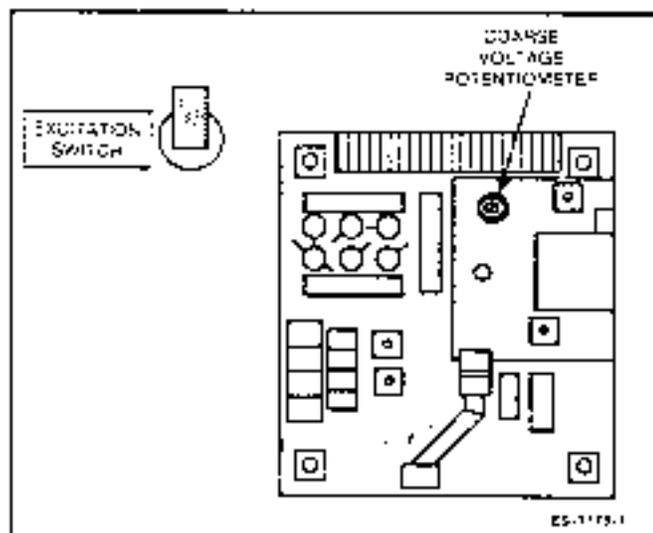


FIGURE 1-7. VOLTAGE REGULATOR AND EXCITATION SWITCH

VOLTAGE REGULATOR AND EXCITATION SWITCH

These components are located on the back side of the generator conduit box. Refer to *Adjustments* section for further description and adjustment procedure of the Voltage Regulator.

The Excitation Switch, located next to the voltage regulator, is basically an over-voltage protection circuit breaker. The switch should always be in the up, ON, position. See Figure 1-7.

ENGINE SENSORS

The generator set has a number of sensor units that continuously monitor the engine for abnormal conditions such as high coolant temperature and low oil pressure (see Figure 1-8). If an abnormal condition does occur, the engine control circuit board will activate a fault lamp and may also stop the engine depending on the condition. If the generator set does shut down, the operator may be able to restart the set after making certain adjustments or corrections. Refer to *Troubleshooting* section for further information regarding fault conditions and corrective actions.

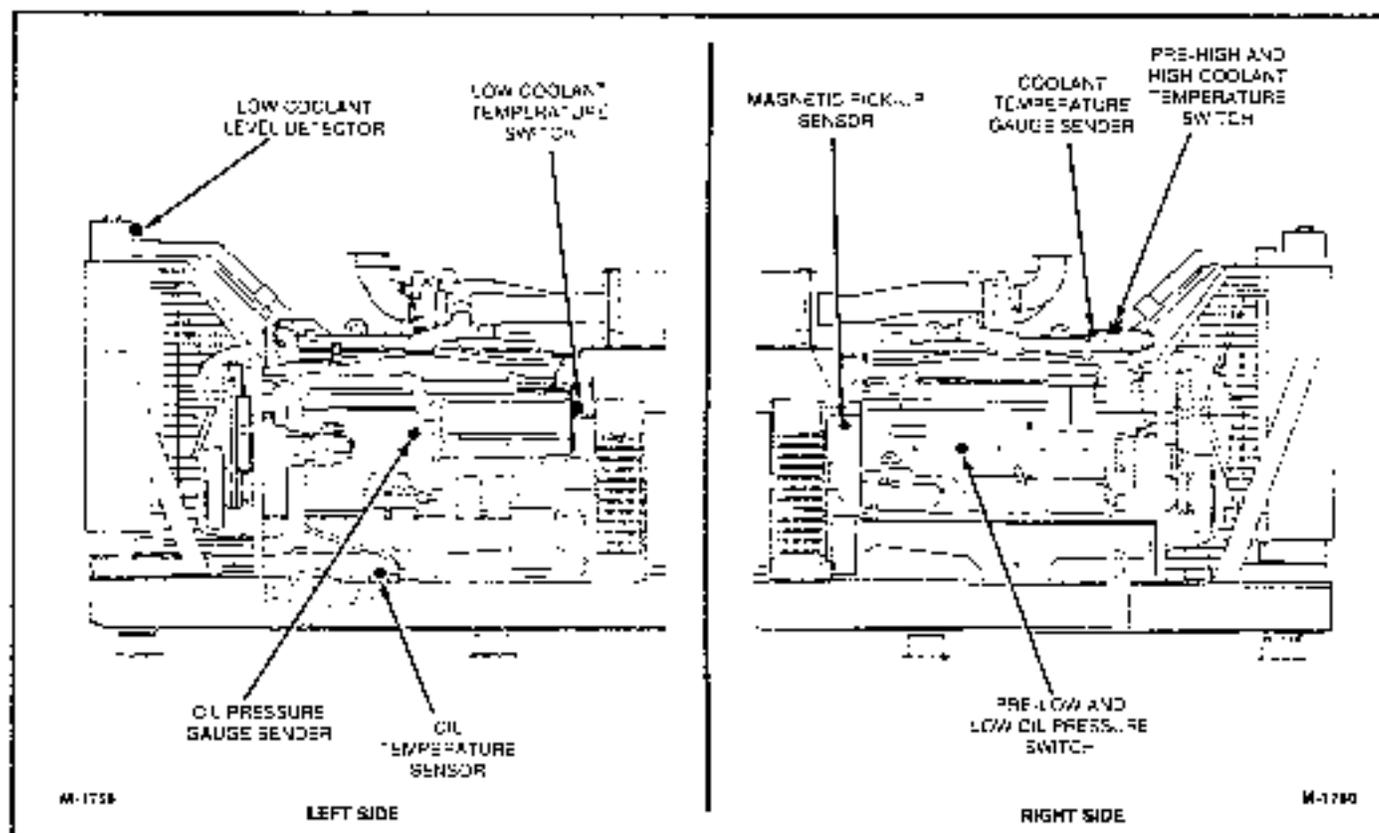


FIGURE 1-8. SENSORS LOCATIONS

Section 2. Operation

GENERAL

This section covers prestart checks, starting, operating checks, stopping and other operating considerations of the generator set. The operator should read through this entire section before starting the generator set. It is essential that the operator be completely familiar with the generator set for safe operation.

PRESTART CHECKS

Before starting, be sure the following checks have been made and the unit is ready for operation. See Figure 2-1. Refer to the Maintenance section for the recommended procedures.

Lubrication

Check the engine oil level. Keep the oil level near as possible to the dipstick high (H) mark without overfilling.

Coolant

Check the engine coolant level. The coolant level should be about two inches (51 mm) below the radiator cap opening. Do not check while the coolant is hot.

WARNING Contact with hot coolant can result in severe burns. Do not bleed hot, pressurized coolant from a closed cooling system. Allow system to cool before removing pressure cap.

Fuel

Make sure the fuel tanks have sufficient fuel and fuel system is primed. See the Maintenance section for recommended fuel.

WARNING Spilled fuel can ignite or explode and cause severe personal injury or death. Never fill the fuel tank when the engine is running. Do not allow any lit cigarette, flame, pilot light, spark, arcing equipment, or other source of ignition in the area when refueling.

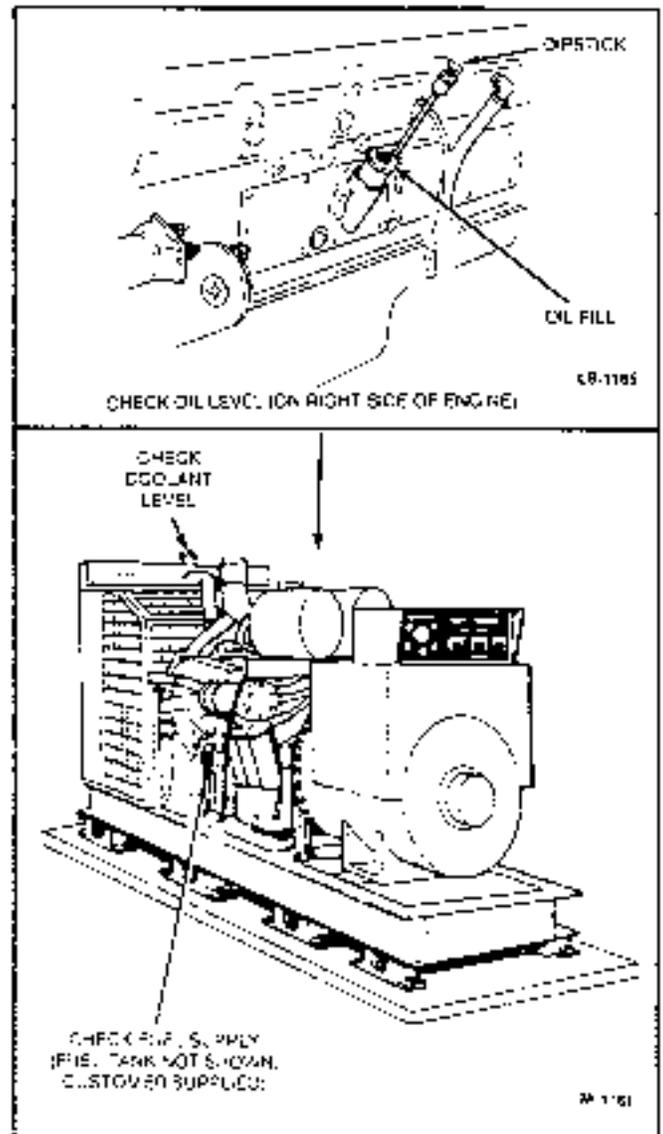


FIGURE 2-1. PRESTART CHECKS

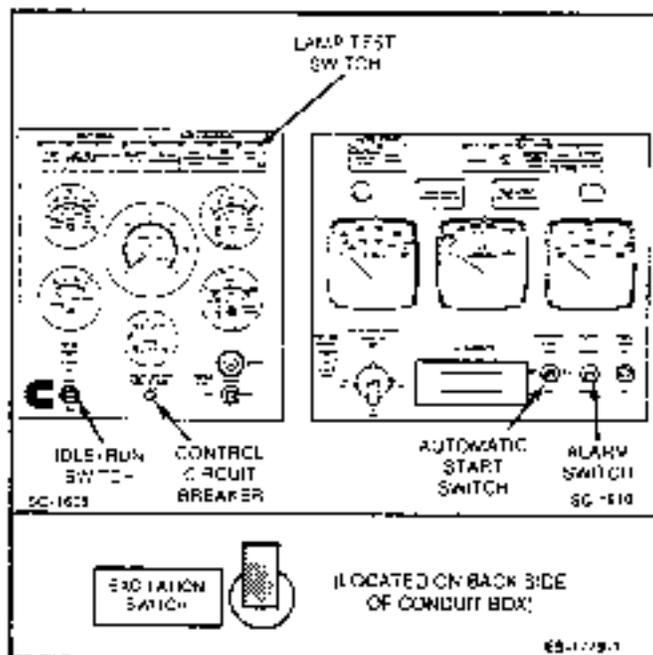


FIGURE 2-2. PRESTART CONTROL CHECKS

Controls

Refer to Figure 2-2.

- Place the Idle/Run switch at RUN position
- Confirm that control Circuit Breaker is at Reset position.
- Place the Automatic Start switch at OFF/RESET position to clear any fault condition.
- Depress Lamp Test switch. Indicator lamps illuminate.
- Check that Alarm switch is at NORMAL position.
- Place Excitation Switch up to ON position (located on back side of conduit box).

Ancillary Equipment

Refer to Figure 2-3.

- Check operation readiness of all ancillary systems; fresh air supply and exhaust system, transfer switch is open (no load connected to generator set) etc.

⚠ WARNING

EXHAUST GAS IS DEADLY! Engine exhaust gases contain carbon monoxide, an odorless and colorless gas. Carbon monoxide is poisonous and can cause unconsciousness and death. Symptoms of carbon monoxide poisoning can include:

- | | | |
|---------------------------|---------------------------------|------------|
| • Dizziness | • Throbbing in Temples | • Nausea |
| • Muscular Twitching | • Headache | • Vomiting |
| • Weakness and Sleepiness | • Inability to Think Coherently | |

IF YOU OR ANYONE ELSE EXPERIENCE ANY OF THESE SYMPTOMS, GET OUT INTO THE FRESH AIR IMMEDIATELY. If symptoms persist, seek medical attention. Shut down the unit and do not operate until it has been inspected and repaired.

Protection against carbon monoxide inhalation includes proper installation and regular, frequent visual and audible inspections of the complete exhaust system.

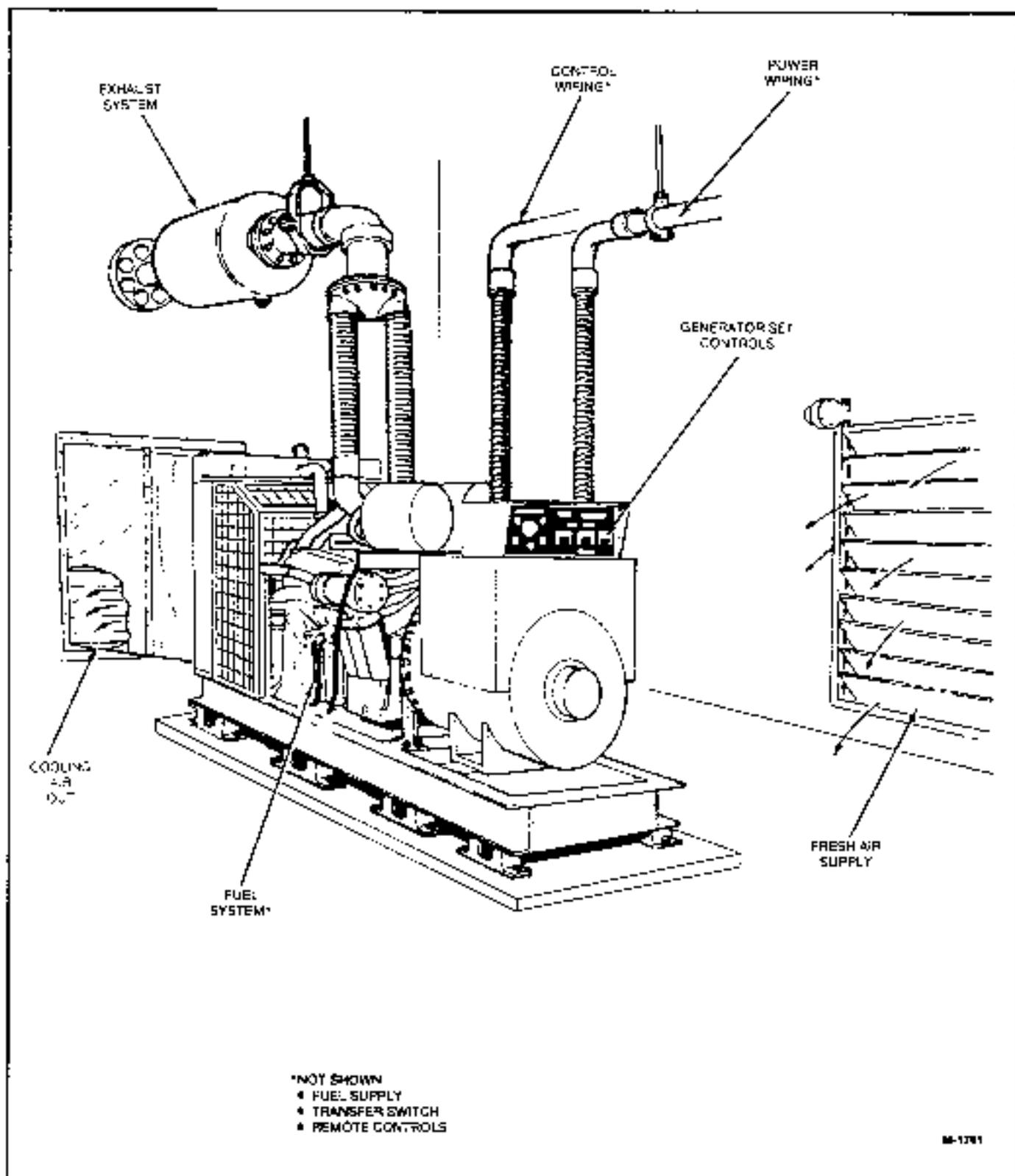


FIGURE 2-3. SYSTEM CHECKS

STARTING

The following describes the three methods used to start the generator set; local, remote, and automatic.

Starting at Control Panel (Manual Start)

Review *Prestart Checks*, previous in this section.

Lift and hold the Manual Start - Permissive switch at START position, and depress and hold Manual Crank switch downward (see Figure 2-4). The starter will begin cranking and after a few seconds the engine should start. When engine starts, release both Manual Start switches. Bring engine to normal operating temperature before applying load.

If the engine does not start after 15 seconds of cranking, release Manual Start switches, wait for one minute for the starter motor to cool and then repeat the starting procedure. If the engine does not run after a second attempt at starting, refer to the *Troubleshooting* section.

Starting From Remote Location

Review *Prestart Checks*, previous in this section.

Place the Automatic Start switch at AUTO position (see Figure 2-5). This allows the generator set to be started from a remote switch. Closing the remote switch initiates an automatic start cycle cranking starting sequence. The engine will crank for 15 seconds and then stop for 15 seconds until the engine starts or until 90 seconds of cycle cranking has lapsed causing an Overcrank fault. Silence the alarm horn by placing the Alarm switch to SILENCE position, then return it to NORMAL position. To clear an Overcrank fault place the Automatic Start switch to OFF/RESET position. Wait two minutes for the starter motor to cool and then repeat the starting procedure. If the engine does not run after a second attempt at starting, refer to the *Troubleshooting* section.

Automatic Starting

Review *Prestart Checks*, previous in this section.

Place the Automatic Start switch at AUTO position (see Figure 2-5) if an automatic transfer switch is used. When properly interconnected, this allows the transfer switch to start the generator set if a power outage occurs and stop it when the normal power returns.

Cycle cranking start-up of generator set is same as Remote start described above. If a fault condition occurs, there is no means of automatically clearing a fault and resetting the generator set control. Operator action is required.

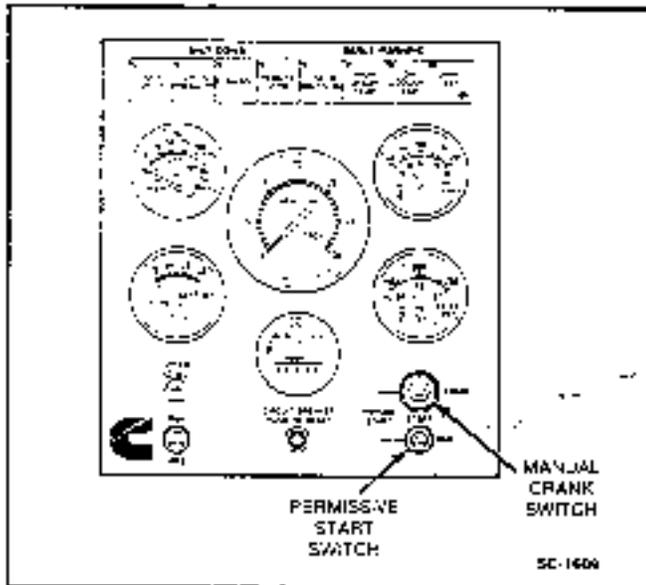


FIGURE 2-4. MANUAL START

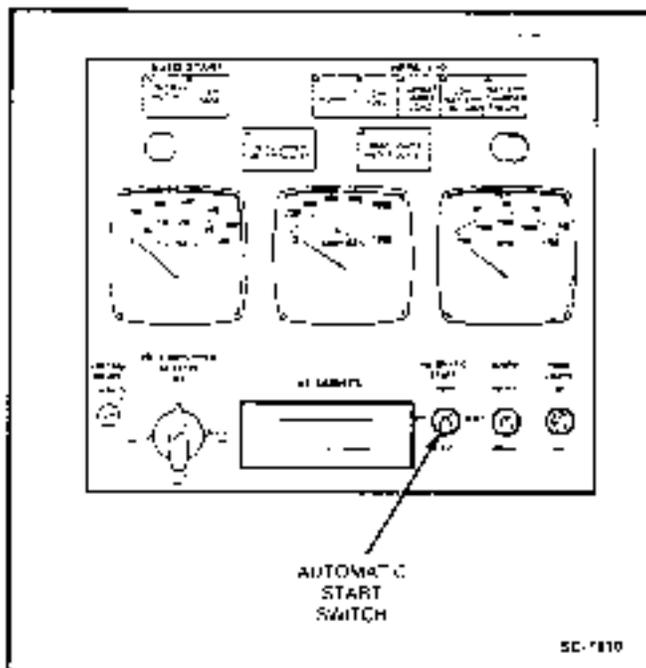


FIGURE 2-5. REMOTE OR AUTOMATIC START

OPERATING CHECKS

After generator set start-up, monitor all system components for proper operation. See Figure 2-3.

- Refer to Maintenance section and perform operating checks as indicated under Generator Set Inspection (exhaust, fuel, and AC electrical systems).
- Gen Set control gauges are reading properly.
- Adequate fresh air supply through generator set area.
- Transfer switch equipment (not shown).
- No Pre-Alarm (yellow) fault lamps are illuminated.

STOPPING

Before Stopping

Disconnect loads and run the generator set at no-load for three to five minutes before stopping. This allows the lubricating oil and engine coolant to carry heat away from the combustion chamber and bearings.

To Stop

- If the set was started manually at the set Engine Control Panel, place the Manual Start—Permissive Start switch to OFF position. See Figure 2-6.
- If the set was started at a remote control panel, place the remote starting switch to the Stop or Off position or place the Automatic Start switch at OFF position, then return the switch to AUTO position to enable the next remote start signal. See Figure 2-6.
- If the set was started by an automatic transfer switch, the set will automatically stop after the normal power source returns and any time delay stop function has timed out.

NO-LOAD OPERATION

Periods of no-load operation should be held to a minimum. If it is necessary to run the engine for long periods when no electric output is required, best engine performance will be obtained by connecting a non-critical or load bank electrical load that is at least 25 to 50 percent of unit rating. Or, if possible, place the Idle / Run switch to IDLE position to allow the engine to operate at considerably less r/min. See Figure 2-7.

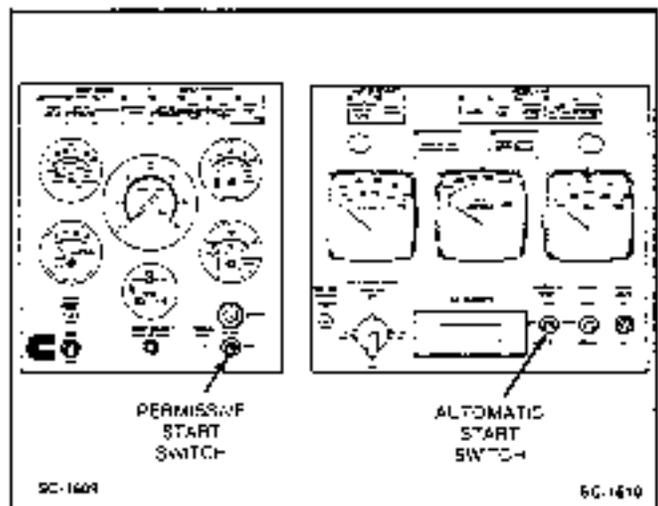


FIGURE 2-6. STOPPING SET AT CONTROL PANEL

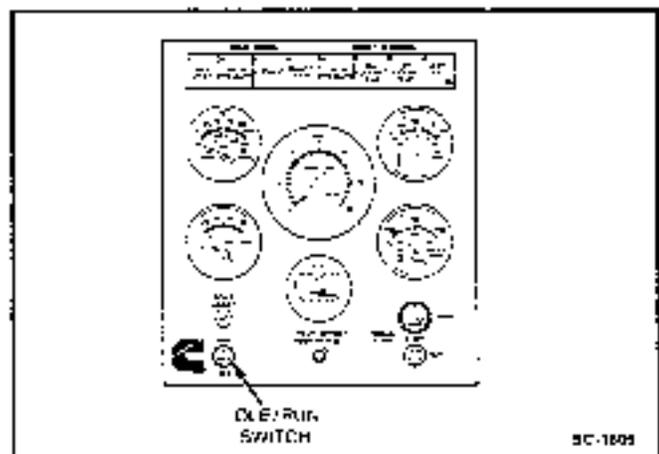


FIGURE 2-7. LOAD BANK OR IDLE OPERATION

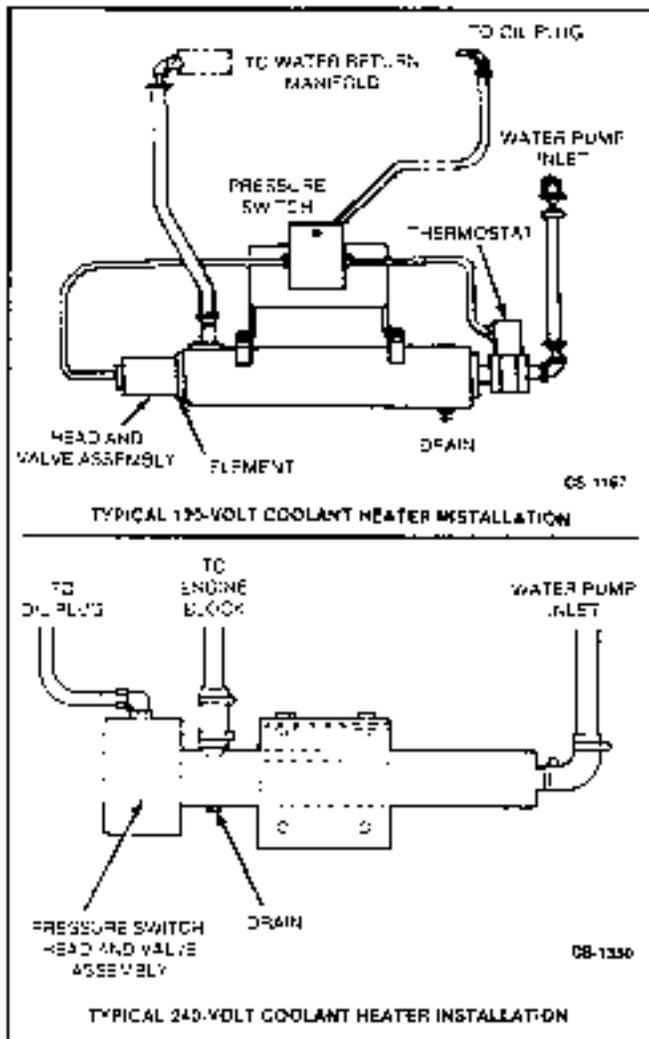


FIGURE 2-8. TYPICAL COOLANT HEATERS

EXERCISE PERIOD

Regular exercising keeps engine parts lubricated, prevents oxidation of electrical contacts and in general helps provide reliable engine starting. Exercise the generator set at least once a week for a minimum of 30 minutes with no load so the engine reaches normal operating temperatures.

Most automatic transfer switches have an optional exerciser clock that can be preset to provide regular exercise periods. Typically the exerciser can be set for time of start, length of run, and day of week.

LOW OPERATING TEMPERATURES

If rapid generator set starts are required in low ambient temperatures, engine coolant heaters should be used so that best combustion temperatures exist at start-up. Optional plumbing packages, and heaters to match utility voltages can be obtained from your distributor. See Figure 2-8, for coolant heater examples.

CAUTION To avoid damage to heater, be sure the cooling system is full before applying power to the heater.

Section 3. Troubleshooting

This section contains suggested troubleshooting procedures. The operator should periodically review the *Introduction* and *Operation* sections of this manual to most effectively diagnose a fault condition and perform proper corrective action. When a fault occurs during operation, perform the following. For any symptom not listed, contact your distributor for assistance.

- Silence Alarm Horn (if sounding) by placing the Alarm switch to SILENCE position (see Figure 3-1).
- Review all fault indicator lamps on control panels (see Figure 3-1).
- Refer to Table 3-1 to help determine fault condition and proper corrective action.
- For any symptom not listed, contact your distributor for assistance.
- For any corrective action that requires the batteries to remain connected, control panels to be opened, conduit box covers removed or the generator set operating, only qualified, well-trained service personnel should perform. Contact your distributor.

⚠ WARNING *Incorrect service or replacement of parts can result in severe personal injury or death, and equipment damage. Service personnel must be qualified to perform electrical and mechanical service.*

- Stop generator set, if not already shut down. Place Manual and Automatic Start switches to OFF position (see Figure 3-1).
- Disconnect the negative (-) battery cable from the generator set starting batteries.

⚠ WARNING *Accidental starting of the generator set during troubleshooting can cause severe personal injury or death. Disable the generator set by disconnecting the negative (-) battery cable before troubleshooting.*

- Perform necessary corrective action(s).
- Replace all covers or shrouding removed, and close control panels if opened.
- Reconnect generator set negative (-) battery cable to starting batteries.
- Review *Prestart Checks* in *Operation* section.
- If the fault condition was related to an automatic start function of the generator set controls, the Automatic switch can be depressed to TEST position to start the GenSet.
- Perform *Starting and Stopping procedures*, and *Operating Checks* in *Operation* section to confirm proper unit operation.

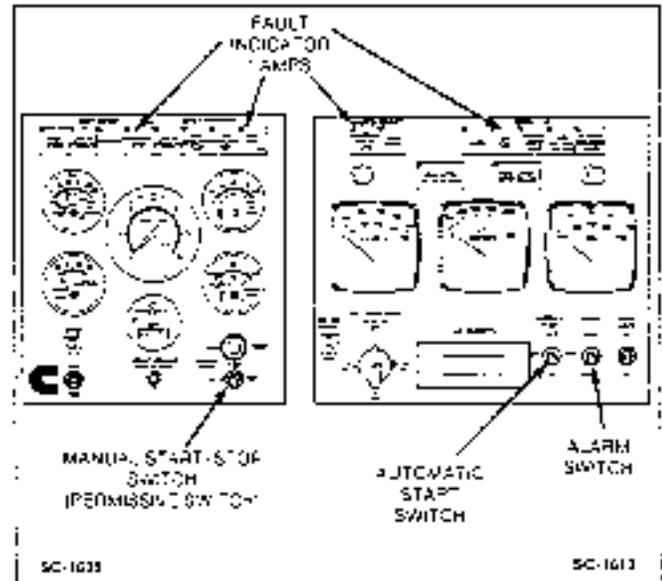


FIGURE 3-1 GENERATOR SET CONTROL PANEL

TABLE 3-1. TROUBLESHOOTING

WARNING

Many troubleshooting procedures present hazards which can result in severe personal injury or death. Only qualified service personnel with knowledge of fuels, electricity, and machinery hazards should perform service procedures. Review Safety Precautions on page i and ii.

SYMPTOM	CORRECTIVE ACTION
<p>1. Engine will not crank. Also refer to LOW BATTERY VOLTAGE, step 15.</p>	<p>1. Indicates possible fault with control or starting system. Check for the following conditions:</p> <ul style="list-style-type: none"> a. Fault lamp on. Correct fault and reset control. b. Poor battery cable connections. Clean the battery cable terminals and tighten all connections. c. Discharged or defective battery. Recharge or replace the battery. d. Contact your distributor for assistance if none of the above applies.
<p>2. Engine starts from Manual Start controls but will not start automatically or from a remote panel. (Note: The Automatic Start switch must be in the Auto position for automatic or remote starting.)</p>	<p>2. A remote circuit breaker is tripped, reset breaker and restart. Contact your distributor if breaker trips after resetting. Remote wiring connections are incorrect. Review all remote start wiring, correct as needed.</p>
<p>3. No AC output voltage.</p>	<p>3. Confirm that Exciter Switch is at ON position.</p> <p>Voltage regulator is inoperative. Refer to <i>Initial Start and Checks and Adjustments</i> sections for voltage check and adjustment procedures. Contact your distributor if voltage build-up is still a problem.</p>
<p>4. Engine runs and then shuts down. OVERSPEED lamp lights.</p>	<p>4. Indicates engine has exceeded normal operating speed. Contact your distributor for service.</p>
<p>5. LOW OIL PRESS lamp lights. Engine shuts down. NOTE: See also step 12.</p>	<p>5. Indicates engine oil pressure has dropped to 12 psi (88 kPa). Check oil level, lines and filters. If oil system is okay but oil level is low, replenish. Reset control and restart. Contact your distributor if oil pressure is not in the range of 50 to 90 psi (345 to 620 kPa).</p>
<p>6. HI ENG COOLANT TEMP lamp lights. Engine shuts down.</p>	<p>6. Indicates engine has overheated (engine coolant temperature has risen above 223°F/106°C) or coolant level is low (sets with coolant level sensor). Allow engine to cool down completely before proceeding with the following checks:</p> <ul style="list-style-type: none"> a. Check coolant level and replenish if low. Look for possible coolant leakage points and repair if necessary. b. Check for obstructions to cooling airflow and correct as necessary. c. Check for a slipping fan belt, tighten if loose. d. Reset control and restart after locating and correcting problem. Contact your distributor if none of the above applies.

TABLE 3-1. TROUBLESHOOTING (Continued)

⚠WARNING Many troubleshooting procedures present hazards which can result in severe personal injury or death. Only qualified service personnel with knowledge of fuels, electricity, and machinery hazards should perform service procedures. Review Safety Precautions on page i and ii.

SYMPTOM	CORRECTIVE ACTION
<p>7. REMOTE STOP lamp lights. Engine shuts down immediately.</p>	<p>7. This fault function is programmed to shut down the set immediately, as in the case of an Emergency Stop pushbutton. The nature and location of the fault is an optional selection that is determined when the set installation is designed. Refer to specifics of on-site equipment.</p>
<p>8. PRE LO OIL PRES lamp lights. Engine continues to operate.</p>	<p>8. Indicates engine oil pressure has dropped to 18 psi (124 kPa). If generator is powering critical loads and cannot be shut down, wait until next shutdown period and then follow step 5 procedure. If engine can be stopped, follow procedure in step 5.</p>
<p>9. PRE HI ENGINE COOLANT TEMP lamp lights. Engine continues to operate</p>	<p>9. Indicates engine has begun to overheat and engine coolant temperature has risen to approximately 215°F (102°C). If generator is powering non-critical and critical loads and cannot be shut down, use the following: a. Reduce load if possible by turning off non-critical loads b. Check air inlets and outlets and remove any obstructions to airflow c. Open doors or windows in generator area to increase ventilation If engine can be stopped, follow procedure in step 6</p>
<p>10. LO ENG TEMP lamp lights. Set is in standby mode but is not operating</p> <p>{Lamp lights when engine coolant temperature is 70°F (21°C) or lower. Since the lamp goes out after the engine warms up, there should be no cause for alarm if it remains lighted during initial generator set operation.}</p>	<p>10. Indicates engine coolant heater is not operating or is not circulating coolant. Check for the following conditions: a. Coolant heater not connected to power supply. Check for blown fuse or disconnected heater cord and correct as required. b. Check for low coolant level and replenish if required. Look for possible coolant leakage points and repair as required. c. Contact your distributor if none of the above applies.</p>
<p>11. CONTROL NOT IN AUTO lamp flashes.</p>	<p>11. Indicates Automatic Start switch is not at AUTO position which will prevent automatic starting. Moving the Automatic Start switch to the AUTO position will stop the lamp flashing and enable automatic starting.</p>

TABLE 3-1. TROUBLESHOOTING (Continued)

WARNING Many troubleshooting procedures present hazards which can result in severe personal injury or death. Only qualified service personnel with knowledge of fuels, electricity, and machinery hazards should perform service procedures. Review Safety Precautions on page i and ii.

SYMPTOM	CORRECTIVE ACTION
<p>12. Engine cranks but will not start. OVERCRANK lamp lights and engine stops cranking. Or. Engine runs, shuts down, and LO OIL PRES lamp lights</p>	<p>12. Indicates possible fuel system or air intake problem.</p> <ol style="list-style-type: none"> Check for empty fuel tank, fuel leaks, or plugged fuel lines and correct as required. Check for dirty fuel filter and replace if necessary (see Maintenance section). Also check for fuel shutoff valves not open, and leaks into suction line, etc. Check for dirty or plugged air filter and replace if necessary (see Maintenance section.) Refer to step 5. Reset the control and restart after correcting the problem. Contact your distributor for service if none of the above applies.
<p>13. LO FUEL lamp lights. Engine continues to run. LO FUEL lamp lights. Engine shuts down and LO OIL PRES lamp lights.</p>	<p>13. Indicates diesel fuel supply is running low. Check fuel supply and replenish as required. Indicates engine has run out of fuel. Check fuel level and replenish as required.</p>
<p>14. GEN SET UNDER LOAD lamp lights, when attempting to start generator set, EXCITER SWITCH trips to OFF position.</p>	<p>14. Remove all loads from generator set. Reset Exciter Switch to ON position.</p>
<p>15. LOW BATTERY VOLTAGE lamp lights</p>	<p>15. Poor battery cable connections. Clean the battery cable terminals and tighten all connections. Discharged or defective battery. Recharge or replace the battery.</p>
<p>16. BATTERY CHARGER FAILURE lamp lights.</p>	<p>16. Refer to battery charger unit and remedy condition.</p>
<p>17. Set-mounted circuit breaker tripped</p>	<p>17. The optional line circuit breaker mounts on the generator conduit box. If the load exceeds the circuit breaker current rating, the circuit breaker will open to prevent the generator from being overloaded. If the circuit breaker trips, locate the source of the overload and correct as required. Manually reset the breaker to reconnect the load to the generator. Optional short trip functions can cause the generator set to shut down and will require resetting the control.</p>

Section 4. Maintenance

Establish and adhere to a definite schedule for maintenance and service based on the application and severity of the environment. Table 4-1 covers the recommended service intervals for a generator set on standby service. If the set will be subjected to extreme operating conditions, the service intervals should be reduced accordingly. Some of the factors that can effect the maintenance schedule are the following:

- Use for continuous duty (prime power)
- Extremes in ambient temperature
- Exposure to elements
- Exposure to salt water
- Exposure to windblown dust or sand

Consult with your distributor if the generator set will be subjected to any extreme operating conditions and determine suitable schedule of maintenance. Use the running time meter to keep an accurate log of all service performed for warranty support. Perform all service at the time period indicated or after the number of operating hours indicated, whichever occurs first. Use Table 4-1 to determine the maintenance required and then refer to the sections that follow for the correct service procedures.

⚠WARNING

Accidental starting of the generator set can cause severe personal injury or death. Disconnect the negative battery cable before repairs are made to the engine, controls, or generator.

TABLE 4-1. MAINTENANCE SCHEDULE

MAINTENANCE CHECKS	SERVICE TIME				
	Daily or after 8 hours	Weekly or after 50 hours	Monthly or after 100 hours	6 Months or after 250 hours	Yearly or after 500 hours
Inspect Generator Set	x ¹				
Check Coolant Heater	x				
Check Oil Level		x			
Check Coolant Level		x			
Check Air Cleaner (clean if required)		x ²			
Check Battery Charging System		x			
Check Drive Belt Tension			x ²		
Check Fuel Level			x		
Drain Exhaust Condensation Trap			x		
Check Battery Level / Specific Gravity			x		
Check Generator Air Outlet			x		
Drain Water / Sediment from Fuel Tanks				x ⁴	
Check Antifreeze and DCA Concentration				x	
Clean Generator Assembly				x	
Change Crankcase Oil and Filter				x ^{5,6}	
Check Heat Exchanger Plugs (if equipped)				x	
Change Coolant Filter				x	
Change Air Cleaner Element				x ²	
Clean Crankcase Breathers				x ²	
Change Fuel Filters				x	
Clean Cooling System					x

- 1 - Check for oil, fuel, cooling, and exhaust leaks. Check exhaust system audibly and visually with the generator set running. Repair any leaks immediately.
- 2 - Perform more often in extremely dusty conditions.
- 3 - Visually check belts for evidence of slippage.
- 4 - Drain 1 cup or more of fuel to remove water and sediment.
- 5 - Perform initial change after first 50 hours, subsequent changes per maintenance schedule.

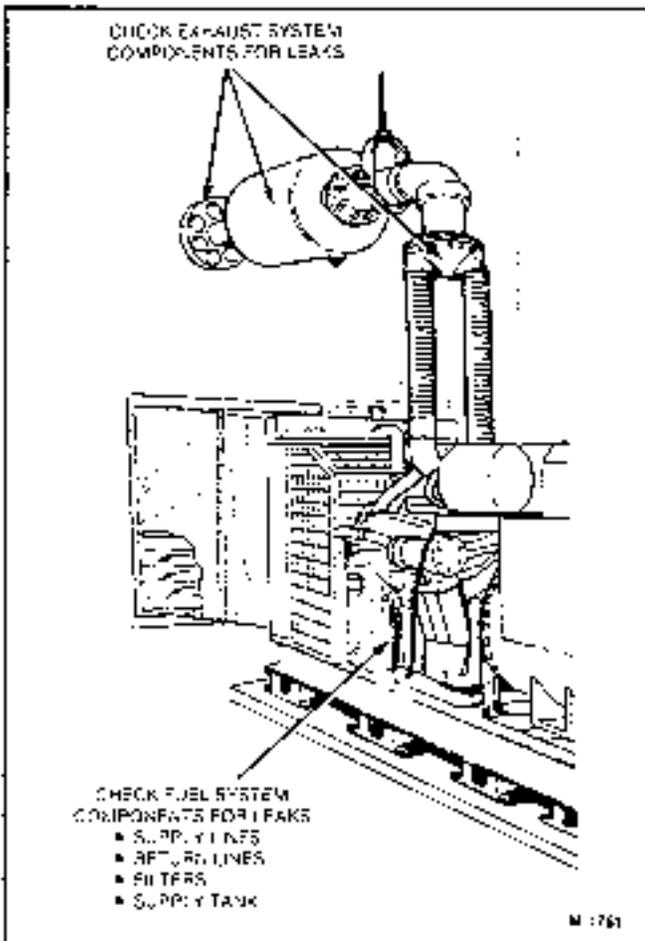


FIGURE 4-1 EXHAUST AND FUEL SYSTEM CHECKS

GENERATOR SET INSPECTION

During operation, be alert for problems that could create unsafe or hazardous conditions. The following sections cover several areas that should be frequently inspected to provide continued safe operation.

Exhaust System

With the generator set operating, inspect the entire exhaust system visually and audibly (see Figure 4-1) including the exhaust manifold, turbocharger, muffler, and exhaust pipe. Check for leaks at all connections, welds, gaskets, and joints and also make sure that exhaust pipes are not heating surrounding areas excessively. If any leaks are detected, shut down the generator set and have leaks corrected immediately.

WARNING *Inhalation of exhaust gases can result in serious personal injury or death. Be sure deadly exhaust gas is piped outside and away from windows, doors or other inlets to building.*

Fuel System

With the generator set operating, inspect the fuel supply lines, return lines, filters and fittings for leaks (see Figure 4-1). Check any flexible sections for cuts, cracks and abrasions and make sure they are not rubbing against anything that could cause breakage. If any leaks are detected, have them corrected immediately.

WARNING *Ignition of fuel can cause serious personal injury or death by fire or explosion. Do not permit any flame, lit cigarette, spark, pilot light, arcing equipment, or other igniter near the fuel system.*

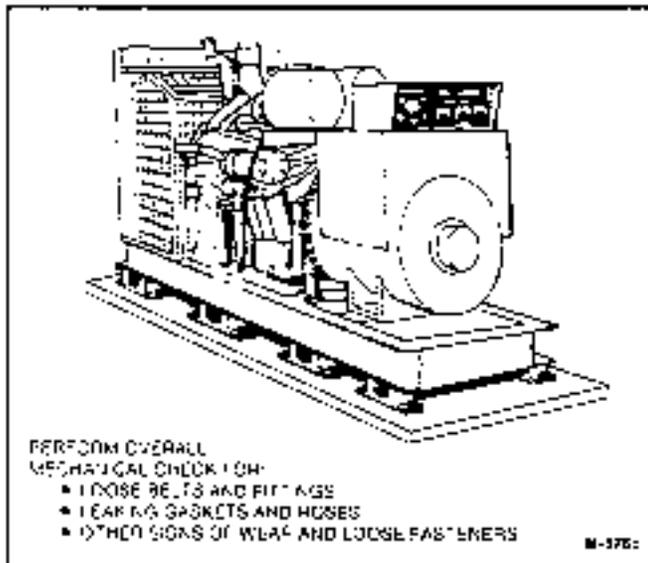


FIGURE 4-5. MECHANICAL CHECKS

Mechanical

Follow warning below before proceeding. With the generator set stopped, check for loose belts and fittings, leaking gaskets and hoses, or any signs of mechanical damage (see Figure 4-5). If any problems are found, have them corrected immediately. With the set running, listen for any unusual noises that may indicate mechanical problems and check the oil pressure frequently. Investigate anything that indicates possible mechanical problems.

⚠ WARNING *Accidental starting of the generator set can cause severe personal injury or death. Place the Automatic Start switch to OFF position and disconnect the negative (-) battery cable before inspecting generator set.*

LUBRICATION SYSTEM

The lubrication system must be primed and filled with oil of the recommended classification and viscosity. Refer to *Installation — Specifications* section for lubricating oil capacity.

Oil API Classification

The lubricating oil recommended for turbocharged diesel engines is API (American Petroleum Institute) Class CC/CD with a maximum sulphated ash content of 1.85 percent. Oils in this class satisfy the engine manufacturer's recommendations for satisfactory operation under most conditions. A book entitled "Lubricating Oils Data Book" is available from EMA (Engine Manufacturers Association) that lists the commercially available oils by brand name and the corresponding API classification. Once an oil is selected, do not mix it with oils of another classification or brand.

Oil Viscosity

The viscosity of an oil is a measure of its resistance to flow at certain specified temperatures. Oils that can meet both low (0°F or -18°C) and high (212°F or 100°C) temperature flow requirements are labeled as multigrade or multiviscosity oils. Multigrade oils that meet the API classification requirements are recommended. The use of a multigrade oil will improve oil control, improve engine cranking in cold weather, maintain adequate lubrication, and can also contribute to improved fuel economy.

Table 4-2 shows the oil viscosity grades that are recommended for various ambient temperatures. Use only the viscosity grades shown in the table. Cummins does not recommend the use of a single grade oil.

When selecting the oil viscosity, pick the grade that is right for the lowest temperature expected. Oil that is too thick may result in a lack of lubrication when the engine is started. Change oil viscosity grade as necessary for seasonal climate changes.

TABLE 4-2. OIL VISCOSITY GRADE SELECTION

AMBIENT TEMPERATURE	SAE VISCOSITY GRADE
-13°F (-25°C) and below	See following section
-13° to 35°F (-25° to 25°C)	10W-30
14°F (-10°C) and above	15W-40
32°F (0°C) and above	20W-40

Oil Viscosity for Extreme Cold

Cummins recommends using a synthetic lubricating oil when the ambient temperature is consistently below -13°F (-25°C) and there is no provision to keep the engine warm. Use an SAE5W grade synthetic oil provided it meets the following requirements:

- API class CC/CD
- Sulphated ash content does not exceed 1.85 percent.
- Pour point is 9°F (5°C) below the lowest expected temperature (minimum).
- Viscosity is 10,000 mPa·s (maximum) at -31°F (-35°C) and 4.1 mm²/s (minimum) at 212°F (100°C).

Do not use a petroleum base 5W grade oil for extreme cold since it usually will not perform satisfactorily.

Engine Oil Level

Check the engine oil level during engine shutdown periods at the intervals specified in Table 4-1. The oil dipstick and fill port are located on the right side of the engine (see Figure 4-6). The dipstick is stamped with high and low marks to indicate the level of oil in the crankcase. For accurate readings, shut off the engine and wait approximately 15 minutes before checking the oil level. This allows oil in the upper portion of the engine to drain back into the crankcase.

WARNING Crankcase pressure can blow out hot oil and cause serious burns. Do NOT check oil while the generator is operating.

Keep the oil level as near as possible to the high mark on the dipstick. Remove the oil fill cap and add oil of the same API classification and brand when necessary. Check unit log book to confirm oil viscosity to use.

CAUTION Do not operate the engine with the oil level below the low mark or above the high mark. Overfilling causes foaming or aeration of the oil, while operation below the low mark causes loss of oil pressure.

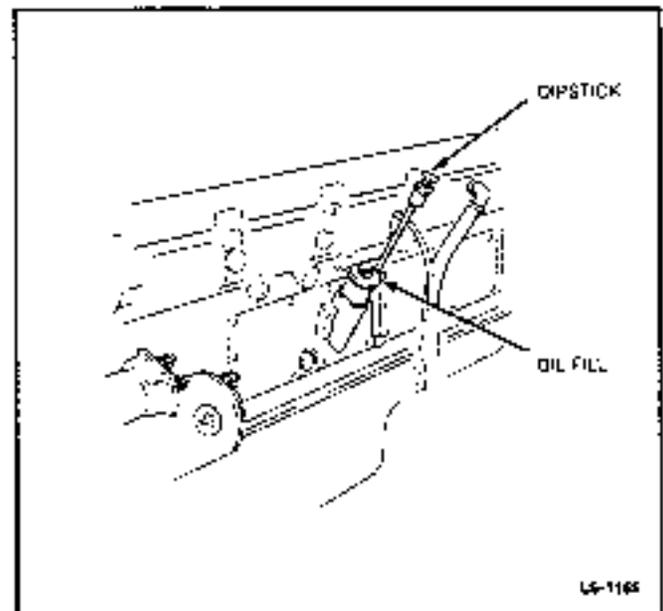


FIGURE 4-6. OIL DIPSTICK AND FILL CAP

Oil and Filter Change

Change the oil and filter at the intervals recommended in Table 4-1. Use oil that meets the API Classification and viscosity requirements.

1. Start the generator set and allow engine to warm up to operating temperature and then shut generator set off. Ensure that Automatic Start switch is at OFF position and the negative (-) battery cable is disconnected to avoid accidental start-up during this procedure.
2. Remove the oil drain plug or open the drain valve and collect the engine oil in a suitable size waste container. When the crankcase is drained, replace the oil drain plug or close the drain valve. Torque the oil drain plug to 60-70 ft-lb (81-95 Nm).
3. Unscrew the oil filter and discard.
4. Apply a light coat of oil to the gasket sealing surface of the new filter and fill filter with clean, new oil.
5. Install filter and tighten 2/3 turn by hand after the seal touches the sealing surface of the bracket. Do not overtighten.
6. Fill the crankcase with the amount of oil to achieve reading at high mark of dipstick.
7. Reconnect the negative (-) starting battery cable, start the engine and check for oil leaks.
8. Shut off the engine, wait 15 minutes, and then check the oil level. Add oil if required.

WARNING: Crankcase pressure can blow out hot oil and cause serious burns. Do NOT check oil while the generator set is operating.

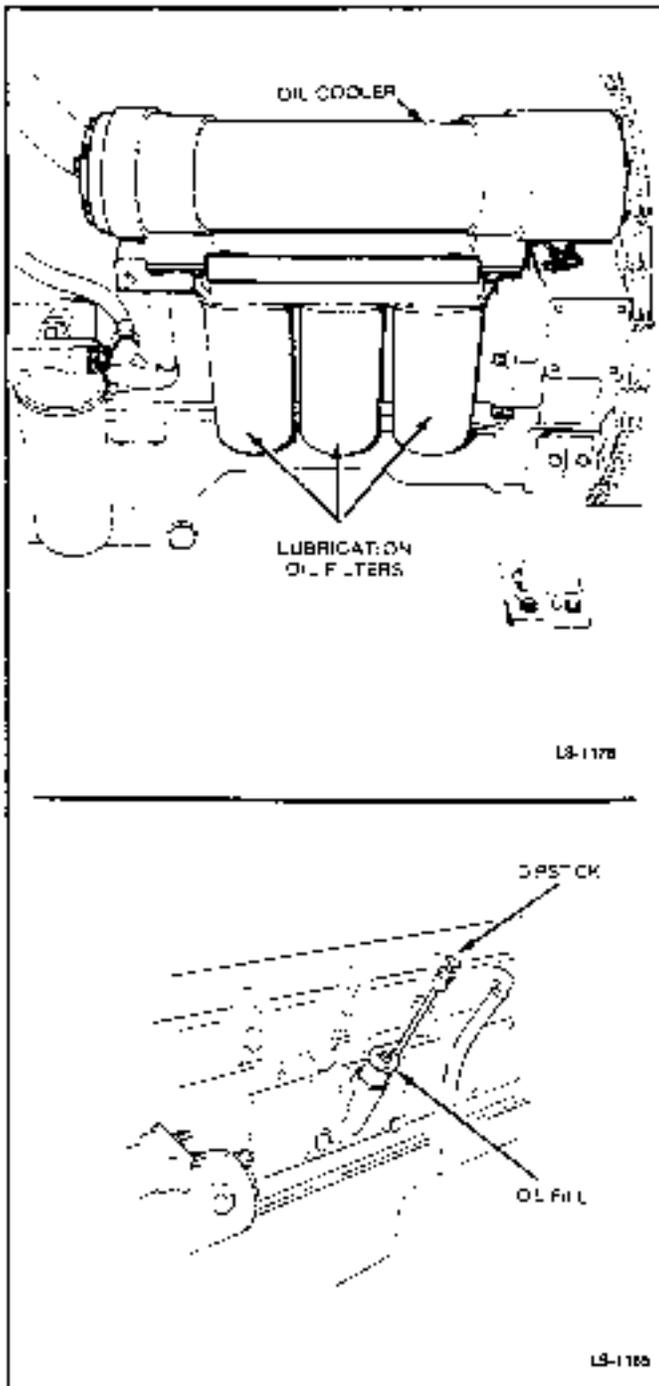


FIGURE 4-7 OIL FILTERS, DIPSTICK AND FILL CAP

CRANKCASE BREATHERS

Remove and clean the crankcase breathers at the interval specified in Table 4-1.

- 1 Remove wing nut, flat washer and rubber washer holding cover. Lift cover and swing away from filter assembly.
- 2 Lift out breather element, vapor element and gasket.
- 3 Clean all parts with approved solvent. Dry with compressed air (30 psi/207 kPa recommended).
- 4 Inspect all parts, replace if necessary.
- 5 Reassemble filter assembly, replace cover and secure.

COOLING SYSTEM

The cooling system must be refilled (radiator and heat exchanger) before being operated. The cooling system capacity of the standard unit with set mounted radiator is shown in the *Installation — Specifications* section.

CAUTION *The heater must not be operated while the cooling system is empty or when the engine is running or damage to the heater will occur.*

Coolant Level

Check the coolant level during shutdown periods at the intervals specified in Table 4-1. Remove the radiator cap after allowing the engine to cool and if necessary, add coolant until the level is near the top of the radiator (see Figure 4-9). Use a coolant solution that meets the engine coolant requirements.

WARNING *Contact with hot coolant can result in serious burns. Allow cooling system to cool before releasing pressure and removing radiator cap.*

CAUTION *High Engine Temperature Cutoff will shut down engine in an overheat condition only if coolant is sufficiently high to physically contact shutdown switch. Loss of coolant will allow engine to overheat without protection of shutdown device and cause severe damage to the engine. It is therefore imperative that adequate engine coolant levels be maintained to provide operational integrity of cooling system and engine coolant overheat shutdown protection. For best protection, be sure unit is equipped with optional Coolant Level Sensor and Shutdown.*

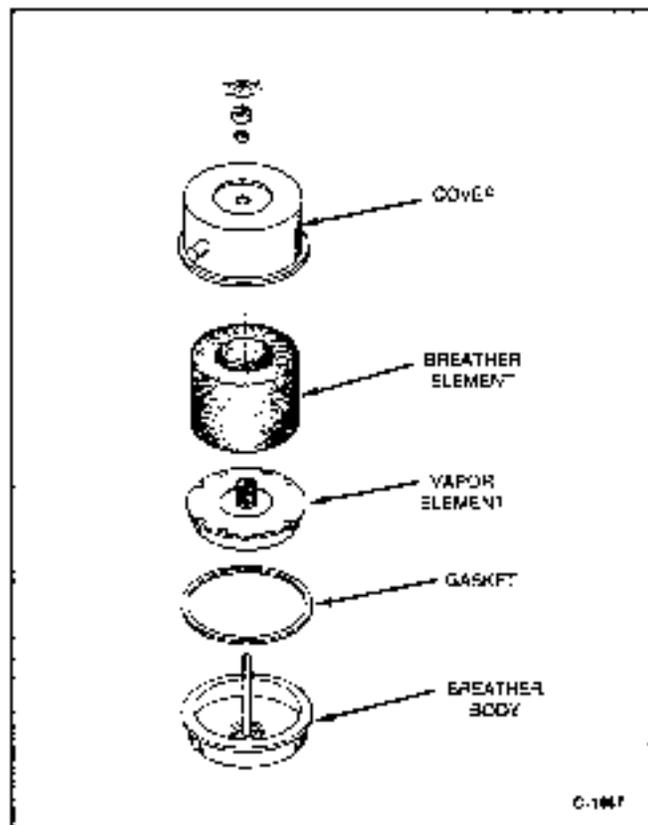


FIGURE 4-8. CRANKCASE BREATHERS

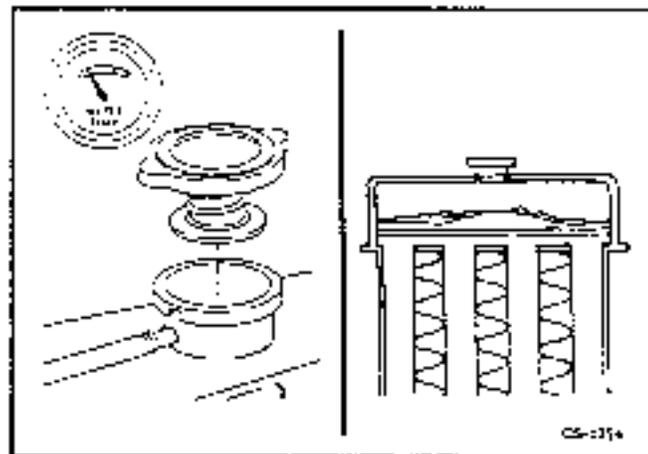


FIGURE 4-9. RADIATOR CAP

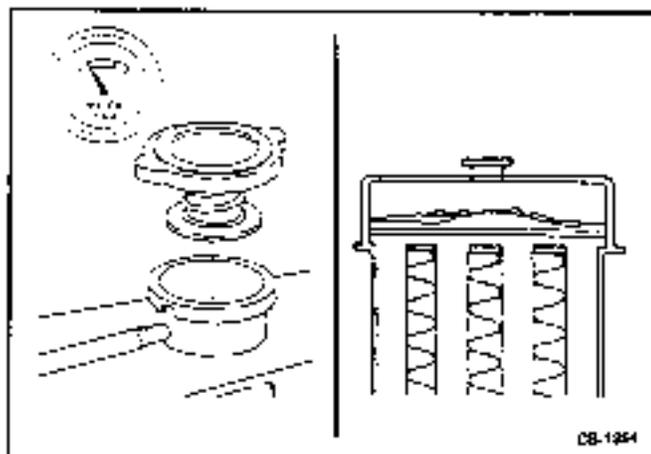


FIGURE 4-10. STANDARD SET-MOUNTED RADIATOR

Coolant Requirements

The water used for engine coolant should be clean, low in mineral content, and free of any corrosive chemicals such as chloride, sulphate, or acid. Generally, any water that is suitable for drinking can be treated for use as engine coolant.

Cooling systems must be protected with a permanent type antifreeze. Mix the water and antifreeze in the proportion recommended by the supplier for the lowest expected ambient temperature. Do not use an antifreeze that contains anti-leak additives. The water filter element will trap the additives and possibly become clogged.

CAUTION Do not use antifreeze with an anti-leak formula. The stop leak element can prevent or retard the coolant flow through the filter thereby eliminating the filtering process completely.

WARNING Contact with hot coolant can result in serious burns. Do not bleed hot, pressurized coolant from a closed cooling system. Allow system to cool before removing pressure cap.

Filling the Cooling System

(Standard Radiator and Heat Exchanger Sets)

Remove the cooling system pressure cap and fill the system with water/antifreeze mixture. On the initial fill, the precharge coolant filter (see Figure 4-12) will automatically add the required anti-corrosion chemicals to the cooling system.

Fill the cooling system with proper antifreeze/water/DCA mixture. Start and operate the engine to 194°F (90°C) temperature and check for leaks. Stop engine and repair leaks if found.

CAUTION Be sure the electric solenoid valve used with heat exchanger cooled sets is open before initially starting unit to allow coolant chambers to fill. Otherwise overheating and damage to the engine can result.

Coolant Filter

When changing the coolant filter, replace the DCA precharge element filter with the DCA service element filter. After the third element change, check the DCA concentration to ensure that adequate corrosion protection is maintained. Each time the cooling system (set mounted radiator) is drained, install a new DCA pre-charge element water filter to bring the DCA concentration up to the recommended level.

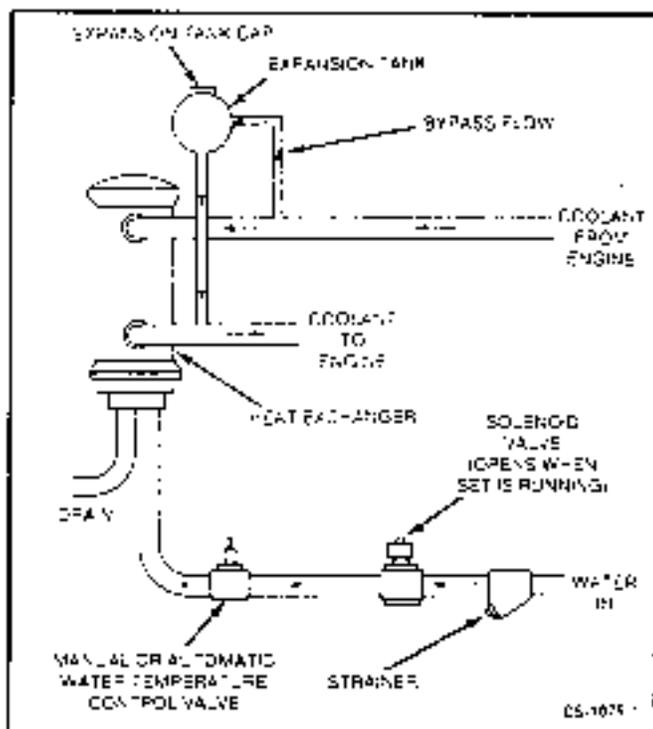


FIGURE 4-11. TYPICAL HEAT EXCHANGER SYSTEM

To Service:

1. Close the shutoff valves.
2. Unscrew the coolant filters and discard.

⚠WARNING Contact with hot coolant can result in severe burns. Do not bleed hot, pressurized coolant from a closed cooling system. Allow system to cool before removing filters.

3. Apply a light coat of lubricating oil to the gasket surface.
4. Install new filters and tighten by hand until the seals just touch the filter head. Tighten an additional one-half to three-fourths turn.
5. Open the shutoff valves.

Cleaning and Flushing the Cooling System

The cooling system must be clean and free of rust and scale if it is to perform properly. Use only coolant that meets the engine requirements.

Chemical Cleaning: Thoroughly clean the cooling system if rust and scale have collected on the engine water jacket or in the radiator. Rust and scale slow down heat transfer and can block the coolant flow. Use a good cooling system cleaner such as sodium bisulfate or oxalic acid and follow the instructions provided by the supplier. Follow up by neutralizing and flushing with clean water.

Flushing: Flush the radiator and block after cleaning or before refilling the system with new coolant as follows (refer to Figure 4-13)

1. Drain Cooling System
 - A. Disconnect coolant heater from AC power source if equipped.
 - B. Remove radiator/expansion tank cap.
 - C. Open the radiator draincock, and disconnect lower radiator hose from radiator, or, remove drain plug from heat exchanger.
 - D. Open oil cooler draincock.
 - E. Open thermostat housing drain plug.
 - F. Open cylinder block draincock.
 - G. Allow system to drain completely.
 - H. Close cylinder block, thermostat housing, and oil cooler drains.
 - I. Close the radiator draincock, and reconnect the lower radiator hose, or, replace drain plug to heat exchanger.

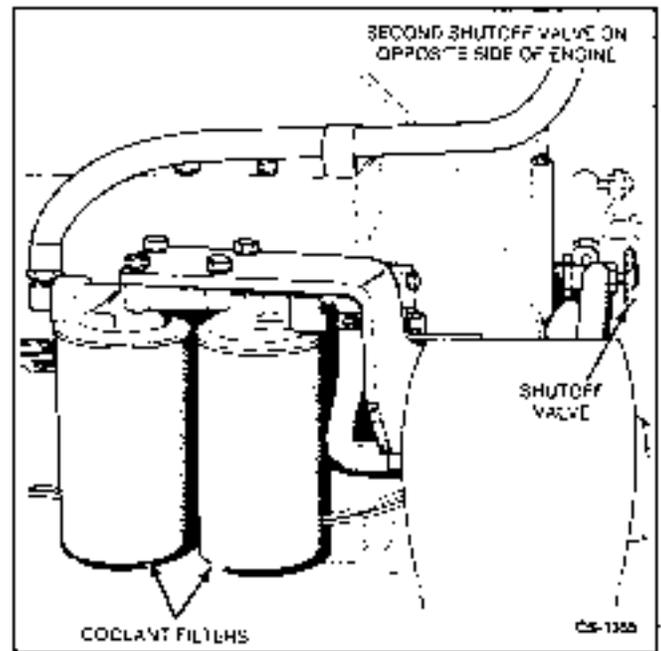


FIGURE 4-11. TYPICAL COOLANT FILTER

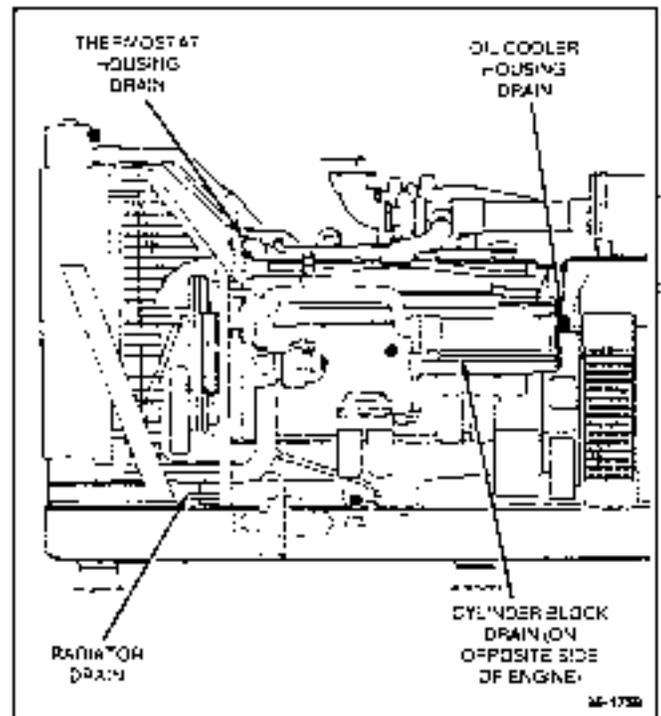


FIGURE 4-12. COOLING SYSTEM DRAINS

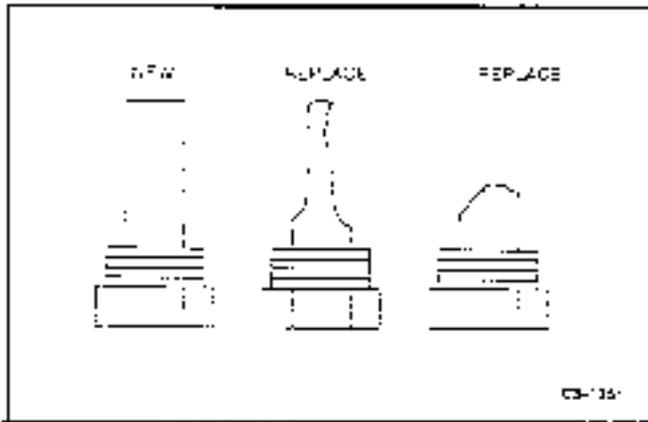


FIGURE 4-14. HEAT EXCHANGER PLUGS

2 Flush Cooling System

- A. Fill cooling system with clean water. Do not install radiator/expansion tank cap.
- B. Operate engine for 5 minutes with the coolant temperature above 194°F (90°C).
- C. Shut off engine and drain cooling system (see Drain Cooling System).

If the water being drained is still dirty, the system must be flushed again until the water is clean.

- D. When flushing water is clean, drain completely, then refer to Filling the Cooling System, previous this section.

Heat Exchanger Plugs

Check the zinc plugs in the heat exchanger and replace if they are eroded to less than half their original size. The frequency of replacement is dependent on the chemical reaction that occurs when the plugs are in contact with the raw water. See Figure 4-14.

Coolant Heater

Check the operation of the optional coolant heater by verifying that hot coolant is being discharged from the outlet hose. For efficient operation and maximum life, clean the coolant heater whenever the cooling system is drained for flushing.

To Service:

1. Remove AC power from coolant heater.

⚠ WARNING: Failure to remove AC power presents a shock hazard and can cause serious personal injury or death.

2. Allow heater to cool before proceeding.

⚠ WARNING: Contact with hot coolant can result in serious burns. Do not bleed hot, pressurized coolant from a closed cooling system.

3. Remove the head and valve assembly.
4. Clean any scale deposits out of the tank.
5. Remove heating element and scrape off any scale deposits that have accumulated on the sheathing.

When reassembling threaded aluminum parts, be sure to use anti-seize compound.

6. Restore AC power to heater after system has been filled with coolant.

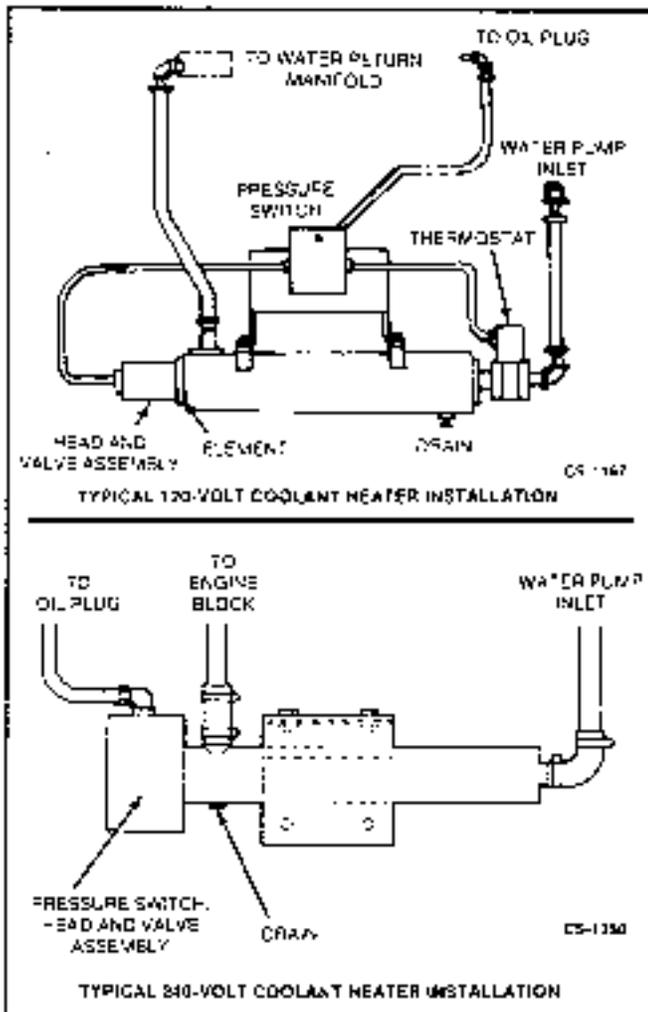


FIGURE 4-15. TYPICAL COOLANT HEATERS

FUEL SYSTEM

The engine has been primarily designed to operate on No. 2 diesel fuels since such fuels have a higher energy content and are generally lower in cost. The engine will also operate satisfactorily on No. 1 fuel or other similar fuels if they meet certain specifications. Refer to the engine manual or consult your distributor for the specific requirements if using a non-standard fuel.

Fuel Handling Precautions

Take appropriate precautions to prevent the entrance of dirt, water, or other contaminants into the fuel system. Filter or strain the fuel as the tank is filled.

▲WARNING Ignition of fuel can cause serious personal injury or death by fire or explosion. Do not permit any flame, lit cigarette, spark, pilot light, arcing equipment, or other igniter near the fuel system.

To avoid condensation problems, keep fuel supply tanks as full as possible by filling up each time the engine is used. In cold weather, warm fuel returning from the injectors heats the fuel in the supply tank. If the fuel level is low, the upper portion of the tank tends to form condensation. In warm weather, both the fuel and the tank will be warm during the daytime. At night, cool air tends to lower the temperature of the tank more rapidly than the temperature of the fuel. If the fuel level is low, the upper portion of the tank will cool more rapidly and tend to form condensation.

Condensation (water) can cause fuel pump and injector problems, clogging of fuel filters as well as freezing problems. In addition, water mixing with the sulphur in the fuel forms an acid which can corrode and damage engine parts.

Fuel Filters

At intervals recommended in Table 4-1, remove the fuel filters and discard (see Figure 4-15). Fill the new filters with diesel fuel and put a light coat of fuel on the sealing gasket. Install and tighten by hand until the gasket just touches the filter head. Tighten an additional one-half to three-fourths of a turn.

Fuel Water/Sediment Separator

A water/sediment separator is normally installed between the generator set and the transfer tank (if used) or the main tank. This separator should be drained or cleaned at regular intervals as specified in Table 4-1.

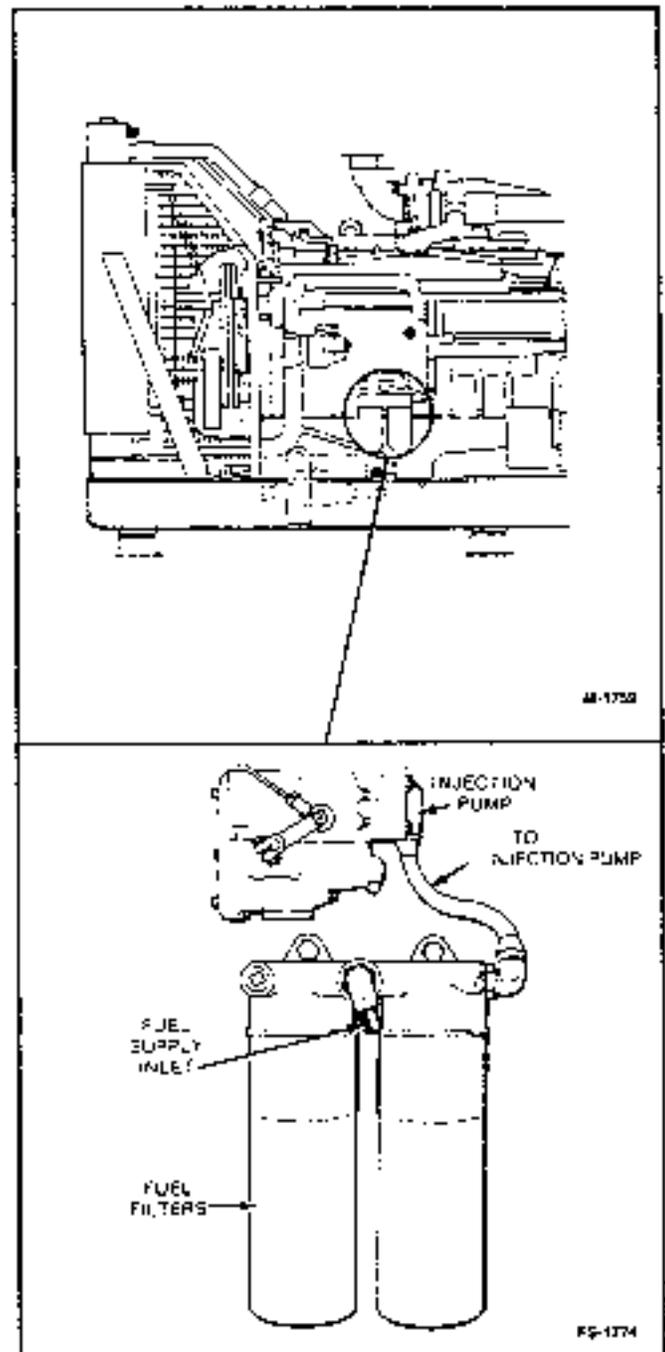


FIGURE 4-16. FUEL FILTERS

AIR CLEANER

The engine air intake components should be checked at the interval indicated in Table 4-1. The frequency of cleaning or replacing an cleaner filter element(s) is primarily determined by the conditions that the generator set operates in. The normal duty indoor and outdoor air cleaners contain a paper cartridge filter element which can be cleaned and reused if not damaged, or discarded and replaced. The heavy duty outdoor air cleaner contains dual filter elements, that can be cleaned and reused, or discarded and replaced.

To Service the Air Cleaner:

1. Loosen fasteners and remove air cleaner housing end cap
2. Remove the air filter element(s) from the filter housing.
3. To clean, blow low pressure compressed air (30 psi/207 kPa) through the element(s), from the inside to outside. Hold the nozzle at least 1 inch (25 mm) away to avoid damaging the element.
4. Soak the filter for at least 15 minutes in water and Donaldsons D1400 solvent (or equivalent other cleaning solvent) to remove soot and carbon as well as dirt.
5. Rinse with clean water (low pressure) and allow to air dry. Do not blow dry with compressed air. Reinstall when the filter element is dry. Replace the filter after two cleanings to avoid restricting the airflow.

CAUTION *Filters should be handled with care to prevent damage. If the filter does become damaged, install recommended replacement part.*

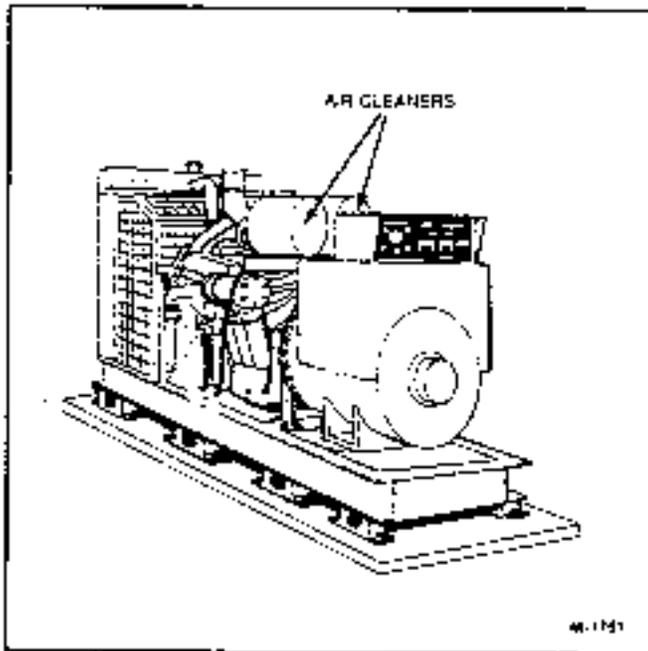


FIGURE 4-17. AIR CLEANERS (Indoor Type Shown)

AC GENERATOR

General

These generators require very little servicing. Periodic inspections, to coincide with engine oil changes, will help provide good performance.

Remove PMG endbell housing and generator cooling air intake covers. Visually inspect the generator for dust, dirt and grease. Excessive foreign matter will degrade generator performance and can lead to unit failure if not removed.

Check generator voltage. It may be necessary to make a slight readjustment to obtain the preferred voltage at average load. Refer to Adjustments section for proper procedure.

Generator Bearing

Have the bearing inspected for wear every 1000 hours. If the unit is used for prime power, have the bearing replaced every 10,000 hours or after two years. If the unit is used for standby power, have the bearing replaced every five years.

BATTERIES

Check the condition of the starting batteries at the interval specified in Table 4-1. See that connections are clean and tight. A light coating of non-conductive grease will retard corrosion at terminals. Keep the electrolyte at the proper level above the plates by adding distilled water. Check specific gravity and recharge if below 1.260.

If the generator set is operated in an area where the ambient temperature is consistently above 95°F (35°C), a specific gravity of 1.225 is recommended to reduce electrolyte loss.

WARNING Ignition of explosive battery gases can cause severe personal injury. Do not smoke while servicing batteries. Wear protective apron and goggles when checking specific gravity and adding distilled water.

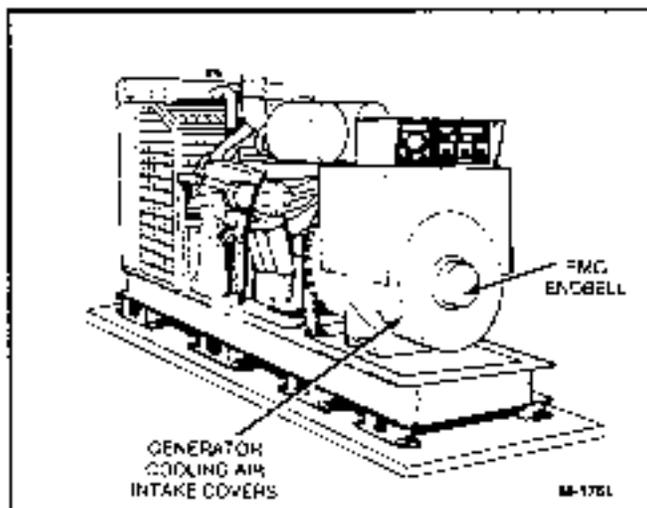


FIGURE 4-18. AC GENERATOR

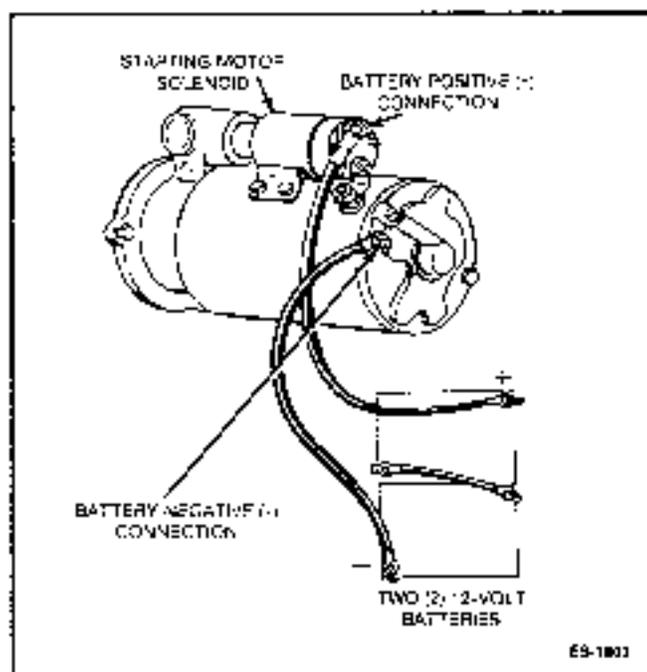


FIGURE 4-19. STARTING BATTERY CONNECTIONS

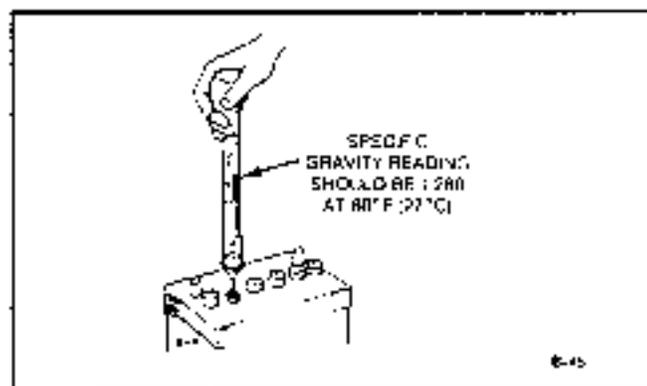


FIGURE 4-20. CHECKING BATTERIES

Section 5. Installation

GENERAL

This section of the manual provides the following generator set installation instructions:

- Mounting—Recommendations for fastening generator set to base and space requirements for normal operation and service.
- Mechanical Connections—Connection points for fuel, exhaust, ventilation, and cooling.
- Electrical Connections—Location of electrical connection points for the control, generator, and starting system.

INSTALLATION OVERVIEW

The installation recommendations in this section apply to typical generator set installations with standard model generator sets (see Figure 5-1). Whenever possible, these recommendations also cover factory designed options or modifications. However, because of the many variables in any installation, it is not possible to provide specific recommendations for every situation. For engineering data specific to the generator set, refer to the specification and product data sheets. For generator application information about generator set installation or any questions not answered by this manual, contact your distributor for assistance.

Power Rating Factors

The standard generator set power rating applies to sets used in standby applications. The rating indicates the generator output for the duration of normal utility power interruptions. The rating was established for a standard radiator cooled generator set running on diesel fuel and operating at the the referenced Product Data Sheet conditions.

Cummins also has published ratings for optional prime power sets, sets without fans and sets with short stack generators. All Generator Set Data Tags will show such ratings for sets built with these options.

For a rating relative to other applications, altitudes, cooling systems, or ambient temperatures, contact your distributor.

Application and Installation

An electrical power system must be carefully planned and correctly installed to provide proper operation. This involves two essential elements: application and installation.

Application (as it applies to generator set installations) refers to the design of the complete power system. The generator set is only one component in an integrated power system that usually includes power distribution equipment, transfer switches, ventilation equipment, mounting pads, and cooling, exhaust, and fuel systems. Each component must be designed so the complete system will function as intended. Application and design is generally done by specifying engineers or other trained specialists. They are responsible for the design of the complete power system and for the selection of the materials and products required.

Installation refers to the actual set-up and commissioning the power system. The installers set-up and connect the various components of the system as specified in the system design plan. The complexity of the system normally requires qualified electricians, plumbers and sheetmetal workers to properly complete the various segments of the installation. Refer to the Typical Installation figure and Specifications that follow while reviewing this section.

Safety Considerations

The generator set has been carefully designed to provide safe and efficient service. However, the overall safety and reliability of the complete system is dependent on many factors outside the control of the generator set manufacturer. To avoid possible safety hazards, make all mechanical and electrical connections to the generator set exactly as specified in this manual. All systems external to the generator (fuel, exhaust, electrical, etc.) must comply with all applicable codes. Make certain all required inspections and tests have been completed and all code requirements have been satisfied before certifying the installation as complete and ready for service.

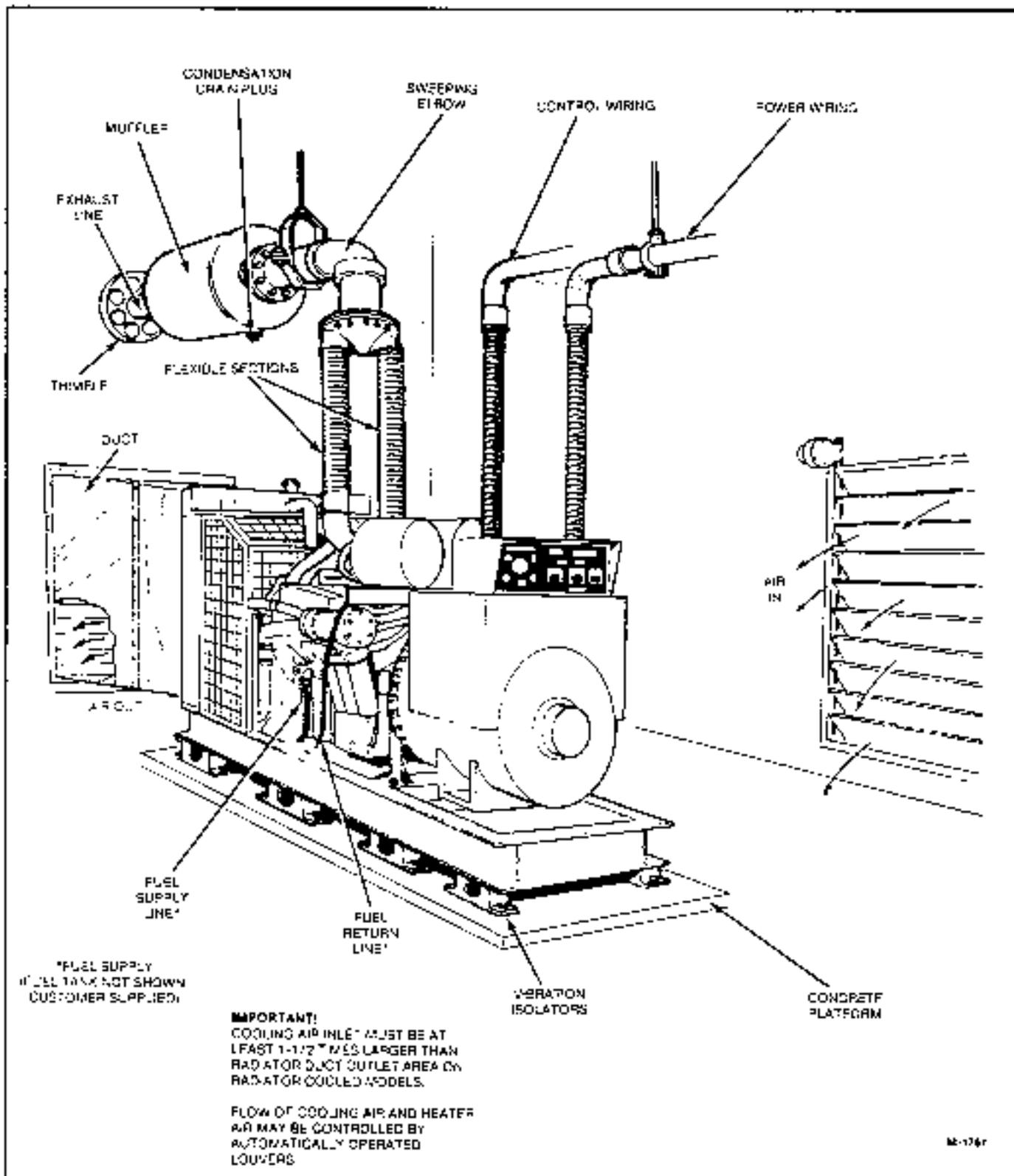


FIGURE 5-1. TYPICAL INSTALLATION

SPECIFICATIONS

SYSTEM	GENSET MODEL*		
	500VTA1	550VTA3	600VTA2
Engine Cummins Model	VTA-28-G1	VTA-28-G3	VTA-28-G2
Coolant Capacity Engine Only	21.25 U.S. Gal. 85 Litres	21.25 U.S. Gal. 85 Litres	21.25 U.S. Gal. 85 Litres
With Standard Mounted Radiator	47.5 U.S. Gal. 180 Litres	47.5 U.S. Gal. 180 Litres	47.5 U.S. Gal. 180 Litres
Lubrication Oil Capacity (Includes standard by pass filter)	22.3 U.S. Gal. 84.4 Litres	22.3 U.S. Gal. 84.4 Litres	22.3 U.S. Gal. 84.4 Litres
Oil Type	Normal duty -32°F (0°C) and above - SAE 20W-40 Refer to your Cummins Engine Manual for extreme conditions		
Fuel	ASTM No. 2 Diesel Engine Fuel (Refer to your Cummins Engine Manual for analysis limits.) Fuel pump (lifting capacity): 5 feet (1.525 m)		
Exhaust	Exhaust backpressure (maximum Allowable): 41 inches H ₂ O/3.0 inches Hg		
Connections	Refer to your GenSet Outline Drawing for size and location.		
Electrical DC System	Starting—24 Volt DC Charging—Engine belt driven, 35 ampere, regulated, 24 VDC output. Batteries—Two 12-volt DC series connected.		
AC System	Refer to your generator set Product Data Sheet for available voltages and output ratings.		
General	Refer to your generator Product Data Sheet for application data and limits.		

*This table represents a cross-section of VTA-28 generator set models. Contact your distributor for data of models not listed.

⚠ WARNING

INCORRECT INSTALLATION, SERVICE OR REPLACEMENT OF PARTS CAN RESULT IN SEVERE PERSONAL INJURY OR DEATH, AND EQUIPMENT DAMAGE. SERVICE PERSONNEL MUST BE QUALIFIED TO PERFORM ELECTRICAL AND MECHANICAL COMPONENT INSTALLATION.

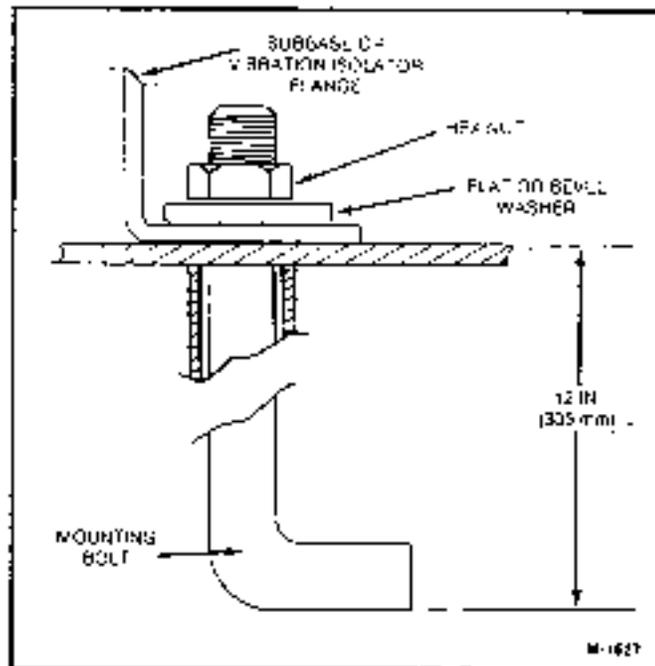


FIGURE 5-2. TYPICAL ANCHOR BOLT DIAGRAM

MOUNTING THE GENERATOR SET

General

Most generator set installations must be designed so that the generator set will function properly under all anticipated operating conditions. Use these instructions as a general guide only. Follow the instructions of the consulting engineer when locating or installing any components. The complete installation must comply with all local and state building codes, fire ordinances and other applicable regulations.

Requirements to be considered prior to installation (refer to Figure 5-1):

- Level mounting surface
- Adequate cooling air supply
- Adequate fresh induction air
- Discharge of cooling air
- Discharge of exhaust gases
- Fuel system installation
- Electrical connections
- Accessibility for operation and servicing
- Noise levels
- Vibration isolation

Location

Optimum generator set location is determined by related systems such as ventilation, wiring, fuel, and exhaust. The set should be located as near as possible to the main power use box.

Provide a location away from extreme ambient temperatures. Protect the generator set from adverse weather conditions, and unauthorized personnel.

Mounting

Generator sets are mounted on a steel subbase that provides proper support. Mount the generator set on a substantial and level base such as a concrete pad. For most installations, vibration isolators between the subbase and foundation are required. Contact your distributor.

Typically 3/4-inch diameter, anchored mounting bolts are used to secure the generator set subbase to the floor to prevent movement. Secure the subbase/vibration isolators using flat or bevel washer and hexagon nut for each bolt. For proper spacing of mounting bolts and set mounting dimensions, see your generator set outline drawing.

Access to Set

Plan for access to the generator set for servicing and provide adequate lighting around the unit. For convenience in general servicing such as the radiator, fan belt, and changing the crankcase oil, the surface of the mounting base should be at least 6 inches (152 mm) above the floor.

MECHANICAL CONNECTIONS

General

The generator set mechanical system installation includes connecting the fuel, exhaust, ventilation, and cooling systems (see Figure 5-1). Before starting any type of fuel installation, all pertinent state and local codes must be complied with and the installation must be inspected before the unit is put in service.

Fuel System

Cummins engines used on the generator sets normally use ASTM No. 2 Diesel fuel. They will, however, operate on alternate diesel fuels within the specifications delineated in the Cummins engine manual.

In all fuel system installations, cleanliness is of the utmost importance. Make every effort to prevent entrance of moisture, dirt or contaminants of any kind. Clean all fuel system components before installing.

Use only compatible metal fuel lines to avoid electrolysis when fuel lines must be buried. Use a flexible section of tubing between the engine and fuel supply line to provide vibration isolation. Refer to your generator set outline drawing for sizes and locations.

CAUTION *Never use galvanized fuel lines, fittings or fuel tanks. Condensation in the tank and lines combines with the sulfur in diesel fuel to produce sulfuric acid. The zinc coating on galvanized lines or tanks reacts with the acid and flakes off to contaminate the fuel.*

An electric solenoid shutoff valve in the supply line is recommended for all installations and required for indoor automatic or remote starting installations. Connect the solenoid wires to the battery ignition circuit to open the valve during generator set operation.

Supply Tank: Locate the fuel tank as close as possible to the generator set and within the 5 foot (1.5 meter) lift capacity of the fuel pump, if possible. Install a fuel tank that has sufficient capacity to keep the generator set operating continuously at full load for at least 36 hours.

WARNING *Fuel leaks create fire and explosion hazards which can result in severe personal injury or death. Always use flexible tubing between engine and the fuel supply to avoid line failure and leaks due to vibration. The fuel system must meet applicable codes.*

If the main fuel tank is installed below the lift capabilities of the standard fuel transfer pump, a transfer tank and auxiliary pump will also be required. If an overhead main fuel tank is installed, a transfer tank and float valve will be required to prevent fuel head pressures from being placed on the fuel system components. See Transfer Tank and Figure 5-3, following.

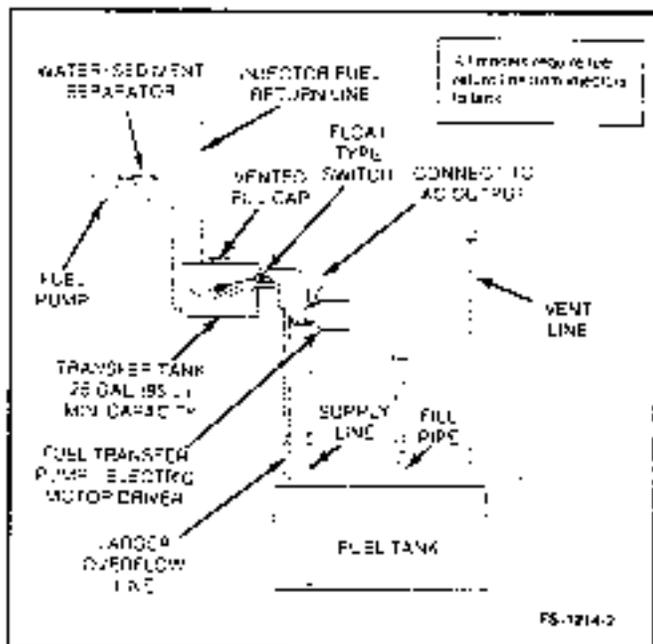


FIGURE 5-3. TYPICAL FUEL SUPPLY INSTALLATION

Transfer Tank (If Used): Fuel transfer tanks are used when the standard engine fuel pump does not have the capacity to draw the fuel from the supply tank; or the supply tank is overhead and presents problems of high fuel head pressure for the fuel return.

Supply Tank Lower Than Engine: With this installation, the transfer tank is installed near the generator set and within the engine fuel pump lift capability, but below the fuel injection system. Install an auxiliary fuel pump as close as possible to the supply tank to pump fuel from the supply tank to the transfer tank. A float switch in the transfer tank controls operation of the auxiliary fuel pump.

The supply tank top must be below the transfer tank top to prevent siphoning from the fuel supply tank to the transfer tank.

Provide a return line from the engine injection system return connection to the transfer tank (near the top). Provide a transfer tank overflow line to the supply tank in case the float switch fails to shut off the fuel transfer pump.

⚠WARNING *Spilled fuel presents the hazard of fire or explosion which can result in severe personal injury or death. Provide an overflow line to the supply tank from the transfer tank.*

Supply Tank Higher Than Engine: Install the transfer tank near the generator set, but below the fuel injection system. Use fuel line at least as large as the fuel pump inlet. The engine fuel return line must enter the transfer tank.

Include a shutoff solenoid in the fuel line between the fuel supply tank and the transfer tank. It stops fuel flow when the generator set is off.

Engine Fuel Connections

Identification tags are attached to the fuel supply line and fuel return line connections by the factory. Flexible lines for connecting between the engine and the stationary fuel line are supplied as standard equipment.

Exhaust System

Pipe exhaust gases to the outside of any enclosure. Locate the exhaust outlet away from any air inlets to avoid exhaust gases re-entering the enclosure. Exhaust installations are subject to various detrimental conditions such as extreme heat, infrequent operation, hanging loads, etc. Regularly inspect the exhaust system both visually and audibly to ensure the entire system remains airtight and safe for operation.

⚠WARNING *Inhalation of exhaust gases can result in severe personal injury or death. Use extreme care during installation to make sure all connections are secure and will not leak exhaust gases.*

Use an approved thimble, or other refractory insulation system where exhaust pipes pass through walls or partitions (see Figure 5-4). Build according to all applicable code requirements.

⚠WARNING *Inhalation of exhaust gases can result in severe personal injury or death. Do not use exhaust heat to warm a room, compartment or storage area.*

Rain caps are available for the discharge end of vertical exhaust pipes. The rain cap clamps onto the end of the pipe and opens due to exhaust discharge force from the generator set. When the generator set is stopped, the rain cap automatically closes, protecting the exhaust system from rain, snow, etc.

Use a section of flexible exhaust pipe between engine and remainder of exhaust system. Support exhaust system to minimize weight applied to engine exhaust outlet elbow/turbocharger connection.

⚠CAUTION *Weight applied to the exhaust elbow can result in turbocharger damage. Support the muffler and exhaust piping so no weight or stress is applied to the engine exhaust elbow.*

Avoid sharp bends by using sweeping, long radius elbows and provide adequate support for mufflers, and tailpipe. Pitch a horizontal run of exhaust pipe **DOWNWARD** to allow any moisture condensation to drain away from the engine. If an exhaust pipe must be turned upward, install a condensation trap at the point where the rise begins (see Figure 5-5).

Shield or insulate exhaust lines if there is danger of personal contact. Allow at least 12 inches (305 mm) of clearance if the pipes pass close to a combustible wall or partition.

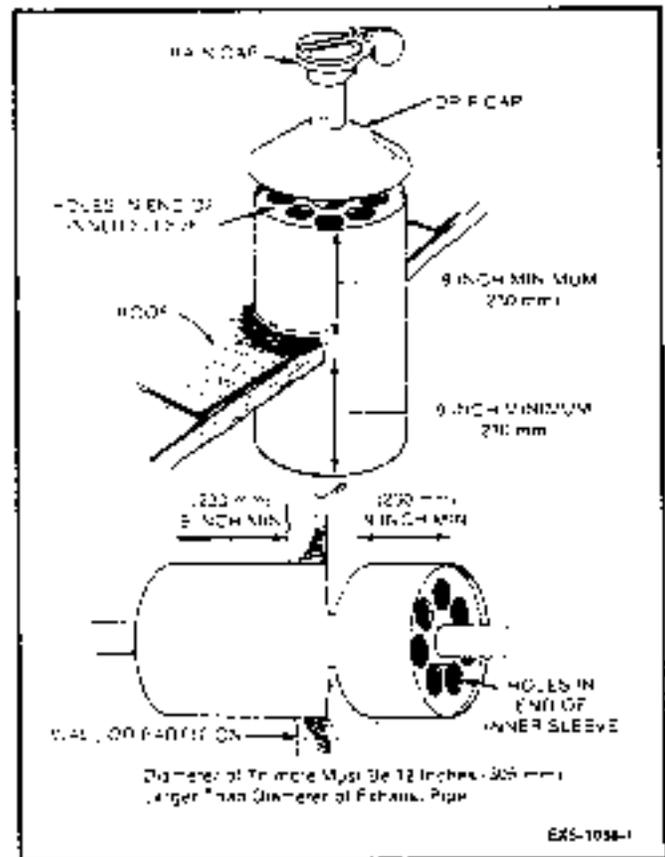


FIGURE 5-4. MOUNTING EXHAUST THIMBLE THROUGH ROOF OR WALL

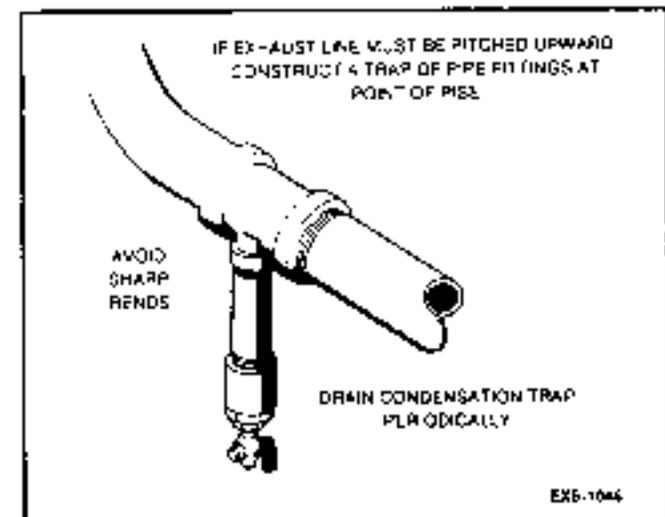


FIGURE 5-5. EXHAUST CONDENSATION TRAP

Ventilation System

Generator sets create considerable heat which must be removed by proper ventilation. Outdoor installations rely on natural air circulation. Indoor installations need properly sized and positioned vents for the required airflow.

Vents and Ducts: For indoor installations (see Figure 5-6), locate vents so incoming air passes through the immediate area of the installation before exhausting. Install the air outlet higher than the air inlet to allow for convection air movement.

Size the vents and ducts so they are large enough to allow the required flow rate of air. The "free area" of ducts must be as large as the radiator core. Refer to the Product Data Sheets for the airflow requirements.

Wind will restrict free airflow if it blows directly into the air outlet vent. Locate the outlet vent so the effects of wind are eliminated.

Dampers: Dampers can be used in any system to block the airflow through the vents when the generator set is not running. This is sometimes necessary in cold climates to keep the generator enclosure at a normal temperature. Dampers must be open when engine is running.

Cooling System

A set mounted radiator with engine driven fan is standard on the generator sets. Optional cooling systems include remote radiator cooling and heat exchanger cooling. The following briefly cover the installation requirements for each system.

Radiator Cooling (Standard): The standard radiator cooling system uses a set mounted radiator with an engine driven pusher type fan to cool the generator set (see Figure 5-6). Air is pulled from the generator end of the set across the engine and then forced through the radiator. An air duct adapter flange surrounds the radiator grill to allow mounting of the air discharge duct.

Locate the air inlet to the rear of set and near the floor. Make the air inlet vent opening 1.5 to 2 times larger than the radiator opening.

Locate the air outlet directly in front of the radiator and as close as possible. The effective opening area should be at least as large as the radiator area. Length and shape of the air outlet duct should offer minimum restriction to airflow. Use a duct of canvas or sheet metal between the radiator and the air outlet opening to prevent recirculation of heated air and provide for flexible connection. The outlet opening size must be increased proportionate to any added restriction caused by ducting or louvres.

Refer to Specifications in this section for standard cooling system capacities, and Maintenance — Cooling System section for further setup procedures.

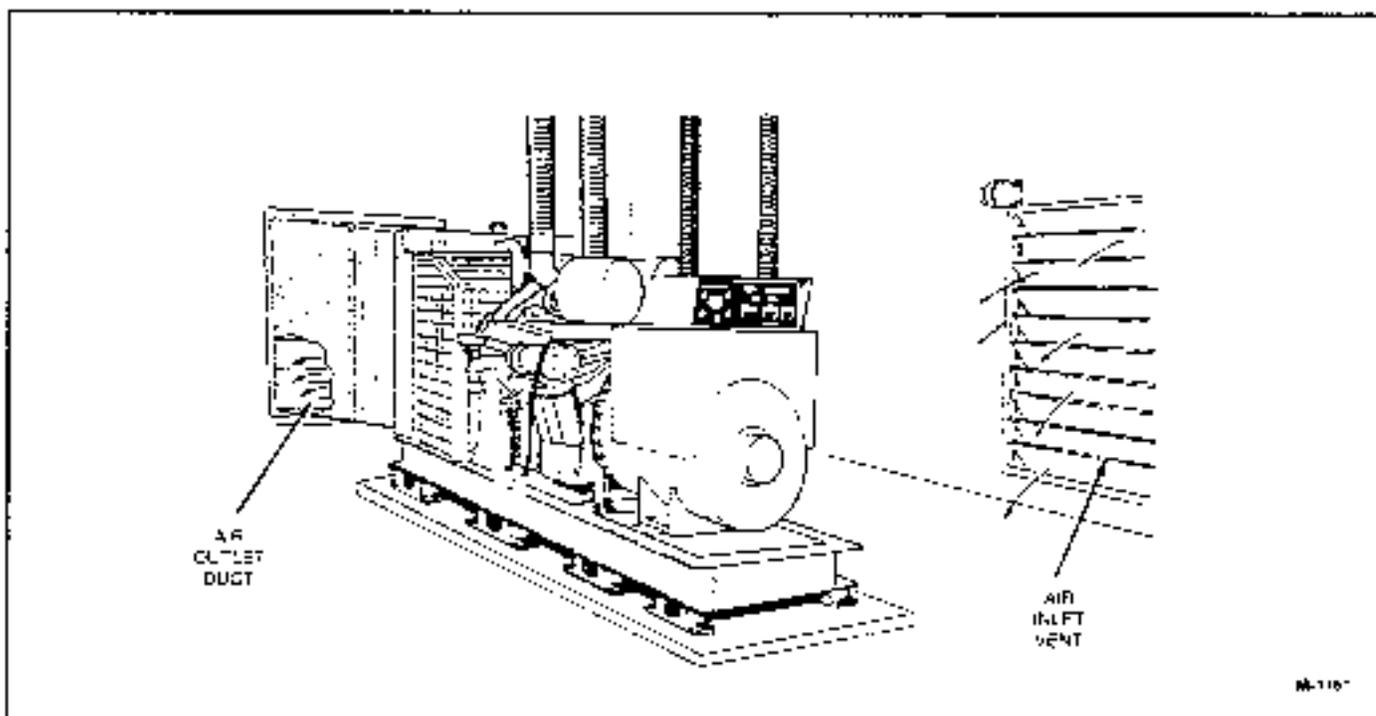


FIGURE 5-6. VENTILATION SYSTEM

Remote Radiator (Optional): Remote radiators can be located a horizontal or a vertical distance from an engine. The horizontal distance is limited by the capability of the engine driven water pump and the maximum external Friction Head pressure. The vertical distance is limited to the maximum Static Head pressure which can be imposed on coolant system gaskets and seals without leakage of coolant from coolant system components. The Friction and Static Head pressures of each GenSet are included in their Product Data Sheet.

Two key design considerations in a remote radiator installation are the vertical distance (X) from the engine centerline to the radiator top and the horizontal distance (Y) from the engine front to the radiator centerline (see Figure 5-7). These distances determine if any additional equipment is required such as a surge tank, auxiliary pump, or hot well. Because of the many design considerations, all remote radiator installations must be designed to insure that the system will function properly. Follow the instructions of the consulting engineer when installing a remote radiator system.

Heat Exchanger (Optional): Heat exchanger cooled sets (see Figure 5-8) do not use a conventional radiator. Instead, a constantly changing water flow cools the heat exchanger which in turn cools the engine coolant. Sufficient air movement and fresh air must be available to disperse heat radiated from the heat exchanger.

To provide sufficient airflow, engine room ventilation fans may be required. Size the fans to remove all heat rejected to the room by the generator set, exhaust pipes and other heat producing equipment. Maintaining a temperature differential of 20° to 30°F (11° to 17°C) is usually satisfactory.

This cooling system uses a shell and tube type heat exchanger instead of the standard radiator and fan. Engine jacket coolant circulates through the shell side of the heat exchanger, while the cooling water is pumped through the tubes. Engine coolant and raw water do not mix. This type of cooling separation is necessary because the raw water contains scale forming impurities and lacks corrosion inhibitors.

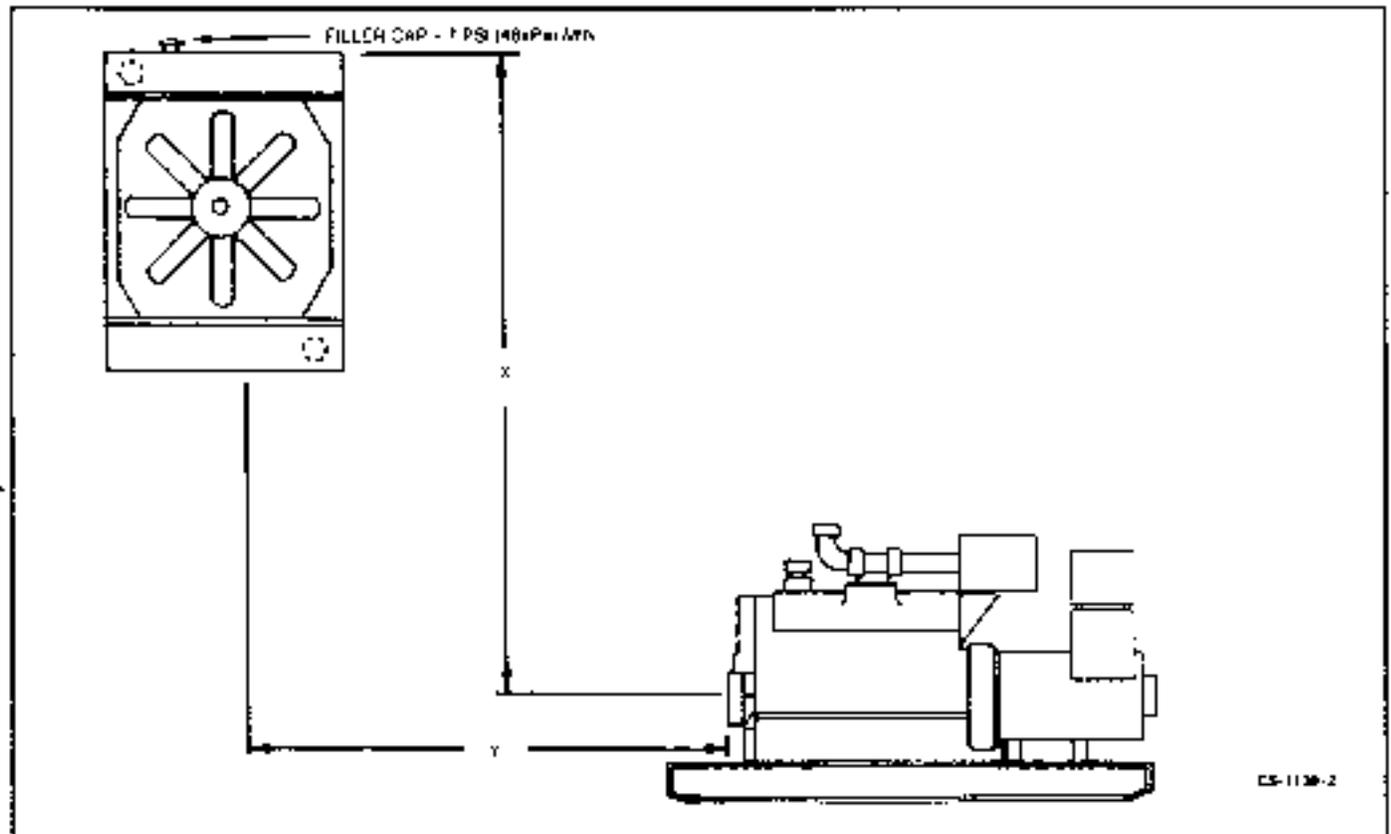


FIGURE 5-7. REMOTE RADIATOR INSTALLATION

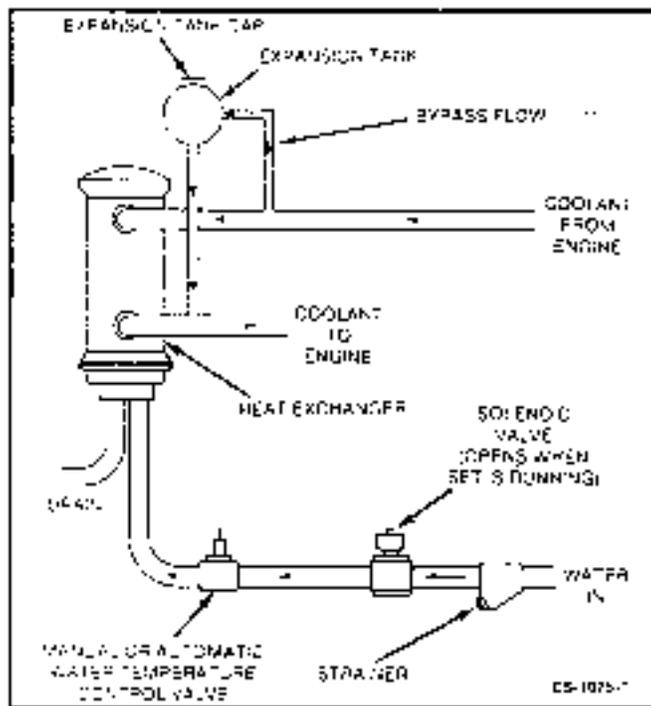


FIGURE 5-8. TYPICAL HEAT EXCHANGER SYSTEM

This system can reduce set enclosure airflow requirements and noise levels. Proper operation depends on a constant supply of raw water for heat removal. Adjust the flow to maintain water temperature between 185° and 195°F (74° and 91°C) while viewing the water temperature gauge. The engine coolant side of the system can be protected from freezing; the raw water side cannot.

All heat exchanger cooled sets must be connected to a pressurized supply of cold water. Make connections to the set with flexible pipe to absorb vibration. On the cool water line, install a solenoid valve to shut off the flow when the set is shut down and a rate of flow valve to control engine temperature. This valve can be either manual or automatic. Actual rate of flow will depend on inlet water temperature.

If an automatic water flow control valve is used, the thermostat must be removed from engine.

Before filling cooling system, check all hardware for tightness. This includes hose clamps, capscrews, fittings and connections.

Coolant Filters: Spin-on type corrosion filters are standard equipment (see Figure 5-9). These precharge filters are compatible with plain water and all ethylene glycol base permanent antifreeze coolants. Refer to engine manual for instructions if a methoxy propanal base antifreeze is desired. Replace filter periodically as recommended in *Maintenance* section.

Coolant Heater (Optional): A coolant heater is used to keep engine coolant warm when the engine is shut down (see Figure 5-10). It heats and circulates the coolant within the engine. This reduces start-up time and lessens engine wear caused by cold starts. It is electrically operated and thermostatically controlled. A pressure switch (connected to the oil filter mounting head), senses a rise in oil pressure when the engine starts, and disconnects power to the heater element.

CAUTION: The heater must not be operated while the cooling system is empty or when the generator set is operating or damage to the heater will occur.

Connect the heater to a source of power that will be available when the generator set is not operating. Be sure the voltage is correct for the heater element rating.

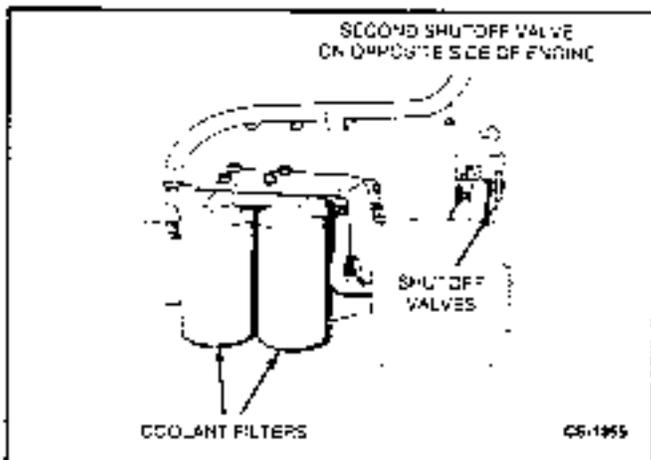


FIGURE 5-9. TYPICAL COOLANT (CORROSION) FILTER

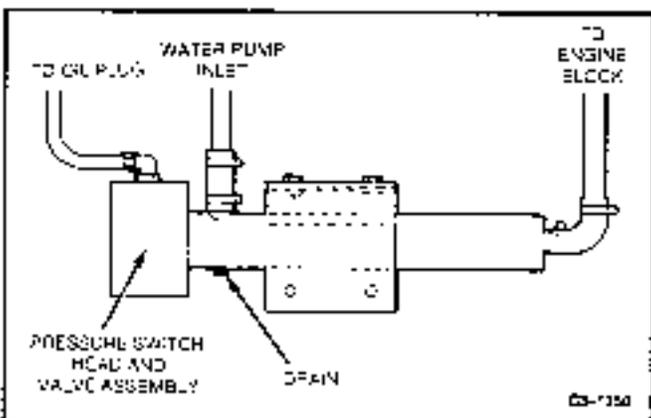


FIGURE 5-10. TYPICAL COOLANT HEATER

ELECTRICAL CONNECTIONS

General

The generator set electrical installation includes connecting the load, installing the control wiring, and connecting the batteries. The batteries should be connected last to avoid accidental starting of the unit during installation. Always connect the negative (-) battery cable last.

Most local regulations require that wiring connections be made by a licensed electrician and the installation inspected and approved before operation. All connections, wire sizes, etc., must conform to the requirements of electrical codes in effect at the installation site.

⚠ WARNING *Improper wiring presents the hazard of fire or electrical shock which can result in severe personal injury or death, and equipment damage. All electrical connections must be made by qualified personnel and meet all applicable codes.*

Transfer Switch

If the installation is for standby service, a transfer switch may be used to switch the load from the normal power source to the generator set (see Figure 5-11). Either a manual or automatic transfer switch may be used. Follow the installation instructions provided with the transfer switch when connecting the load and control wiring. Your distributor can supply transfer switches matched to the generator rating.

AC Wiring

Generator Voltage Connections: The generator output voltage and maximum current rating are specified on the generator set data tag. Line-to-neutral voltage is always the lower voltage shown on the data tag and line-to-line voltage is the higher rating.

These generators can be configured for the voltages shown in Reconnection Diagram (see Figure 5-12). Most of these generators must be reconnected by the installer to give the voltage required for the installation. Before shipping, the factory tests the generator set output by connecting the generator to produce a particular test voltage. The generators may be connected at the factory to produce a specified voltage per customer order. The installer must always check the stator lead terminal block connections and perform any necessary reconnect to obtain the voltage desired.

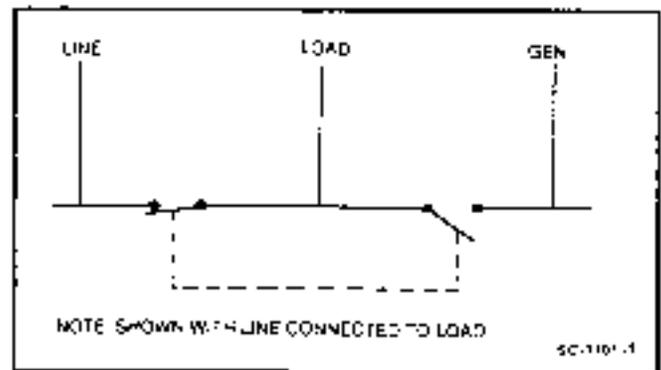


FIGURE 5-11. LOAD TRANSFER SWITCH (TYPICAL FUNCTION)

VOLTAGE	PHASES	FREQUENCY (Hz)	Generator Connection	Current Transf. Conn.	GENERATOR CONNECTION SCHEMATIC DIAGRAM	GENERATOR CONNECTION WIRING DIAGRAM		
						PHASE SEQUENCE - U.V.W. WHEN ROTATING CLOCKWISE, VIEWED AT THE DRIVE END.		
120/240	1	60	DOUBLE DELTA*	1 and 3				
115/230 110/220	1	50						
120/240	3	60	HIGH (SERIES) DELTA	1 and 2				
110/220 115/230	3	50						
120/208 127/220 139/240	3	60	LOW (PARALLEL) WYE	1 and 3				
110/150 115/200 120/208 127/220	3	50						
220/380 240/416 254/440 277/480	3	60			HIGH (SERIES) WYE	1 and 2		
200/345 220/380 230/400 240/415 254/440	3	50						

* Single phase, double delta connection will reduce set rating, and may not work with 3-phase meters, etc.

FIGURE 5-12. RECONNECTION DIAGRAM

Refer to Reconnection Diagram (see Figure 5-12) when reviewing the voltage connection information; and use the electrical schematic supplied with your generator set when actually performing load connections.

CAUTION Reconnecting factory connected generator sets to lower voltages may reduce set ratings, and also render line circuit breakers too small. Consult with your distributor before performing reconnection for different voltage.

Load Connections: All loads are connected to the generator by bolting the load wires to the appropriate terminals on the generator terminal block (see Figure 5-12). The terminals are stamped U, V, W, and N to indicate the line and neutral connections. (Reference: U, V, and W correspond with L1, L2, and L3; and N with L0 respectively.)

When installing sets with AC meters, the generator output leads must be routed through current transformers for proper meter operation (see Figure 5-13). The transformers are identified CT1, CT2, and CT3 on the wiring diagram and electrical schematics. Refer to Reconnection Diagram to identify the output leads that must be routed through each transformer, and also appropriate transformer post selection for meter lead harness connection. Use cable ties to secure the loose transformers to the generator output leads.

The AC meters wiring harness plug inside the control box must be connected to read either High Wye or Low Wye voltage (see Figure 5-14). Confirm that plug-in is connected to proper jack on AC control printed circuit board.

Load Balancing: When connecting loads to the generator set, balance the loads so that the current flow from each line terminal (L1, L2, and L3) is about the same. This is especially important if both single phase and three phase loads are connected. Any combination of single phase and three phase loading can be used as long as each line current is within 10 percent of median value, and no line current exceeds the nameplate rating of the generator. Check the current flow from each line after connections by observing the control panel ammeter (see Figure 5-15).

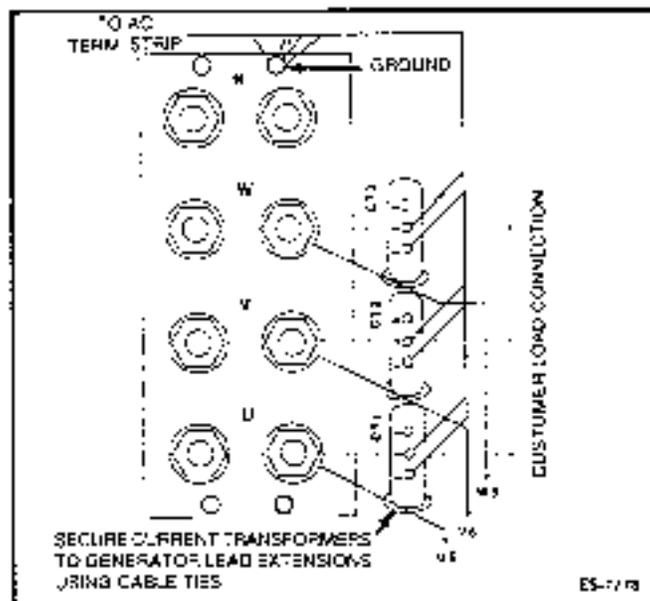


FIGURE 5-13. CURRENT TRANSFORMERS

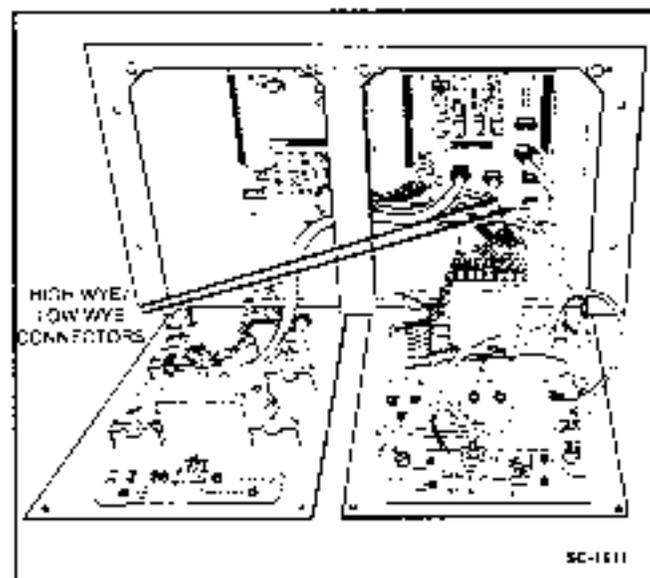


FIGURE 5-14. AC METER HARNESS PLUG-IN CONNECTORS

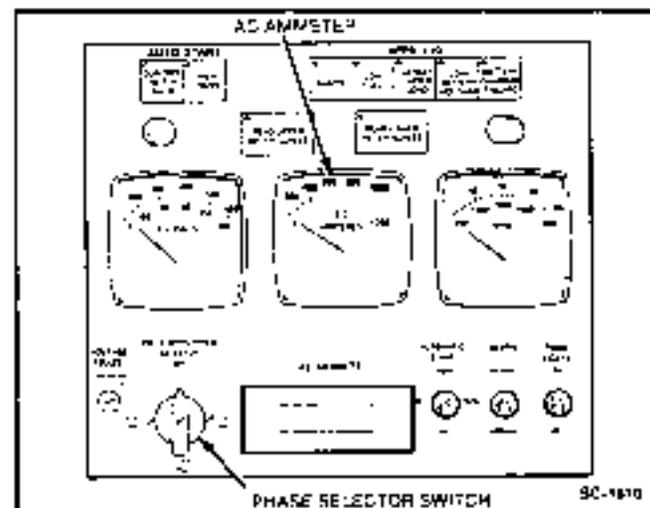


FIGURE 5-15. CHECK LOAD BALANCE

Grounding: Grounding involves making a conducting connection between the metal parts of the generator set or one of its electrical circuits and the earth. The design and installation of a grounding system is affected by many factors such as use of multiple transformers, ground fault protection requirements, and physical location of the generator. Follow the recommendations of the consulting engineer when installing the grounding system.

⚠WARNING Contact with electrically "hot" equipment can result in severe personal injury or death. It is extremely important that bonding and equipment grounding be properly done. All metallic parts that could become energized under abnormal conditions must be properly grounded.

DC Wiring

Remote Control Connections: Provisions are made in the control box for adding optional remote start/stop controls, monitoring, and alarms. Connections are made on terminal blocks located on the Engine and Generator circuit boards (see Figure 5-15). Refer to proper DC wiring diagram for further information.

If the distance between the set and remote stations is less than 1000 feet (305 m), use 18 gauge stranded copper wire. If the distance is 1000 to 2000 feet (305 to 610 m), use 16 gauge stranded copper wire. Always run control circuit wiring in a conduit separate from the AC power cables to avoid interference problems with the control.

⚠CAUTION Do Not install DC control wiring in the same conduit as the AC power. AC voltage induced currents can create operational problems with electronic solid-state devices.

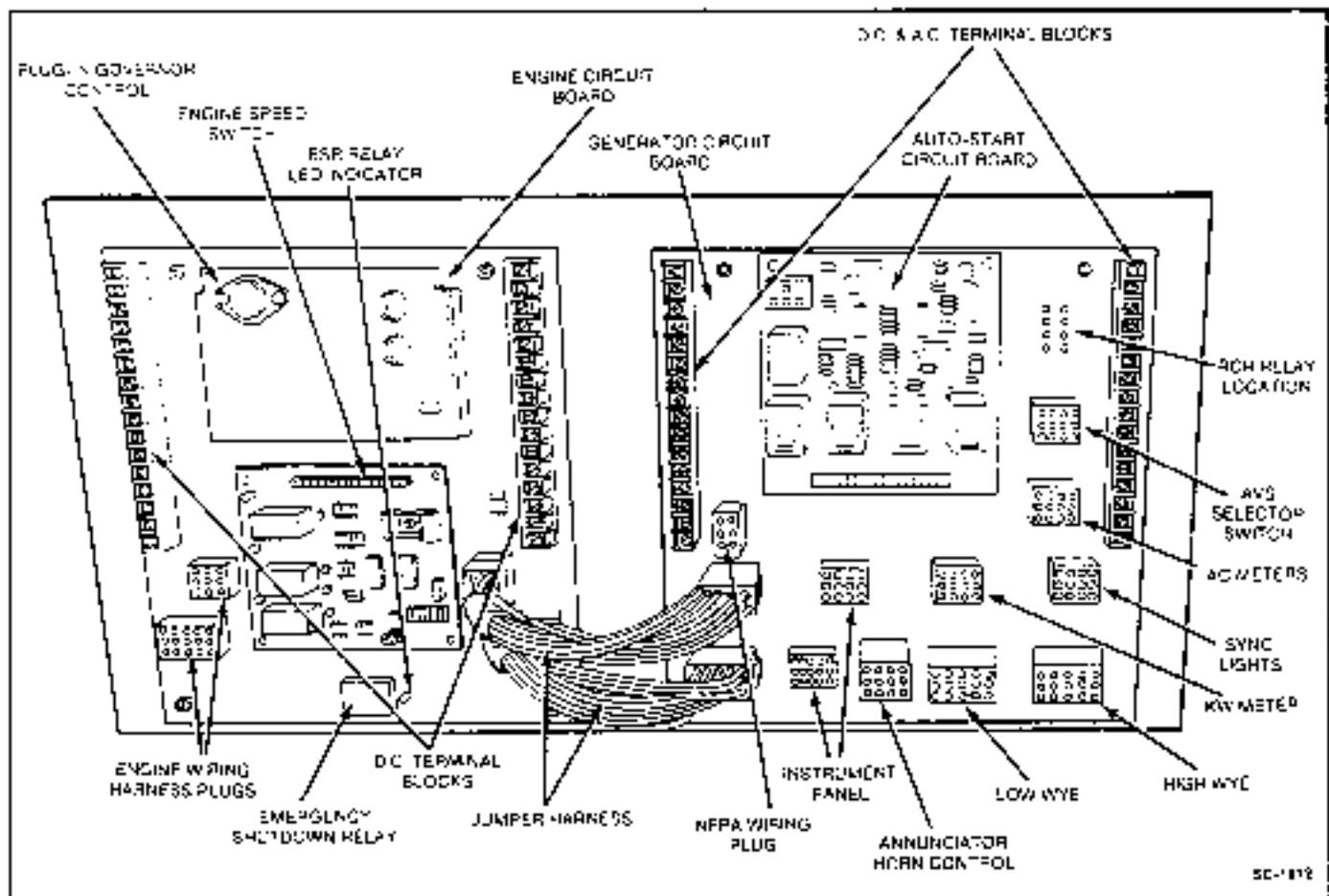


FIGURE 5-16. ENGINE AND GENERATOR PRINTED CIRCUIT BOARD CONTROLS

Battery Connections: Starting the unit requires 24-volt battery current. Use two 12-volt batteries for a normal installation (see Figure 5-17). Connect the batteries in series (negative post of first battery to positive post of second). Normal installation battery cables are included. Increase the cable size if batteries are located remotely from generator set. Service the batteries as necessary. Infrequent unit use (as in emergency standby service) may allow the batteries to discharge to the point where they cannot start the unit. Connect a float charger to the batteries to avoid self-discharge problems.

⚠WARNING *Ignition of explosive battery gases can cause severe personal injury. Do not smoke or allow any arc-producing devices around the battery area. Do not disconnect battery cables while the generator set is cranking or running.*

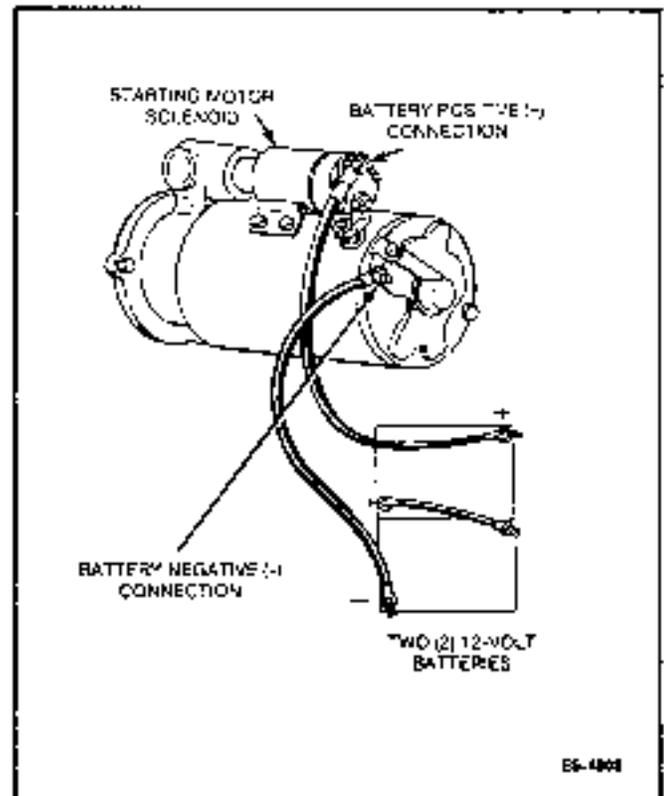
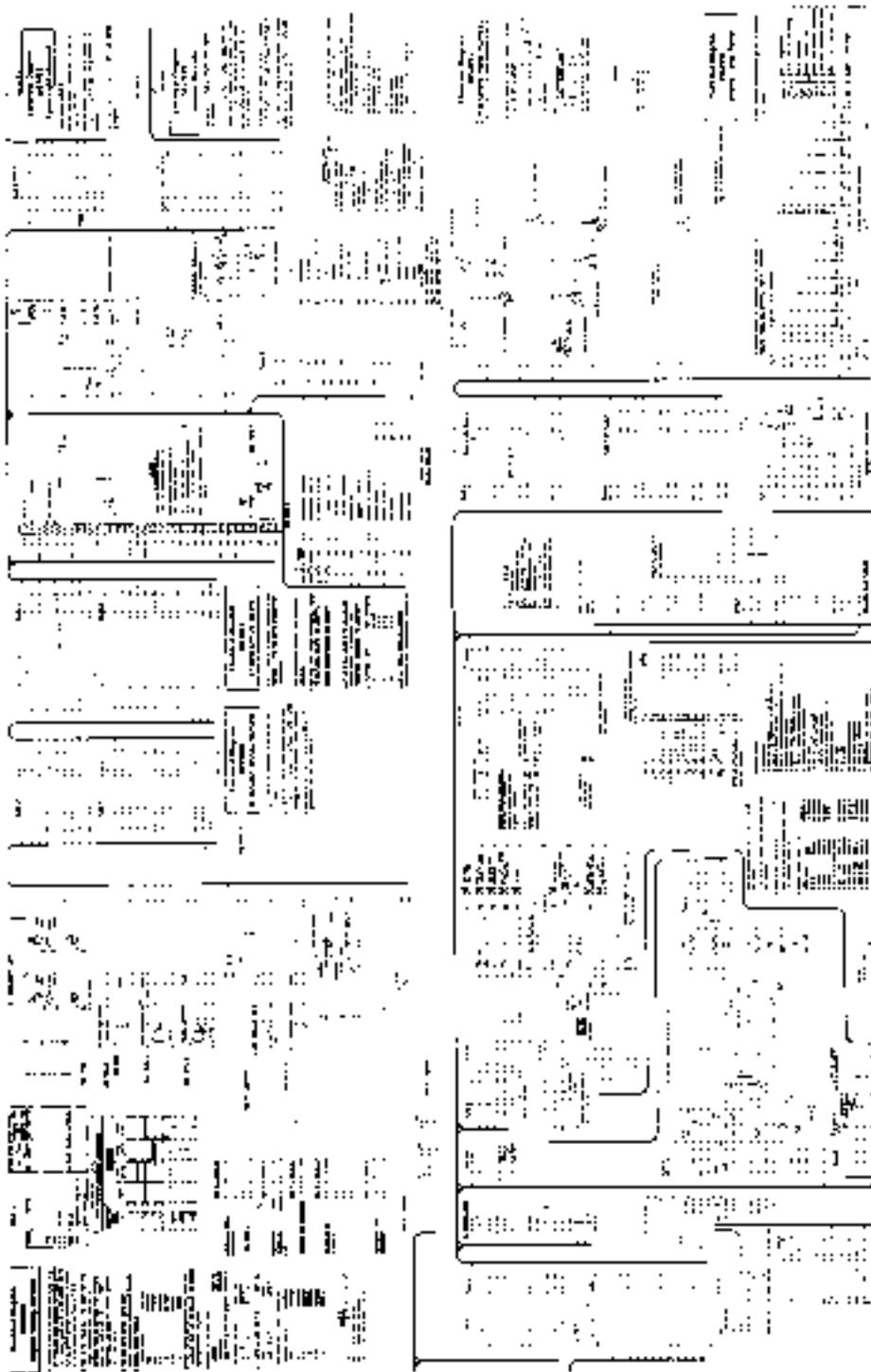


FIGURE 5-17. BATTERY CONNECTIONS

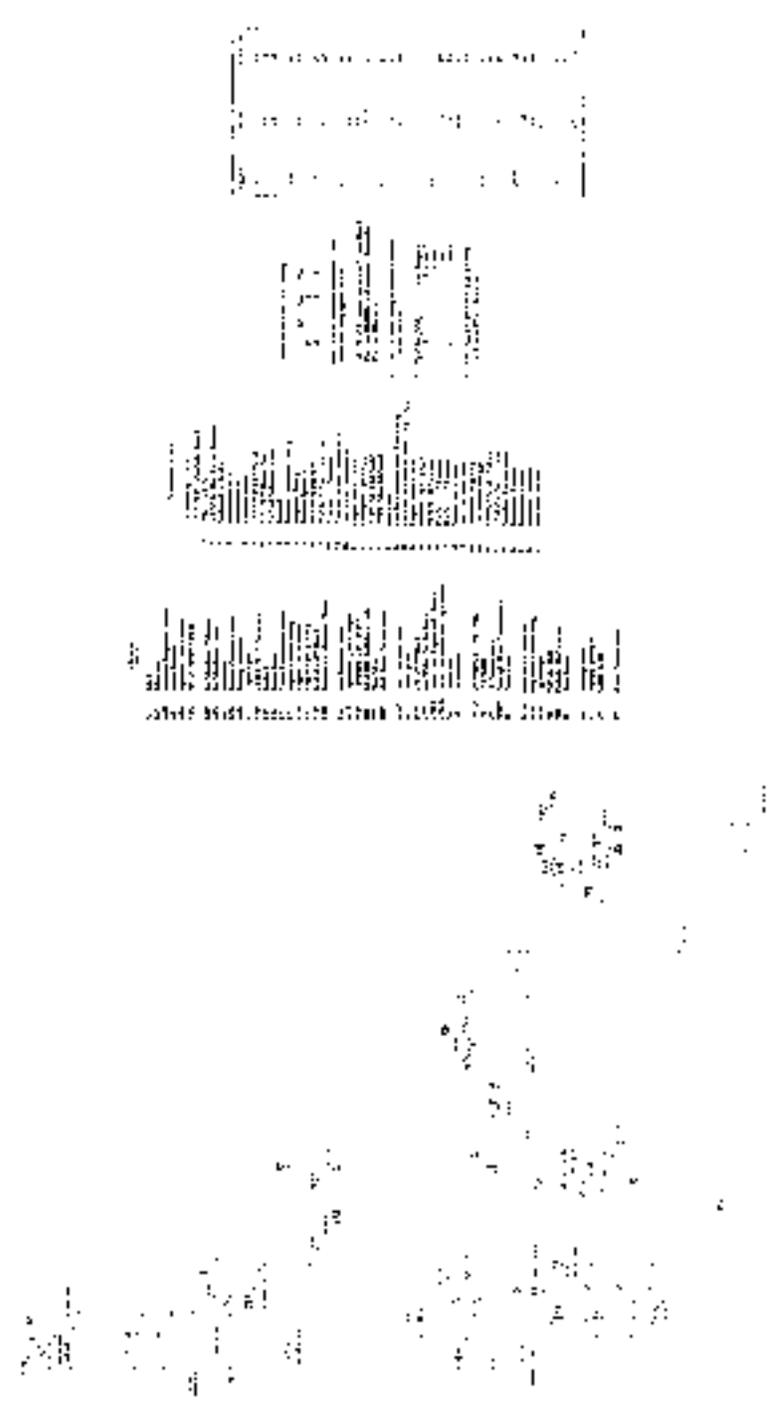
WIRING DIAGRAMS

Title	Page
Composite Wiring Diagram For Gen Set Control Panel And Engine Electrics	5-17
Gen Set Control Panel Logic Diagram	5-18
Gen Set Control Panel Logic Diagram With NFPA 110, Auto-Start Generator Panel, Speed Switch, And Pre-Alarms	5-19
Gen Set Control Panel AC Logic Diagram	5-20
Gen Set Control Panel AC Logic Diagram With Kilowattmeter	5-21
Main Generator (12 Lead Generator)	5-22
Main Generator (6 Lead Generator) (L1, L2, L3)	5-23
Engine Wiring Harness	5-24
Engine Circuit Board	5-25
Generator Circuit Board (2 Sheets)	5-26/5-27
Engine Instrument Panel Harness	5-28
Remote Alarm Panel (NFPA 110) Electrical Diagram	5-29

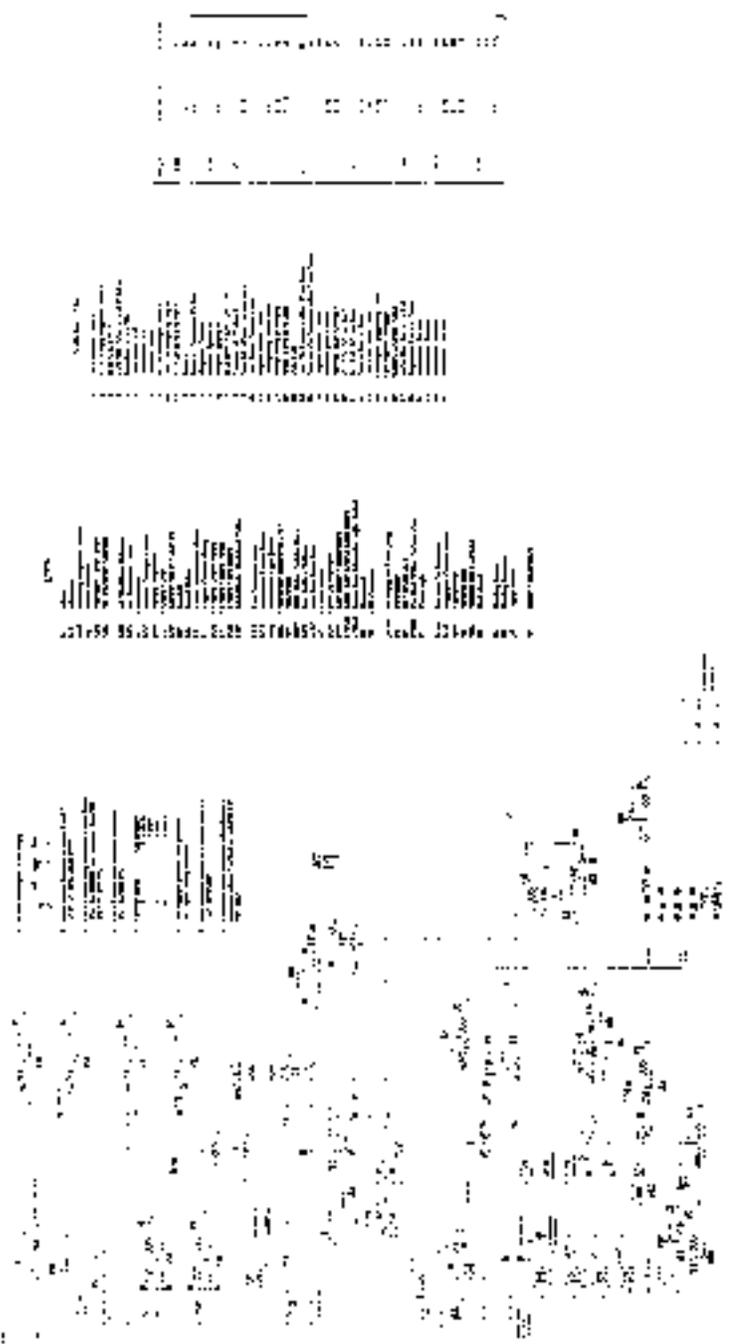


ASSEMBLY DRAWING OF GEAR
 (SEE PARTS LIST)

GEN SET CONTROL PANEL LOGIC DIAGRAM



GEN SET CONTROL PANEL LOGIC DIAGRAM
 WITH NEPS 110, AUTO-START, GENERATOR PANEL, SPEED SWITCH,
 AND PRE-ALARMS



GEN SET CONTROL PANEL AC LOGIC DIAGRAM WITH KILOWATTMETER

LEGEND

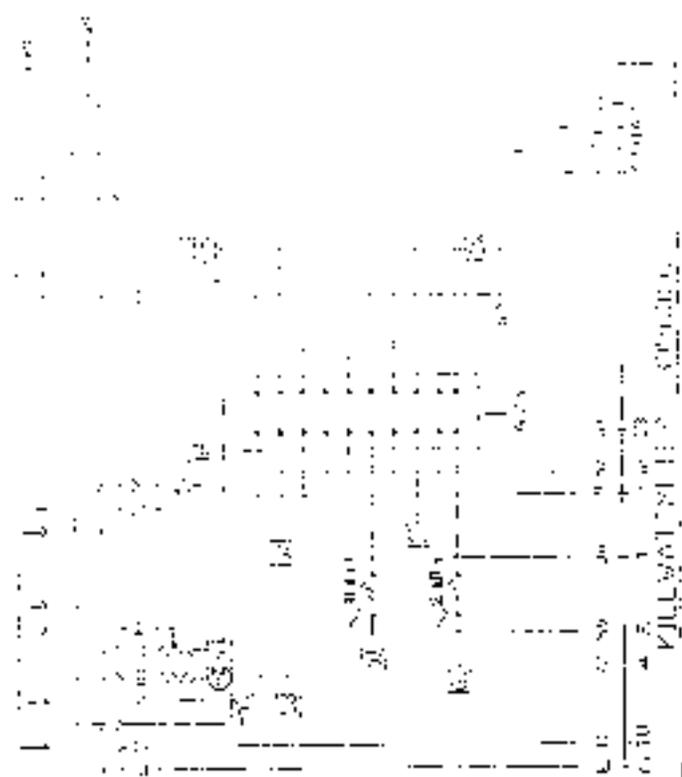
- 4 - Generator
- 402 - Generator Ammeter
- 403 - Generator Meter
- 50 - Generator
- 50 - Generator
- 50 - Generator

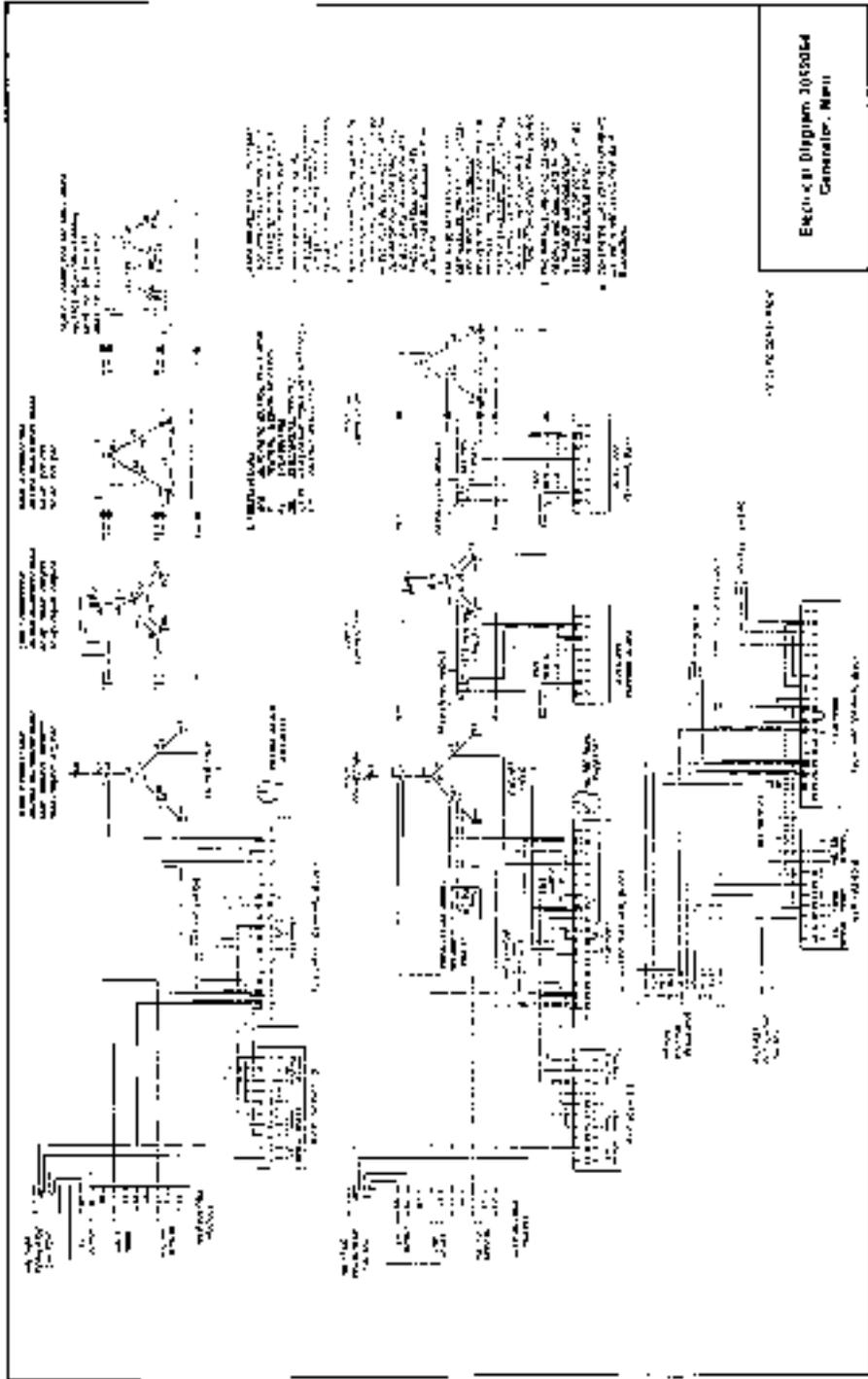
TERMINAL SHEET

- 1 - Generator
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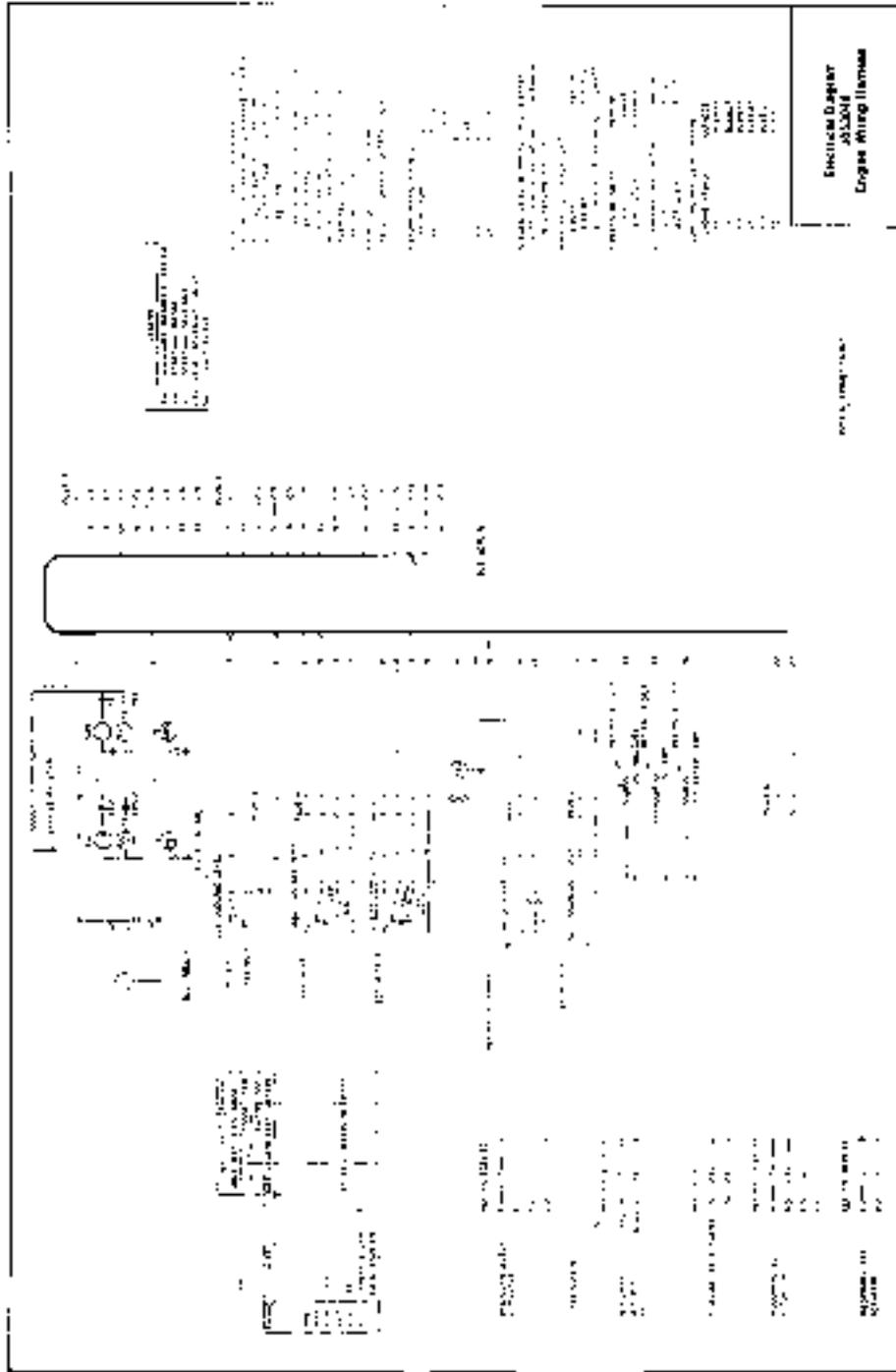
Terminal	Wire	Color	Notes
1	1	Red	Generator
2	2	Blue	Generator
3	3	Green	Generator
4	4	Black	Generator
5	5	White	Generator
6	6	Yellow	Generator
7	7	Purple	Generator
8	8	Brown	Generator
9	9	Pink	Generator
10	10	Grey	Generator
11	11	Orange	Generator
12	12	Light Blue	Generator
13	13	Light Green	Generator
14	14	Light Purple	Generator
15	15	Light Brown	Generator
16	16	Light Pink	Generator
17	17	Light Grey	Generator
18	18	Light Orange	Generator
19	19	Light Light Blue	Generator
20	20	Light Light Green	Generator
21	21	Light Light Purple	Generator
22	22	Light Light Brown	Generator
23	23	Light Light Pink	Generator
24	24	Light Light Grey	Generator
25	25	Light Light Orange	Generator
26	26	Light Light Light Blue	Generator
27	27	Light Light Light Green	Generator
28	28	Light Light Light Purple	Generator
29	29	Light Light Light Brown	Generator
30	30	Light Light Light Pink	Generator
31	31	Light Light Light Grey	Generator
32	32	Light Light Light Orange	Generator
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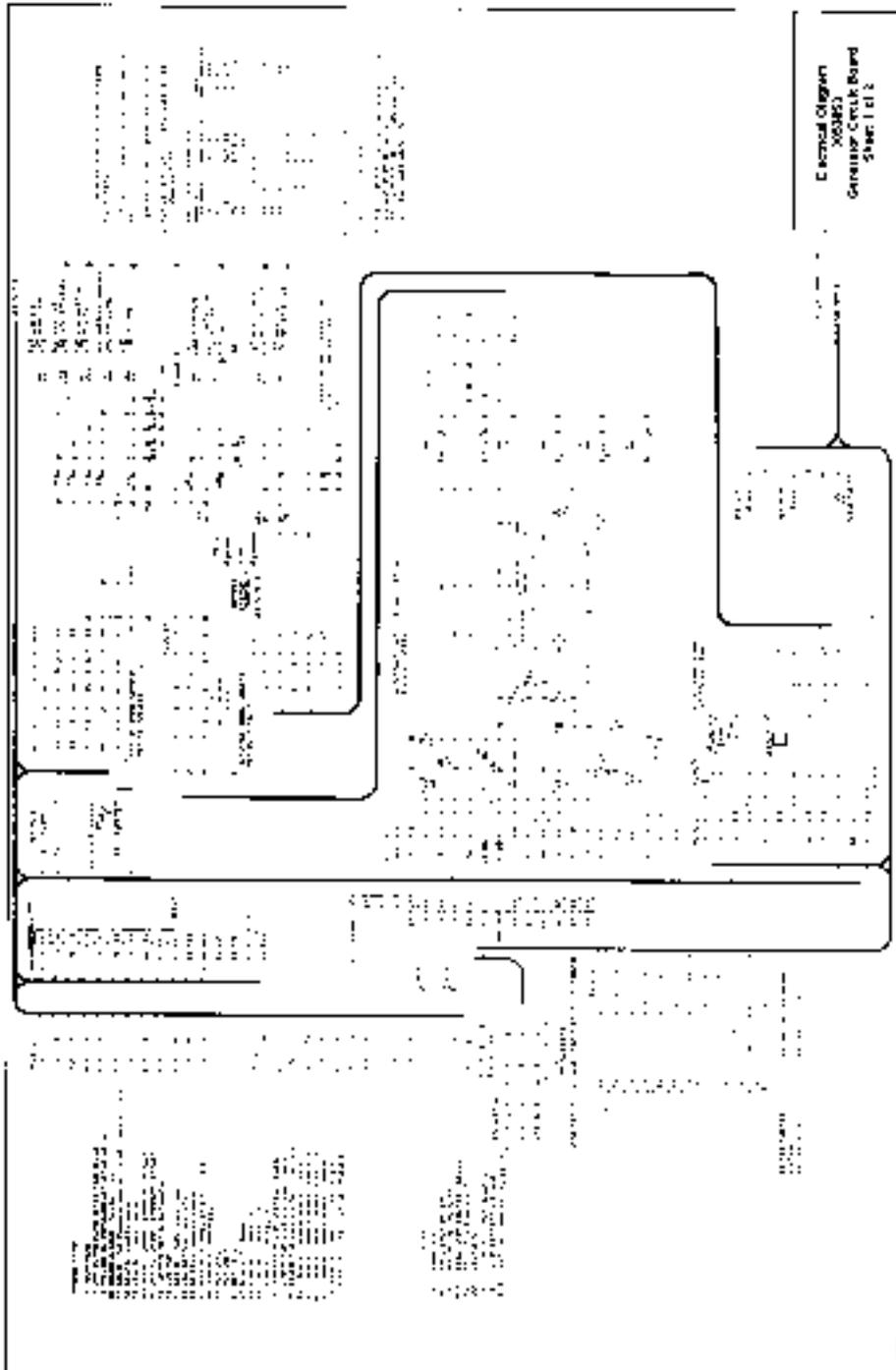




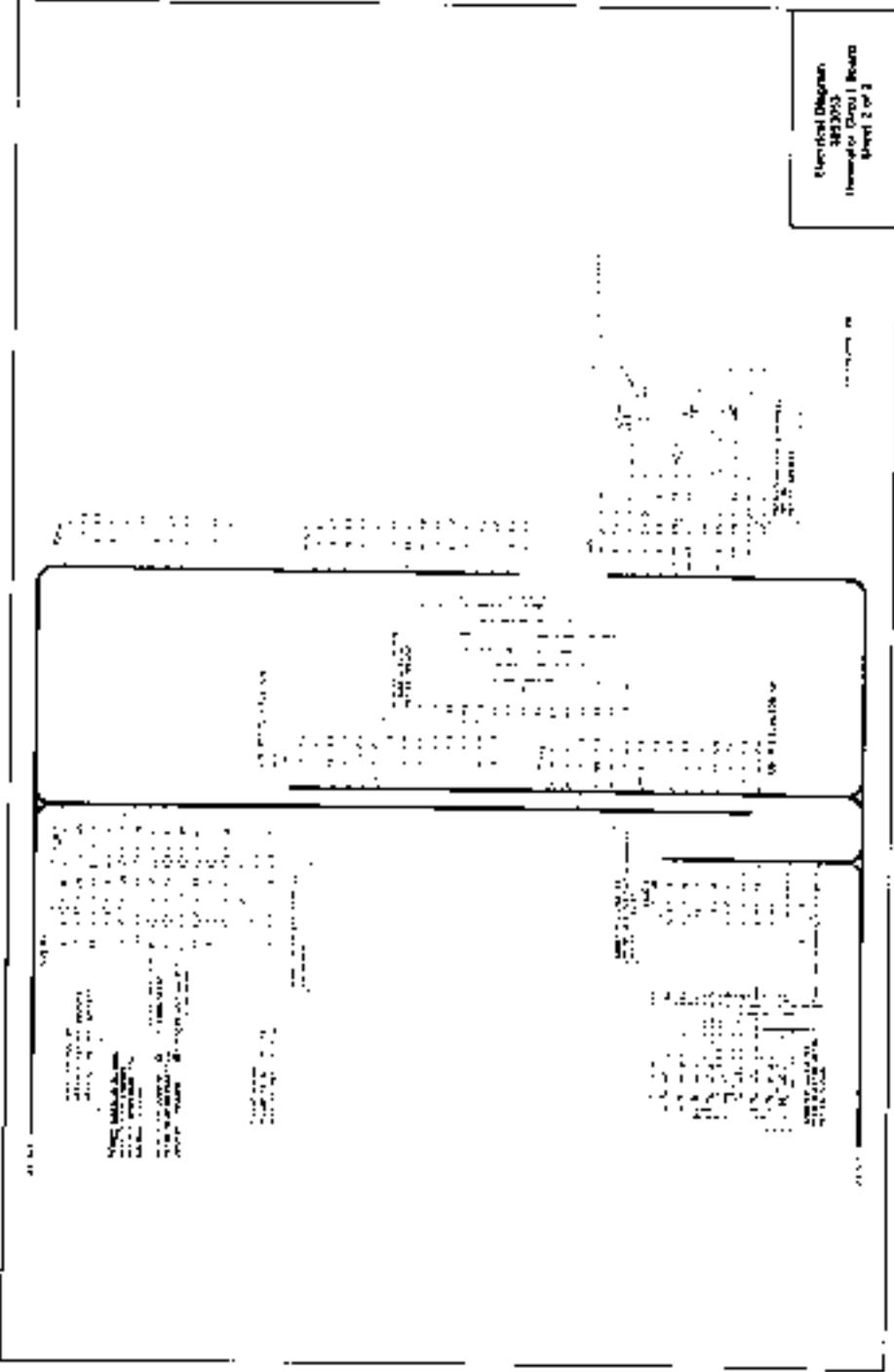
Electrical Diagram 3055054
Generator - Menu



Electric Diagram
 253304
 Engine Wiring Harness



Electrical Outline
303850
Generator Circuit Board
Sheet 1 of 2



Section 6. Prestart Preparations

Before attempting the initial starting of the generator set, be sure it is serviced and ready for operation. Perform the following (see Figure 6-1).

- Check ventilation and exhaust systems
- Check all mechanical connections
- Fill the coolant, lubrication and fuel systems
- Prime the lubrication and fuel systems

VENTILATION

Verify all air vents and ducts are open and free of any obstructions. Verify dampers, if used, operate properly.

EXHAUST SYSTEM

Check the exhaust system for proper installation. Verify there is at least 12 inches (305 mm) clearance between exhaust pipes and any combustible materials, and all connections are tight.

MECHANICAL CHECK

Check the generator set for loose or damaged components and repair or replace as required.

ELECTRICAL SYSTEM

Verify all electrical connections are secure and all wiring is complete. Replace and secure any access panels that may have been removed during installation.

Load Connections

Check that load cables from generator set are properly connected to either a transfer switch or circuit breaker panel.

Battery Connections

Use two 12-volt batteries connected in series for a normal installation. Connect positive battery cable before connecting negative battery cable to prevent arcing.

Service the battery as necessary. If an automatic transfer switch is not used or is installed without a built-in charge circuit, connect a separate trickle charger to the battery.

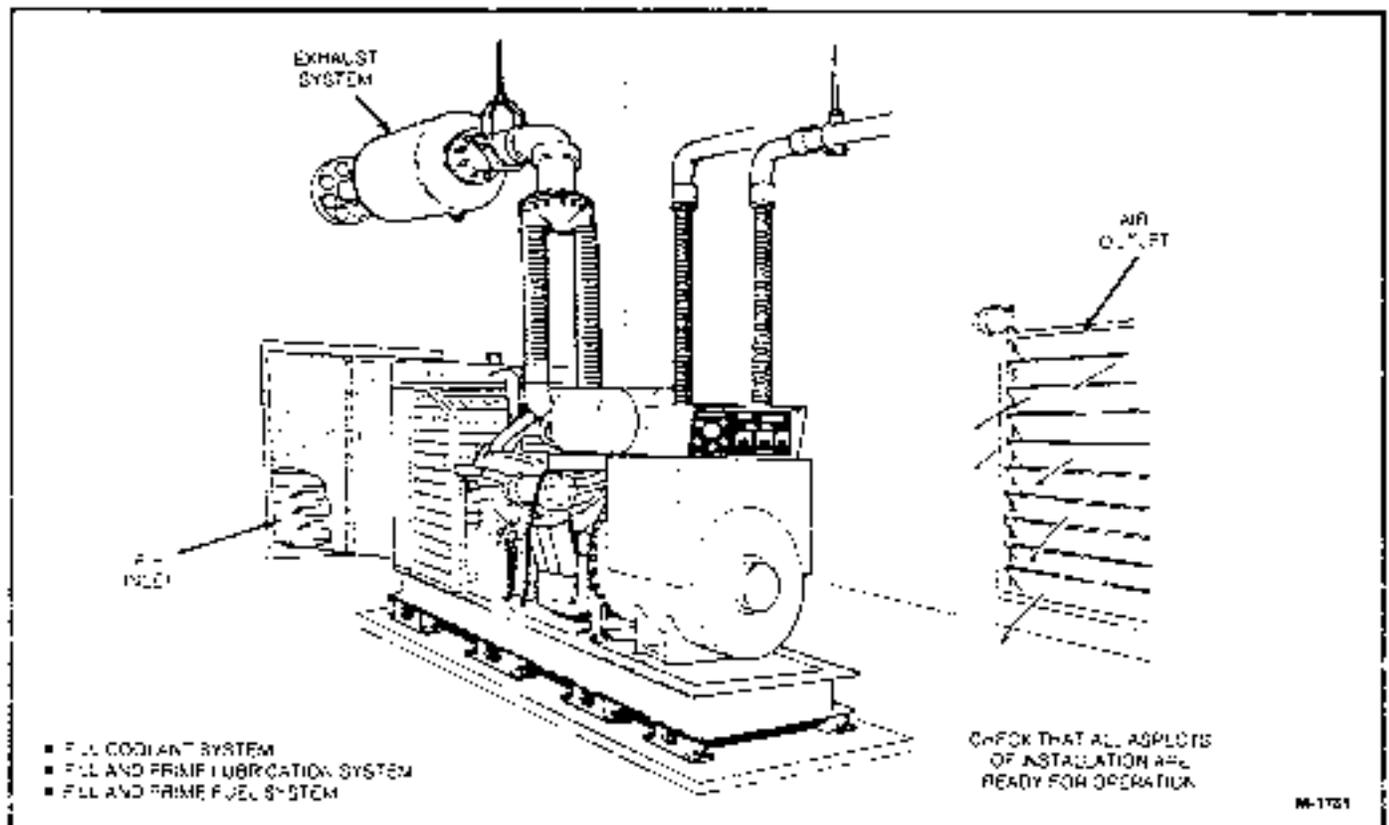


FIGURE 6-1. TYPICAL INSTALLATION

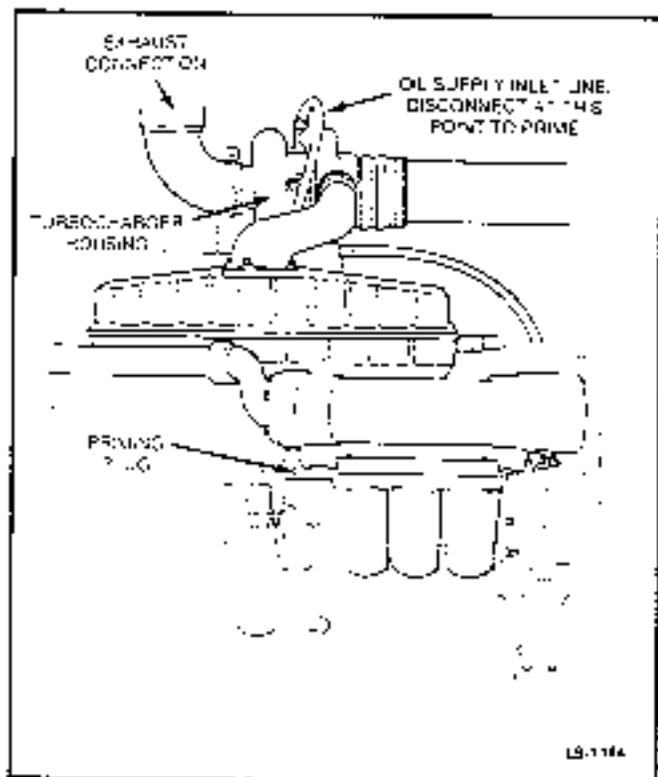


FIGURE 6-2. PRIMING TURBOCHARGER

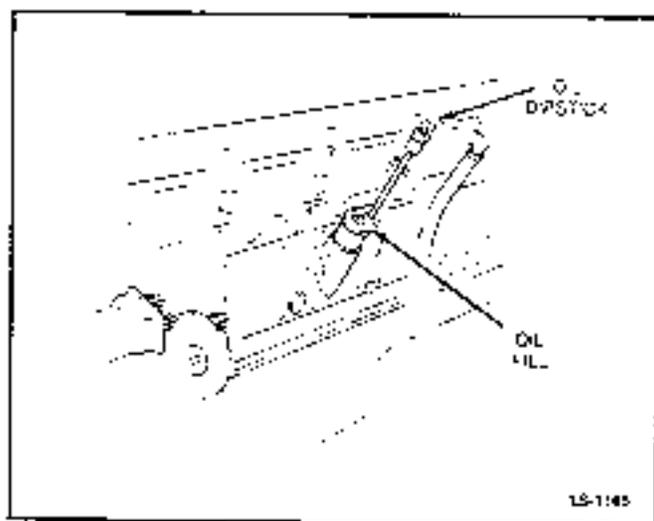


FIGURE 6-3. OIL FILL AND DIPSTICK LOCATION

COOLANT

Engine coolant is drained prior to shipment. Before starting, fill the coolant system with the recommended coolant, refer to *Maintenance* section (Coolant instructions).

LUBRICATION

Engine lubrication is drained prior to shipment. Before starting, fill and prime the lubrication system with oil as follows: (see Figure 6-2)

- 1 Remove oil inlet line from turbocharger housing, fill bearing housing with clean engine lubricating oil; replace line, secure.
- 2 Fill crankcase to "L" (low) mark on dipstick (see Figure 6-3) and refer to *Maintenance—Lubrication System* section.
- 3 Remove plug from head of oil filter housing (see Figure 5-2) and connect a hand or motor-driven priming pump, equipped with pressure gauge, from a source of clear lubricating oil to the plug boss in filter housing.
- 4 Prime until a 30 psi (207 kPa) pressure is obtained.

5. Disconnect wire from fuel solenoid valve (see Figure 6-4).
6. On the Engine Control Panel, depress the Crank switch to crank engine, while maintaining an oil priming pressure of 15 psi (103 kPa), for 15 seconds at filter head priming port.
7. Stop engine cranking, remove external priming equipment, replace plug in filter housing and torque to 15 to 20 ft-lb (20 to 27 Nm).
8. Reconnect wire to fuel solenoid valve.
9. Complete oil fill to "H" (high) mark on dipstick.

FUEL SYSTEM

Engine fuel may not be primed at the fuel filters after shipment (see Figure 6-5). To verify and reprime the fuel system, perform the following procedure:

1. Remove each fuel filter and fill with clean fuel.
2. Put a light coat of fuel on the sealing gasket.
3. Install and tighten, by hand until the gasket just touches the filter head.
4. Tighten the filter an additional one-half to three-fourths of a turn.

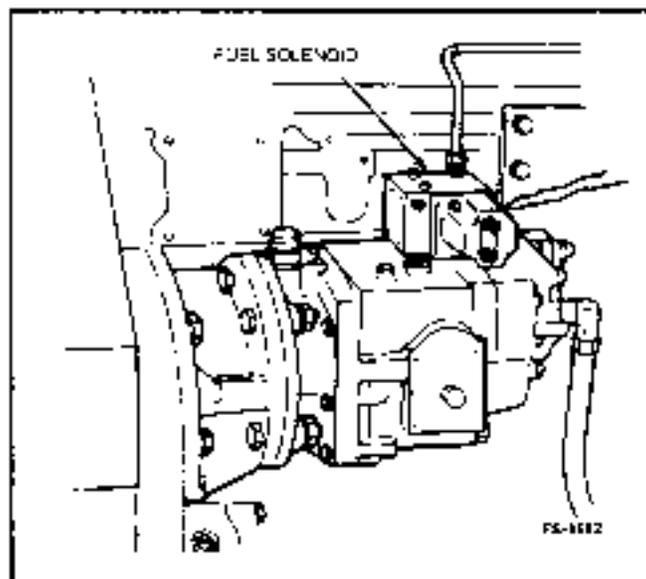


FIGURE 6-4. FUEL SOLENOID VALVE LOCATION

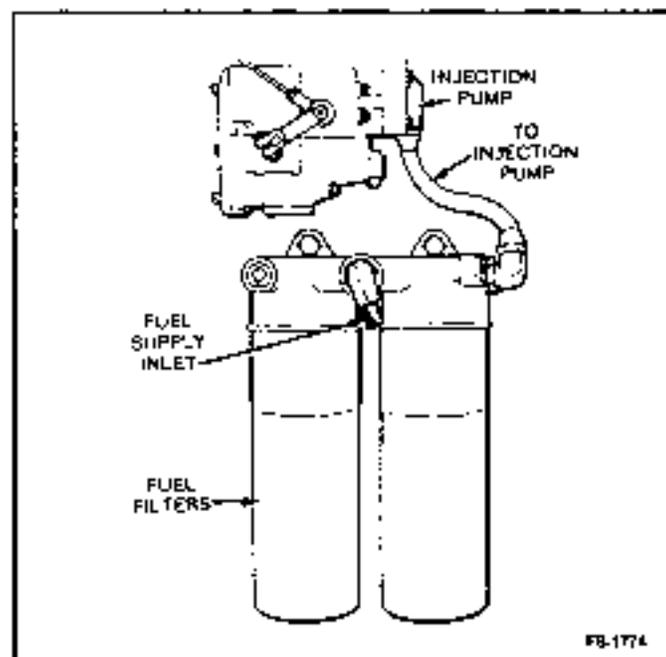


FIGURE 6-5. FUEL FILTERS

Section 7. Initial Start and Checks

Before putting the generator set under load conditions, verify the generator set will perform correctly by checking the following areas.

Mechanical

With the generator set stopped, check for loose belts and fittings, leaking gaskets and hoses, or any sign of mechanical damage. If any problems are found, have them corrected immediately.

DC Electrical System

With the generator set off, check the terminals on the battery for clean and tight connections. Loose or corroded connections create resistance that can hinder starting. Clean and reconnect the battery cables if loose. Always connect the negative battery cable last.

⚠ WARNING Ignition of explosive battery gases can cause severe personal injury. Do not smoke while servicing batteries.

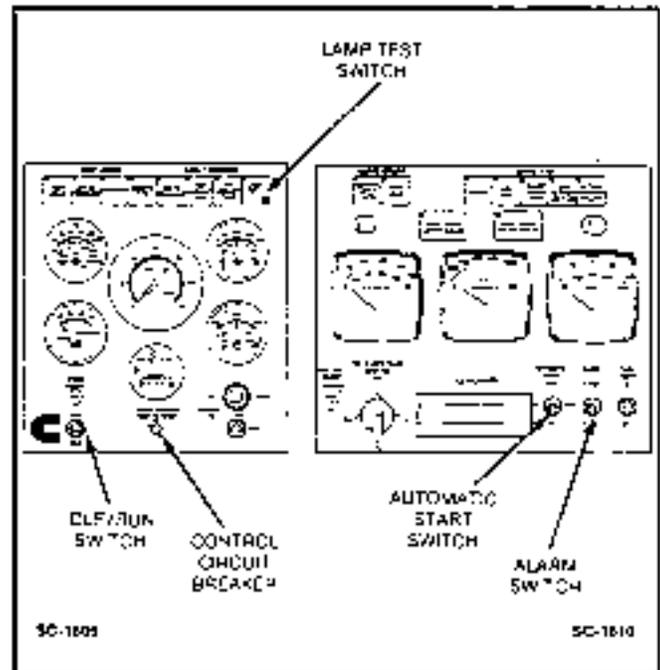


FIGURE 7-1. PRESTART CONTROL CHECKS

PRESTART CONTROL CHECKS

Perform the following control checks (see Figure 7-1):

- Place the Idle/Run switch at RUN position.
- Confirm that control Circuit Breaker is at Reset position.
- Place the Automatic Start switch at OFF/RESET position to clear any fault condition.
- Depress the Lamp Test switch downward. All indicator lamps should light. Verify all of the lamps are on and then release the switch. Contact your distributor if any indicator lamps fail to light.
- Check that Alarm switch is at NORMAL position.
- Place Excitation Switch up to ON position (located on back side of conduit box).

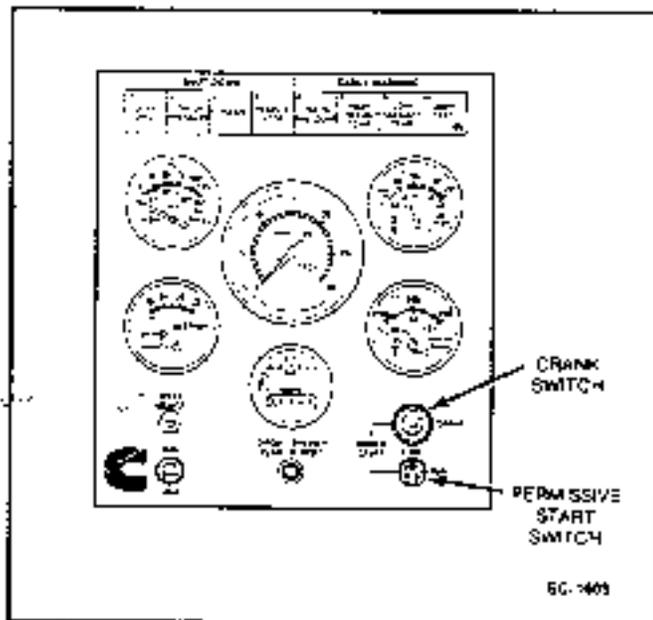


FIGURE 7-2. INITIAL MANUAL START

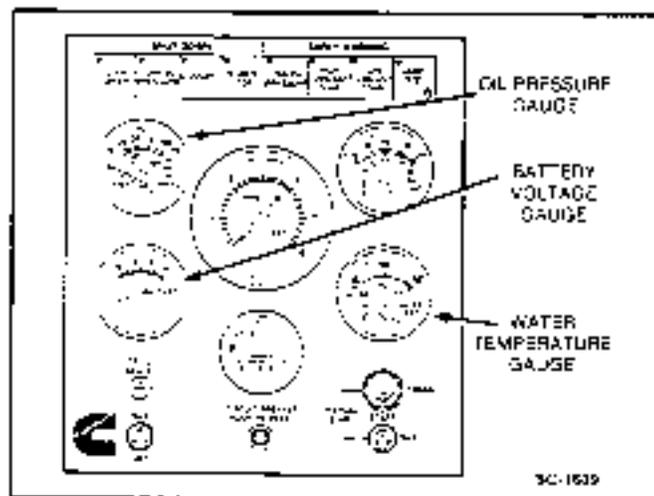


FIGURE 7-3. ENGINE GAUGES

STARTING

Move and hold the Manual Start—Permissive Start switch on the engine control panel at the START position, then depress and hold the Crank switch downward to crank and start the engine. The starter should crank the engine and the engine should start within a few seconds. Release switches when engine starts. If after a few seconds of cranking the engine fails to start or starts, runs, and then stops and a fault lamp lights, refer to *Troubleshooting* section.

Cooling System

When the engine is first started, remove the pressure cap and monitor the coolant level. As trapped air is expelled from the system, the coolant level will drop and additional coolant should be added. Replace the pressure cap when the coolant level is stable.

WARNING Contact with hot coolant can result in severe burns. Allow cooling system to cool before releasing pressure and removing the radiator cap.

ENGINE GAUGES

Check the following while the generator set is operating.

Oil Pressure Gauge

The oil pressure should be in the range of 50 to 90 psi (345 to 620 kPa) when the engine is at operating temperature.

Battery Gauge

This is a voltage reference gauge, indicating condition of the batteries and also of battery charging circuit. Gauge should read approximately 26 to 28 volts while set is running; if reading is high or low, check batteries and battery charger circuit.

Water Temperature Gauge

The water temperature should be in the range of 165° to 195°F (74° to 91°C) depending on the load and ambient temperature.

AC CHECK

Frequency Checks

The generator frequency is a result of engine speed, which is automatically controlled. The generator frequency meter should be stable and the reading should be the same as the nameplate rating (50 or 60 Hz). If the generator frequency is outside of specifications, adjust the Speed Adjust potentiometer on the Engine Control Panel, or refer to the *Adjustments* section for electric governor adjustment procedure.

AC Ampere Check

Turn the phase selector switch to each phase selection shown on the amperes scale. At no-load, the current reading should be zero. With a load applied, all three phases should be approximately the same, and no line current should exceed the set nameplate rating.

⚠ WARNING *High AC voltages produced by the generator set present the hazard of severe personal injury or death. During a no-load test there should be no AC output current readings at generator set.*

AC Voltage Check

Turn the phase selector switch to each line-to-line phase selection shown on the volts scale (L1-L2 on single phase sets; L1-L2, L2-L3, and L3-L1 on three phase sets). Read the AC voltmeter (using the upper or lower voltage scale as indicated by the scale indicator light). At full-load, the line-to-line voltage should be the same as the set nameplate rating. Adjust the Voltage Adjust rheostat on the control panel as necessary to set voltage. If voltage cannot be adjusted to rated values, refer to the *Adjustments* section for voltage regulator adjustment procedure.

On generator sets without AC meters, use a remote voltmeter to verify generator set voltages. If voltage is not at rated value, refer to the *Adjustments* section for voltage regulator adjustment procedure.

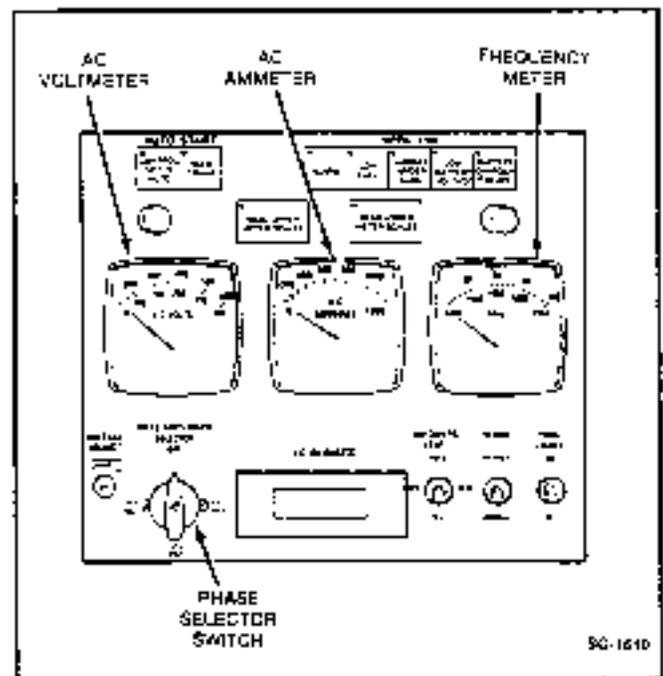


FIGURE 7-4. AC CHECKS

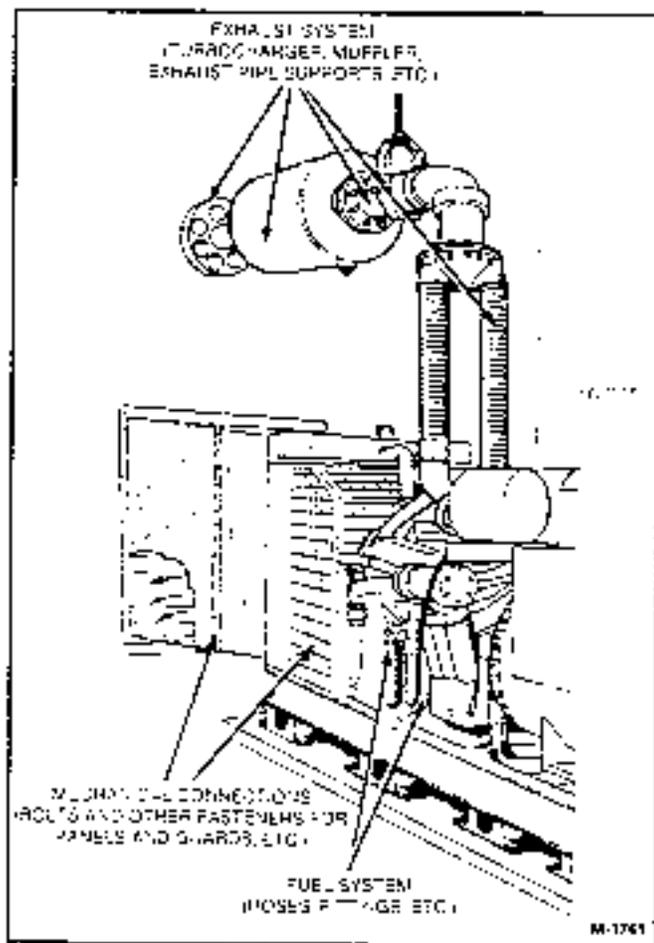


FIGURE 7-5. GENERATOR SET INSPECTION

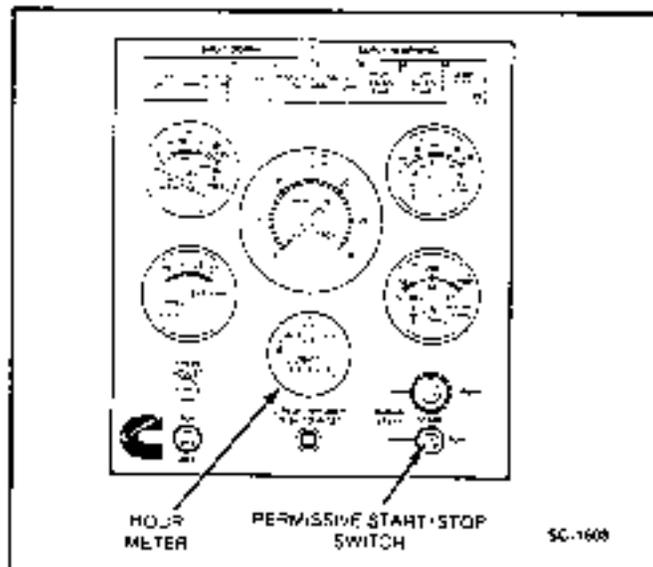


FIGURE 7-6. ENGINE CONTROL PANEL

EXHAUST SYSTEM

With the generator set operating, inspect the entire exhaust system including the exhaust manifold, muffler, turbocharger and exhaust pipe. Visually and audibly check for leaks at all connections, welds, gaskets, and joints. Make sure exhaust pipes are not heating surrounding areas excessively. If any leaks are detected, have them corrected immediately. (See Figure 7-5.)

WARNING *Inhalation of exhaust gases can result in severe personal injury or death. Inspect exhaust system audibly and visually for leaks daily. Shut down the unit and repair any leaks immediately.*

FUEL SYSTEM

With the generator set operating, inspect the fuel supply lines, fillers, and fittings for leaks. Check any flexible sections for cuts, cracks and abrasions and make sure they are not rubbing against anything that could cause breakage. (Reference Figure 7-5.)

WARNING *Leaking fuel will create a fire or explosion hazard that can result in severe personal injury or death. If any leaks are detected, shut down the unit and have them corrected immediately.*

MECHANICAL

With the set running, listen for any unusual noises that may indicate mechanical problems and check the oil pressure frequently. Investigate anything that indicates possible mechanical problems. (Reference Figure 7-5.)

STOPPING

Stop the generator set by moving the Manual Start — Permissive Start switch to OFF position (see Figure 7-6). Refer to *Operation* section to properly reset the controls for Manual, Remote, or Automatic starting.

BREAK-IN PROCEDURE

Make a special entry in unit log book to drain and replace the crankcase oil after the first 50 hours of operation on new generator sets. Use Hour Meter (see Figure 7-6). Refer to the *Maintenance* section, Table 4-1.

Section 8. Adjustments

ELECTRIC GOVERNOR ADJUSTMENT

Generator frequency is in direct ratio to engine speed which is controlled by the governor. A standard generator set uses a Cummins model EFC electric governor. (Other governor options are available, contact your distributor for further information.) The governor control has four potentiometers for making adjustments (see Figure 8-1). Use a frequency meter or tachometer to monitor the unit during adjustment procedure.

Gain: The Gain control is a one-turn potentiometer. It is used to adjust the sensitivity of the governor. A clockwise rotation of the potentiometer will shorten the response time to load changes.

Drop: The Drop control is a one-turn potentiometer. It is adjustable for zero % (isochronous) to 5% speed drop. Fully counterclockwise rotation will decrease the speed drop.

Run Speed: The Run Speed control is a 20-turn potentiometer for setting the desired no-load governed speed. A clockwise rotation will increase the run speed.

Idle Speed: The Idle Speed control is a 20-turn potentiometer for adjusting the idle speed. A clockwise rotation will increase the idle speed.

Preliminary Adjustments

1. Idle Speed potentiometer (see Figure 8-1)
 - A. Turn the screw counterclockwise 20 turns.
 - B. Turn the screw clockwise 10 turns.
 - C. This will set the Idle speed potentiometer to its mid position.
2. Run Speed potentiometer (see Figure 8-1).
 - A. Turn the screw counterclockwise 20 turns.
 - B. Turn the screw clockwise 10 turns.
 - C. This will set the run speed potentiometer to its mid position.
3. Gain potentiometer (see Figures 8-1 and 8-2).
 - A. Turn the screw fully counterclockwise.
4. Drop potentiometer (see Figures 8-1 and 8-2).
 - A. Turn the screw fully counterclockwise for isochronous operation.
 - B. Turn the screw to approximately 40 for 3 percent droop.
 - C. Turn the screw to approximately 80 for 5 percent droop.

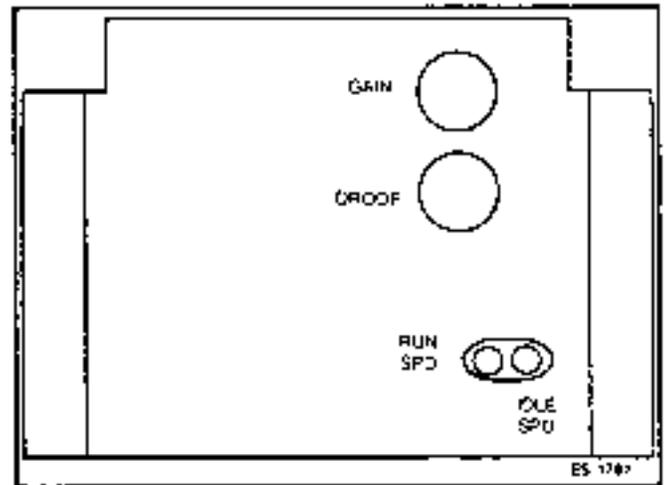


FIGURE 8-1. ELECTRIC GOVERNOR

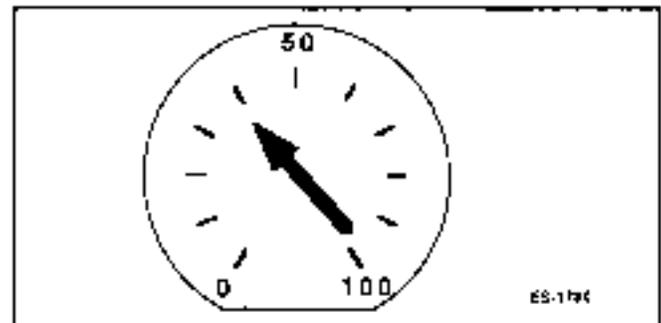


FIGURE 8-2. GAIN AND DROOP POTENTIOMETERS

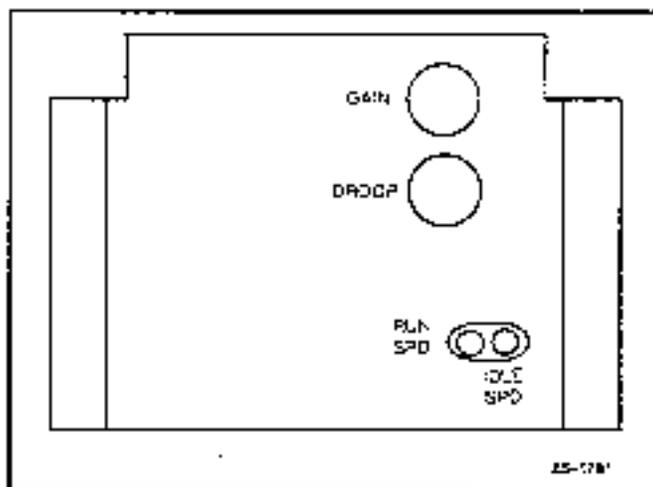


FIGURE 8-3. ELECTRIC GOVERNOR

Governed Speed Adjustment (Run Speed)

Generators which are to operate at 60 Hz full load, must have the engine no-load governed speed adjusted to; (see Figure 8-3).

- 60.0 Hz (1800 RPM) for isochronous operation
- 61.8 Hz (1854 RPM) for 3% speed droop
- 63.0 Hz (1890 RPM) for 5% speed droop

For generators which are to operate at 50 Hz full load, the engine no-load governed speed must be adjusted to; (see Figure 8-3).

- 50.0 Hz (1500 RPM) for isochronous operation
- 51.5 Hz (1545 RPM) for 3% speed droop
- 52.5 Hz (1575 RPM) for 5% speed droop

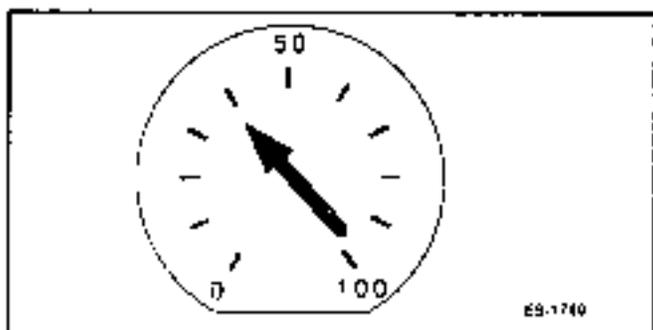


FIGURE 8-4. GAIN AND DROOP POTENTIOMETERS

Droop Adjustment - Isochronous Operation

For isochronous operation, the droop potentiometer (see Figures 8-3 and 8-4) must be turned fully counter-clockwise and will not require any further adjustment.

Gain Adjustment

1. Close the main line circuit breaker and apply approximately 3/4 of the rated load.
2. Make sure the engine speed is constant. If the engine speed is constant, turn the Gain potentiometer (see Figures 8-3 and 8-4) clockwise slowly until the engine speed is not constant.
 - A. Slowly turn the potentiometer counterclockwise until a constant speed is achieved. Turn the potentiometer counterclockwise an additional 1/2 division.

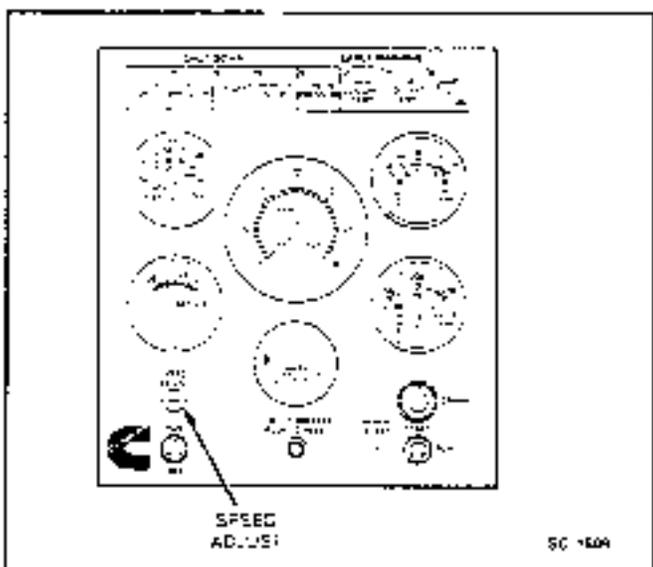


FIGURE 8-5. ENGINE CONTROL PANEL

Fine Speed Adjustment

After the gain adjustment is made, the full load governed engine speed may require a minor adjustment to equal the desired speed (i.e. 60 Hz, 1800 RPM or 50 Hz, 1500 RPM). Use the Speed Adjust potentiometer on the engine control panel (see Figure 8-5) for fine speed adjustments of less than ± 100 RPM.

VOLTAGE REGULATOR ADJUSTMENT

The AC generator is fitted with a permanent-magnet exciter which ensures voltage build-up from a low speed such that nominal voltage is achieved within a very short period after generator set start-up. Generator voltage is controlled by the voltage control rheostat located on the Generator Control Panel and the solid-state Voltage Regulator located on the engine side of the generator conduit box (see Figures 8-6 and 8-7).

The generator voltage may be adjusted within ± 3 percent of the rated nameplate voltage via the control panel mounted voltage control rheostat. If proper voltage cannot be obtained by adjusting the control rheostat, adjust the voltage regulator as follows:

1. Loosen the voltage control rheostat locking nut. With a screwdriver, turn rheostat fully counter-clockwise, then fully clockwise, then to mid position (see Figure 8-6).
2. Remove the cover from the voltage regulator housing, located on the engine side of the generator conduit box (see Figure 8-7).
3. With the generator set operating, and the voltage being monitored (either by meters on the set or with remote metering), adjust voltage regulator board Coarse Voltage Potentiometer to the desired generator voltage (see Figure 8-7).
4. Perform line voltage adjustment (± 3 percent) of control rheostat as necessary and retighten locking nut (see Figure 8-8).
5. Stop and restart generator set to confirm proper operation.
6. If adjusting the Coarse Voltage Potentiometer of the voltage regulator board does not allow the generator voltage to come within desired range, refer to wiring diagram included with unit and check for proper connections. Repeat the adjustment procedure. If proper adjustment is still not possible, contact your service representative for assistance.

CAUTION Do not adjust any other voltage regulator potentiometers or rheostats. They are factory-calibrated for operation with this generator set. Any adjustment of other components could cause generator set voltage instability or overheating. Any other adjustments should only be made by a qualified service representative.

7. Shut down the generator set. Replace cover on voltage regulator housing before returning the generator set to service.

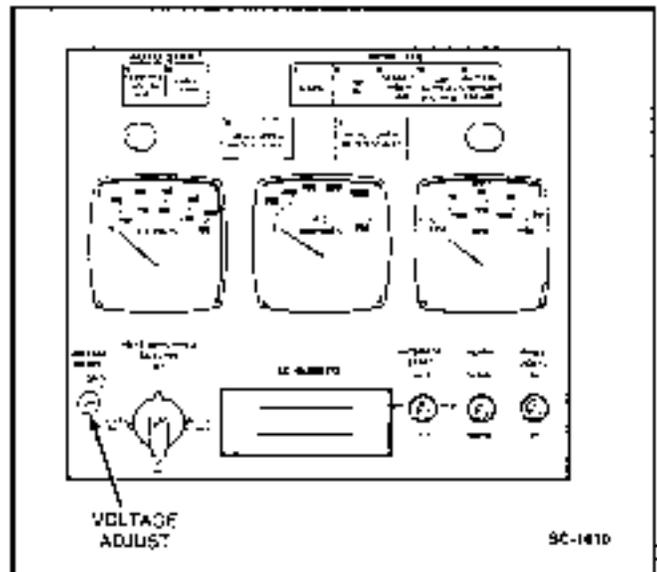


FIGURE 8-6. GENERATOR CONTROL PANEL

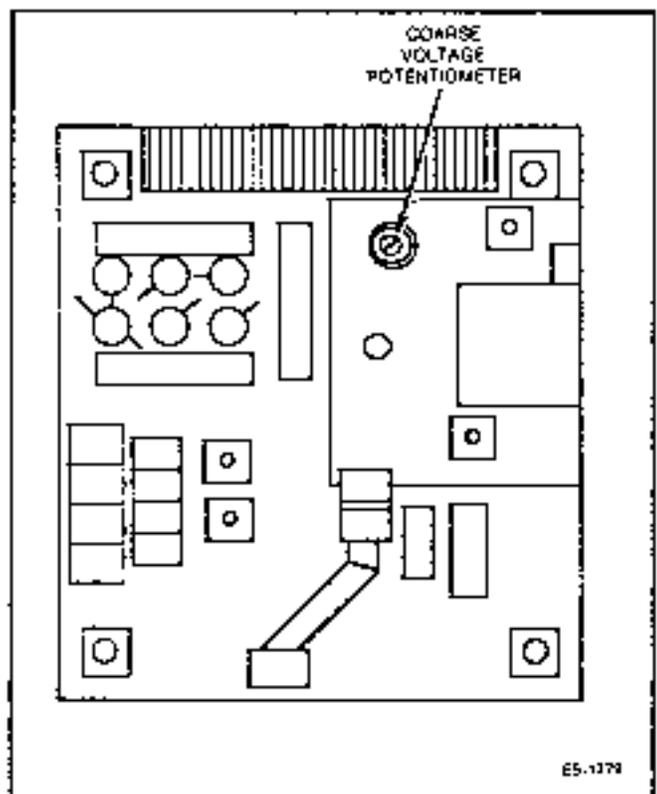


FIGURE 8-7. VOLTAGE REGULATOR



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